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AN OVERVIEW OF MARITIME CYBER SECURITY CHALLENGES

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ABSTRACT

The vulnerabilities to cyber-attacks of today's marine transportation system have not yet been well studied. The dependence of many maritime systems on the Global Positioning System (GPS), and the relative ease by which these systems can be jammed (through denial of reception by a competing signal) or spoofed (through deliberate introduction of a false signal) is of particular con Market forces and advances in technology are integrating these systems with one another, and with other systems, increasing both vulnerabilities and the potential consequences in the event of system failure. This paper explores vulnerabilities of shipboard systems, propose a way of thinking about cybersecurity that unifies the various forms of attack and indicate the potential solutions to it.

Keywords: cyber security, shipboard systems, GPS jamming and spoofing, electronic chart display and information system (ECDIS), automatic identification system (AIS)

1 INTRODUCTION

Cyber security can be defined as 'the collection of tools, policies, security concepts, security safeguards, guidelines, risk management approaches, actions, training, best practices, assurance and technologies that can be used to protect the cyber environment and organisation and user's assets' [14].

Within this definition, 'cyber environment' comprises the interconnected networks of both IT and cyber-physical systems utilising electronic, computer-based and wireless systems, including the information, services, social and business functions that exist only in cyberspace. On a ship the computer-based systems will comprise a range of information technology components (for example, personal computers (PCs), laptops, tablet devices, servers and networking component such as routers and switches, etc.) and operational technology (for example, control systems, sensors, actuators, radar, etc.) [4].

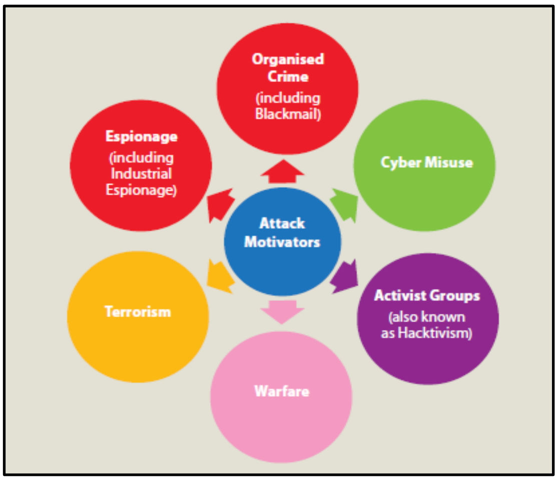
The vulnerabilities to cyber-attacks of today's marine transportation system have not yet been well studied. The dependence of many maritime systems on the Global Positioning System (GPS), and the relative ease by which these systems can be jammed (through denial of reception by a competing signal) or spoofed (through deliberate introduction of a false signal) is of particular concern. GPS is a vital part of a broad array of shipboard, port, and even oil rig systems [7], [24]. Current shipboard control systems contain significant levels of automation to perform complex functions such as navigation and propulsion control. The purpose for employing automated systems have been to reduce cost and improve performance. While automation offers great benefits, it also introduces a set of corresponding cyber security related risks [8].

In 2017, the International Maritime Organization (IMO) adopted resolution MSC.428(98) on *Maritime Cyber Risk Management in Safety Management System (SMS)* [13]. The Resolution stated that an approved SMS should take into account cyber risk management in accordance with the objectives and functional requirements of the *International Safety Management Code (ISM Code)* [12]. It further encourages administrations to ensure that cyber risks are appropriately addressed in safety management systems no later than the first annual verification of the company's Document of Compliance after 1 January 2021. IMO also developed *Guidelines on maritime cyber risk management* that provide high-level recommendations on maritime cyber risk management to safeguard shipping from current and emerging cyber threats and vulnerabilities in which was highlighted that effective cyber risk management should start at the senior management level [11]. Aligned with both IMO documents *The Guidelines on Cyber Security On-board Ships* were made to provide practical recommendations on maritime cyber risk management covering both cyber security and cyber safety [1].

2 THREATS THAT CYBER SECURITY IS TO ADDRESS

The motivation for a cyber-attack on a ship system, as illustrated in Figure 1, may be for one of the following six purposes [4]:

- *cyber misuse* – this includes low-level criminal activities including vandalism and disruption of systems, defacement of web sites and unauthorised access to systems.
- *activist groups* (also known as 'hacktivism') – seeking publicity or creating pressure on behalf of a specific objective or cause, for example, to prevent the handling of specific cargoes or to disrupt the operation of the ship. The target may be the ship itself, the operator of a ship or a third party such as the supplier or recipient of the cargo.
- *espionage* – seeking unauthorised access to sensitive information (intellectual property, commercial information, corporate strategies, personal data, pattern of life) and disruption for state or commercial purposes.
- *organised crime* – largely driven by financial gain, this may include criminal damage, theft of cargo, smuggling of goods and people, and seeking to evade taxes and excise duties.
- *terrorism* – use of the ship to instil fear and cause physical and economic disruption.
- *warfare* – conflict between nation states, where the aim is disruption of tranship systems/infrastructure to deny operational use or disable specific ships, such as product tankers.



Source: [4]

Figure 1: Motivation of cyber security threat actors.

The threat actors may be classified into one of seven categories: individuals, activist groups (also known as 'hacktivists'), commercial competitors, cyber criminals, terrorists and nation states (state sponsored actors). Any of these threat actors are equally relevant to: elements of the ship's systems located remotely; ship information/data stored on external servers; services delivered by third parties; and the ship's supply chain. There may be some convergence between the aims and objectives of individual groups i.e. some of the malware developed by cyber-criminal gangs includes sophisticated command and control functionality, allowing secure exfiltration of information and update of modular components to deliver new or varied exploits over time. Thus a machine or device that was compromised initially for financial crime could be used in future to access sensitive data or to provide a backdoor to allow attacks on the ships themselves [4].

3 SHIPBOARD SYSTEMS

A ship is a complex cyber-physical engineered system that encompasses both waterborne activities and systems, and remote elements such as navigation signals. A ship comprises five main asset types (i.e. plant and machinery, operational technology, information technology, radio frequency (RF) communications, and navigation systems) that are used to provide a range of operational services and where technology plays an increasingly important role [4].

The loss, or compromise, of one or more of these assets has the potential to impact upon [4]:

- the health and safety of staff and other people impacted upon by the work activities being undertaken and to whom a duty of care is owed;
- the ability of the ship to operate safely and to not endanger other ships, maritime structures or the environment; and
- the speed and efficiency at which the ship can operate.

In fact, ships are increasingly using systems that rely on digitisation, digitalisation, integration, and automation, which call for cyber risk management on board. As technology continues to develop, information technology (IT) and operational technology (OT) on-board ships are being networked together – and more frequently connected to the internet. This brings the greater risk of unauthorised access or malicious attacks to ships' systems and networks. Risks may also occur from personnel accessing systems on board, for example by introducing malware via removable media [1]. In relation to access to the systems it is also important to identify who requires access to it and for what purpose. As ships become more and more automated and complex the need to track access on all systems will increase in order to carry out any investigations, should an incident occur [4].

The main difference between a general maritime safety issue and the cyber issue is that victim of a cyber-attack is generally not aware of the threat and following consequences even after the attack, making the situation even more dangerous in term of loses [15].

Modern ships are dependent on a proliferation of sophisticated technology, such as ECDIS (Electronic Chart Display and Information System), AIS (Automatic Identification System), Radar/ARPA (Radio Direction and Ranging) (Automatic Radar Plotting Aid), Compass (Gyro, Fluxgate, GPS and others), Steering (Computerized Automatic Steering System), VDR (Voyage Data Recorder – 'Black Box'), GMDSS (Global Maritime Distress and Safety System) and numerous other advanced units and systems. All of these systems are potentially open to cyber-attacks [7].

Consider for example the ECDIS flaws could allow an attacker to access and modify files and charts on board or on shore. The result of modified chart data would be unreliable and potentially dangerously misleading navigation information. That could lead to a mishap resulting in environmental and financial damage [20]. Researchers from the University of Texas demonstrated that it was possible to change a ships direction by hacking their GPS signal to dupe its on-board navigation systems [23]. An unauthorised access could exploit the AIS weaknesses and falsify a vessel's identity or type, or its position, heading, and speed, impersonate port authorities, communicate with the ship or effectively shut down communications between ships and with ports [20].

4 COMMON WAYS FOR CYBER-ATTACKS ON SHIPS

As per data, a majority of the cyber-attacks on board are triggered accidentally by seafarers which can be due to the opening of phishing email attachments or hyperlinks or using infected removable media. The ship system is an intranet system, i.e. there are computers installed at various locations and departments, which are all connected. However, the same system is used by seafarers for both official and personal use, which makes the complete connected system vulnerable to cyber-attacks [15].

The categories of cyber-attacks that can affect the Maritime industry are [16]:

- Targeted, where a company or a ship's systems and data are the intended target.
- Untargeted, where a company or a ship's systems and data are one of potential targets.
- Intentional, where the cyber breach comes from intentional malicious actions.
- Unintentional, where the breach is an effect of negligence or ignorance.

The following are common ways for cyber-attack on ships [15]:

- *Malware* – malicious software and tools are the most common ways that are used to initiate a cyber-attack. Viruses, spyware, Trojan horses, worms etc. are used to highjack, alter, steal, encrypt and delete sensitive data of a system without the knowledge or permission of the user.
- *Phishing emails* – is the most commonly used techniques to extract sensitive data from users illegally. Cybercriminals design and send emails (or use other communication channels) which appear to be sent from a legitimate and reputable company or person. These messages contain malicious links or attachments which ask for victim's sensitive details such as login credentials, bank details etc.
- *Social Engineering* – is a technique which deals with manipulating people to break security procedures for gaining access to a particular system or network.
- *Email Virus* – is yet another very commonly used technique to infect the desired system with a virus. An email with malicious code is distributed through emails, when activated infects the system with the virus.
- *Honey trap* – is another method, in which, a seafarer plays an indirect role in implanting a virus in the ship's system.
- *Free gadgets* – offered free pen-drives/flash drives as a gift might contain malicious software.
- *SMS* – Short Messaging Service or SMS is also popular way to infect the mobile device od seafarers. The message may contain a free or lucrative offer along with a link which will lure the reader click it. Once connected to another device, it will get transferred to it. As the SMS does not depend on the internet, this is one of the preferred methods of attack.
- *Free Wifi* – in public places are not secure and can be accessed by anyone. There is always a danger of cyber-attacks in such open and vulnerable systems.

5 CAPTURING LESSONS LEARNED

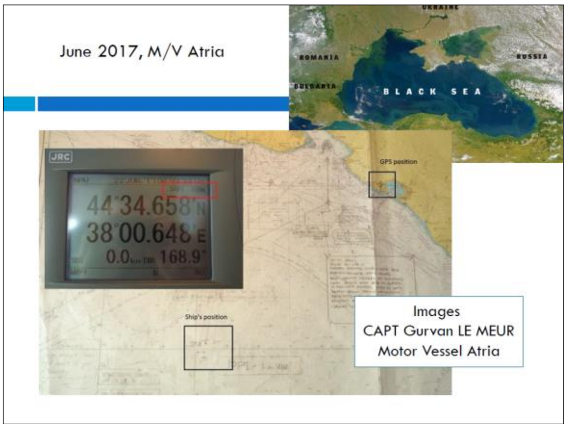
There are more than 51.000 commercial ships in the world. Together, they can carry the vast majority - 90% - of the world trade. Maersk has already experienced significant disruption thanks to a piece of particularly virulent malware.

In 2017, the world's largest container shipping company; Maersk suffered one of the worst kind of cyber-attack. The notorious Not Petya wiped off data from company's 4500 PCs, resulting in massive damages of up to $250 - $300 million. For the recovery from the attack, the company had to install 4000 new servers, 4500 new PCs and 2500 applications, utilising an enormous amount of human and financial resources. With ship acquiring new advanced technologies even year for both engine room and bridge navigation, the issue of cyber-attacks is more prevalent than ever as newest systems on ships are highly automated and extensively dependent on information technology and data exchange. These technological advancements have become an easy target for hackers and cybercriminals to find their way into ship's systems, and from there, to various systems on shore [15]. With Maersk being a victim to a co-ordinated international cyber-attack, shipping was made starkly aware of its vulnerability to hacking and the associated implications for safety [6]. If the world's biggest shipping line can fall victim to such a criminal manoeuvre, despite major investment in IT development, what might be the implications for smaller "players" that rely on connected digital systems for communication and navigation?

In February 2017 hackers reportedly took control of the navigation systems of a German owned 8.250 teu container vessel. The 10-hour attack was carried out by “pirates” who gained full control of the vessel’s navigation system intending to steer it to an area where they could board and take over. The crew attempted to regain control of the navigation system but had to bring IT experts on board, who eventually managed to get them running again after hours of work. The case serves as a “pre-warning”, about what will happen in the future of shipping, with pirates using hacking to gain control and entry to vessels in order to carry out kidnap and ransom [2], [3].

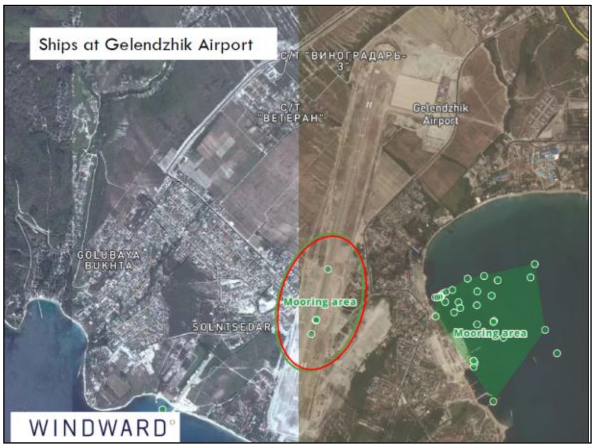
Ships that are totally dependent, as they are today, on GPS will find spoofing is a problem. GPS spoofing is radically different from GPS jammers. While navigation systems sound alarms when they recognize jammers, spoofing systems create false signals that confuse even state-of-the-art GNSS systems, leading to more serious consequences. Apart from deflecting targeted missiles during wartime, GPS spoofing could potentially be used to confuse autonomous vessels and put them in dangerous situations. There have been 9,883 suspected incidents of GNSS hacking across 10 locations, including 1,311 civilian maritime vessel navigation systems since February 2016. All these instances point to Russian interference – wilfully creating a threat to navigation systems across the world. [21]

The shipping industry has been aware of the threat of GPS spoofing for years, but one incident in 2017 pushed the issue higher up the global news agenda. In June of that year, at least 20 vessels in the Black Sea, in the vicinity of Novorossiysk Commercial Sea Port, reported that their Automatic Identification System (AIS) traces erroneously showed their position as Gelendzhik Airport, around 32km inland, as illustrated in Figure 2 and 3.



Source: [5]

Figure 2: Images from m/v Atria.

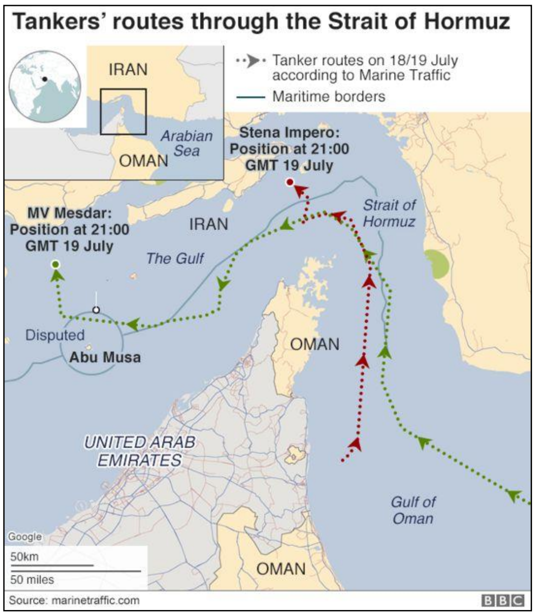


Source: [5]

Figure 3: GNSS Spoofing at Gelendzhik Airport

The large number of vessels involved and the fact that all of the ships’ tracking systems placed them in the same nonsensical location, led to informed speculation that the incident could be attributed to Russian testing of satellite navigation spoofing technology as part of its electronic warfare arsenal. Since then, there have been persistent concerns that the shipping industry may be vulnerable to GPS spoofing, raising the risk of keeping ships at sea longer than necessary to clear the confusion, as occurred in the Black Sea, or even dangerous scenarios such as ship collisions, either with other ships or with land. Up until the last few years, there was a wide gulf in the knowledge and equipment required for a user to carry out a full GNSS spoofing attack, rather than a jamming hack, which simply blocks the satellite signal and is much easier to detect. More recently, however, the commercial availability of radio hardware and downloadable software has brought GNSS spoofing from the military into the civilian realm [17].

A targeted attack could even alter the co-ordinates broadcast by the system, potentially allowing someone to spoof the position of the ship - although shipping industry experts have pointed out in the past that a spoofed location would likely be quickly spotted by maritime observers. On July 2019, a British oil tanker was seized by Tehran after steering into Iranian waters and is believed to have been steered by false GPS co-ordinates. Two British oil tankers, the Stena Impero and Mesdar, changed direction sharply after entering the Gulf through the Strait of Hormuz, taking up a course toward Iran, as illustrated in Figure 4.



Source: [19]

Figure 4: M/V Stena Impero route through the Strait of Hormuz.

That means the tanker may have thought it was a safe distance from Iranian waters. Refinitiv data later showed Mesdar changing direction again heading back into the Gulf. If in fact Iran carried out such a cyber-attack, the question must be asked whether it did so independently or with Russia's help [10]. Some questions cannot be fully determined without access to the ship itself. As a consequence, many of the 2,000 companies operating ships in the region have ordered their vessels to transit Hormuz only during the daylight hours and at high speed (one-third of the world's seaborne oil – some 17 million barrels per day – passes through the strait, making it one of the most important oil trading routes in the world).

The question we might be asking in the wake of this and other cases now being made public is: What might happen next?

6 CONCLUSION

The industry is now aware that physical shipping operations are vulnerable to digital disruption. Shipping lines will have to face the challenge of dealing with new ransomware and hacking attacks [22]. Awareness is growing, but there is still a lot of work to be done. Unless they see it happening, and see real-world attacks happening to other peoples in maritime domain, they don't consider it high enough impact to do something about [9].

The industry will soon be under the obligation to incorporate measures to deal with cyber risks in the ship's safety management system. As highlighted in the IMO guidelines, effective cyber risk management should start at the senior management level. Senior management should embed a culture of cyber risk awareness into all levels and departments of an organization and ensure a holistic and flexible cyber risk management regime that is in continuous operation and constantly evaluated through effective feedback mechanisms [1]. The IMO has given ship-owners until January 2021 to incorporate cyber risk management into ship safety protocols, and as navigational security is likely to play a central role in these measures, so in the coming years protection against spoofing is likely to become a matter of regulatory compliance, rather than simply operational risk management.

The complexity of cyber threats has grown considerably, 80% of data breaches happen because of employee mistakes. The naturally transient nature of maritime industry, with its constantly moving ships and changing crews, adds further complexity to building in cyber awareness defence [18]. People and organisations need to understand the risks and threats to information, so education and awareness is vital to reducing information risk. The best technology in the world will be vulnerable if the people using it aren't trained and aware of the risks. Therefore, it is vital to train seafarers on good practices of using information technology related systems, including social media and other personal means of communication.

The approaching prospect of autonomous and semi-autonomous ship technology raises the stakes in terms of cyber security, especially with regards to on-board navigation systems. One way or another, the spoofing threat will have to be dealt with definitively before the industry entrusts ship navigation to automated systems or remote operators. We cannot save an autonomous ship if it's completely controlled by a malicious actor. It should be a very slow process and it should only be done when we're almost 100% sure it's cyber-secure. Given that GPS spoofing exists in the shadowy world of cybercrime and electronic warfare raises another disturbing possibility: that the ease with which malicious actors can access GNSS spoofing tech could turn protecting commercial vessels against pirate raids from tricky to near-impossible [17].

So cyber is going to pervade everything we do. It's an opportunity, it's a vulnerability.

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ROAD SAFETY PERFORMANCE INDICATORS: BELGRADE EXPERIENCE

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ABSTRACT

Road Safety Performance Indicators (RSPIs) are well known in strategic and system approach related to the increasing of the road safety level. City of Belgrade, as a capital of the Republic of Serbia, for several years has performed measuring of the RSPIs. All results which are obtained during several field of research are carefully analysed and afterwards implemented in programs and strategic documents. Also, goals presented in road safety strategy are defined through targets related to RSPIs. During several years, methodology was improved and there are lot of useful conclusions we want to share. In this paper, methodology, results and some critical review related to the Belgrade experience in RSPIs, will be presented.

Keywords: Road Safety, Road Safety Performance Indicators, Road Safety Strategy, Improving of the methodology, Targets, Road Safety Level

1 INTRODUCTION

It is well known fact that more than 3.000 people are killed in traffic accidents every day, which is 1,35 million fatalities annually (WHO, 2019). Statistics became even worse when is took into account fact that road accidents are leading cause of death among children and young population between 19 and 25 years (WHO, 2019).

Road safety management, as a process, requires accurate data related to the current road safety level, but also knowing of the most effective road safety measures for reaching desired level of the traffic safety and decrease the number of fatalities in traffic. Traditional assessment of the road traffic safety level was based on consequences – figures related to the traffic accidents, injured and killed in traffic. This is "worst case scenario" (Avenoso, 2014). According to the modern trends in the field of road traffic safety, often is raised a question "Is it possible to evaluate the traffic safety before the first traffic accident occurrence, or without knowledge of the data on accidents and their consequences?" (Lipovac, 2008). Implementation of the RSPIs in past 20 years showed that the answer to the previous question is positive.

RSPIs as a part of the safety management system was originally presented by the New Zealand Land Traffic Safety Authority (LTSA, 2000) and European Traffic Safety Council (ETSC, 2001).

Based on LTSA, 2000, Road Safety pyramid (Figure 1) with target hierarchy was presented (Koornstra et al., 2002) and later on Project SafetyNet (released by the European Commission), introduced methodology for SPI development (Hakkert et al, 2007).

Source: (Koornstra et al., 2002, and LTSA, 2000).

Figure 1: A target hierarchy for road safety

There are several fields where RSPIs could be successfully implemented, such as monitoring of performance, determination of the trends, comparison on different levels, prediction of road safety issues etc (Pešić and Antić, 2012).

One of the most significant benefits of the RSPIs is related to simple utilization among decision-makers, but also easy for understanding between stakeholders. Therefore, monitoring of the RSPIs are nowadays one of the most implemented measure for evaluation of the current situation in road safety and comparisons on various levels (Regional, National, International etc).

2 METHODOLOGY

Monitoring of the RSPIs in the Republic of Serbia has started in 2013. National Road Traffic Safety Agency has recognized the significance of the RSPIs and initiated realization of the Project: "Methods for monitoring road safety indicators in Serbia and their importance for strategic road safety management". According to the Terms of Reference, first step was related to the methodology - selection of the RSPIs and data collection, while second step includes selection of the values (measuring scales) for each chosen RSPI. Following groups of RSPIs were selected:

- Usage of protective systems (seatbelts, child restraints, helmets),
- Usage of DRL,
- Usage of mobile phone,
- Speeding,
- DUI of alcohol,
- Pedestrian behaviours,
- RSPIs regard health care,
- RSPIs road infrastructure, vehicles etc.

Usage of protective systems and speeding are especially significant, so collection of the relevant data should be made at the daily traffic conditions (also at night for speeding) on motorways, rural roads and urban roads, during spring (April or May) and autumn (September or October). Also, all measurements should be made on Tuesday, Wednesday or Thursday, in the morning (8:00 to 12:00) or in the afternoon (13:00 to 18:00). During next 5 years, monitoring of the RSPIs was successfully realized and 27 police department, on which is Serbia divided, were compared according to values of RSPIs. Methodology was revised in year 2017. and in year 2018. has started monitoring of the RSPIs on more detailed municipality level (Serbia is also divided on cca 150 municipalities). Comparisons between municipalities provoke competition and each municipality tried to increase road safety level and i.a. to score better RSPIs values. It is important to notice, that almost in all categories values of RSPIs on annual level became better and better from the year 2013 (Table 1). Seatbelts usage and child protection systems have significantly positive trends.

Table 1: Values of RSPIs in Republic of Serbia

RSI	Vehicle category	Indicator	Urban							Outside urban						
			2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
	Car	Driver (%)	64.7	66.2	69.7	74.3	75.8	81.9	82.3	71.9	73.4	77.9	76.9	79.4	84.2	86.8
Seatbelts usage		Front occupant (%)	61.0	60.6	64.6	69.5	68.0	75.8	78.7	67.8	71.1	72.9	73.4	72.9	80.0	84.0
		Front seats (%)	63.1	64.3	68.2	72.3	72.6	79.5	81.0	70.1	72.6	76.3	75.3	76.7	82.6	85.8
		Rear seats (%)	2.2	2.8	5.7	8.8	10.6	9.3	18.4	2.0	3.1	7.6	8.8	10.8	12.3	19.4
	Truck	Driver (%)	16.1	32.5	35.0	20.0	36.0	27.1	47.0	25.7	34.5	43.0	25.2	37.0	31.5	53.1
		Front occupant (%)	9.4	15.9	22.0	7.5	15.2	11.0	37.8	11.7	20.0	30.7	9.5	20.9	13.6	42.0
		Front seats (%)	14.3	28.8	32.0	14.0	28.3	21.1	44.2	22.5	31.4	40.6	17.7	31.3	25.9	49.6
	Bus	Driver (%)	-	4.2	5.1	4.7	8.6	4.5	9.0	-	6.7	12.9	5.6	11.2	6.0	9.5
		Front occupant (%)	-	6.2	9.4	1.1	2.6	1.6	21.8	-	5.4	13.4	1.2	4.7	1.1	33.1
		Front seats (%)	-	4.4	5.3	3.0	6.0	3.5	17.2	-	6.5	13.0	3.4	8.5	4.2	17.8
Child restraints usage	Car	Children (0-3 year) (%)	31.2	34.1	43.7	38.1	43.2	52.9	59.1	28.8	33.5	39.2	36.9	45.3	50.1	63.2
		Children (4-12 year) (%)	7.2	8.4	12.4	15.8	23.1	60.7	34.2	4.9	7.6	13.6	15.3	23.4	58.0	40.9
		Total (0-12 year) (%)	17.8	17.2	25.8	25.6	32.6	45.9	45.3	15.6	16.1	23.0	24.9	33.6	42.5	50.6
Helmets usage	Moped	Rider (%)	85.0	71.3	75.8	79.2	65.6	84.2	67.4	83.3	74.8	70.8	81.2	73.7	85.1	68.6
		Passenger (%)	-	64.8	58.2	73.8	55.7	79.7	38.6	-	63.6	48.3	74.8	61.3	80.4	36.2
	Motocycle	Rider (%)	91.7	87.8	87.5	88.3	84.2	92.0	85.3	94.1	94.4	88.9	90.0	89.0	94.7	87.9
		Passenger (%)	-	82.7	63.6	83.7	79.3	87.3	78.6	-	83.8	75.5	84.8	82.3	90.4	85.5
Speeding	Car	Average speed (km/h)	-	53.1	51.4	52.0	50.8	50.7	51.6	-	78.3	76.3	75.9	75.7	75.7	75.1
		85^{th} percentile (km/h)	-	64.0	62.0	62.0	60.0	60.0	61.0	-	92.0	89.0	88.0	87.0	87.0	88.0
		% of speeding	-	56.3	51.0	53.8	49.4	48.4	51.0	-	39.5	34.5	34.2	32.9	30.4	31.4
	Truck	Average speed (km/h)	-	47.7	46.6	46.8	46.2	46.5	45.6	-	67.4	66.8	67.6	67.4	67.5	67.0
		85^{th} percentile (km/h)	-	57.0	56.0	55.0	54.0	55.0	54.0	-	78.0	78.0	78.0	78.0	78.0	78.0
		% of speeding	-	35.7	32.0	30.9	28.2	31.1	27.4	-	37.7	35.9	39.6	42.3	41.6	37.3
	Bus	Average speed (km/h)	-	48.9	47.1	47.6	47.1	47.1	45.4	-	72.0	70.9	71.6	70.3	70.2	68.8
		85^{th} percentile (km/h)	-	58.0	57.0	55.0	54.0	54.0	53.0	-	84.0	83.0	80.0	80.0	80.0	79.2
		% of speeding	-	40.3	34.7	31.5	29.8	30.6	25.1	-	26.5	21.5	13.7	12.8	13.1	12.1
	Moped	Average speed (km/h)	-	41.5	41.8	43.3	42.2	42.3	41.9	-	43.9	45.9	44.4	44.6	44.7	44.2
		85^{th} percentile (km/h)	-	52.0	51.0	50.0	50.0	70.0	51.0	-	52.0	55.0	51.0	52.0	53.0	53.0
		% of speeding	-	18.3	17.4	14.4	14.5	15.7	15.5	-	18.9	29.4	16.7	21.8	21.7	21.9
	Motorcycle	Average speed (km/h)	-	59.5	57.4	60.0	58.5	58.1	56.6	-	87.5	86.5	87.7	85.5	84.8	82.4
		85^{th} percentile (km/h)	-	75.0	73.0	72.0	71.0	51.0	70.0	-	106.0	104.0	100.0	98.0	98.0	98.0
		% of speeding	-	69.6	65.3	76.7	72.7	71.5	63.8	-	66.3	61.1	65.3	62.6	59.2	51.9

Source: (Pešić and Pešić, 2020)

Belgrade as a capital of Republic of Serbia adopted Road Safety Strategy, as well as Action plan, during the year 2011. Since then, RSPIs are included in determination of current and desired level of traffic safety. Also, objectives related to the Road Safety Strategy are, among others, defined on the basis of RSPIs. Until the year 2018, RSPIs for Belgrade were not especially measured/collected but data from national RSPIs research were used for traffic safety management and comparisons. Since 2018. City of Belgrade - City Administration - Secretariat for Transport recognized the importance of the particular research related to RSPIs for Belgrade.

As it was case in national research, first step was methodology. Following groups of RSPIs were selected for first Belgrade RSPIs research (2018):

- Usage of protective systems (seatbelts, child restraints, helmets),
- Usage of DRL,
- Speeding,
- Pedestrians/drivers behaviours

During 2019. is introduced RSPI: Percentage of pedestrian crossings which are not covered with traffic lights, on streets with more than two traffic lanes and presence of public transport.

Protective systems covered usage of seatbelts, child restraints and helmets, while speeding took into account percentage of driving for more than 10 km/h above speed limit. Pedestrians/drivers behaviours were analysed according to:

- Pedestian red light crossing violation
- Pedestrian crossing violation (around or close to crossing)
- Drivers red light violation (related to pedestrians)
- Drivers right-of-way on crossings violation (related to pedestrians)

Collection of the relevant data was made on the basis of same methodology for national RSPIs and afterwards, level of the road safety level related to RSPIs was defined for each of the 17 Belgrade municipalities.

3 RESULTS

According to seatbelt usage in passenger cars, all municipalities are far from the targets which are defined in Road Safety Strategy for Belgrade. Seatbelt usage on back seats are one of the most urgent issues.

Table 2: RSPI: Seatbelt usage in passenger cars in Belgrade

Municipality	% seatbelt usage – urban							
	Passenger cars							
	Driver		Front passenger		Front seats		Back seats	
	2018	2019	2018	2019	2018	2019	2018	2019
Barajevo	65,0	81,7	65,2	74,7	65,1	79,2	34,3	25,3
Voždovac	85,6	91,8	75,9	78,6	82,3	87,2	13,8	17,5
Vračar	79,8	92,2	66,5	85,5	74,0	89,8	15,9	14,1
Grocka	70,2	84,0	63,0	76,6	66,9	81,4	26,7	13,2
Zvezdara	82,6	93,3	74,0	84,8	78,9	90,1	21,5	16,7
Zemun	91,4	88,8	80,5	88,6	86,2	88,7	27,7	31,5
Lazarevac	74,8	65,8	67,4	71,6	71,3	67,9	23,6	6,6
Mladenovac	69,2	78,5	49,0	78,7	63,5	78,6	43,1	4,2
Novi Beograd	94,6	90,3	85,2	84,1	90,0	88,1	34,3	34,6
Obrenovac	61,8	77,3	56,0	75,2	59,1	76,6	20,2	24,6
Palilula	81,6	94,3	67,2	82,0	75,6	90,1	21,4	24,6
Rakovica	87,5	87,7	84,1	81,7	86,0	85,6	28,8	16,2
Savski venac	94,6	87,8	84,5	84,1	89,9	86,5	42,1	14,4
Sopot	53,0	59,0	43,1	65,8	50,2	61,4	20,5	5,7
Stari grad	89,1	92,5	80,3	85,5	85,1	90,0	23,8	15,4
Surčin	73,0	81,2	59,5	76,2	67,2	79,4	30,6	38,4
Čukarica	88,9	93,8	81,9	84,3	85,6	90,5	40,3	31,5

Table 3: RSPI: Seatbelt usage in commercial vehicles in Belgrade

Municipality	% seatbelt usage – urban							
	Trucks				BUS			
	Driver		Front passenger		Driver		Front passenger	
	2018	2019	2018	2019	2018	2019	2018	2019
Barajevo	0,0	36,7	0,0	55,6	20,0	16,7	-	11,1
Voždovac	39,7	62,5	66,7	34,9	1,0	5,0	-	6,3
Vračar	30,0	13,3	25,0	62,5	3,5	25,9	-	28,6
Grocka	34,0	47,5	22,2	40,0	0,0	6,7	0,0	28,6
Zvezdara	26,3	62,0	0,0	54,7	0,0	6,0	-	4,0
Zemun	11,1	60,0	0,0	55,6	1,9	6,1	0,0	33,3
Lazarevac	11,1	31,8	0,0	100,0	0,0	3,3	-	11,1
Mladenovac	60,0	33,3	50,0	20,0	4,0	10,0	-	16,7
Novi Beograd	41,2	59,3	11,1	50,0	2,0	37,0	-	12,1
Obrenovac	0,0	79,2	0,0	40,0	0,0	16,7	-	40,0
Palilula	40,0	75,0	28,6	44,4	0,0	22,0	-	8,3
Rakovica	33,3	84,0	21,4	63,9	0,0	31,7	0,0	23,5
Savski venac	21,7	43,5	14,3	25,0	11,0	17,9	25,0	33,3
Sopot	0,0	26,7	0,0	50,0	0,0	10,0	-	33,3
Stari grad	42,9	19,0	0,0	100,0	2,0	28,0	0,0	28,6
Surčin	7,7	36,6	0,0	30,0	0,0	13,3	-	25,0
Čukarica	39,5	63,8	18,2	66,7	7,5	11,1	0,0	2,3

Table 4: RSPI: Child restraint usage in Belgrade

Municipality	% Child restraint usage					
	Up to 3 years		from 4 to 12 years		Total (up to 12 years)	
	2018	2019	2018	2019	2018	2019
Barajevo	73,3	65,0	33,9	13,6	51,5	29,7
Voždovac	60,0	85,4	33,3	62,5	44,7	74,1
Vračar	71,7	72,0	40,7	43,0	56,1	56,0
Grocka	61,2	78,0	76,4	40,0	69,2	62,0
Zvezdara	63,0	86,7	33,8	83,7	48,3	85,4
Zemun	81,4	81,3	13,8	33,3	59,1	58,1
Lazarevac	51,1	45,0	7,0	26,3	26,9	32,8
Mladenovac	68,8	85,0	68,4	20,0	68,6	52,5
Novi Beograd	90,9	80,0	10,0	85,0	52,4	82,5
Obrenovac	58,3	52,9	13,8	7,2	34,9	20,5
Palilula	66,7	83,3	39,7	72,0	53,1	77,9
Rakovica	73,9	71,8	36,0	26,7	51,5	47,6
Savski venac	63,3	67,3	46,2	42,9	55,4	55,4
Sopot	28,9	45,0	16,7	21,9	23,0	30,8
Stari grad	76,7	59,0	17,5	32,1	42,9	43,7
Surčin	53,7	61,0	36,4	42,0	45,9	50,5
Čukarica	86,5	80,8	39,0	41,9	62,3	59,6

Table 5: RSPI: Helmets usage in Belgrade

Municipality	% Helmets usage									
	Mopeds				Motorcycles				Total PTW	
	Driver		Passenger		Driver		Passenger		Driver	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
Barajevo	-	100,0	-	40,0	66,7	60,0	50,0	66,7	66,7	80,0
Voždovac	94,4	100,0	0,0	100,0	91,2	100,0	100,0	33,3	92,3	100,0
Vračar	94,7	82,1	-	66,7	97,5	93,0	100,0	100,0	96,4	88,6
Grocka	66,7	80,0	50,0	25,0	90,9	91,7	77,8	100,0	85,7	88,2
Zvezdara	100,0	85,7	0,0	25,0	96,6	100,0	88,9	100,0	97,3	88,7
Zemun	60,0	100,0	-	100,0	91,2	96,2	66,7	100,0	84,1	96,8
Lazarevac	42,9	46,2	-	100,0	75,0	63,6	75,0	100,0	69,2	54,2
Mladenovac	58,3	36,4	-	40,0	100,0	100,0	100,0	66,7	70,6	56,3
Novi Beograd	94,4	100,0	33,3	100,0	96,1	100,0	83,3	100,0	95,7	100,0
Obrenovac	50,0	100,0	-	25,0	63,2	92,0	100,0	85,7	60,9	93,3
Palilula	66,7	75,8	100,0	40,0	95,9	98,9	80,0	90,0	86,3	92,7
Rakovica	100,0	100,0	100,0	40,0	96,2	100,0	90,9	66,7	96,7	100,0
Savski venac	100,0	94,1	100,0	100,0	96,2	90,6	100,0	88,9	97,4	92,0
Sopot	0,0	30,0	0,0	25,0	0,0	80,0	0,0	66,7	0,0	40,0
Stari grad	97,8	90,6	33,3	100,0	98,9	97,3	91,7	81,8	98,5	95,3
Surčin	77,8	100,0	-	25,0	76,9	100,0	100,0	100,0	77,1	100,0
Čukarica	88,9	100,0	50,0	25,0	90,3	86,8	100,0	100,0	90,1	88,6

Among drivers, all municipalities (except Savski Venac) have increased the seatbelt usage (Table 2), and similar situation is when front passengers are took into account (only Novi Beograd decreased the seatbelt usage). Seatbelt usage among drivers and passengers in heavy vehicles and buses is almost "black" in all municipalities (Table 3). Campaigns related to seatbelt usage, especially focused on youngsters, are frequent on TV and social media and police enforcement is intensified.

Child restraint usage in Belgrade presents special cause for concern (Table 4). Situation is slightly better among children up to 3 years, but older children rarely use seatbelt. Parents take more care when children are in the age which fits to child seats, but later on, seatbelt usage on back seats among children from 4 to 12 years is poor. According to these results, strong actions were performed. One of the most important actions, related to children, is improving of knowledge in elementary schools, while for parents were organised tribunes and round tables.

RSPIs results for helmet usage show that motorcycle drivers are much more aware of hazard related to non-use of helmets (Table 5). This is probably related to speed, because drivers of mopeds has distorted image of driving at 40 km/h or 50 km/h. It is important to mention that better results are achieved in central than suburban municipalities of Belgrade. One of the biggest problems is wearing of non-homologated helmets, such as helmets for bicycles, army helmets etc. Moto clubs are involved in road safety activities.

Very inhomogeneous and bad results are noticed related to speeding (Table 6). 13 of 17 Belgrade municipalities increased number of violations related to speeding. It is interesting that speeding violations for more than 10 km/h are present both during the day and during the night. Municipality Lazarevac (suburban municipality) has the worst score of 78,2% of violation during night, and 70,8% of violation during the day. Therefore, National Road Safety Agency has realized a plenty of various proactive measures, while police intensified enforcement.

Table 6: RSPI: Speeding (more than 10 km/h above speed limit) in Belgrade

Municipality	% violations related to speeding for more than 10 km/h		
	Passenger cars		
	2018	2019	
		Day	Night
Barajevo	0,9	1,0	10,9
Voždovac	17,5	34,7	53,5
Vračar	4,6	0,7	7,2
Grocka	5,9	3,2	3,8
Zvezdara	13,7	4,4	7,8
Zemun	22,6	13,6	15,6
Lazarevac	3,8	70,8	78,2
Mladenovac	13,3	47,5	27,3
Novi Beograd	16,4	16,7	29,0
Obrenovac	9,0	3,0	2,9
Palilula	6,0	16,0	21,5
Rakovica	16,2	28,3	14,3
Savski venac	11,9	33,3	31,8
Sopot	47,6	23,8	9,5
Stari grad	8,2	9,3	20,2
Surčin	2,7	5,0	6,7
Čukarica	18,7	32,7	39,5

Pedestrians, as a vulnerable road users, are in Belgrade extremely endangered. Almost 27% of killed, and 14% of injured in traffic are pededstrians. Ages between 15 and 30 years, and 65+ presents almost 50% of killed and injured in traffic (NRSA, 2020).

Average percentages of the pedestrians crossing violation (around or close to crossing) of almost 37% is very high and males tend to do more violations than females. Barajevo and Rakovica are municipalities with the highest percentage of this type of violation.

Table 7: RSPI: Pedestrians behaviours in Belgrade

Municipality	% Pedestrian crossing violation (around or close to crossing)			% Pedestrian red light violation	
	2018	2019		2018	2019
		Male	Female		
Barajevo	61,8	76,0	69,6	-	12,0
Voždovac	36,7	36,8	44,8	22,2	23,6
Vračar	6,8	23,6	22,0	23,8	23,2
Grocka	15,9	28,8	17,2	14,3	12,4
Zvezdara	47,3	25,6	25,2	13,9	43,8
Zemun	22,2	26,8	26,0	12,7	28,0
Lazarevac	42,6	60,4	48,1	23,8	28,4
Mladenovac	13,1	22,3	6,2	10,4	14,4
Novi Beograd	17,6	34,0	32,4	37,2	18,2
Obrenovac	20,4	25,2	11,6	10,6	24,0
Palilula	53,8	24,9	29,2	12,7	27,4
Rakovica	15,4	75,2	61,6	19,1	27,8
Savski venac	21,8	23,4	18,5	16,4	32,0
Sopot	37,0	52,3	44,1	28,8	38,6
Stari grad	29,8	24,8	23,6	11,7	11,4
Surčin	37,8	40,8	27,6	34,5	13,8
Čukarica	14,2	22,0	14,4	20,8	18,8

Table 8: RSPI: Drivers/pedestrians behaviours in Belgrade

Municipality	% Drivers right-of-way on crossings violation (related to pedestrians)		% Drivers red light violation (related to pedestrians)					
	2018	2019	2018	2019				
				ПА	ТТВ	БУС	МОТ	МОП
Barajevo	62,0	32,4	0,0	1,0	0,0	0,0	0,0	0,0
Voždovac	47,0	59,2	19,9	5,0	3,3	13,3	0,0	0,0
Vračar	23,0	57,6	5,0	2,8	0,0	8,0	5,0	0,0
Grocka	31,5	28,4	5,5	3,0	2,2	0,0	12,5	0,0
Zvezdara	65,5	21,2	5,6	3,6	4,6	3,5	2,4	0,0
Zemun	39,4	38,0	1,2	2,0	0,0	3,0	0,0	0,0
Lazarevac	47,0	71,5	6,3	0,4	0,0	0,0	0,0	0,0
Mladenovac	23,0	53,2	0,0	0,0	0,0	0,0	0,0	0,0
Novi Beograd	31,1	60,0	3,7	0,2	0,0	0,0	0,0	0,0
Obrenovac	31,7	46,8	8,2	3,2	0,0	0,0	0,0	0,0
Palilula	62,8	47,2	0,5	4,2	5,4	7,8	12,3	6,1
Rakovica	49,0	50,4	3,4	2,8	0,0	7,5	0,0	0,0
Savski venac	23,5	52,4	1,2	2,0	12,5	4,3	0,0	0,0
Sopot	28,2	39,5	0,0	0,0	0,0	0,0	0,0	0,0
Stari grad	39,0	58,4	8,4	3,4	0,0	1,5	3,7	0,0
Surčin	70,3	26,0	3,3	3,8	0,0	0,0	0,0	0,0
Čukarica	53,5	54,8	4,3	2,8	4,2	4,0	2,8	0,0

Pedestrians' red light violation is increased in 2019. (avg 23,4%) considering result in 2018. (avg 19,6%). It is clear that pedestrians in Serbia have very low level of traffic safety culture (Table 7). Also, awareness related to the road traffic safety is poor. Therefore, City of Belgrade, City Administration, Secretariat for Transport planns a lot of activities to increase safe pedestrian behaviour in traffic, such as, road safety campaigns, tribunes, social media activities etc. As it is already mentioned above, extremely endangered groups are youngsters, age between 15 and 30, and older population, age 65+. Drivers behaviour related to pedestrians is devastating, with negative trend (Table 8). During 2018. average percentage of drivers who do not give the right-of-way to pedestrians was 42,8% and during 2019 is increased to 46,9%. During 2018. suburban municipalities tends to have lower scores (even 70% of violations), but in 2019. some of the central municipalities also have high percentage of above 50% of violations. Situation is much better, considering drivers red light violation (related to pedestrians). However, in some of municipalities percentage of this type of violation is above 10%. It is interesting to mention that these scores were not relevant to passenger cars, but trucks, buses and motorcycles. One of the most significant activities was related to trafic safety knowledge among drivers.

Chart 1: RSPI: Pedestrian crossings without traffic lights

Special seminars, intended for employees in driving schools, were realized. Main task was to educate educators in terms to increase awareness among drivers, related to drivers/pedestrians relationship in traffic. According to enforcement, Belgrade has intentions to increase the number of automated control units – red light cameras and cameras for surveillance of traffic. This is certainly the best way to monitor negative behaviours of drivers, but also to protect pedestrians.

Finally, last step was related to infrastructure. It is important to cover mostly pedestrian crossing with traffic lights on wide streets (with more than two traffic lanes) without median, where public transport is present. Public transport initiate a large number of pedestrians in traffic. On such a wide streets without median, it is hard for pedestrians to cross the street safely and therefore, traffic lights have to be implemented. After the identification of all streets in Belgrade with above mentioned characteristics, field research was conducted. Seven streets (almost 30%) have more than 50% of crossings which are not covered with traffic lights (Chart 1). These data was linked to traffic accidents in order to define most dangerous locations. After ranking, traffic lights were implemented on identified black spots, according to the risk level.

4 CONCLUSION

Road safety can be assessed in terms of the social costs of crashes and injuries, but simply counting crashes or injuries is an imperfect indicator of the level of road safety (Yannis et al., 2014). Human is the most connected factor, associated with traffic accident occurrence. So, road user behaviour, described through RSPIs, support various road safety activities in the country and enable international comparisons (Gitelman, 2014). On the other side, more and more RSPIs are used to describe the complex character of the road safety phenomenon, so RSPIs are useful tool in prevention of dropping underlying information, but also in monitoring of road safety performance (Shen and Hermans, 2014). It is important to mention, that RSPIs enable monitoring and evaluation of traffic safety before accidents occur, which makes it possible to proactively detect potential road safety problems (Pešić and Lipovac, 2014).

One of the benefits of RSPIs is crucial for decision makers. Through analysis of the ratio between invested and obtained and ranking of the observed problems, resources, as well as, other funds intended for the improvement of road safety, could be allocated in the most effective way (Pešić and Pešić, 2020). Because of strong connection RSPIs with road accidents and followed consequences, RSPIs are inevitable in road safety management and preparing of the Road safety strategies and programs.

Belgrade experience shows that number of killed in traffic has been reduced significantly, since monitoring of the RSPIs is implemented in Serbia and Belgrade. (688 people were killed in traffic in Serbia and 127 people in Belgrade during 2012. compared to 534 and 93 in 2019).

It is important to mention that in previous several years, almost all municipalities in Belgrade have increased the seatbelt usage in all vehicles categories, but situation is still poor. Child restraint usage in Belgrade is far away from the desired level, while results for helmets usage are the best among RSPIs. Almost 27% of killed, and 14% of injured in traffic are pededstrians, so RSPIs related to pedestrians behavior, drivers/pedestrians behaviours and percentage of pedestrian crossings with traffic lights on wide street are also took into account.

For quality monitoring of RSPIs Pešić and Pešić, (2020) have recommended implementation of the following steps:

1. Preparing of the RSPIs Manual;
2. Realization of a series of seminars and trainings related to the RSPIs monitoring;
3. Realization of the RSPIs data collection;
4. Monitoring and harmonization of the methodology.

Further research should be focused on introducing new RSPIs related to behaviours in traffic, but also related to other factors, such as vehicle, road, environment. Also, in the future it is important to, periodically, make some revisions of the methodology.

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ANALYSIS OF THE NOMOTO SHIP MODEL RESPONSE TO COURSE CHANGES USING PID CONTROLLER IN MATLAB/SIMULINK

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ABSTRACT

This paper presents system based on Nomoto model of ship and its response to course changes using regulation loop for course control with PID controller.
Central element of analysis is selecting an appropriate mathematical model of system being analyzed. Equations which describe ship motion are given by Newton laws of motion, considering two coordinate systems: inertial system X0Y0Z0 (ECEF – Earth Centered Earth Fixed) and XOYZ reference ship centered system.
Reference model was created based on linearized equations for surging, swaying and yawing while other motions were ignored.
Using designed system shown in this paper, response to course changes of a Nomoto model ship had been analyzed.
Analysis had been conducted using Matlab/Simulink program package with first order Nomoto model using real parameters of a fully loaded tanker.
Results of an analysis had been used to conclude about characteristics of presented system and its response to course changes along with possible improvements in such system.

Keywords: Nomoto model, ship dynamics, PID controller, ship course control, Matlab/Simulink

1 BASIC SHIP MOTIONS

Equations which describe ship motions are retrieved using Newton's laws of motion, considering two coordinate systems: inertial system X0Y0Z0 (ECEF – Earth Centered Earth Fixed) and XOYZ reference ship centered system as shown in figure 1.

Motion equations can be entirely described with six degrees of freedom of a rigid body in movement using three translation equations (swaying, heaving, surging) and three rotation equations (yawing, rolling, pitching).

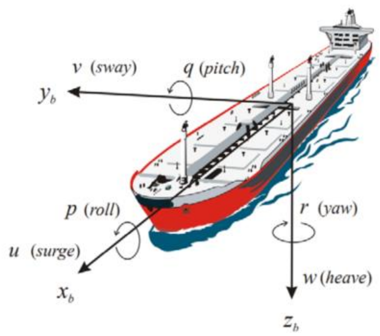

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Figure 1: Ship centered system

Only horizontal motion is taken into consideration for ship, while pitching, rolling and heaving are ignored. Thus, the number of degrees of freedom is reduced to three: yawing in direction of z-axis, surging in direction of x-axis and swaying in direction of y-axis.

According to that, throughout this paper only horizontal plane movements in previously mentioned x, y and z axis were considered while the remaining movements were ignored.

2 NOMOTO SHIP MODEl

Nomoto suggests two simple linear transfer functions. This model is intensively used by engineers for analysis and design of ship auto pilots. This type of model gives accurate description of higher GRT ships motion. Since the speed of navigation is considered constant, model is only applicable for constant thrust and small rudder angle changes.

Nomoto second order model of a ship can be described by following equations:

$$x_l = A_1\dot{x}_1 + B_1u \tag{1}$$

$$\frac{\Psi(s)}{\delta(s)} = C(SI - A_1)^{-1}B_1\,; C = [0\ 0\ 1] \tag{2}$$

or:

$$\frac{\dot{\Psi}(s)}{\delta(s)} = \frac{b_1 s + b_2}{(s^2 + a_1 s + a_2)} \tag{3}$$

where:

$$a_1 = -a_{11} - a_{22} \tag{4}$$

$$a_2 = a_{11}a_{22} - a_{12}a_{21} \tag{5}$$

$$b_1 = b_{21} \tag{6}$$

$$b_2 = a_{21}b_{11} - a_{11}b_{21} \tag{7}$$

Ψ represents yaw, while δ represents rudder angle.

Earlier mentioned transfer function (3) is usually written in following form which is known as Nomoto second order model:

$$\frac{\dot{\Psi}(s)}{\delta(s)} = \frac{K(T_3 s + 1)}{(T_1 s + 1)(T_2 s + 1)} \tag{8}$$

$$K = \frac{b_2}{a_2}\,;\ T_3 = \frac{b_1}{b_2}\,;\ T_1 \cdot T_2 = a_2\,; T_1 + T_2 = \frac{a_1}{a_2}$$

Equation (8) can be written in time domain as:

$$T_1T_2\dddot{\Psi} + (T_1 + T_2)\ddot{\Psi} + \dot{\Psi} = K(\delta + T_3\dot{\delta}) \tag{9}$$

Equations in time domain are transferred into frequency domain, usually called s-domain, by applying Laplace transform. By transferring equations into frequency domain, calculations are easier since differentiation and integration are replaced by multiplication or division with frequency variable s.

Parameters T_1, T_2 and T_3 are time constants. Value depends on work conditions and they are usually called control quality index. While T_2 and T_3 are usually positive, K and T_1 can be positive or negative value. T_1 is usually positive for ships which maintain originally given course, while it becomes negative for those ships who cannot maintain stable course. K represents static yaw rate gain.

Approximation of equation (8) is given by setting up parameter $T = T_1+T_2-T_3$:

$$T_1 \to T\,;\ T_2 \to T_3$$

$$\frac{\dot{\Psi}(s)}{\delta(s)} = \frac{K(T_3 s + 1)}{(T_1 s + 1)(T_2 s + 1)} \approx \frac{K(T_3 s + 1)}{(Ts + 1)(T_3 s + 1)}$$

$$\frac{\dot{\Psi}(s)}{\delta(s)} = \frac{K}{(Ts + 1)} \tag{10}$$

Equation (10) represents Nomoto first order model, in time domain it is described with following equation:

$$T\ddot{\Psi} + \dot{\Psi} = \mathrm{K}\delta \tag{11}$$

Parameters K, T, T_1, T_2 and T_3 can be calculated by using equations mentioned earlier and they differ for different types of ship.

Nomoto first order model equation can be reformulated as following:

$$\frac{\dot{\Psi}(s)}{\delta(s)} = \frac{b}{(s + a)} \qquad b = \frac{K}{T} \quad a = \frac{1}{T} \tag{12}$$

3 SHIP COURSE CONTROL SYSTEM

Automatic course control has its roots in the beginning of last century, after invention of gyrocompass. Generally speaking, ship course control system has one input and one output, so it is SISO (Single input single output) system as shown on figure 2.

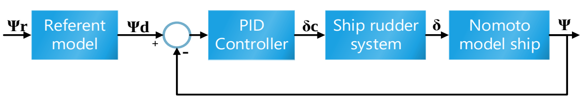

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Figure 2: Ship course control system block diagram

Every block shown on figure 2 represents a subsystem. Therefore, in the following four figures these subsystems will be presented and explained.

Figure 3 presents Nomoto ship model subsystem block used in simulations.

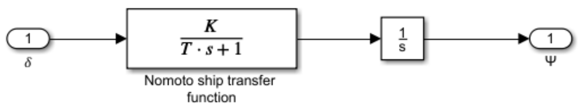

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Figure 3: Nomoto model subsystem block in Simulink

Referent model, shown on figure 4 is considered as a pre-filter which eliminates numerical difficulties attributed to high values of input step signal. Dynamics of reference model should be adjusted to the ship's dynamics regardless of value of desired reference yawing angle. Too sluggish referent model cannot give optimal performances due to ships inability to achieve desired course on time. On the other side, faster referent model, in other words, faster than ships response cannot be used due to rudder actuator saturation and performance degradation. Ψ_r represents referent course, which is a referent value set by an operator, while Ψ_d represents output value of a course.

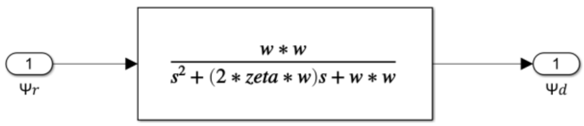

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Figure 4: Referent model subsystem block in Simulink

Second order referent model is usually used, described mathematically by following equation:

$$\frac{\Psi_d}{\Psi_r} = \frac{K_m}{T_m s^2 + s + K_m} \tag{13}$$

Where T_m and K_m are parameters used to describe closed loop system response. T_m represents time constant of the referent model, while K_m represents gain factor of the referent model. For majority of practical uses, these parameters are selected as following:

$$T_m \leq \frac{1}{2}\frac{LT}{U} \qquad K_m = \frac{1}{4\zeta^2 T_m} \tag{14}$$

Where ζ represents closed loop system damping ratio, typically in interval $0.8 \leq \zeta \leq 1$. L represents length of a ship, U represents velocity of a ship, while T represents time constant of a ship.

By comparing equation (13) with general second order system resulting equation is:

$$\frac{\Psi_d}{\Psi_r} = \frac{{\omega_n}^2}{s^2 + 2\zeta\omega_n s + {\omega_n}^2} \tag{15}$$

T_m and K_m can be expressed through damping ratio and closed loop system natural frequency via equation:

$$T_m = \frac{1}{2\zeta\omega_n} \qquad K_m = {\omega_n}^2 T_m \tag{16}$$

Function of ships rudder system shown on figure 5 is to move rudder to desired position according to instructions from control system or helmsman.

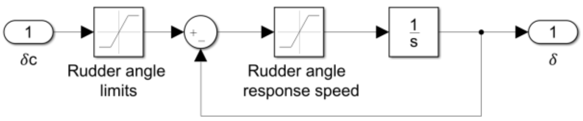

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Figure 5: Ships rudder subsystem block in Simulink

Rudder angle limiter represents mechanical limitation of rudder angles, in this case 35° in both directions. Maximum rate of movement of a rudder is defined by hydraulic pump capacity, usually between 2 and 7 degrees per second. Minimum values are defined by classification societies which demand rudder to be moved from 35° one side to 35° opposite side in less than 30 seconds.

$$\delta_{max} = \pm 35° \qquad \dot{\delta}_{max} = \pm 2°/s \quad to \quad \pm 7°/s \tag{17}$$

Ships rudder system consists of:

- Rudder angle limiter (δ_{max}),
- Rudder movement rate limiter ($\dot{\delta}_{max}$),
- Feedback.

PID controller can be expressed via equation:

$$u(t) = K_p\left[e(t) + \frac{1}{T_1}\int_0^1 e(\tau)d\tau + T_d\frac{de(t)}{dt}\right] \tag{18}$$

Where $T_i = \frac{K_p}{K_i}$ and $T_d = \frac{K_d}{K_p}$ are integration and derivation time constants.

In specific case of ships course control system shown on figure 6, PID controller is expressed via equation:

$$\delta_c = K_p(\Psi_d - \Psi) - K_d\dot{\Psi} + K_i\int_0^t(\Psi_d - \Psi)d\tau \tag{19}$$

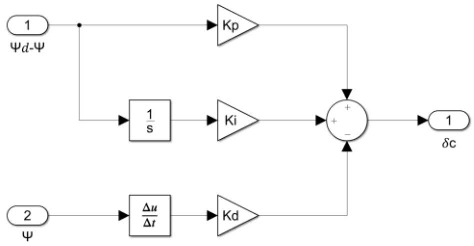

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Figure 6: PID controller subsystem block in Simulink

For the sake of simplicity, PD controller was firstly built, and integration component was added subsequently.

PD controller can be expressed as following:

$$\delta = K_p(\Psi_d - \Psi) - K_d\dot{\Psi} \tag{20}$$

If ship dynamics is expressed by first order Nomoto model, following closed loop system characteristics are obtained by inserting (20) into (11):

$$T\ddot{\Psi} + (1 + KK_d)\dot{\Psi} + KK_p\Psi = KK_p\Psi_d \tag{21}$$

Damping ratio and natural frequency can be calculated by following equation:

$$\zeta = \frac{1 + KK_d}{2\sqrt{TKK_p}} \qquad \omega_n = \sqrt{\frac{KK_p}{T}} \tag{22}$$

Consequently, K_p and K_d can be calculated as following:

$$K_p = \frac{T\omega_n^2}{K} \qquad K_d = \frac{2T\zeta\omega_n - 1}{K} \tag{23}$$

Fossen (2004) recommends following rule for integration component:

$$\frac{K_i}{K_p} \approx \frac{\omega_n}{10} \tag{24}$$

Therefore:

$$K_i = \frac{\omega_n K_p}{10} = \frac{\omega_n^3 T}{10K} \tag{25}$$

4 SIMULATIONS

For simulations, fully loaded tanker of 350 meters length overall is considered. At speed of 8.1 m/s, parameters K and T are -0.019 and -153.7.

Rudder angle limiter is set to ±30° while rudder movement rate is limited to ±2.33°/s. To acquire wanted ship characteristics, second order reference model according to equation (15) was used.

If damping ratio is 1 and natural frequency 0.03 rad/s, then PID controller parameters are calculated according to equation (23) and (25). In this particular case, values are as following:

$K_p = 7.2805$, $K_d = 538$ and $K_i = 0.0218$.

Figure 7 shows control system scheme used for simulation in MATLAB/Simulink.

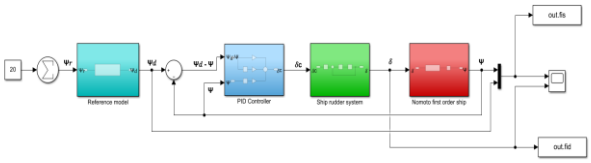

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Figure 7: Ship control system block diagram in MATLAB/Simulink

Using Nomoto model through equations (23) and (25) ideal P, I and D components of PID controller were calculated. System's response to desired 20° course is shown in figure 8.

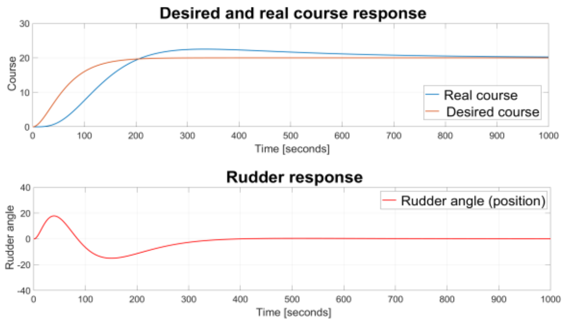

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Figure 8: System's response to desired course of 20°

Figure 9 shows system's response to desired course of 50°.

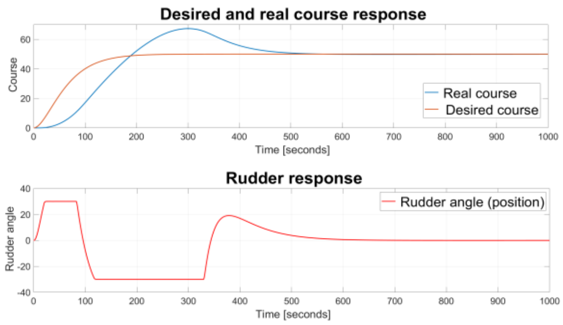

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Figure 9: System's response to desired course of 50°

Figure 10 shows system's response to firstly desired course of 10°. After the desired course is achieved, desired course is set to 50°, and lastly, after achievement of 50° course, desired course of 30° is set.

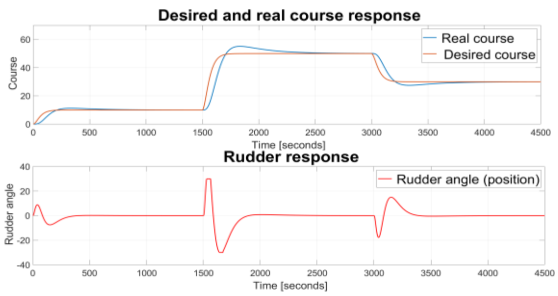

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Figure 10: System's response to desired courses of 10°, 50° and 30° respectively

Since PID controller is designed with respect to Nomoto second order model, it can be further tuned but then the questions of stability, response time and steady state error arises.

Given the aforementioned, following three figures will show system's response with tuned parameters of PID controller.

Figure 11 shows system's response to desired course of 20° with greater proportional (P) component of PID controller, where is obvious that the ship dynamics is faster at the expense of stability. Proportional component is set to 15.

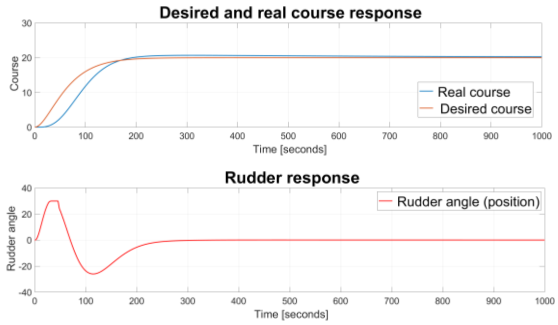

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Figure 11: System's response to desired course of 20° with greater P component, $K_p = 15$

If integral (I) component of a PID controller is increased, while proportional component restored to value already defined by equation (23) it can be concluded that ship's dynamics is faster, and stability is increased as shown in figure 12. K_i is set to 0.1.

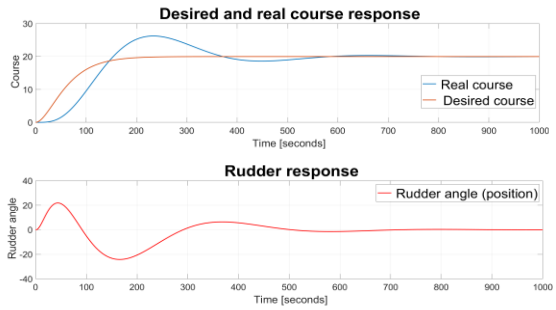

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Figure 12: System's response to desired course of 20° with greater I component, $K_i = 0.1$

Further on, by increasing derivative (D) component of a PID controller, with integral and proportional components defined by equation (23), it is obvious that the response is slower as shown on figure 13. K_d is set to 1000.

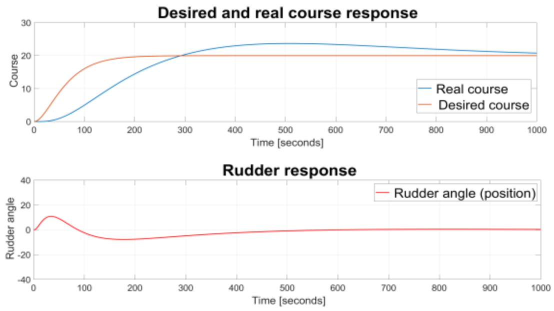

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Figure 13: System's response to desired course of 20° with greater I component, K_d = 1000

5 CONCLUSION

Using Nomoto model ideal values of P, I and D components of a PID controller are calculated via equations (23) and (25). System's response with calculated values for desired course of 20° show that ship does not follow up desired value but after some time value is achieved which was expected. It can be concluded that this does not cause problems as far as the course changes are not sudden.

On the other side, sudden changes of course, in example course change to 50° as simulated and shown in figure 9 where there is an overshoot of 17.28° can be dangerous in case of ship being in the vicinity of other ships or when navigating a narrow channel. Saturation of rudder angle indicates that the performance of the PID controller is not robust, even at constant ship speeds.

Tuning PID controller involved in course control represents great challenge. This paper proved that the equations (23) and (25) provide good enough parameters for PID controller if there are no sudden course changes.

This paper presents complex system which includes ship rudder system because for calculation Nomoto model constants, as well as its use, parameters depend on maximum rudder movement rate and maximum rudder angle.

Furthermore, presented system can be expanded with additional parameters that affect ships course such as wind impact, waves, draft and more. Such complex system is also more realistic. Also, system can be enhanced by using neural networks or fuzzy logic which would contribute to robustness of a PID controller used as autopilot for any kind of ship.

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LINKING VOCATIONAL EDUCATION TRAINING IN LOGISTICS AND TRANSPORT WITH THE LABOUR MARKET: LEARNER-CENTRED AND NEEDS-BASED CURRICULUM DEVELOPMENT

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ABSTRACT

The purpose of this paper is to examine the curricula of selected Slovene, Italian, Croatian, and French vocational education training (VET) schools in logistics and transport, compare them against the needs of the logistics and transport as well as other industries that employ VET graduates in logistics and transport, and present the learner-centred and needs-based training modules (TM) that were designed to bridge the gap between the needs of the employers and the current VET offer.

To analyse the training offer, a SWOT analysis of 17 VET diplomas in logistics and transport were performed. In the following step, 49 interviews were conducted in pertinent logistics and other companies that employ VET graduates to determine the level of competence of VET students in transport and logistics. The findings indicate an imbalance between the training offer and employer needs. Five TMs were designed: TM1 – Maritime and Intermodal Management, TM2 – Supply Chain Management of Cold Products, TM3 – Warehouse Analysis, TM4 – Transport Organisation, and TM5 – Key Soft Skills.

This paper provides new insights into the knowledge and skills that have to be developed by VET graduates from transport and logistics from the employers' point of view, and proposes a framework for contemporary curriculum design for VET in logistics and transport.

The paper is based on the intellectual output reports of the Erasmus+ project, KA2 – Strategic Partnership in VET 2017-2020, entitled Summer Logistics School (SLS).

Keywords: curriculum design, needs, transport, logistics, vocational education and training, VET

1 INTRODUCTION

Due to globalisation, the frequency of international transactions, and rapidly changing demands for services, the level of logistics complexity increases and "calls for a reliable and strongly efficient logistics system, operating at full capacity" (Marinov & Fraszczyk, 2014). To operate an efficient logistics system, logistics providers have to be able to respond adequately to any changes and new needs of the sectors that they complement and work with (Marinov & Fraszczyk, 2014). Thus, VET graduates that apply for new jobs in the logistics sector must now be equipped with an appropriate and diverse set of skills and competences (van Hoek et al., 2013) that logistics providers request.

VET schools in logistics and transport are a primary source of knowledge and competences for numerous newcomers into the logistics and transport industries. They deliver VET programmes and are responsible for creating a curriculum that adequately responds to the requested changes and particular needs in logistics and transport. The competitiveness of VET graduates in obtaining a job as well as their subsequent effectiveness at the workplace depends on VET trends and needs monitoring. The logistics sector cannot be efficient without up-to-date education and training, and in turn, VET schools cannot be competitive in the long run without meeting the expectations of the logistics industry.

The connection between the competences acquired through VET programmes in logistics and transport and the qualifications or industry expectations are still largely unexplored. Several research studies have been conducted on logistics skills and the mismatch between the current logistics curricula in higher education and real-world requirements (Cronjé, 2015; Gromovs & Lammi, 2017; Grubišić, Perić-Hadžić, & Jardas, 2017; Niine & Koppel, 2014; van Hoek et al., 2013; Wong, Grant, Allan, & Jasiuvian, 2014).

However, only few studies have explored VET curricula in logistics and transport. Psifidou (2010) compared curriculum policies in nine European countries and analysed learning programmes in the occupational field of logistics. The study only highlights the key role that the learning outcomes play in curricular reforms and brings evidence of essential changes in national curricula. Amado et al. (2019) made a step further and planned a new course (Urban Transit for VET in Brasil). Their study considers the skills and competences as the main aspects in the elaboration of a curriculum. Therefore, they proposed "a course that emphasises a multi- and interdisciplinary approach, not one based on traditional subjects and disciplines." (Amado et al., 2019). Educational programmes and training modules were developed for crane operators in ports. These were based on the requirements, needs and demand of the logistics business and the International Labour Organisation (ILO) within the NEWLOG project (Mikhail, 2016). To our knowledge, no study has been conducted to date to design a learner-centred training programme based on the current needs of the logistics industry and innovative teaching approaches.

This paper, therefore, aims to present a new and up-to-date training programme for VET in logistics and transport, designed in accordance with the European Credit System for Vocational Education and Training (ECVET). To this end, two research questions were formed:

- **RQ1**: What is the gap between the needs of the transport and logistics industry and the current VET training offer in transport and logistics in selected European countries?
- **RQ2**: Which training modules can be provided to VET students in transport and logistics to bridge this gap?

Based on an analysis conducted in four European countries (Slovenia, Croatia, Italy and France), a mismatch between the current curricula in VET in logistics and transport and the requirements of the logistics industry was found. Nowadays, a logistician should, in the view of the practitioners, be able to use information communication technology (ICT) and other communication tools, deal with specific data and situations, put theoretical knowledge into practical use, process orders, and manage inventories and truck drivers. To help improve and further develop a VET logistician's knowledge and skills, five TMs were designed based on the premises of the ECVET system.

This paper provides the following unique contributions. It helps to identify the skills and competences that enable VET graduates in logistics and transport to successfully enter and function in the workplace in the logistics and transport sector. Furthermore, it highlights significant weaknesses of the current curricula in VET in transport and logistics and helps VET in logistics and transport to upgrade and modify their curricula to increase the interest in the logistics profession and the competitiveness of the pertinent schools. The study is based on real data and reflects the situation in several Western and Eastern European countries.

The paper is organised as follows. Section 2 presents the background literature to this study. The adopted research methodology is outlined in the third section, followed by the presentation of the results. A discussion is provided in section four. The article concludes with suggestions for future research and the limitations of the presented approach.

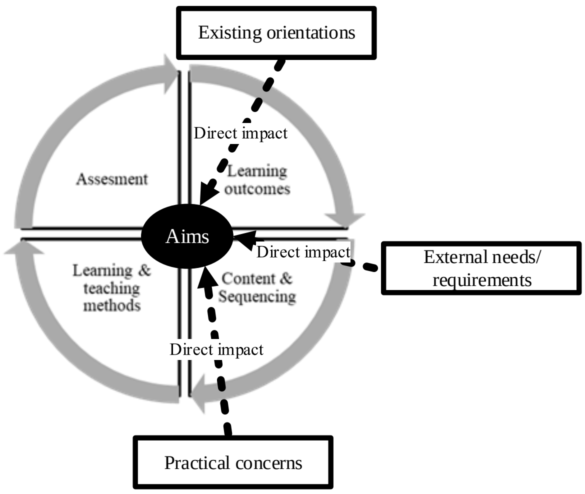
2 LITERATURE REVIEW ON CURRICULUM DESIGN

The word curriculum derives from the Latin word "currere" (to run a course) (McKimm, 2007). From there the word "the course of study" or syllabus originates (Hussain, Dogar, Azeem, & Shakoor, 2011; Prideaux, 2003). A curriculum is more than a syllabus. A curriculum defines the learning that will take place during a programme of study and includes all the planned learning experiences of an educational institution (McKimm, 2007; Prideaux, 2003). A syllabus is only one part of the curriculum and describes only the content of a programme (McKimm, 2007).

One of the functions of a curriculum is to provide a design which enables learning to take place. "Curriculum cannot be stagnant. It must be a living document that is in constant flux. It must be adaptable to changes in the educational community and in society in general. Only then will it be able to be an effective change agent in the educational process" (Alsubaie, 2016).

2.1 Elements of the curriculum design process

There is a large range of constituent elements to consider when designing a curriculum (Figure 1). The process of defining and organising these elements into a logical pattern is known as the curriculum design process (Macalister & Nation, 2019). All the elements in curriculum design are interlinked. No element should be decided without considering the others.



Source: (Boschman, McKenney, & Voogt, 2014; Macalister & Nation, 2019)

Figure 1: Elements of the curriculum design process

Existing orientations, external needs and practical concerns have a major effect in guiding the process of curriculum development (Boschman, McKenney, & Voogt, 2014). They directly impact the aims of a training programme or course. If these factors are not considered, the curriculum may not be harmonised with the needs, the situation and the learners for whom it is used (Macalister & Nation, 2019).

Existing orientations involves teachers' practical knowledge obtained through experiences in teaching as well as through their knowledge and beliefs related to how the curriculum is designed and used. Practical knowledge refers to instructional strategies, classroom strategies and knowledge about learners, learning and teaching. Content knowledge includes the organisation of ideas, concepts and facts as well as syntactic structure. Technological knowledge is the knowledge about several technologies used for education purposes (Boschman et al., 2014).

Identifying the **various stakeholders' needs** is crucial to effective learning and assessment. These needs are discovered by different stakeholders on different levels, varying from the macro-level (e.g., industry, national standards, trends), to the (near) school level, as expressed by school boards or principals by using a variety of means (questioning, interviewing, consulting employers, investigating the situations where the learners will need to use this knowledge). According to Laurillard (2010), the curriculum developers should never be interested simply in the learners' ability to do what they were taught to do but also in their ability to generalise what they were taught to other situations. Besides external stakeholders' needs also learners' needs (what learners lack and want) have to be reviewed. Curriculum developers need to have access to information about learners' characteristics (age, knowledge, experience, etc.). Both, the learners' and external stakeholders' needs, establish the overall aims and learning outcomes for the course.

Curriculum design and instruction are also influenced by **practical considerations** concerning concrete classroom activities. The factors that teachers consider most include the time available for the course, the size of the class, teachers' experience and training, the organisation of seats in the classroom (Macalister & Nation, 2019), how content is presented to the learners, how the learners will react to the content, teaching strategies and what they will do with the content (Boschman et al., 2014). Practical considerations make sure that the training programme or course is appropriate, practical and realistic (Macalister & Nation, 2019).

The **aims** are located in the centre of the curriculum design process (Figure 1) for two reasons: first, they reflect the importance of having clear goals of the training programme, and second, they ensure that the goal of producing competent graduates is achieved. In other words, the aims describe what the teacher is trying to achieve.

The cycle of the curriculum design process shown in Figure 1 represents the syllabus and its elements: learning outcomes/objectives (knowledge, skills and attitudes) and content of the course, teaching and learning strategies, assessment methods (Prideaux, 2003), supporting elements (learning resources such as teachers, books, IT support) and student support, and an indication of the learning resources required to support the effective delivery of the course (McKimm, 2007).

"**Learning Outcomes** are carefully defined descriptions of the level of knowledge and skills learners should be able to demonstrate at the end of the course. They will determine the nature of the summative assessment that will be most appropriate, and the teaching-learning activities needed" (Laurillard, 2010). The **content** and sequencing represent the items to learn in a course or training programme and the order in which they are presented (Macalister & Nation, 2019). The content should reflect the job that the learners will do after training and should relate directly to the learning (McKimm & Barrow, 2009). Course content can be derived from many sources: one's own existing curriculum if available, other organisation's curricula, textbooks, an analysis of the training needs of the industry, national professional bodies, etc. In the view of McKimm (2007), the outcomes guide both learners and teachers on the choice of **relevant learning and teaching methods** to achieve the intended learning. Macalister & Nation (2019) claim that this is the element of the curriculum that the learners are most aware of and, therefore, must be realised by using the appropriate and efficient teaching and learning methods. Besides traditional teaching approaches, many innovative teaching and learning methods have appeared with the developments in information and communication technology.

In designing the assessment methods that measure learners' performance, the starting point should always be the stated learning outcomes. **Assessment** checks that the whole content has been presented and that the learners have achieved the learning outcomes. Several different methods can be used to measure learners' performance (exams, interim assessments, hinge-point questions, exit-pass questions, etc.). According to Laurrilard (2010), a variety of methods should be used to evaluate not only final success but also interim progress. The assessment provides feedback to the learners but also information that leads to changes in the curriculum.

Finally, the goal of effective curriculum development is to meet the needs and current demands of the society and the expectations of the population being served (Alsubaie, 2016). Therefore, the involvement of all stakeholders is crucial in successful curriculum development (Johnson, 2001).

3 RESEARCH METHODOLOGY

A three-phase methodological approach was used to develop a new training programme for VET in logistics and transport (Figure 2).

In the first phase, a SWOT analysis of the current training offer in VET in transport and logistics was conducted based on a sample of eight selected schools from Slovenia, Croatia, Italy, and France. The analysis was divided into two segments: logistics and transport. In addition, the knowledge, skills and competences constructed through these curricula were analysed. The objective of this first phase was to highlight the strengths, weaknesses and opportunities of the current curricula in VET in logistics and transport in the selected European countries. The identified weaknesses were divided into the following aspects: practical aspects, simulation aspects, up-to-date aspects, curricula orientation aspects, language aspects, teaching methodology and assessment aspects, and work placement aspects.

In the second phase, 49 semi-structured interviews were conducted with representatives of the logistics and transport sectors that provide employment to graduates from VET logistics and transport. The interviewees were managers, directors and heads of diverse logistics departments, logistics providers, traders, producers, and port employees (customs clearance department, rail/road/air transport department, warehouses, etc). All interviews were then recorded and transcribed. The objective of this phase was to determine the level of competence of newcomers for the categories of employment to which the VET programmes in transport and logistics lead, and highlight the knowledge, skills, and competences that merit further investigation.

In the third phase, an appropriate and up-to-date training programme consisting of five TMs for VET learners in logistics and transport was developed based on the identified gaps between the current VET offer and the needs of the logistics and transport industry.

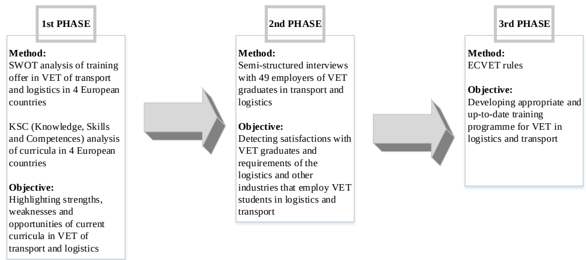


Figure 2: Curriculum design process

In the following section, the results of each of these phases will be presented.

4 RESULTS

4.1 VET curricula in transport and logistics

The weaknesses of the analysed curricula in VET in logistics and transport that required change can be summarised in three main points: disparate content, lack of simulation and practical work, and lack of knowledge updating and involvement of professional stakeholders.

First of all, differences in the content of the training offer were identified among the selected VET curricula in logistics and transport in Croatia, France, Italy and Slovenia. Given that the current labour market often requires national mobility, and increasingly often international mobility, such disparities in content could be detrimental to learners in terms of their geographic mobility. For example, in Croatia the curricula appear to be complete and cover both general and specific knowledge and skills. However, this is not the case in Slovenia (where not all modes of transport are covered by all schools) nor in Italy (where there are relatively large gaps concerning the knowledge of geography, or the development of logistics). In addition to having a detrimental effect on mobility, this may jeopardise the insertion of students into the local labour market.

Second, most analysed curricula displayed a lack of use of simulations and practical work. The use of simulations refers to smart games but also pedagogical uses of professional software, such as the Warehouse Management System (WMS) for logistics, and the Transport Management System (TMS) for transport activities. Moreover, practical hands-on experience and learning are very often lacking or non-existent, which means that the knowledge is too theoretical while the opportunities for the development of skills are scarce despite the mandatory work placement periods. In order to increase the employability of graduates from VET in logistics and transport, it appears necessary to provide them with greater practical training and thus empower them to quickly take on the functions for which they are trained.

Last but not least, the third identified category of weaknesses refers to lack of knowledge updating and involvement of professional stakeholders. In fact, the knowledge contained in the course materials is frequently outdated and not in line with the current developments, trends, methods and practices. In the fast developing logistics and transport industry, it is essential to provide the VET students and teachers with support and courses that are up-to-date. A related phenomenon is lack of instructors from the professional world, who would be able to make highly valuable contributions to the teaching and learning process, and familiarise students with new processes and sector specific methods and practices, especially through authentic case studies, role plays and simulations.

4.2 Logistics and transport industry needs

We will first present the knowledge, skills and competences that, in the opinion of the interviewed representatives from the logistics and transport sector, are mainly managed by VET graduates.

In terms of logistics, these are skills linked to global warehousing activities (e.g., different warehouse areas, such as receiving, order picking, and shipping), basic IT skills (e.g., basic functions of MS Office), and internal communication (e.g., sending information to line managers). In relation to transport, the knowledge and skills that are mostly mastered by VET graduates in logistics and transport include the skills linked to transport organisation (e.g., organisation of transport missions), the knowledge of regulations (e.g., application of legal norms that regulate transport operations), and the skills needed to adapt to new inputs (e.g., reviewing planning according to last minute requests).

However, content analysis of the in-depth interview transcriptions revealed several knowledge and skills areas that the existing VET programmes in logistics and transport do not sufficiently cater for and that need to be addressed by a tailor-made learner-centred training programme for VET graduates in logistics and transport. These lacks represent the gaps based on which the training programme will be designed and are presented below, first for logistics and then for transport.

Therefore, the following section will provide an answer to **RQ1**: What is the gap between the needs of the transport and logistics industry and the current VET training offer in transport and logistics in selected European countries?

The skills and knowledge related to **logistics activities** that have to be addressed by a training programme for VET graduates from transport and logistics include:

1. putting theoretical knowledge into practice (knowledge is usually too theoretical, and VET graduates have difficulties putting this knowledge into practice in their everyday work, which indicates the need for more practical training through the use of simulations, role plays, and case studies, among other methods),
2. order processing (concrete realisation of theoretical knowledge is problematic, for instance choosing the best support according to the volume of the order, organising the different references of the order on the support so that they can be delivered in good condition, and determining the best protection for the order),
3. inventory management (because of the computerisation of inventory management the need for training in inventory control is particularly high and at least basic knowledge in stock management required), and
4. sectoral ICT tools (the knowledge of software specific to the sector tends to be quite poor and has to be the subject of company training. With the growing computerisation of warehouse management, it seems inevitable that professionals working in this field are familiar with WMS as the main software used in logistics).

On the other hand, the skills and knowledge that merit further investigation and are related to **transport activities** include:

1. drivers' management (often approached from a legal and theoretical point of view in the training whereas future operators should develop procedural knowledge through real-life scenarios),
2. use of ICT tools (Excel spreadsheets to plan activities, the knowledge and skills in the use of sector-specific software are limited, for instance of TMS),
3. adaptability to new trends and processes (transport operators will be the first users of new tools and processes, such as the eCMR, and should demonstrate adaptability to novelty; in addition, they will be in charge of training the drivers and other employees in the use of new tools),
4. dealing with specificities (VET graduates lack specific knowledge and skills, for instance referring to temperature-controlled transport, or the transport of hazardous materials), and
5. different types of communication (transport operators have to communicate with different actors, such as customers, management, and drivers, which predetermines the way in which the operator communicates with these different interlocutors).

These gaps provided the starting points for the preparation of five ECVET-based TMs. They are presented in detail in the next section.

4.3 Training programme

Based on the gaps identified between the provision of VET schools in logistics and transport and the logistics and transport industry needs, five TMs have been designed:

- TM1: Maritime and Intermodal Management
- TM2: Supply Chain Management of Cold Products
- TM3: Warehouse Analysis
- TM4: Transport Organisation
- TM5: Key Soft Skills

Each TM is further divided into Learning Outcomes Units (LO Units), presented below together with the suggested teaching methodology for each TM.

This section will provide an answer to **RQ2**: Which training modules can be provided to VET students in transport and logistics to bridge this gap?

TM1: Maritime and Intermodal Management

The adopted teaching methodology in TM1 focuses on the practical application of theoretical knowledge through the work in the nautical simulator, the use of case studies, a visit to a cargo port and/or intermodal terminal, and the use of online simulators for the replication of the management of a rail-road intermodal terminal.

TM1 addresses maritime and intermodal transport, and consists of four LO Units:

LO Unit 1: Assessing the main parameters for navigation. This LO Unit presents the Electronic Chart Display and Information System (ECDIS), and the Automatic Radar Plotting Aid (ARPA) for safe conduct of maritime navigation. It takes place in a nautical simulator. This LO Unit also includes the possibility of practising navigation on small vessels, thus understanding and using navigation techniques to assess weather parameters and conditions.

LO Unit 2: Recognising the main infrastructures and vehicles of maritime ports. LO Unit 2 focuses on various types and characteristics of vessels, port terminals, cargo handling equipment, coordination of the arrival and departure of shipments, and documentation related to shipments' arrival/departure, etc.

LO Unit 3: Coordinating the arrival and departure of freight trains. Here, the participants simulate various activities. For example, they prepare a train list for a departing train, use the information from a train list of an incoming train, check the truck's booking list, and organise the activities taking into account the KPIs for the terminal.

LO Unit 4: Managing the storage of UTIs at the rail-road terminal. The practical skills acquired in LO Unit 4 include, for instance, the organisation of the loading operations according to the booking list and truck arriving at the terminal, and the provision of instructions on the operations to be performed by the reach stackers or crane drivers/operators.

TM2: Supply Chain Management of Cold Products

The main objective of TM2 is to familiarise the participants with the supply chain management of a specific category of products, i.e., products that require a special temperature regime.

The teaching methodology is first oriented to the development of declarative knowledge and then the application of this knowledge in practical situations through the use of board games, case studies, simulations, and in-company visits.

This TM is divided into the following LO Units:

LO Unit 1: Understanding the basics of supply chains. After the completion of this unit, the participants are able to understand the difference between a supply chain and a logistics chain, select the right type and supply chain strategy with respect to the type of product, make a lean and/or agile supply chain, and manage supply chain risks.

LO Unit 2: Organising a supply chain of cold products. As with the other LO Units, both declarative knowledge (e.g., the classification of cold products, and safety rules and procedures for different types of cold products) and procedural skills (e.g., classify different types of cold products, their temperature, environmental requirements, and shelf lives) are developed.

LO Unit 3: Cold chain warehousing. Here the participants learn about, for example, types and characteristics of warehouses for storing cold products, and technical requirements for cold products storage, and standard operating procedures for the storage of cold products.

LO Unit 4: Understanding the main aspects of transporting cold products. This LO Unit focuses on the main regulations and standards related to the transport of different cold products, main types and characteristics of cold chain technologies in providing a temperature-controlled environment during transport, the main types of cold chain monitoring equipment, and safe transport of cold products.

TM3: Warehouse Analysis

This TM covers three main topics, which are warehouse activities with a focus on order processing, WMS, and methods for the optimal management of a warehouse.

In terms of the teaching methodology, direct instruction is used to present warehouse processes and equipment. On the other hand, case studies, video presentations, and WMS can be used in this TM for the development of practical skills. Warehouse analysis can be carried out using real data while the calculation of the basic KPIs can be presented to and done by the participants. Finally, a visit to a warehouse for fresh products can be organised to show the application of the presented theory in practice.

TM3 is divided into four LO Units presented below.

LO Unit 1: Calculating and assessing the KPIs of a logistics warehouse. In addition to providing declarative knowledge to the participants, LO Unit 1 focuses on the development of the following skills: calculating the proper value of basic warehouse KPIs, explaining the value of KPIs and their influence on warehouse processes, using different methods for the calculation of KPIs, and applying actions according to
KPI results.

LO Unit 2: Proper use of a Warehouse Management System. Once completing LO Unit 2, the participants have the necessary skills to use WMS in warehouse processes, understand basic WMS features, use a bar code scanner, use a bar code reader, and enter proper data in WMS.

LO Unit 3: Preparing an order. LO Unit 3 focuses on the development of the knowledge of warehouse documents, different warehouse procedures, and procedures for completing warehouse documents. After the completion of this unit, the participants have the skill to use warehouse documents, produce dispatch documentation, record and store documents, and follow up purchase orders.

LO Unit 4: Using methods/techniques for the optimisation of warehouse operations. Finally, in LO Unit 4 the participants learn about the effective layout for each warehouse type, efficient warehouse systems, and available storage space within a warehouse. The practical skills that are addressed include the movement and handling of goods and materials, evaluating warehouse processes, and storing goods efficiently within a warehouse.

TM4: Transport Organisation

This TM addresses the organisation of a transport mission by road and focuses on all the details that are involved in the preparation of a road transport mission.

In terms of the applied teaching methodology, this TM relies on direct instruction for the development of declarative knowledge and several learner-oriented methods for the development of procedural knowledge. These include case studies based on authentic parameters, the use of authentic documents, and TMS or simulators for the management and monitoring of transport missions.

TM4 consists of five LO Units:

LO Unit 1: Calculating the costs of a transport mission. Once completing this LO Unit, the participants know the main components of a transport mission, the costs to be included in the calculation, company margin politics, and the road transport tariff system. In addition to this, they have the skill to calculate the costs of a transport mission, apply a company's price policy, and interact with customers regarding transport prices.

LO Unit 2: Preparing a transport mission. In LO Unit 2, the participants learn about the documents used in road transport, communication with internal actors regarding a transport mission, and contract details and features. The skills that they develop refer to the preparation of the necessary documents for a transport mission, and communication with internal and external actors.

LO Unit 3: Assessing the feasibility of a transport mission. The third LO Unit of TM4 addresses transport means, the schedule for each transport means, and rules linked to transport organisation. In addition, the participants are able to determine if the company can accept a mission, establish a schedule for each transport means, and re-organise the established schedules.

LO Unit 4: Monitoring a transport mission. Here the participants learn about the equipment and tools to monitor transport means, and approaches to risk management. In addition, they develop the skills of following transport operations, interacting with mission actors, and finding solutions in case of risk/problems.

LO Unit 5: Assessing the KPIs of a transport mission. The last LO Unit in TM5 addresses the main KPIs of a transport mission, and provides the participants with an understanding of the scope of KPIs in a transport mission, and analyses of KPIs and solutions that lead to the improvement of transport activities.

TM5: Key Soft Skills

TM5 focuses on two transversal topics that are common to all sectors, all countries, and all categories of workers and learners: stress resilience and change management.

This TM first addresses the reasons and consequences of stress through direct instruction and then uses role-play to present different techniques for stress prevention and coping mechanisms.

TM5 is divided into three LO Units:

LO Unit 1: Managing stress. Among the most relevant knowledge and skills that the participants acquire in this LO Unit we can find the reasons and consequences of stress, different techniques for stress prevention and coping mechanisms, how to recognise stress and various stressors, and how to recognise the need for personal development/training and prepare a personal development plan.

LO Unit 2: Time management and prioritising. In this LO Unit the participants focus on time management and prioritising (e.g., developing a plan of action for a job with many demands) and goal setting in their personal and professional lives. In addition, they are familiarised with daily/weekly work plans, and distractors.

LO Unit 3: Managing changes. The final LO Unit of TM5 addresses change, in particular organisational change, barriers to change, change management, collaboration skills, and personal development and training needs.

5 DISCUSSION

This paper addressed two research questions. The first aimed at identifying the gap between the needs of the transport and logistics industry and the current VET offer in transport and logistics in selected European countries while the second led to the design of five TMs that were provided to VET students in transport and logistics to bridge the gaps identified in the first step.

In this way, the curriculum design process for the Summer Logistics School relied on all the necessary elements of curriculum design as defined by (Boschman et al., 2014; Macalister & Nation, 2019). The learning outcomes were based on the identified gaps between the provision of the VET offer in logistics and transport and the needs of the logistics and transport industries. The content and sequencing of the TMs were designed in such a way to proceed from the general to the specific, and from the development of declarative knowledge to procedural skills. The selection of the learning and teaching methods guaranteed the efficiency of the learning and teaching process by focusing on learner-centred methods, for instance smart games, case studies and simulations. Finally, the self-assessment conducted before and after the implementation of the curriculum indicated the progress made by the participants.

In addition, the curriculum design also took into consideration the existing orientations of the participating teachers and thus contributed to the development of teacher cognition (Borg, 2019). The various stakeholders' needs were explored in the second step of the curriculum design process through semi-structured interviews and their analysis. Finally, the practical considerations concerning concrete classroom activities were addressed at the lesson planning stage.

This project study has extended the mismatch between the real-world requirements and current logistics curricula identified in higher education (Cronjé, 2015; Gromovs & Lammi, 2017; Grubišić, Perić-Hadžić, & Jardas, 2017; Niine & Koppel, 2014; van Hoek et al., 2013; Wong, Grant, Allan, & Jasiuvian, 2014) to the VET level as well. In fact, the results indicate that some aspects of knowledge, skills, and competences are sufficiently covered by the VET schools in logistics and transport while others are not sufficiently catered for.

However, VET graduates that apply for new jobs in the logistics sector need a diverse set of knowledge, skills and competences to be successful (van Hoek et al., 2013). Some among these had to be addressed by the learner-centred and needs-based curriculum designed for the Summer Logistics School. In summary, the identified gaps in the field of logistics refer to the use of theoretical knowledge in practical situations, order processing, inventory management, and the use of sectoral ICT tools. On the other hand, the gaps identified in the field of transport were drivers' management, use of ICT tools, adaptability to new trends and processes, dealing with specificities, and different types of communication.

6 CONCLUSION

Reporting data from the evaluation that was conducted after the completion of the Summer Logistics School reaches beyond the purpose of this paper. However, the evaluation process has allowed us to identify the points in VET in logistics and transport that require further research attention.

First, the evaluation has shown that the students would like student-centred teaching methods to be used more often by their teachers and that they believe that they are efficient. However, their teachers most often are not suitably trained for their use. Therefore, the teachers could learn from examples that they experienced as participants but it would also be beneficial for them to try these methods is simulated classes on their own. To make this possible, flipped learning developed within a MOOC environment could focus on theoretical knowledge and thus allow VET teachers to exclusively focus on the practical development of skills and competences in their classes. Finally, training based on the principle of twinning of subject and English teachers would allow participants with lower levels of English to concomitantly develop their knowledge, skills, and competences in two fields: subject matter and English as a foreign language for specific purposes.

As in any research, there are limitations. The sample scope and size was small, which limits the generalisation of results to other settings and could limit the reliability and validity of the results. Therefore, future studies may consider large-scale multi-national data collection to reduce the possibility of bias.

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ALIPHATIC AND POLYCYCLIC AROMATIC HYDROCARBONS IN MUSSELS (*MYTILUS GALLOPROVINCIALIS*) FROM THE GULF OF TRIESTE (NORTHERN ADRIATC)-THE IMPACT OF MARITIME TRAFFIC

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ABSTRACT

The aim of the present work was to study the distribution and origin of aliphatic hydrocarbons and polycyclic aromatic hydrocarbons in mussels to assess the impact of maritime traffic and port activities in the Port of Koper (Gulf of Trieste). Aliphatic and polycyclic aromatic hydrocarbons (PAH) are an important group of pollutants. Many marine organisms living in contaminated areas accumulate hydrocarbons. Mussels are filter-feeding organisms, they filter big quantities of seawater and accumulate different pollutants in their tissue. Therefore, they are very important indicator organisms.
The investigated area is one of the most urbanized areas in the northern Adriatic, with intense industrial activities, maritime traffic and developed nautical tourism. Two sampling sites were selected, at the entrance to the port of Koper (KP) and in Strunjan nature park (ST). Concentrations of aliphatic hydrocarbons were higher at station KP. The major component of the total aliphatic hydrocarbons was the unresolved complex mixture, indicating intense degradation processes. Application of different evaluation indices revealed the petrogenic origin (oil) as the prevailing one, although the biogenic is also important.
Concentrations of total PAHs were 2-3 times higher at station KP, compared to station ST. The main PAH origin is pyrogenic, with significant part connected to petroleum combustion, especially at station ST. The petrogenic origin is relatively less important.
The presented results show an important impact of maritime traffic and port activities on hydrocarbon pollution in the Port of Koper area (south-eastern part of the Gulf of Trieste), especially in the case of aliphatic hydrocarbons.

Keywords: aliphatic hydrocarbons, PAH, Gulf of Trieste, maritime traffic

1 INTRODUCTION

Aliphatic and polycyclic aromatic hydrocarbons (PAH) are an important group of pollutants, distributed in soils, sediments and natural waters. The most important sources of pollution by hydrocarbons are oil seepage, oil spillage, combustion of organic matter (e.g. fossil fuels), traffic, domestic and industrial waste waters, as well as urban runoff and atmospheric deposition [1]. Their concentrations are usually higher in urbanized coastal areas due to intense human activity. Hydrocarbons, especially polycyclic aromatic hydrocarbons (PAH), have been recognized as hazardous environmental chemicals [1]. Many marine organisms living in contaminated areas accumulate hydrocarbons. Consequently, the elevated concentrations of these compounds in seafood might also be harmful to human health.

Hydrocarbons are relatively stable in the natural environment and they accumulate in sediments and biological communities. For this reason, sediment and biota samples are usually used for analyses since the concentration in seawater is usually very low due to fast dilution. The most used marine organisms for this purpose are mussels [2,3]. They have a broad distribution in coastal waters. Their abundance, distribution and ability to accumulate pollutants have made them an important indicator organism. They filter large volumes of water and they have only a limited ability to metabolize different lipophilic compounds. In this way they accumulate pollutants in levels higher than those in the surrounding water or sediments and this phenomenon can be observed in relatively short periods of time [3, 4]. The study of the impact and fate of hydrocarbons is therefore of great importance, especially in marine coastal waters since these areas are biologically active and receive considerable pollutant inputs from different land-based sources and via coastal and river runoff.

Two main origins are usually considered in case of PAHs, petrogenic (unburned oil and oil products) and pyrolytic (combustion of fossil fuels and biomass) [5]. To establish their origin in marine waters, sediments and biota, different molecular indices are used. In particular, the ratios between low (LMW) and high molecular weight (HMW) PAHs [6, 7] or the ratio of some isomers, e.g. phenanthrene/anthracene, fluoroanthrene/pyrene [6, 8]. Petrogenic contamination is characterized by the predominance of low molecular fraction (LMW), while high molecular fraction (HMW) prevails in pyrolytic PAHs.

In case of aliphatic hydrocarbons, some other evaluation indices are used to distinguish between the petrogenic and biogenic origin [5, 9, 10]. Among them are, the content of resolved aliphatic hydrocarbons, the presence/lack of unresolved complex mixture (UCM), concentrations and ratios of some alkanes (n-C17, n-C18) and isoprenoids (Pristane, Phytane), the ratio between hydrocarbons with an even and an odd number of C-atoms and the carbon preference index (CPI).

1.1 Study area

The investigated area is a part of the northern Adriatic (Figure 1). This coastal area is one of the most urbanized areas in the northern Adriatic, with many industrial activities. Intense maritime traffic to the ports of Koper, Trieste and Monfalcone (over 37 million tons of oil and oil products per year) and developed nautical tourism (several marinas) are considered as important hydrocarbon pollution sources. This area is also affected by wastewaters from sewage treatment plants, industrial wastewaters and runoff waters from the coastal roads. The whole area is under the influence of fluvial inputs by the Isonzo, Tagliamento, Rizana and Dragonja rivers. These rivers also carry wastewater from the local industry, as well as waters that drain rather large agricultural areas.

Figure 1: Positions of sampling sites; site KP at the entrance to the port of Koper and marina of Koper, site ST in Strunjan nature park

The content and distribution of PAHs in mussels and other marine organisms in the Gulf of Trieste has attracted little attention until now, despite important pollution sources. Only Notar and Leskovsek (2000) [11] reported some results about the content of PAHs in mussels from the two sites in this area. A more comprehensive study would be therefore necessary in the future for better assessment of the state of pollution in this part of northern Adriatic. For this reason, the aim of the present work was to compare two different sites in the Gulf of Trieste, differing in the expected degree of pollution. The main goal was to assess the impact of maritime traffic and port activities on sea pollution by the analyses of distribution and origin of aliphatic and polycyclic aromatic hydrocarbons in mussel samples. The first sampling site KP was situated in the Bay of Koper, at the entrance to the port of Koper and marina of Koper. This area is usually considered as one of the most polluted parts in the investigated area. For comparison, the second sampling site ST was selected in Strunjan, which is a part of a nature park and without important point pollution sources. However, this area could be somewhat under the influence of nonpoint pollution sources, e.g. transport of water masses from other parts of the Gulf of Trieste and atmospheric deposition.

2 EXPERIMENTAL

The entire experimental procedure was performed according to the guidelines of UNEP/FAO/IOC/IAEA (1993) [12].

2.1 Collection of mussels and extraction of hydrocarbons[

Mussels were sampled manually using a home-made grab in the first part of September each year to avoid the influence of the difference in the uptake of contaminants during different seasons. About 100 mussels were collected at each sampling site. Five subsamples were formed, each composed of 15 specimens, after the partition of specimens of similar shell length. After the removal of the shell, samples of the whole mussel tissues were homogenized and than freezedried. About 5 g of dry sample (accurately weighted) was extracted in a Soxhlet apparatus with methanol for 8 hours. KOH solution and water were added to saponify the lipids. Hydrocarbons were extracted from the resulting alkaline mixture with hexane. The clean-up of samples and partition of hydrocarbons into aliphatic and aromatic fractions was performed by column chromatography.

2.2 Chemical analyses

Concentrated extracts were analysed using an HP 6890 gas chromatograph equipped with an FID detector. The HP Ultra 2 column (25 m x 0.32 mm x 0.17 μm) was used for analyses.
In the case of aliphatic hydrocarbons, for each sampling site the n-alkane concentrations (n-C14 to n-C34), the isoprenoids pristane and phytane concentrations, the total resolved aliphatic (sum of n-alkanes and isoprenoids), the unresolved complex mixture (UCM) and the total aliphatic hydrocarbons were calculated. The UCM comprises different unresolved compounds, e.g. branched alkanes and cycloalkanes. Total aliphatic hydrocarbons means the sum of the total resolved aliphatic hydrocarbons and the UCM.

In the case of PAHs, concentrations of the individual PAH were calculated and the total PAH concentration (sum of resolved PAHs).

2.3 Quality control and quality assurance

During the work, quality control procedures were applied. Procedural blanks were performed at the same time as the analyses. Concentrations of all target compounds were below the detection limit in blank samples. For recovery determination, two sets of internal standards were added to each sediment sample prior to the analyses. Results were corrected for recoveries. A standard reference material NIST 2977 (mussel sample, National Institute of Standards and Technology, USA) was also analyzed prior to the analyses of mussel samples to assess the accuracy of our work.

3 RESULTS AND DISCUSSION

Data about the average length and width of analyzed mussel samples are presented in table 1.

Table 1: Average length and width of analyzed mussel samples (STD-standard deviation, n=15)

Year	Sampling	Length (cm)		Width (cm)	
		average	STD	average	STD
2007	KP	6.6	0.4	3.1	0.1
	ST	7.3	0.3	3.5	0.1
2008	KP	6.8	0.3	3.1	0.1
	ST	7.4	0.4	3.4	0.1
2009	KP	7.1	0.1	3.3	0.1
	ST	7.3	0.1	3.5	0.1

3.1 Aliphatic hydrocarbons

Concentrations of aliphatic hydrocarbons are presented in table 2. These results revealed substantially higher concentrations of almost all parameters at station KP. The total aliphatic hydrocarbons concentrations were up to six times higher at station KP, compared to the station ST. The major component of the total aliphatic hydrocarbons was the unresolved complex mixture UCM. It is considered as a mixture of branched aliphatic hydrocarbons, cyclic saturated hydrocarbons and degradation products of hydrocarbons. Linked to degraded or weathered petroleum residues indicates a chronic petroleum input [13]. A continuous homologous series of n-alkanes from n-C14 was also observed in all samples, indicating the contribution of hydrocarbons of anthropogenic origin [9].

The intense degradation processes are exhibited by the very high ratios between the UCM and resolved aliphatic hydrocarbons. They range from 5 to 26. This is an important confirmation of petrogenic input, since values higher than 4 are indicative for petrogenic contamination [14]. Appearance of isoprenoids pristane and phytane in higher amounts could additionally indicate the petrogenic origin. They are often considered as good indicators of petroleum contamination. The ratio of pristane to phytane around 1 indicates petrogenic input, while higher ratios are more significant for biogenic input [15]. Results in table 2 confirm the prevailing petrogenic origin of aliphatic hydrocarbons in the Bay of Koper and imply relatively more pronounced biogenic origin in Strunjan area. The isoprenoids pristane and phytane can be also used in connection to n-C17 and n-C18 to evaluate the presence of degraded oil and the relative biodegradation of n-alkanes. Pristane and phytane are relatively persistent compounds. As the oil is biodegraded, bacteria preferentially consume n-C17 and n-C18. The result is a relative enrichment of isoprenoids. Values of the n-C17/Pri and n-C18/Phy ratios bellow 1 suggest the presence of degraded oil while higher values suggest lower degradation of hydrocarbons [8]. In this study the rather low n-C17/Pri and n-C18/Phy ratios, especially at station KP, further confirm important degradation processes of aliphatic hydrocarbons.

Table 2: Concentrations of aliphatic hydrocarbons in mussels (ng/g d.w.; UCM and total aliphatic in µg/g d.w.) and some evaluation indices

Aliphatic	2007		2008		2009	
	KP	ST	KP	ST	KP	ST
n-heptadecane (C17)	142	108	254	179	199	227
Pristane	269	42	809	98	634	220
n-octadecane (C18)	52	39	59	54	47	79
Phytane	207	15	746	53	285	25
∑n-C14 – n-C34	3390	1417	3461	1506	5643	1698
Total resolved	3866	1474	5016	1657	6562	1943
UCM	99.93	23.99	130.33	18.82	112.11	20.11
Total aliphatic	103.8	25.46	135.35	20.48	118.67	22.05
UCM/Resolved	26	15	26	10	17	5
Pri/Phy	1.3	2.8	1.1	1.8	2.2	8.8
n-C17/Pri	0.5	2.6	0.3	1.8	0.3	1.0
n-C18/Phy	0.3	2.6	0.1	1.0	0.2	3.2
CPI	2.4	2.8	1.6	2.3	1.2	4.8

The contribution of aliphatic hydrocarbons of biogenic origin seems to be also important. This appears from the CPI index of the HMW alkane fraction. Values around one are attributed to petrogenic origin, while higher values (3-6) are connected to the degradation of terrestrial vascular plants [8]. Our results are considerable lower than 3 at site KP and up to 5 at site ST, indicating again the prevailing petrogenic origin with different contribution of the biogenic. Beside the terrestrial biogenic input, the marine biogenic input is also evident from the relatively higher concentrations of n-C15 and n-C17 (Figure 2). This is characteristic for marine macro and micro-algae [16]. In our case, this is not surprising because the entire investigated area could be considered as a highly productive coastal area, due to significant inputs of nutrients from rivers and from sewage treatment plants.

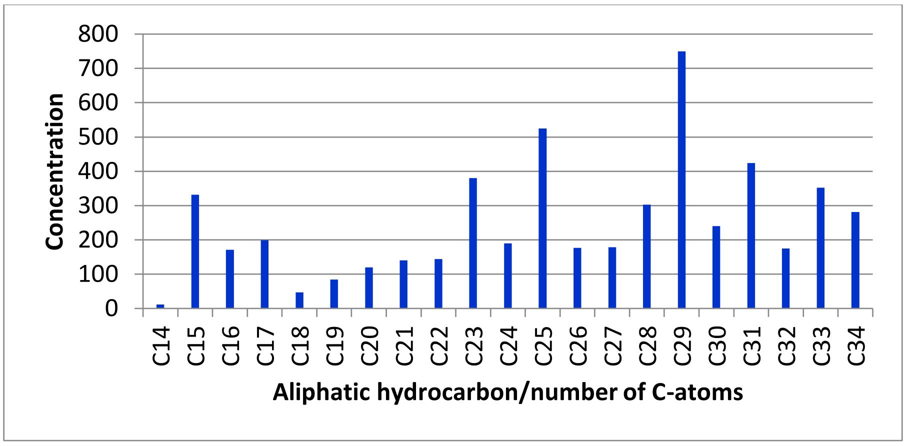

Figure 2: Concentrations of individual aliphatic hydrocarbons at station KP (ng/g d.w.)

3.2 Polycyclic aromatic hydrocarbons (PAH)

Table 3 gives the concentrations of 18 PAHs determined in mussel samples. A significant difference was observed between both sampling sites; concentrations of total PAH were roughly 2-3 times higher at station KP. The difference in concentrations of individual PAH congeners was not so uniform, but generally, the individual PAH concentrations were higher at site close to the Port of Koper (KP). This was somehow expected regarding the very different pollution pressures in the investigated areas.

Table 3: Concentrations of PAHs in mussels (ng/g d.w.) and some evaluation indices (AN-anthracene, PHE-phenanthrene, FLU-fluoranthene, PY-pyrene)

PAH	2007		2008		2009	
	KP	ST	KP	ST	KP	ST
Naphthalene	*				2	
Acenaphthene					2	4
Acenaphthylene						
Phenanthrene	54	20	44	37	60	27
Anthracene	26	18	11	4	44	3
1-Me-Phenanthrene	21	21	32	16	9	8
2-Me-Phenanthrene	35	33	69	3	19	9
Fluorene		1			6	7
Fluoranthene	89	28	105	15	61	9
Pyrene	87	35	78	26	62	10
Chrysene	64	33	85	34	48	10
Benzo(a)anthracene	42	35	19	5	23	4
Benzo(b)fluoranthene	66	44	25	11	34	10
Benzo(k)fluoranthene	40	32	72	29	35	23
Benzo(a)pyrene	24	9	19	16	31	10
Indeno(1,2,3-c,d)pyrene	21	26	11	21	17	13
Dibenzo(a,h)anthracene	20	31	16	16	15	13
Benzo(g,h,i)perylene	16	19	8	3	15	15
Total PAH	**605**	**385**	**594**	**236**	**483**	**175**

PAH	2007		2008		2009	
	KP	ST	KP	ST	KP	ST
LMW/HMW	0.29	0.32	0.36	0.34	0.42	0.50
AN/AN+PHE	0.33	0.47	0.20	0.10	0.42	0.10
FLU/FLU+PY	0.51	0.44	0.57	0.37	0.50	0.47

*empty cell=below detection limit (1 ng/g d.w.)

Comparison of these results with published results for different Mediterranean areas [17-22] mainly shows relatively lower or at least comparable PAH concentrations in our investigated area, even in the Port of Koper. This is certainly the result of many measures, applied in the port in last years, for the reduction of pollution.

3.2.1 Origin of PAH

PAHs are very widespread contaminants in natural environment. It is well known that they may have multiple origins. Two major origins are usually considered in the case of PAHs, petrogenic (from oil and oil products) and pyrolytic (combustion of organic matter, e.g. fossil fuels), although some can also be derived naturally (e.g. perylene). In most actual cases, we are often dealing with mixed origins, with different prevalence of a particular origin. Their determination is therefore a rather complex issue.

To distinguish between petrogenic and pyrolytic origins, different evaluation indices have been used [5, 6]. It is well known that high molecular weight PAHs (HMW; 4, 5 and 6 aromatic rings) are mostly formed during the combustion of organic matter (pyrolytic origin), e.g. wood, petroleum, coal [6], although some of the 4-ring congeners could also be of petrogenic origin. On the other hand, low molecular weight PAHs (LMW; 2 and 3 aromatic rings) usually contribute to pollution by petroleum and its products (petrogenic origin) [6]. For this reason the ratio LMW/HMW PAH is frequently used for the first general determination of PAH origin. This ratio is low (<1) for pyrolytic origin and higher (>1) for petrogenic origin [23]. In our case all the calculated ratios were far below 1, indicating a strong prevalence of the pyrolytic origin.

The distribution of the individual PAH congeners reveals a predominance of high molecular weight congeners (HMW), especially those with 4 and 5 aromatic rings (Figure 3). The proportion of PAHs with 2 and 3 aromatic rings (low molecular weight, LMW) is mainly less than 30 %. Mussels are filter-feeding bivalves. In the seawater, they are exposed to both dissolved and particulate forms of hydrocarbons. The partitioning into these two forms is also dependent on their solubility. LMW PAHs are more soluble and mostly present in dissolved form and they accumulate in the surface seawater, while HMW PAHs appear in suspended form with higher accumulation to the sea bottom. The distribution of PAHs with different number of aromatic rings shows similar portion of LMW PAHs (2+3 rings) for both sites, but relatively higher proportion in favor of 5 and 6-ring PAHs at site ST. Beside the different distance from the important pollution sources and therefore different input of particular PAH congeners, the reason could be also connected to different sampling depth. Mussels in the Bay of Koper were grown just beneath the sea surface, while those in Strunjan extended down to 10 m of depth.

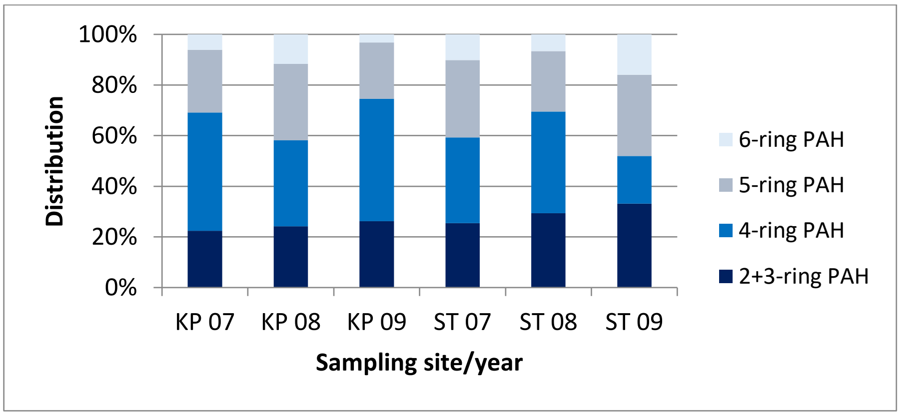

Figure 3: Distribution of PAHs according to the number of aromatic rings

For further elucidation of PAH origin in the studied area, the two most commonly used ratios were applied. The cross plot of these two diagnostic ratios, presented in figure 4, displays important difference in the prevailing pyrolytic origin of PAHs between investigated sampling sites. The origin of PAHs at site KP is pyrolytic, more connected to the combustion of coal and wood, and much less to petroleum combustion. Even though the influence of intense maritime traffic is important in the Koper area, the combustion sources on the coast seem to prevail. This could be due to the pollution of the sea from the Cities of Koper and Trieste, as well as from the local industry. On the other hand, petroleum combustion is the most important source at site ST, together with the petrogenic one. This could be ascribed to the intense maritime traffic in the entire investigated area and distant position from important coastal point pollution sources (e.g. cities, industry).

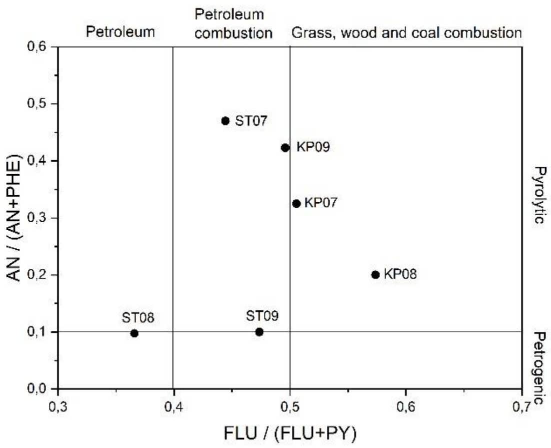

Figure 4: Crossplot of two evaluation indices for PAH origin determination (abbreviations presented in table 3)

4 CONCLUSIONS

Results of the present study show differencies in concentrations and origin of aliphatic hydrocarbons and PAHs in mussels from two investigated sites, the first one under strong impact of pollution and the second one in a nature park. Concentrations of hydrocarbons, aliphatic and polycyclic aromatic, were significantly higher at the entrance to the Port of Koper, compared to less polluted area in Strunjan. Application of different evaluation indices revealed the petrogenic origin (oil) of aliphatic hydrocarbons as the prevailing one, although the biogenic was also important. The main PAH origin was pyrogenic, with significant part connected to petroleum combustion in Strunjan area. The petrogenic origin was relatively less important. On the other hand, PAHs from the area close to the Port of Koper originate preferently from combustion of wood and coal. This indicates the influence of the Cities of Koper and Trieste, beside the combustion of oil and oil products.

These results show important impact of maritime traffic and port activities on sea pollution with hydrocarbons. They also confirm mussels as good bioindicators for marine pollution monitoring.

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LIAISON BETWEEN PROACTIVE AND PREDICTIVE METHODOLOGY OF AVIATION SAFETY MANAGEMENT SYSTEM

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ABSTRACT

Safety Management System (SMS) is an obligation of each organisation providing services in the field of aviation. The implementation and maintaining of effective SMS are regulated on global, regional, and national level. Safety management recognizes three methodology: reactive, proactive, and predictive. Most of the aviation organisations apply reactive or proactive management methodology. Predictive methodology is not yet established, even though predictive methods are used in some segments of aviation. Using the safety data of actual pilot training organisation, the examples of two methodologies (proactive and predictive) are elaborated and presented. The focus of the paper is to show the liaison between proactive and predictive safety management methodologies based on given examples, as well as to show how predictive methods can be efficiently applied to improve safety performance in an organisation.

Keywords: safety management system, aviation, proactive methodology, predictive methodology, liaison

1 INTRODUCTION

Safety management systems have made a large contributions to aviation safety since the first introduction in the field. Today every aviation organisation has the obligation to implement safety management system (SMS) and actively record and report every occurrence (hazard) that happens or potentially could happen in the organisation.

On the global level International Civil Aviation Organisation (ICAO) prescribes 19 Annexes of Standard and Recommended Practices (SARPs) among which Annex 19 (ICAO Annex 19, 2016) brings rules and regulations regarding Safety Management and issues ICAO Safety Management Manual (ICAO SMM Doc 9859, 2018) as a guide for each member state to implement State Safety Programmes on the national level and Safety Management Systems within each aviation organisation. On the territory of European Union (EU) the duty of rulemaking is delegated to European Union Aviation Safety Agency (EASA). EASA issues regulations regarding safety reporting and accident investigation as well as general regulations on implementing safety management systems in the organisations within the territory of EU. The Commission Regulation (EU) 376/2014 (Commission Regulation (EU) 376/2014, 2014) and Implementing Regulation (EU) 2015/1018 (Implementing Regulation (EU) 2015/1018, 2015) establish regulations regarding safety reporting and reportable occurrences, while Commission Regulation (EU) 965/2012: Part-ORO (Commission Regulation (EU) 965/2012, 2012), Commission Regulation (EU) 1178/2011: Part-ORA (Commission Regulation (EU) 1178/2011, 2011), and Commission Regulation (EU) 1321/2014 (Commission Regulation (EU) 1321/2014, 2014) establish regulations on implementing and maintaining effective SMS for every operator or organisation providing services in the field of aviation.

Implementing and maintaining effective SMS requires each aviation organisation to comply with all regulations mentioned above. Effective SMS has to have four main components in place in order to work properly and efficiently. Those four components include safety policy, safety risk management, safety assurance and safety promotion. The second component is Safety Risk Management (SRM) and it is the core of efficient SMS. It deals with occurrence (hazard) identification, risk assessment and risk mitigation. (Čokorilo & Dell'Acqua, 2013; Čokorilo et al., 2011; Jakovljević et al., 2017) The third component is Safety Assurance and it includes safety performance monitoring and measurement, management of change and continuous improvement of SMS.

The SMS also defines three management methodologies: reactive, proactive, and predictive. (Jr et al., 2013; Mirosavljević et al., 2008) All three methodologies are closely linked to two components mentioned above: safety risk management and safety assurance. The SMS needs input data to be able to provide viable results and these methodologies are the SMS tool that enables it to acquire necessary safety data. Reactive methodology gathers safety data from the accidents and incidents that has already occurred in the past and learns from their outcomes. Proactive methodology uses safety reporting systems and safety performance indicators to gather safety data in order to discover and mitigate the potential threats and hazards that may consequently trigger the occurrence of accident or incident. Predictive methodology is not yet well established, as it assumes discovering potential and possible hazards based on predictive analyses (forecasts) that extract information from historical and current safety data and use it to predict trends and behaviour patterns (Ancel et al., 2015, Čokorilo et al., 2019; ICAO SMM Doc 9859, 2018; Luxhoj, 2013; Stanton et al., 2008).

The focus of this paper is to show liaison between proactive and predictive methodology of safety management systems in order to obtain improved and more efficient SMS. For the purpose of this research, actual safety data of pilot training organisation (XY organisation) were used to show the liaison of two safety methodologies as an example.

2 EXAMPLE OF REACTIVE AND PROACTIVE METHODOLOGY IN PILOT TRAINING ORGANISATION

The pilot training organisation (XY) is an organisation that provides the services of pilot training; hence it is certified by the national authority as the Approved Training Organisation (ATO). Since it owns its own fleet of aircraft, XY is also certified as Aircraft Maintenance Organisation (AMO) and Continuing Airworthiness Management Organisation (CAMO). As it provides the pilot training for the level of commercial pilot licence (CPL) it is required to provide the synthetic flight training as well, hence it is certified as Flight Simulation Training Device (FSTD) Operator. XY is therefore certified as four different organisations (XY organisation, 2014-2019), where each organisation requires to have well implemented and maintained SMS. Therefore, XY has implemented one unique SMS adjusted to monitor safety occurrences (hazards) of all four organisations.

Applied safety management methodologies in XY to gather safety information and data are reactive and proactive. XY has established safety reporting system which enables gathering safety information. There are three categories of reports that are gathered: mandatory, voluntary and changes. Mandatory reports refer to set of occurrences which are predetermined by the regulations with the obligation to report. Voluntary reports record potentially hazardous occurrences which are not predefined in the scope of mandatory occurrences. Reports on changes record every change that happens inside or outside the organisation, since every change represents potential hazard, and those reports can refer to internal changes (within organisation) or external changes (usually in regulations). Mandatory report is made when occurrence has already happened, hence it can be characterised as reactive methodology of gathering safety data. Voluntary reports and reports on changes record potential threats and hazards that could possibly or potentially lead to more serious occurrence, therefore those reports are characterised as proactive methodology of safety management. The predictive methods of safety management are not established nor implemented in XY.

As a part of the Safety Assurance component, XY has established several Safety Performance Indicators (SPIs). SPIs are monitored on yearly basis to show the safety performance of the organisation. Targets for some of the SPIs are set, and for some are not. The safety data and SPIs of the XY SMS are presented and elaborated in the following tables and figures (XY organisation, 2014-2019).

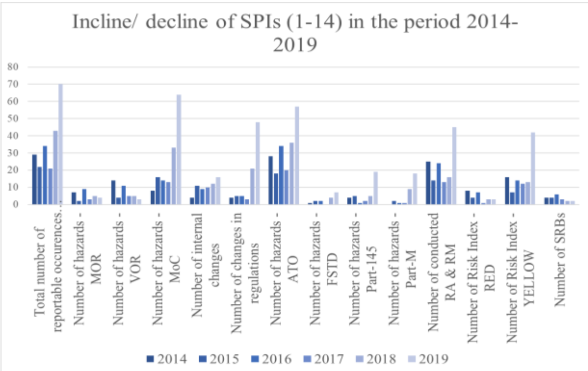
Table 1 shows XY actual safety data and safety performance indicators (SPIs) in the period from 2014 to 2019 (XY organisation, 2014-2019). There are 15 defined SPIs: Total number of reported hazards (SPI1), Number of hazards/ reported via Mandatory Occurrence Report – MOR (SPI2), Number of hazards reported via Voluntary Occurrence Report – VOR (SPI3), Number of hazards reported as Management of Change – MoC (SPI4), Number of hazards reported as an internal change in Management of Change – MoC (SPI5), Number of hazards reported as an external change (regulations) in Management of Change – MoC (SPI6), Number of hazards reported in the ATO organisation (SPI7), Number of hazards reported at the FSTD operator (SPI8), Number of hazards reported in the AMO organisation (SPI9), Number of hazards reported in the CAMO organisation (SPI10), Number of conducted risk assessments and mitigations (SPI11), Number of Risk Index evaluated as RED i.e. unacceptable (SPI12), Number of Risk Index evaluated as YELLOW i.e. tolerable (SPI13), Number of conducted Safety Review Boards – SRBs (SPI14), and Number of reported occurrences vs. number of flight hours (SPI15). The last column shows achieved number of flight hours during each year in the period from 2014 to 2019, and it is necessary to calculate SPI15. Last two rows show target areas for five SPIs: SPI1, SPI2, SPI11, SPI14 and SPI15 (marked in green).

Table 1: XY's safety data and safety performance indicators (SPIs) in the period 2014-2019

Safety Performance Indicators (SPIs)	Total No. of reported hazards (occurrences)	No. of hazards – MOR	No. of hazards – VOR	No. of hazards – MoC	No. of internal changes – MoC	No. of regulation changes – MoC	No. of hazards – ATO	No. of hazards – FSTD	No. of hazards – AMO	No. of hazards – CAMO	No. of conducted risk assessment & mitigations	No. of Risk Index – RED	No. of Risk Index – YELLOW	No. of Safety Review Boards (SRBs)	Number of reportable occurrences vs. number of flight hours	*Flight hours*
	SPI1	SPI2	SPI3	SPI4	SPI5	SPI6	SPI7	SPI8	SPI9	SPI10	SPI11	SPI12	SPI13	SPI14	SPI15	
2014	29	7	14	8	4	4	28	1	4	0	25	8	16	4	0.012	*2,483.66*
2015	22	2	4	16	11	5	18	2	5	2	14	4	7	4	0.017	*1,260.42*
2016	34	9	11	14	9	5	34	2	1	1	24	7	14	6	0.019	*1,754.37*
2017	21	3	5	13	10	3	20	0	2	1	13	1	12	3	0.012	*1,791.17*
2018	43	5	5	33	12	21	36	4	5	9	16	3	13	2	0.020	*2,187.68*
2019	70	4	3	64	16	48	57	7	19	18	45	3	42	2	0.030	*2,350.27*
TARGET	10	2	/	/	/	/	/	/	/	/	10	/	/	5	0.002	
	⇓	⇓	⇓	⇓	⇓	⇓	⇓	⇓	⇓	⇓	⇓	⇓	⇓	⇑	⇓	

Source: Authors according to (XY organisation, 2014-2019)

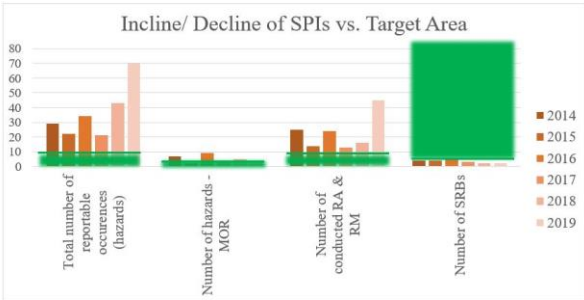
Figure 1 shows incline/ decline of SPIs (1-14) in the period from 2014 to 2019. For every SPI there are 6 values joined to show safety data fluctuation for 6 years in the observed period from 2014 to 2019. The data show the general increase of values over years (except for one) which is (especially 2018 and 2019) completely opposite from the target area which requires the values to decrease (except for one – SPI14) over years as shows in Table 1.



Source: Authors

Figure 1: Incline/ decline of SPIs (1-14) in the period 2014-2019

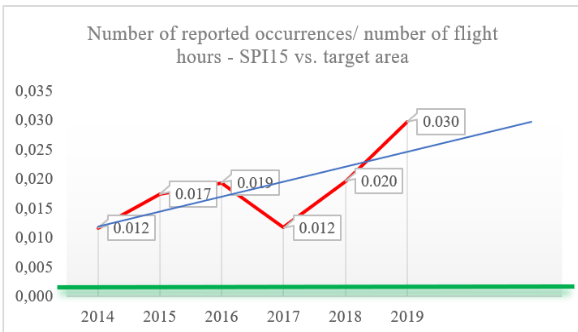
Figure 2 shows incline/ decline of SPIs (1, 2, 11 and 14) in the period from 2014 to 2019 vs. targeted area. It can be observed that only value of SPI2 in 2015 and value of SPI14 in 2016 are inside the targeted area, and all the rest cross the area which shows very negative result.



Source: Authors

Figure 2: Incline/ decline of SPIs (1, 2, 11 and 14) in the period 2014-2019 vs. target area

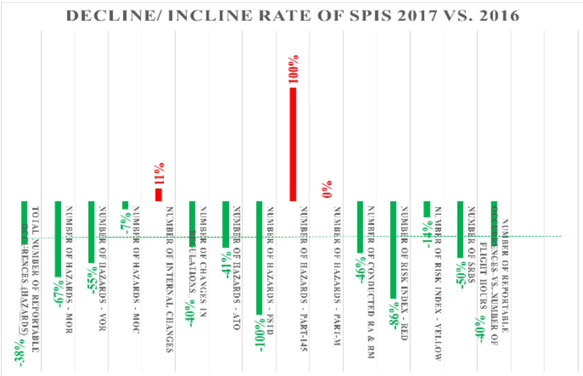
Figure 3 shows incline/ decline of SPI15 in the period from 2014 to 2019 vs. targeted area. It can be observed that the SPI15 has a linear growth trend (blue line) while target area is set to 0.002 or less (green area). In 2014 and 2017 it is evident that values came very close to target area (which is a general goal of the organisation), but in 2018 and 2019 they went far away from it.



Source: Authors

Figure 3: Incline/ decline of SPI15 in the period 2014-2019 vs. target area

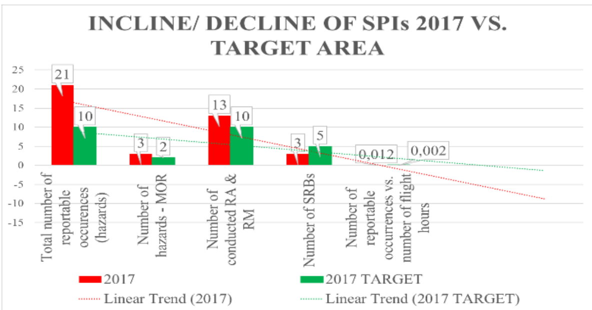
Figure 4 shows incline/ decline rate of SPIs in 2017 vs. 2016, hence whichever SPI with target set to decrease/ increase shows a decrease/ increase in comparison to last year it is marked in the graph with green colour, and whichever shows opposite trend is marked in the graph with red colour. Green line shows the trend of all SPI in comparison to the last year, and it is green if the trend follows the values of targets set for each SPI. It can be observed that 2017 was recording very positive trend of safety performance in the organisation.



Source: Authors

Figure 4: Incline/ decline rate of SPIs in 2017 vs. 2016

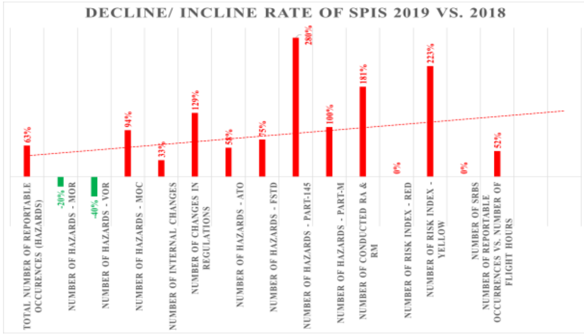
Figure 5 shows incline/ decline of SPIs (1, 2, 11, 14 and 15) in 2017 vs. targeted area. Red columns in the graph represent achieved values of SPIs in 2017, and green areas represent target area of the same SPIs. The red line shows trend of achieved values, and green line shows trend line of target values. The less the inclination between those lines is, the better is the safety performance of the organisation. It can be observed that the lines are very close together which shows the tendency to achieve the target values in the future. If the lines were coinciding that would mean that the target values are achieved.



Source: Authors

Figure 5: Incline/ decline of SPIs in 2017 vs. target area

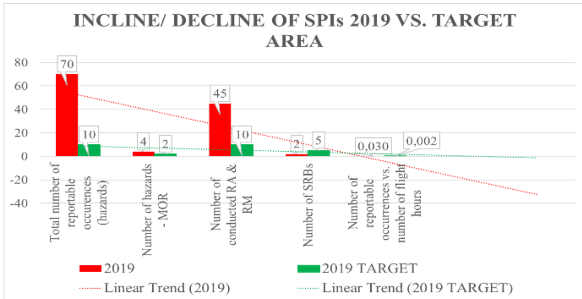
Figure 6 shows incline/ decline rate of SPIs in 2019 vs. 2018, hence whichever SPI with target set to decrease/ increase shows a decrease/ increase in comparison to last year it is marked in the graph with green colour, and whichever shows opposite trend is marked in the graph with red colour. Red line shows the trend of all SPI in comparison to the last year, and it is red if the trend does not follow the values of targets set for each SPI. It can be observed that 2019 was recording very negative trend of safety performance in the organisation.



Source: Authors

Figure 6: Incline/ decline rate of SPIs in 2019 vs. 2018

Figure 7 shows incline/ decline of SPIs (1, 2, 11, 14 and 15) in 2019 vs. targeted area. Red columns in the graph represent achieved values of SPIs in 2019, and green areas represent target area of the same SPIs. The red line shows trend of achieved values, and green line shows trend line of target values. The less the inclination between those lines is, the better is the safety performance of the organisation. It can be observed that the lines are very far away from each other which shows negative trend and larger deviation from targets.



Source: Authors

Figure 7: Incline/ decline of SPIs in 2019 vs. target area

3 PREDICTIVE METHODS OF SAFETY MANAGEMENT SYSTEM ON THE EXAMPLE OF PILOT TRAINING ORGANISATION SAFETY DATA

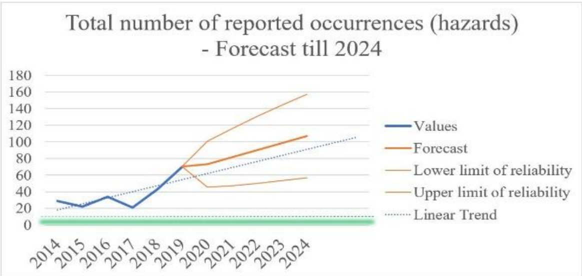
Predictive methods that are used in this Chapter are linear trend analysis and moving average. (Brockwell 6 Davis, 2016) The safety data to be used are historical data of the organisation shown in Table 1. Following tables and graphs show forecasts (with presentation of both used methods) to predict the behaviour of defined organisational safety performance indicators.

Table 2 and Figure 8 show forecast of SPI1 (total number of reported occurrences/ hazards) behaviour in the terms of incline/ decline of its values in the future period from 2020 to 2024 based on historical safety data of the organisation in the period from 2014 to 2019. The deviation from target area is also shown in the Figure (marked green). It can be concluded that the total number of hazards will continue to grow by 2024, which is very negative result given that it should continue to drop to the target area.

Table 2: Total number of reported occurrences (hazards) – Forecast till 2024

Timeline	Values	Forecast	Lower limit of reliability	Upper limit of reliability
2014	29			
2015	22			
2016	34			
2017	21			
2018	43			
2019	70	70	70	70
2020		73	46	101
2021		82	47	116
2022		90	50	130
2023		99	53	144
2024		107	57	157

Source: Authors



Source: Authors

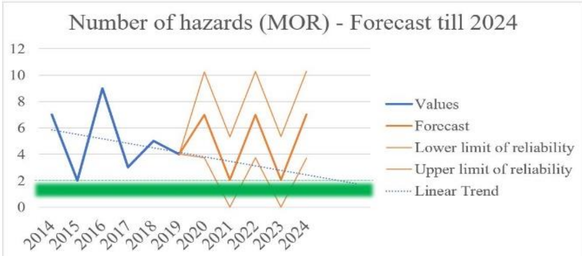
Figure 8: Total number of reported occurrences (hazards) – Forecast till 2024

Table 3 and Figure 9 show forecast of SPI2 (number of reported occurrences/ hazards categorised as mandatory) behaviour in the terms of incline/ decline of its values in the future period from 2020 to 2024 based on historical safety data of the organisation in the period from 2014 to 2019. The deviation from target area is also shown in the Figure (marked green). The forecast shows that the total number of MOR hazards may stay the same or even drop by 2024, which is acceptable result given that it should continue to drop to the target area.

Table 3: Number of hazards (MOR) – Forecast till 2024

Timeline	Values	Forecast	Lower limit of reliability	Upper limit of reliability
2014	7			
2015	2			
2016	9			
2017	3			
2018	5			
2019	4	4	4	4
2020		7	4	10
2021		2	0	5
2022		7	4	10
2023		2	0	5
2024		7	4	10

Source: Authors



Source: Authors

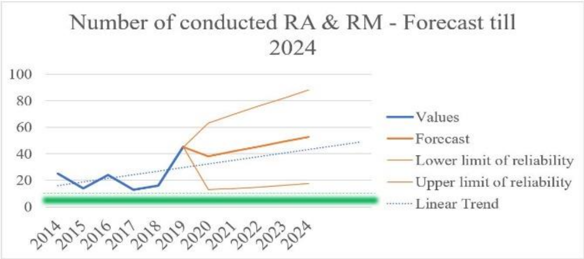
Figure 9: Number of hazards (MOR) – Forecast till 2024

Table 4 and Figure 10 show forecast of SPI11 (number of conducted risk assessments & mitigations) behaviour in the terms of incline/ decline of its values in the future period from 2020 to 2024 based on historical safety data of the organisation in the period from 2014 to 2019. The deviation from target area is also shown in the Figure (marked green). It can be concluded that the total number of conducted risk assessments and mitigations will continue to grow by 2024, which is very negative result given that it should continue to drop to the target area.

Table 4: Number of conducted risk assessments & risk mitigations – Forecast till 2024

Timeline	Values	Forecast	Lower limit of reliability	Upper limit of reliability
2014	25			
2015	14			
2016	24			
2017	13			
2018	16			
2019	45	45	45	45
2020		38	13	63
2021		42	14	69
2022		45	15	76
2023		49	16	82
2024		53	17	88

Source: Authors



Source: Authors

Figure 10: Number of conducted risk assessments & risk mitigations – Forecast till 2024

Table 5 and Figure 11 show forecast of SPI14 (number of conducted Safety Review Boards) behaviour in the terms of incline/ decline of its values in the future period from 2020 to 2024 based on historical safety data of the organisation in the period from 2014 to 2019. The deviation from target area is also shown in the Figure (marked green). It can be concluded that the total number of Safety Review Boards will continue to drop by 2024, which is very negative result given that it should continue to grow to the target area.

Table 5: Number of Safety Review Boards (SRBs) – Forecast till 2024

Timeline	Values	Forecast	Lower limit of reliability	Upper limit of reliability
2014	4			
2015	4			
2016	6			
2017	3			
2018	2			
2019	2	2	2	2
2020		1	0	4
2021		0	0	3
2022		0	0	3
2023		0	0	3
2024		0	0	3

Source: Authors

Source: Authors

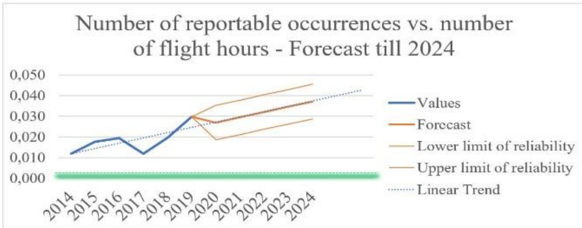
Figure 11: Number of Safety Review Boards (SRBs) – Forecast till 2024

Table 6 and Figure 12 show forecast of SPI15 (total number of reported occurrences/ hazards vs. number of flight hours) behaviour in the terms of incline/ decline of its values in the future period from 2020 to 2024 based on historical safety data of the organisation in the period from 2014 to 2019. The deviation from target area is also shown in the Figure (marked green). It can be concluded that number of reported hazards vs. flight hours will continue to grow by 2024, which is very negative result given that it should continue to drop to the target area.

Table 6: Number of reported occurrences vs. number of flight hours – Forecast till 2024

Timeline	Values	Forecast	Lower limit of reliability	Upper limit of reliability
2014	0.012			
2015	0.017			
2016	0.019			
2017	0.012			
2018	0.020			
2019	0.030	0.030	0.030	0.030
2020		0.027	0.019	0.035
2021		0.029	0.021	0.038
2022		0.032	0.024	0.040
2023		0.034	0.026	0.043
2024		0.037	0.029	0.045

Source: Authors



Source: Authors

Figure 12: Number of reported occurrences vs. number of flight hours – Forecast till 2024

4 LIAISON BETWEEN PROACTIVE AND PREDICTIVE METHODS OF SAFETY MANAGEMENT SYSTEM

Proactive methodology gathers safety data of occurrences or organisation’s process performance and analyses the gathered safety data or its frequency to estimate if a hazard could cause an accident or incident.

The main mechanism for safety data collection of proactive methodology is safety reporting system. Safety data can be collected from various types of safety reports such as: accident or incident investigations, voluntary safety reporting system, management of change, continuing airworthiness reports, operational performance monitoring (flight data analyses), inspections, audits, surveys, or safety studies and reviews.

The main activity of proactive safety management methodology includes defining Safety Performance Indicators (SPIs) and setting of Safety Performance Targets (SPTs).

SPIs are the parameters that give the organization a clear view of its safety performance: where it has been; where it is now; and where it is headed, in relation to its safety performance. The set-up of SPIs should therefore be realistic, relevant, and linked to safety objectives of the organisation. Safety performance targets (SPTs) define desired achievements of safety performance in the organisation. They ensure that the organization is on track to achieving its safety objectives and provide a measurable way of verifying the effectiveness of safety performance management activities. Both SPIs and SPTs provide clear picture of the organization's safety performance.

Example of proactive methodology of the SMS of the pilot training organisation is outlined in Chapter 2. It is evident that the organisation is using safety reporting systems to collect necessary safety data. Organisation has also defined SPIs and SPTs for some SPIs. From the results of monitoring SPIs vs. SPTs it is evident that the safety performance has dropped over the years and that it is moving further away from SPTs, i.e. SPIs and SPTs give a solid picture of where the organisation has been; where it is now; and where it is headed, in relation to its safety performance.

Predictive methodology in general uses predictive methods to identify potential and possible hazards based on predictive analyses (forecasts) that extract information from historical safety and current safety data to predict trends and behaviour patterns of emerging hazards.

Example of predictive methodology of the SMS is outlined in Chapter 3. The historical and current safety data, SPIs and SPTs of the pilot training organisation were used as the input information to conduct predictive analysis. The obtained results show trends and behaviour patterns of established SPIs in the organisation and give improved picture of future development of safety performance in the organisation.

It can be concluded that input safety information and data from safety reporting systems is the common denominator in both proactive and predictive methodology. It represents the liaison between two methodologies. Based on collected safety data, both proactive and predictive methodology can be used to obtain information about safety performance in any organisation.

The advantage of predictive methodology is that it even acts as an upgrade for proactive methodology, as it is shown in the example of Chapter 3, where predictive methods use historical data of previously obtained SPIs and SPTs (which are defined as a part of proactive methodology) and predict the future behaviour pattern of the same SPIs.

5 CONCLUSION

The focus of this paper was to show the liaison between proactive and predictive safety management methodology in aviation. Based on safety data of pilot training organisation, two examples of application of safety management methodologies were conducted. First example showed the proactive methodology that is actually used in pilot training organisation, with defined organisation's safety performance indicators and set safety performance targets. The results show how proactive methodology is used to monitor safety performance of the organisation. Second example shows possible way of using predictive methods to enhance existing proactive methodology, i.e. predictive methodology. The same safety data, safety performance indicators and safety performance targets were used to show the liaison between proactive and predictive methodology and possible upgrade of proactive methodology with predictive one. The predictive methods of trend analysis and moving averages were used to forecast future fluctuation of safety data and safety performance indicators. Two examples in this paper showed that both methodologies use same input data, i.e. safety data obtained from safety reporting systems which therefore shows the liaison between two methodologies. Second example also revealed that predictive methodology may act as an upgrade for proactive methodology, as it can analyse values of safety performance indicators to predict their future behaviour pattern. In future research, the focus will be to define improved breakdown of hazard/ occurrence categories in order to obtain safety performance indicators related to hazard categories vs. timeline and factors influencing them. Improving safety data input process will make predictive methodology more efficient and useful.

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EFFECTIVE MANAGEMENT OF PUBLIC PASSENGER TRANSPORT TO MEET THE ENVIRONMENTAL AND OTHER DEMANDS OF LIFE

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ABSTRACT

Public passenger transport plays a very important role in meeting environmental and quality of life requirements. To achieve these goals, we need an efficient, accessible and user-friendly public passenger transport system.
The paper outlines the target state of managing such a system and the difficulties encountered in achieving such target states.
Since these are public interests, the paper focuses on the Public Service Obligation of Public Passenger Transport (PSO_PPT). This means that the activity of such systems cannot be freely covered and financed according to market principles, but requires financial subsidies from state or local governments.
The content of the paper is based on the knowledge of the operational level of PSO_PPT management and the relationships between the Public Transport Authority (PTA) and contractors (bus operators).
Effective management of such systems requires integration in the following areas: legal, infrastructural, timetable and economic. Based on the requirements for these integrations, the paper presents a model that covers all these areas and outlines the necessary processes in doing so.
These processes of managing public passenger transport include the search for the best PSO_PPT contractors through calls for tenders. Calls for tenders are an opportunity to improve the previous situation. The model also assumes that the preparation of the contents of the tender documentation is based on preliminary analyses of implementation results and pre-set indicators.

Keywords: Public service obligation of public passenger transport, Management, Public transport authority, Contractors

1 INTRODUCTION

Presentations of the research in this article derive from the field of public passenger transport management, which is performed as a Public Service Obligation of the Public Passenger Transport (PSO_PPT), as shown in the literature by Ortuzar and Willumsen [9]. Usually, public passenger transport is managed through management companies, the Public Transport Authority (PTA). Since this is a compulsory public service, the competent PTA carries out subsidization of those lines the revenue of which does not cover the costs. In addition to providing the necessary financial sources, the management of public passenger transport also includes determining all the conditions and obligations for implementation thereof, as shown in Figure 1. The requirements and conditions, as well as the method of allocating financial resources, must be specified in the concession contract between the PTA and the contractors. Research in relation to the search for the best public transport operators has shown good effects of introducing competitive public tenders as shown by our research [2] and research performed by Velde et al. [10].

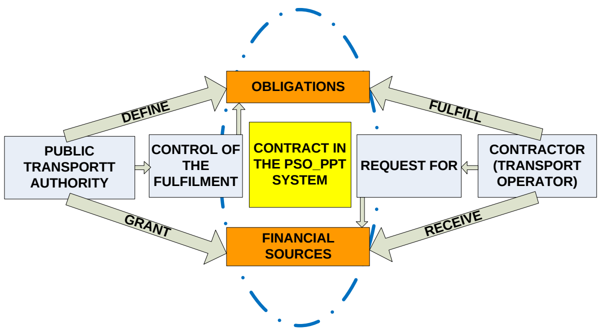


Figure 1: Contractual relationship between Public Transport Authority and Contractors

An example of an in-depth analysis of contractual relationships between the PTA operator and contractors is shown in Figure 2. The PTA first prepares the PSO_PPT implementation system for a new concession period and invites potential bidders to submit bids.

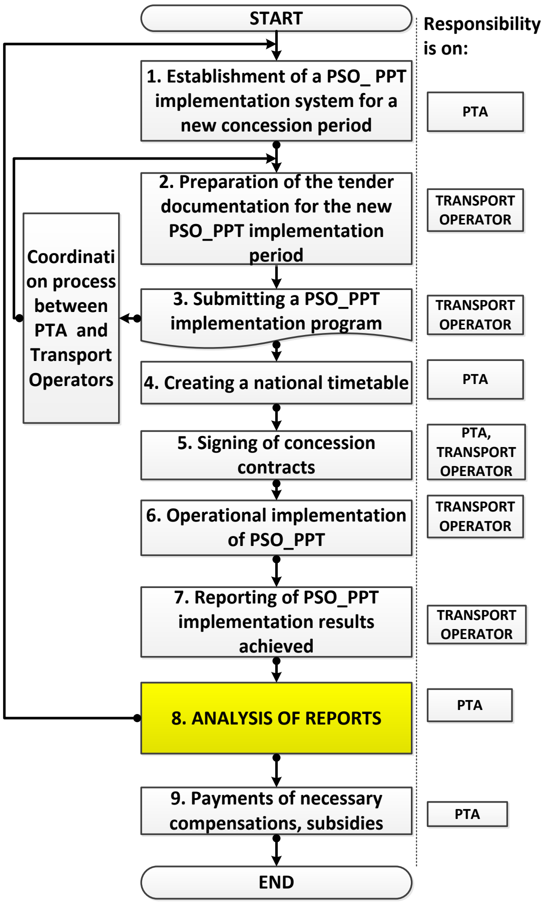


Figure 2: Distribution of responsibilities in the implementation processes of PSO_PPT

Usually, the main components of the bids are documentation relating to the preparation of timetables, cost structure and requirements for vehicles, drivers, etc. An integral part of the tender documentation may also include various initiatives and risks that, depending on the type of concession contracts, can be distributed in a different way between the PTA and the contractors (transport operator). In the next phase, the coordination and detailing of the PSO_PPT implementation program for a new concession period is performed. After setting up the national timetable, the signing of the concession contract and the implementation of PSO_PPT are performed. Reporting on the implementation of this PSO_PPT, which consists of reports on the work done, the number of passengers carried and revenue received, is the basis for the analysis before the payment of compensations and subsidies. The analysis of reports, the evaluation of the implementation of lines and the determination of the efficiency of the entire PSO_PPT are some of the key PTA tasks. All these analyses and research at this stage provide the basis for improving the effectiveness of implementation and are also the basis for the preparation of the system for new concession periods after the expiration of the existing ones.

2 SETTING UP THE INFRASTRUCTURE TRANSPORT MODEL

The PTA must carry out analyses of the existing PSO_PPT implementation and ensure optimal performance in relation to the available public funds. Therefore, in view of the specific circumstances from contractual relations, a model of monitoring and evaluation of the implementation of PSO_PPT lines should be set up. Such models are usually derived from the infrastructure bases on which the lines are running, as shown in the study by Ambrož et al. [1]. Therefore, precise knowledge of the itineraries is required based on which the line sections with appropriate cartographic maps are to be defined. In this way, we can accurately determine the distances and consequently the travel times between the individual line sections.

In our research, two types of experiments were carried out in two different pilot areas, as shown in Figure 3 (point 1.2.) and in our research [3], [4].

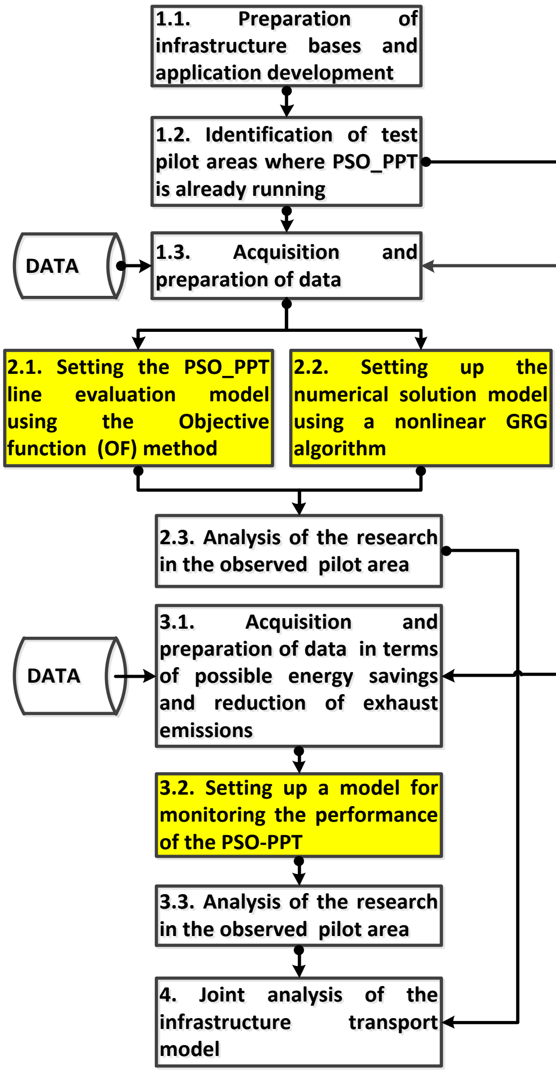


Figure 3: Procedures for evaluating the implementation of lines and identifying possible alternative sources of vehicle propulsion (buses)

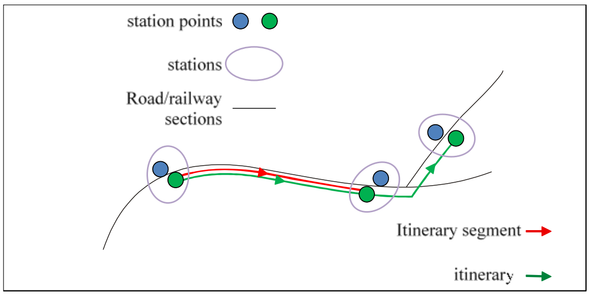
In the first pilot region, we performed measurements of the value of the implementation of individual lines. Using optimization algorithms (point 2.1. and 2.2.), we found comparative analyses of these values and found the causes of deviations. In this way, the PTA could also set up measures to raise the value of the implementation to individual lines (point 2.3.).

The purpose of our research also relates to points 3.1., 3.2., 3.3. and 4, as follows from Figure 3 and from our research [4] and research by Katrašnik [6]. As defined in the EU Strategies [5], the objective is to reduce greenhouse gas (GHG) emissions by at least 60 % compared to those in 1990 and be firmly on the path towards zero. The operational program of measures to decrease GHG emissions by 2020 in Slovenia (Ministry of Environment and Spatial Planning, 2018) sets as an objective that traffic emissions are to be reduced by 15 % by 2030 compared to 2008.

In the continuation of research in this article, we focus on the contents arising from points 2.1, 2.2, 2.3, Figure 3.

2.1 Setting up the infrastructure model and the model for evaluating the implementation of lines

It is important that bus line sections are precisely defined through itineraries, in which public passenger transport lines take place as shown in Figure 4 and as resulting from research by Korinšek et al. [7] and Meignan et al. [8]. This is the basis for setting kilometer distances and driving times between the station points, taking into account the direction of travel (journey) along a certain itinerary on the line. Also, based on this, the calculation of the costs of the PSO_PPT implementation, as well as the rates of fares, are determined (resulting from research by Zanne [11]).



Source: [7]

Figure 4: Entities in the public passenger transport infrastructure network

In the continuation of the research, we set up three models for evaluating the implementation of lines based on pre-set criteria, as shown in Table 1 and as resulting from our research [3]. This table shows all input parameters that enter the individual criteria and the selected model.

When setting up a model for evaluating the implementation of lines, it is first necessary to define the criteria for these evaluations, which we labeled with (X_i). These are the criteria that can be measured during the performance of different lines as shown in Table 1.

Table 1: Input variables in three models studied according to the selected criteria

Name of the Criterion	Defing the criteria by the OF model	Defing the criteria by model of Variant 1	Defing the criteria by model of Variant 2
1. The rate of the line coverage	$X_1 = \frac{G_{SP}}{n_{SP}}$	$X_1 = \frac{G_{SP}}{n_{SP}}$	$X_1 = \frac{G_{SP}}{n_{SP}}$
2. Travel times	$X_2 = \frac{t_{car}}{t_{bus}}$	$X_2 = \frac{1}{(t_{bus} - t_{car})} d_l$	$X_2 = \frac{1}{(t_{bus} - t_{car})}$
3. The diversity of lines	$X_3 = \frac{POV_{SP}}{n_{SP}}$	$X_3 = \frac{POV_{SP}}{n_{SP}}$	$X_3 = \frac{POV_{SP}}{n_{SP}}$
4. Price affordability	$X_4 = \frac{C_{car}}{C_{bus}}$	$X_4 = \frac{1}{(C_{bus} - C_{car})} \frac{1}{d_l}$	$X_4 = \frac{1}{(C_{bus} - C_{car})}$
5. The rate of use PPT	$X_5 = \frac{P_{SP}}{G_{SP}}$	$X_5 = \frac{P_{SP}}{G_{SP}}$	$X_5 = \frac{P_{SP}}{G_{SP}}$
6. The occupancy of buses	$X_6 = \frac{NP_l}{(v_i n_{SP})}$	$X_6 = \frac{NP_l}{(v_i n_{SP})}$	$X_6 = \frac{NP_l}{(v_i n_{SP})}$
7. Time accuracy of the line	$X_7 = \frac{1}{\frac{\sum_{L_{i,j}} \lvert (t_{iACT} - t_{iTT}) \rvert}{\sum_m L_{i,j}}}$		
8. The possibility of extanding the lines	$X_8 = \frac{G_{NSP}}{n_{NSP}}$		

A set of possible input data (variables) acquired from the operational implementation of the PSO_PPT and from which the mathematical notations of the criteria are formed is as follows:

- The number of passengers entering the bus at the station (P_{SP})
- The number of passengers on the bus (occupancy of the bus) (NP_l)
- Auto travel times (t_{car})
- Bus travel times (t_{bus})
- Sum of all links (crossing) of lines at each station point of the observed line (POV_{SP})
- Cost of using bus transport, calculated as the price of a one-way ticket when driving by bus on the observed line (C_{bus}),
- Cost of using a personal car, calculated as the consumption of diesel fuel when traveling by car on the observed line (C_{car})
- Population density in the 500 m radius around each station point (G_{SP})
- Number of bus journeys in the observed time of carrying out measurements in the selected pilot area (v_i)
- Length of lines (d_l)
- Number of station points on the line (n_{SP})
- The absolute values of the difference between the actual driving times and driving times as follows from the timetables on the line ($\lvert (t_{iACT} - t_{iTT}) \rvert$)
- The performed measurements of the actual run times on the L_i driving line on journey j ($L_{i,j}$)
- The number of new station points that can be added to the observed line, thereby improving the accessibility standard (n_{NSP})
- The cumulative number of inhabitants around the new station points (G_{NSP})
- Criterion (q_j)
- Weights (w_j)
- Target cost price (C_c)

Figure 5 and Figure 6, resulting from our research [3], show 28 lines in four concession areas. In the continuation of the research, we collected data in this selected area from the individual bus journeys on these 28 lines according to the valid register, which is managed by the competent PTA.

Figure 5: Selected pilot area in the PTA management area with predefined infrastructure basis

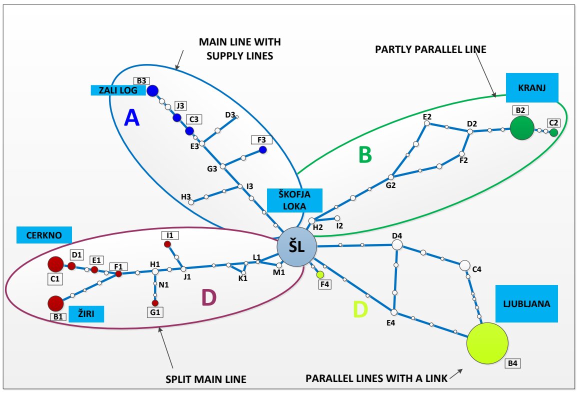


Figure 6: Selected pilot area with four concession areas and 28 lines, which is the subject of further research

The purpose of the optimization model is to set up an optimization process which can be used to evaluate the implementation of lines in the PSO_PPT system. The procedure consists of the phases, as shown in Figure 3.

2.2 Methodology for setting up the model of objective function

We collected all the necessary data as it follows from the mathematical notation of the individual criteria. In the next phase, we calculated the sum of products: criteria, correction factors and weights for each of the lines $i \in \{1, \dots 28\}$ and for each criterion $j \in \{1, \dots 8\}$ and what we call objective function (OF).

$$OF_i = \sum_{i=1}^{28} \sum_{j=1}^{8} X_{ij} \cdot q_j \cdot w_j \tag{1}$$

Each criterion is also weighted. The weight system shows the degree of importance of the influence of each subjective criterion. In these studies, the weighting values were determined from the PTA point of view, but analyses were also made from both the passengers' and from the operators' points of view. The weighting system was normalized in such a way that the weight value for each criterion was between 0 and 1, the total sum of the weights in determining the final value of the function in the observed lines.

To obtain useful values of the function as the sum of all criteria and then to make comparisons of the values, we introduced correction factors (q) to compensate for the differences between the different units in the equations.

2.3 Methodology for setting up the numerical solution model

After the analysis of the results of the objective function model, the results of the optimization model were analysed using linear regression methods and the least squares method. In this case, we used two versions of the models, which we named Variant 1 (V1) and Variant 2 (V2), as follows from Table 1.

The goal of this model (Figure 2, Figure 3) was determined based on the experience of the existing operation of the PTA on the selected pilot area, which in the concession contracts for the implementation of PSO_PPT has set a certain cost price. The cost price can be determined for each line separately, with a requirement that the average price of all lines in the observed area is equal to the target cost price, as the price of a well-functioning company. The basis of the set model is a set of characteristic criteria, the values of which represent the quality of service performance measured on the observed line in the PSO_PPT system.

Since the PTA operator has a certain cost price for a typical well-functioning company in charging the costs of implementing the PSO_PPT, this price represents the target cost price. In the continuation of the research, we formed the following relation between the dependent variable (Y) and the independent criteria (X_i):

$$Y = \beta X + \varepsilon = \beta_1 X_1 + \cdots + \beta_n X_n + \varepsilon. \tag{2}$$

Criteria 7 and 8 were excluded due to insufficient and unreliable input data needed for further statistical processing. Thus, in performing optimization methods according to Variant 1 and Variant 2, in Step 1, calculations of linear regression and optimization based on the entire set of input data were performed taking into account all the six criteria. Since one of the results of the model is an evaluation of the statistical significance of individual criteria, as follows from $((p(\hat{\beta}_j) < 0.05))$, all statistically insignificant criteria were eliminated in Step 2. In this way, we re-evaluated and optimized calculations only on the selection of criteria, as shown in our research [3]. In both tables (Table 2 and Table 3), the probability values (Val. p) are given from which the statistical significance of the coefficients (β) can be read.

Table 2: Optimization processes by Variant 1

	β_1	β_2	β_3	β_4	β_5	β_6
Yreg1	-0.14437009	0.31518185	0.21859679	0.29762479	0.20312520	0.13422008
Yop1	-0.14677137	0.31302232	0.21640598	0.29597583	0.20075972	0.13299863
Yreg2		0.40048314		0.37411746	0.18654925	
Yop2		0.40044901		0.37409142	0.18651190	
Val. p		7.79076E-07		7.93111E-06	0.03311431	

The equation for evaluating the implementation of lines according to Variant 1 can be written in the following form:

$$C_i(V1) = Y_i = 0.40044901x_{i2} + 0.37409142x_{i4} + 0.18651190x_{i5} \quad (3)$$

Table 3: Optimization Processes by variant 2

	β_1	β_2	β_3	β_4	β_5	β_6
Yreg1	-0.11023311	0.01148910	0.08209423	0.23582945	0.06569623	-0.01334254
Yop1	-0.110397546	0.011333194	0.081944232	0.235292571	0.065534312	-0.013426174
Yreg2				0.24283535		
Yop2				0.24534751		
Val. p				0.00707572		

The equation for evaluating the implementation of lines according to Variant 2 can be written in the following form

$$C_i(V2) = Y_i = 0.24534751x_{i4} \quad (4)$$

Comparison of the results of the evaluation of the implementation of 28 lines in the observed pilot region, according to objective function, Variant 1 and Variant 2 is shown in Table 4.

Table 3: Comparison table of the results of the evaluation of the implementation of 28 lines in the observed pilot region, according to objective function, Variant 1 and Variant 2

Line number	Calculated value of (OF)	The order of (OF)	Calculated value of (V1)	The order of the (V1)	Calculated value of (V2)	The order of the (V2)
APRA1915473	3.2	13	1.2903	22	1.4443	24
APRAA191552	3.05	18	1.9763	9	1.7248	20
APRA1916623	2.8	23	1.0906	27	1.3927	26
APRA1916631	3.27	12	1.1174	26	1.3927	27
APRA1916681	2.1	28	2.1438	6	2.1785	2
APRA1960507	4	6	2.1586	5	1.7884	16
APRA19703313	4.05	5	2.1758	4	1.7649	19
APRA1980081	3.3	11	1.2804	23	1.4111	25
APRA19805017	2.55	26	0.8925	28	1.5112	22
APRA19806119	4.29	3	1.9103	11	1.3447	28
BPRA1915128	2.6	25	1.3672	20	1.7845	18
BPRA1915134	3.8	7	1.2727	24	2.0684	4
BPRA1915583	3.01	19	1.5535	18	2.1549	3
BPRA1950136	2.9	21	1.4835	19	1.9405	8
BPRA1950145	3.2	14	1.6161	15	1.9405	9
BPRA1965182	2.48	27	1.3256	21	1.7065	21
BPRA1970168	3.5	8	1.8401	12	1.9405	10
BPRA198006	3.09	16	2.0458	7	1.9405	11
BPRA19806210	4.5	2	2.0144	8	1.9405	12
CPRA1916614	2.69	24	2.4103	2	2.1785	1
CPRA1980175	3.07	17	1.9564	10	1.5112	23
CPRA1980185	3.37	9	2.5705	1	1.9886	5
CPRA19805819	5.05	1	1.7244	14	1.9886	6
DPRA1912166	3.3	10	1.5770	16	1.8046	14
DPRA198065241	2.8	22	1.5741	17	1.8046	15
DPRA198065242	4.09	4	2.2670	3	1.8701	13
DPRA198065243	2.9	20	1.8331	13	1.7845	17
DPRA19903310	3.1	15	1.1310	25	1.9643	7

Figure 7 shows a graphical presentation of the results as follows from our research [3]. From the graphs showing the values of functions, we can see the largest range of values in the objective function graph, followed by the optimization according to Variant 1 and then to Variant 2. The results represent the basis for further analyses.

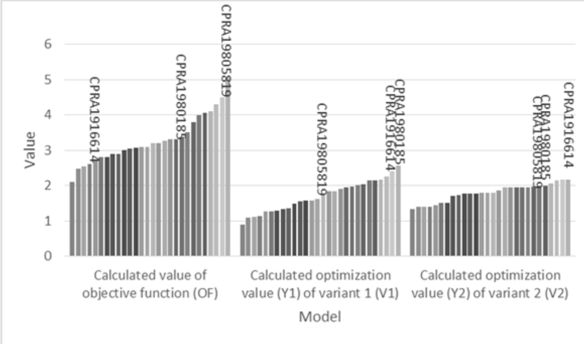


Figure 7: Classification of lines from the minimum value to the maximum value by model: objective function, Variant 1 (V1) and Variant 2 (V2) by marking the position of the lines that reach the highest values in a particular model

3 CONCLUSIONS

When implementing the PSO_PPT management, it was found that the competent PTA has not yet developed an appropriate tool for evaluating the results of the implementation of the lines as described in Figure 2. Therefore, the research has been applied according to the methodology shown in Figure 3.

This paper presents the methodology for the development of such a tool through the three mathematical models described herein. The models offer the option of evaluating the implementation of lines by showing the calculated values of the implementation of lines based on the input parameters. By comparing the results between the lines, we determine which lines achieve high values of functions and which achieve the lower ones. In subsequent analyses, we can determine the reasons for such deviations arising from the input parameters in the model. In the analyses of the three models used, we find that the objective function has the largest range of values (2.1 – 5.05), the model V1 has the range of values (0.89 – 2.57) and the V2 method (1.34 – 2.18). Comparative analyses of the results show that it is reasonable to focus on the three criteria ($X_{2,}X_{4,}X_5$), which have the greatest impact on the value of individual functions.

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REVIEW OF SMART PORTS IN THE EUROPEAN UNION

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ABSTRACT

Ports today are facing a constant increase in operational data such as resource tracking, vessel operations, berth services, marine litter/pollution measurements, etc. Capacities that are currently in use are not sufficient and cannot cope with aforementioned requirements. Due to the lack of space and major expenses, some ports avoid a large expansion of infrastructure and have rather been implementing new, inexpensive and widely available smart technologies. This way, ports can effectively manage operational data, which will create new valuable information that are going to become the basis for tackling new challenges. In this context, many ports are interested in an advanced port concept called *smart port* in which the Internet of Things (IoT)-based communication infrastructure is applied. This paper will present a development and overview of *smart port* concepts in the European Union (EU) and its main benefits and values. Also, the idea of complex connection between the port and city itself will be examined and its importance will be evaluated.

Keywords: smart port, IoT, data, EU

1 INTRODUCTION

In order to answer the question what is actually smart port first we must clarify the definition of the port itself and the problems that it's facing today.

Sea ports are infrastructural hubs in which different transportation branches are connected and are complementing each other in order to achieve goal of transporting people and goods in the most efficient and fastest way. To accomplish that, ports are managing big amounts of various types of traffic and with that even larger operational data. Also, ports are directly connected to their surroundings. City and region are infrastructurally linked to the port, but their interdependence is also visible in various segments such as ecology, social quality, economy etc. So as the demand for port services grows, sometimes beyond its capacities, port cities and regions also feel the impact of the operational overspill. In addition, the services conducted in the port are changing with a goal of increase of quality for less time and at affordable cost. Because of the said reasons, port systems are requiring a change of approach to tackle these problems, and easiest and cheapest way is implementation of newly developed technologies in everyday operations such as Internet of Things (IoT), Big Data, Radio-frequency identification (RFID), etc.

As sad before, requirements in ports have changed, but its surroundings, both sea and shore side, also transformed. Constant development of technology remodeled vessels and cities in more ecologically conscious, automatized, fast responding systems, or to sum up, smarter systems. Smart homes, smart parking and public transport, air, water and soil pollution real time measurements in cities, automatization, energy efficiency, waste and ballast management and navigational aids in vessels require same standards form place they meet, which is the port.

It is not easy to give exact definition of what should smart port be, but definitely its must give operational solutions to new demands and it must build a platform for integration of all stakeholders inside and outside its borders. Ports of the future will have to adapt and overcome their specific problems without negative increase of ecological and social impact on the wider community and the technology like IoT gives the opportunity to do it.

2 FROM ISOLATION TO BEING SMART – DEVELOPMENT OF PORTS

From the beginning, sea ports where used as economical, cultural and political connection between distant areas but they were turned more to the sea then to its hinterland.

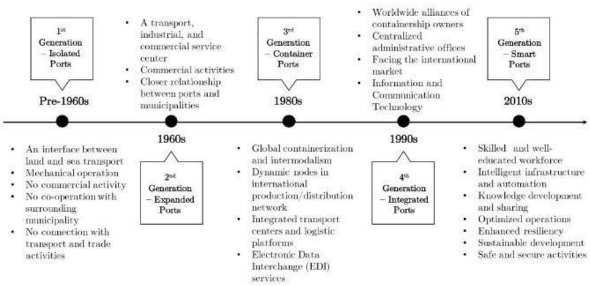

Figure 1: Ports development throughout the history [1]

In this first phase, different types of transportation where not directly linked to each other, so from today's point of view ports where functioning more like isolated systems. [2]

In the second phase of the general development of the ports, larger commercial activity was noted, and with it, closer relationship between different transportation types and the port surroundings. [2]

With the global containerization port systems changed drastically. Intermodalisation and multimodality made fluid transport connections between sea and hinterland with the port as the key link in the logistic chain. Also, the onset of electric data interchange and the value of faster information transition was recognized. [1]

Further development of technology and international market accelerated ongoing progress of global integration of key stakeholders in trade so port management opened to private sector. Trend of awarding port operations to shipping and logistic companies and capital focused organizations brought bigger income but also more traffic and data which sometimes has negative impact on port and its surroundings. Service quality, safety and security, financial structure, environmental and social impact are the key components in normal port function. So if the port is facing frequent traffic congestions or energy inefficiency all key aspects are degraded. That's why today, ports are positioned in between trying to function with the problems and finding appropriate solutions. Those that are investing in change are stepping into a next cycle of development. [3]

Smart port concept is a quite new and it is still not fully reviewed by the scholars, but as all others smart systems, it is based on IoT technology that is connecting different physical devices trough digital platform with the goal of data exchange. [1] [4]

In the terms of sea ports, IoT is recognized as basis for relevant informational structure that is linking all vital elements in port systems which is resulting in harmonization, optimization and automatization of all activities. [4]

3 EUROPEAN UNION AND THE SMART INFRASTRUCTURE

Since TEN-T and Marco Polo programs the main aim was to achieve cost, time and energy efficient transport of people and goods through EU. TEN-T, which started in 2006, was focused on the realization of important transport infrastructure projects, while the goal of Marco Polo program, which began the year after, was shifting freight from roads to greener modes of transport. In 2014. both initiatives where succeeded by Innovation and Networks Executive Agency (INEA) which has two ongoing programs crucial for modern development of EU infrastructure and transport, Connecting Europe Facility (CEF) and Horizon 2020 (H2020). [5]

CEF is a key EU funding instrument that supports the development of high performing, sustainable and efficiently interconnected trans-European networks in the fields of transport, energy and digital services. From CEF total program budget, which is €28.7 billion, €23.7 billion is for Transport only. With it, completion of the

Core Network structured around nine multimodal Core Network Corridors should be done by 2030, and by 2050. completion of the Comprehensive Network that should facilitate accessibility to all European regions. [6]

While CEF program is manly focused on improvement of infrastructure by developing new and modernizing old corridors, H2020 aim in the field of transport is research and implementation of new technologies in order to provide smart, energy efficient and integrated movement of people and goods thought EU. With budget of €6 339[1] million for transport sector, H2020 created a number of projects that should introduce smart technologies to all stakeholders in different segments of transportation. [7]

Regarding the smart port systems, there are 3 distinct projects under H2020.

3.1 COREALIS - Capacity with a pOsitive enviRonmEntal and societAL footprInt

COREALIS proposes a strategic, innovative framework, supported by disruptive technologies, including Internet of Things (IoT), data analytics, next generation traffic management and emerging 5G networks, for cargo ports to handle upcoming and future capacity, traffic efficiency and environmental challenges. [8] Proposed innovations are targeted to increase efficiency and optimize land use, while being financially viable, respecting circular economy principles and being of service to the urban environment. The innovations will be implemented and tested in real operating conditions in 5 Living Labs, namely Piraeus port, Valencia port, Antwerp port, Livorno port and Haminakotka port. [8] The ultimate ambition of COREALIS is to achieve a significant step forward for future ports to maximize their capacity and efficiency with minimum infrastructure upgrades, while at the same time ameliorating the port-city relation. [8]

In order to accomplish mentioned improvements, projects is organized in 3 steps:

- Identification of port requirements (technical, operational, societal, environmental, legal, security etc.)
- Technical design and development of innovations
- Innovations Impact Assessment and Living Labs (LLs) full-scale implementation [8]

Implementation of these steps is going to be delivered by introducing new technologies based on the needs of the ports involved in project.

[1] Large budget inequality between CEF and H2020 programs is a result of cost deference between investment in infrastructure and smart technologies.

Truck Appointing System (TAS), for instance, will minimize waiting time at the port gates, providing to the drivers an optimal time-window to enter the port

based on preference, vessel schedules, the traffic expected from other trucks and real-time data from the urban TMC. [9]

With Model-Driven Real-Time Control module (RTPORT) ports could coordinate and support port operation, providing measurable feedback to the models of Port Operations Process Modelling tool (PORTMOD). It should perform real time control of operations by collecting data via yard vehicles and implanted sensors (including cameras) and take operating decisions based on on-line analytical processing and PORTMOD models. [9]

Mentioned PORTMOD will describe in detail the container placements in the container movement chain and this way it will increase efficiency, safety and give emission analysis using LIPASTO database. [9]

Increase off efficiency will also be achieved by Cargo Flow Optimization tool that is going to harmonize AIS data for vessels ETAs with (big) data from the rail operators and barges ETAs. [9]

These COREALIS tools and solutions are promising the development of new and efficient ports that are going to embrace needs of all stakeholders.

3.2 PIXEL - Where IoT meets the Port of The Future

PIXEL project is described as the first smart, flexible and scalable solution for reducing environmental impacts while enabling the optimization of operations in port ecosystems through IoT. In its two way collaboration between the ports, transport agents and cities it should ensure optimal use of resources which would lead to lower environmental footprint. [10]

Project has 4 interest areas that are being analyzed and upgraded:

- Energy management
- Intermodal transport
- Port – City integration
- Port Environmental Index (PEI) [10]

Ports that are part of the project in one or more mentioned fields are port of Bordeaux, Piraeus, Thessaloniki, Monfalcone and Gorizia Interporto. [10]

In its research Pixel has the specific approach where existing technology and stored data are being analyzed in order to conceive unique needs of each port. With these information's, PIXEL is modeling a future scenarios of use cases, port by port, in order to decide which and in what way new technologies will be implemented, so that every port can reach its objectives. [11]

Maybe the best example of aforementioned approach can be seen in development of a PEI. To change the existing way of the port environmental evaluation, in which port authorities use self-assessment forms, PIXEL is creating data based approach. With it, simulations created on measurable values and IoT based real time data collection systems are producing relevant and accurate environmental results for each segment giving environmental Key performance indicator (eKPI). For example, some components like CO2 and noise pollution are going to be simulated (number and types of engines, type of fuel etc. will be taken in consideration) and others like PM can be measured in real time trough sensors. This way, not only that current state of air quality will be known, but also it will be possible to determine the future condition with grate accuracy. [11]

In the end, value of each eKPI is taken into consideration in order to produce final PEI of the port. Also, gathered data can be compared to other ports that are using similar metric giving PEI even more relevance. [11]

3.3 PortForward

PortForward project is conceptualized as informational platform primarily focused for smaller and medium sized ports and their hinterland. The ports that are involved in the project are Baleares ports, Kristiansand, Livorno/Piombino, Magdeburg, Naples/Salerno, and Vigo. [12]

PortForward proposes a holistic approach that will lead to a smarter, greener and more sustainable port ecosystem and which will include the following features:

- The socio-economic analysis of the port interface with its surrounding area and the port-city, as well as the rest of the logistic value chain.
- The introduction of an Internet of Things (IoT) concept for port assets (infrastructure, vehicles, cargo, people); [12]

IoT, as the backbone in the implementation of the project, is conceptualized in 3 layers.

Main task of the Sensor Layer (IoT-Enabled Port) is to take data from physical environment and to transform it into digital form. This type of IoT data collection is done by specialized sensors, direct input from the human users, data coming from open source data, other environmental sensors, etc. Also, different communication networks can be used, depending on the needed of coverage area. Low-Power Wide Area Network (LPWA) (up to several km), Local Area Network (from 1m to 1km), Wireless Sensor Network (WSN) for multi-hop monitoring networks and Personal Area Network for static platforms (distance below 1m.). [13]

Middleware Layer (Connectivity) role is gathering and pre-processing the data coming from the sensor layer, using different wireless communication technologies, in order to be processed and consumed by the upper level of the PortForward system. This will enable data collection from very heterogeneous sources, with attention for easy deployment, open standards, management as well as secure communications.

Application Layer (PortForward Cloud) involves the development of the PortForward integrated system which will comprise the Virtual Port implementation, the Decision Support System, the novel Smart Logistics Tool, the Intelligent Maintenance Module, the Green Scheduler and the front-end AR-based applications and user interfaces (PortForward Dashboard). [13]

All use-cases that this project will deliver have been identified and documented and will use the IoT Stack to connect the port (IoT) data sources to the (to be) developed applicative services when relevant. [13]

4 SMART SOLUTIONS AROUND US

While EU is introducing smart port concepts through its projects organized under INEA programs CEF and H2020, some European ports already transformed themselves into a smart, green and sustainable systems with positive social and economic impact on its soundings.

4.1 Port of Hamburg

Port of Hamburg is Germany's largest port and, alongside Rotterdam and Antwerp, one of Europe's busiest. In 2018 only, 8.7 million TEU containers, 44.2 million tons of bulk cargoes, 900.562 cruise passengers and 1.5 million tons of general cargo passed through the port. [14] An increase of these numbers is expected in the following years[2], bringing more traffic and profit to the port, but also more road congestions, noise and pollution, or in other words, lower social and ecological standards for citizens. To avoid negative impact, capacities needed to be increased, but since the port is situated in densely urbanized area near the city's centre, physical expansion was not an option. That's why the Hamburg port authority (HPA) found answers in new technologies.

The strategic and operational plan detailing all ongoing and future projects aimed at achieving this goal are specified in the 2025 Port Development Plan issued in 2012 by the Hamburg Port Authority (i.e. the entity in charge of strategic planning, management, and governance of the seaport; henceforth "HPA"). In the report there are lot non-IT schemes that introduce green practices and involve modernization of the port infrastructure. Also, it projects planned progression to a smart port that begun in 2011. [15]

Based on the aforementioned plan, many new programs were developed and with it different technological solutions that changed the port of Hamburg into a smart port. Hamburg smartPORT consists mainly of three smart logistics pillars: Smart port infrastructure, intelligent traffic flows and the flow of goods, with addition of smart port energy. [16]

Under the smart port infrastructure, HPA installed sensors and communicative capacities in the port's main assets which include smart lighting that illuminates only necessary areas, based on motion detection, and this way reducing energy costs. Lighting can also be directed on specific objects or locations that require attention during an activity, fed by an intelligent system which knows exactly what type of activity is taking place. [15] Also, sensors that monitor the use of assets like trucks, carriers, cranes and infrastructure such as roads, warehouses, and parking lots are used to recognize underused capacity so that the systems can be optimized by making adaptations. Storages have sensors that track temperature, humidity, pressure and ventilation so that they can meet the needs of the cargo, and by that decrease the damage and loss. [15]

Implementation of the smart maintenance system extended life-cycle of port assets and infrastructure by tracking wear and tear and preventing damages and malfunctions. [15]

Intelligent traffic flow includes thousands of trucks[3] that pass through the port by managing their flow and optimizing infrastructural capacities. [15] Starting in 2011 the Hamburg port authority placed 300 sensors on roads and bridges to track and manage the roadway traffic in the port. Collected data is used by traffic management system that can accordingly re-direct traffic and minimise congestions. Traffic lights can be adapted accordingly and digital road signs currently communicate proposed directions. [15] All this information is now available to users via smartphones and computers. Similarly, parking recommendations, which are based on continuous parking space monitoring, allow all port visitors to find parking with ease. [15] Traffic optimization went even further by monitoring speed and automatic radar identification of vessels in order to predict eventual delays. With this information it is possible to plan timely and optimised opening and closing of the bridges. Also, mining of aggregated data through long time period will allow the Port Rod Management Centre more precise journey predications what will improve the traffic flow even more. [15]

The Nautical Control Center on the other hand is the entity charged with the management of water traffic. Data collected by the sensors indicate the conditions of the River Elbe and the vessel traffic in port area is provided to the centre that can share this info and assure safer and harmonized navigation. [15] In addition, autonomous water drones are being introduced as another way of gathering valuable information on conditions of channels used by the ships.

Lastly, the Rail Supervision Headquarters similarly manage the rail transport. [15]

Port Monitor, the control room software, allows info sharing to all the stakeholders in the port of Hamburg. A variety of information is centrally gathered and can also be accessed remotely, such as electronic cards, vessel positions, water level data, berths, current construction sites, planned dives and bridge heights and widths. Important information is therefore always

[2] Containers passing through it are expected to rise to 25 million in 2025, and total cargo handled from 121 million tons in 2010 to 296 million tons in 2025. [15]

[3] Over 40,000 truck daily trips [17]

accessible to all those involved on land and on the water. [16] With the combination of automatic identification system (AIS) and RFID, port authorities can constantly monitor the locations of all land and sea transportation objects in the port, with additional info on the origin and destination of goods, times of delivery and nature of port services required for proper handling. [9]

Data mining allows for the optimization of not only cargo routing, but also material handling schedules to minimize handling time. Gathered info can be shared with all involved parties through an integrated cargo information platform. GPS and geo referencing systems give provide info regarding the position, therefore pick-up services or warehouses can automatically be alerted of delays and can readjust delivery or inbound schedules, and adapt handling requirements. The same technologies along with intelligent visual inspection also aid in reducing the amount of physical checks needed at custom control points, which in turn reduces labor costs and time at customs. [15]

In the end, smart energy management is pushing Hamburg port towards a greener future. The port is now consuming over 40% of Hamburg's total energy consumption so key infrastructure is equipped with smart meters that can monitor and control energy use by adjusting factors like pressure, temperature and electric drivers. With smart and more energy efficiency systems port CO2 emission should drop by the yearly amount of 12 thousand tons. [15]

4.2 Port of Cartagena

Although it is fourth Spanish port for freight traffic with

1.4 million tons of general cargo and 6.5 million tons of dry bulk in 2018. , Cartagena port authority was more focused on its cruise passengers, regarding the implementation of smart solutions. [18] With 230 000 passengers in 2018. [18] Cartagena is tenth Spanish cruse destination [19] that is providing more than 40 different sea connections from its two cruiser terminals situated in vicinity of city's center. Because of its many cruise lines and growing numbers of visitors port authority of Cartagena acquired Posidonia SmartPort, a product developed by Prodevelop consisting in an application (app) for accessing port information. With this decision, the Port of Cartagena now reinforces its relationship with the port community, consolidates the integration of the port within the city environment and boosts the positioning of the port within the cruise industry. [20] App is supported by the all relevant platforms and is generating very low impact on IT infrastructure because all services are located in the cloud.

The adoption of this product has allowed the Port of Cartagena to share instant information about vessel situation (info regarding current state, prevision in 12,

24 and 48 hours, movements, vessels arrival, departure or anchorage), operations, traffic history and forecasts. [20]

Apart from vessel and call information, the Port of Cartagena also offers access to its corporate news, integrated with its Twitter account, allowing the user to find out what is going on in the port without needing RSS feeds or Twitter accounts. News information can also be shared using the usual mobile apps (Facebook, WhatsApp, Google+, email). [20]

The application also offers weather data at the port, with current information and forecasts, and it can provide direct access to webcams located throughout the port, displaying real-time images. [20]

Finally, the application includes a complete list of port facilities (docks, buildings, places of interest, terminals, public bodies, etc.) and a directory of all the companies working or offering services at the port (ship agents, freight forwarders, custom agents, stevedores). [20]

Cartagena port website offers same features but on start user can choose between three options regarding the profile, port community, contractor or society, so the offered information's adapted to its interest.

Although port of Cartagena didn't install cutting edge technologies, as port of Hamburg did, and the app that is in use has space for progress, the decision to develop the open source program for information sharing with all stakeholders connected the port made transfer operations for cruise passengers easier and reduced impact on city's center.

5 CONCLUSION

Sea ports changed drastically throughout their history in a way that they became more involved and interdependent to their surroundings. As they changed, the city and transportation methods did simultaneously, and with that the standards and needs for all their users.

Today, ports are stepping into a new era where not only the integration of transport is a must, but so is the connection with the city and region on a social and ecological level. Most of European ports are situated within the city's urbanized areas so the cohesion of these systems is inevitable. Also, a bigger demand for port services has increased traffic to the port and its surroundings and with space limitation, due to the location, port authorities were prompted to find solutions without infrastructural extensions.

To reach that goal productivity increase of the existing infrastructure was necessary and by merging IoT with all vital sea port elements, it was finally possible. Thanks to IoT, variety and speed of information, gathered and processed, allowed better control of all processes within the port which made management of port systems flexible, automatized and energy efficient. With this new technology, ports can finally become not only economically, but also socially and ecologically conscious systems, or in other words, smart systems.

Inside the European community, smart port systems already exist and have been giving positive results and valuable insights. Port of Hamburg has shown that even the biggest and quite complex infrastructural hubs can meet the growing demand for port services but also harmonize them with urban city area and its citizens if they adapt the new concepts of smart technologies. On the other hand, smaller ports that have one leading industry, like Cartagena with its cruising, didn't need to implement such complex technologies that we have seen in Hamburg's example. Port - city integration and needs of all stakeholders were met by introducing wide info-sharing platform in form of an open source app.

Although good smart port practices that already exist show that an investment of this kind is beneficial, all of them are still only spots on the European transportation web. Key aspect of smart technologies is the connection between elements and systems, therefore a relation between the ports is a must in a future development. In this sense, project like Corealis, Pixel and PortForward try to create that future by involving different ports and related institutions in research for smart solutions.

For all port communities that are still positioned in-between the traditional way of managing demand and new needs, smart concepts are offering cheap and achievable solutions for the next step of development.

Even though smart concept derived from technology like IoT, Wi Fi, Big Data, Cloud computing etc., regarding sea ports, it is equally important to change the approach of how we see and manage them. All examples, from Corealis, Pixel, PortForward projects, big and high-tech ports like Hamburg, to smaller and less technologically developed, like Cartagena, the approach was the same. Strong relationship with the community, support for all port users and lowered ecological impact were the basic goals, and that is what smart port should represent.

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OVERVIEW OF S-100 GROUP OF STANDARDS FOR USE IN NAUTICAL NAVIGATION

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ABSTRACT

New formats from the S-100 electronic nautical charts group of standards, as well as hydrographic and meteorological information and forecasts from the same group of standards, are well suited for the navigation of autonomous ships. Selecting from the full range of interpolation algorithms listed by the standard for each individual map interpolation allows a very accurate representation of the seafloor and river bed. A thorough knowledge of the terrain configuration provides additional information in determining the exact position of the vessel (especially for submarines).The integrated Lua scripting language provides accurate dynamic descriptions of processes as well as expected hydrographic and meteorological magnitudes. Examples of possible descriptions are instructions for navigating a complicated waterway, dynamic hydrographic and meteorological forecasts for expected wave heights at a specific time, intensity and direction of sea currents, wind speed and direction, etc.This paper will present several examples and point out some of the benefits the new set of standards offers for navigation. Possibilities of accurately describing the seafloor by selecting the best interpolation used for the observed position, sailing directions for a waterway written in Lua and hydro meteorological forecast written in Lua will be present. All the examples shown are constructed.

Keywords: S-100, Lua, Autonomous vessels

1 INTRODUCTION

For the coming new era in nautical science, made possible by the development of electronic and IT technologies, a new strategy for the exchange of information between different sources and users is defined. This new information strategy allows all four possible directions in the data flow: man to machine, machine to man, human to human and machine to machine. This enables increased use of AI algorithms in individual application nodes and makes it a major step in the direction of autonomous vessels.

The paper is organized as follows: section 2 reviews the S-100 standard group and its members. Section 3 describes the data format used for S-100 files. Section 4 is a very short description of the programming language Lua. Section 5 shows examples for bathymetric surface description, using Lua for generating specific sailing directions and calculation of meteorological data for a specific point at a specific time.

2 S-100 STANDARD GROUP

The list of all new standards is given as follows: S-101 Electronic Navigational Chart ENC, S-102 Bathymetric Surface S-103 Sub-surface Navigation, S-104 Water Level Information for Surface Navigation, S-111 Surface Currents, S-121 Maritime Limits and Boundaries, S-122 Marine Protected Areas, S-123 Radio Services, S-124 Navigational Warnings, S-125 Marine Navigational Services, S-126 Physical Environment, S-127 Traffic management, S-128 Catalogues of Nautical Products, S-129 Under Keel Clearance Management (UKCM), S-1xx Marine Services, S-1xx Digital Mariner Routing Guide, S-1xx Harbour Infrastructure, S-1xx (Social/Political), S-201 Aids to Navigation Information, S-210 Inter-VTS Exchange Format, S-211 Port Call Message Format, S-230 Application Specific Messages, S-240 DGNSS Station Almanac, S-245 eLoran ASF Data, S-246 eLoran Station Almanac, S-247 Differential eLoran Reference Station Almanac, S-401 IEHG Inland ENC, S-402 IEHG Bathymetric Inland ENC, S-411 JCOMM Ice Information, S-412 Weather Overlay (JCOMM), S-413 Weather and Wave Conditions, S-414 Weather and Wave Observations.

The whole standard group S-101 is described with the figure 1:

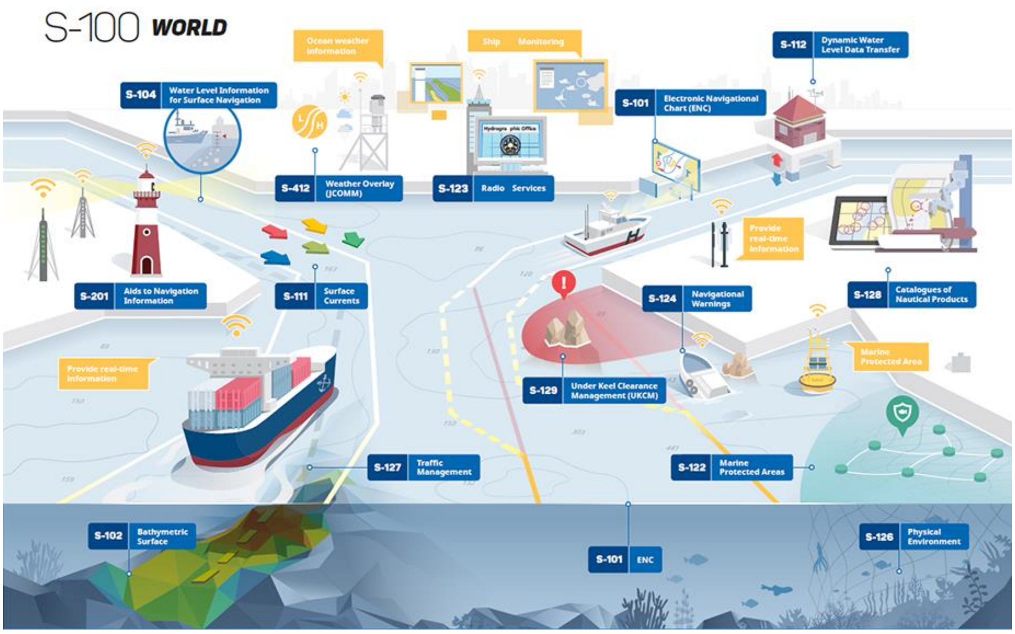

Figure 1: Some of S-100 members

3 DATA FORMAT OF S-100 FILES

The set of standards, listed above, needs a common data format for maximum interoperability. The main ideas incorporated in the chosen data format are:

- Independence of the computer architecture of the target system (big/little endian, variable type sizes etc.)
- Self-describing
- Compact Target file size for exchange over communication networks <= 10 Mbyte Target file size for direct exchange (for example USB stick in harbor) <= 256 Mbyte
- Expandable at any time with new features
- Data update procedures provided
- Data origin (organization, company etc.) included in the file.
- All features used in the data file are defined in feature catalog files. Each standard from the group has its own feature catalog file. Feature catalog files are XML files. Examples: FC_S-101.xml, FC_S-102.xml etc.

The feature catalog file contains the following information:

Author Attribute description: name, reference name, comment, valuetype. S-100 attribute value types are real, integer, text, enumeration, date, time, date Time, Boolean, S100_Codelist, URI, URL, URN, S100_TruncatedDate and value record.

All attributes used in any feature in the feature catalog are described in this part of the catalog. Feature description: name, definition (comment), code (reference name), attribute list with sequential binding flag und multiplicity for each attribute, list of using types (type example: geographic) and list of permitted primitives (examples: coverage, point).The attribute multiplicity says how many times this attribute occurs for this feature (min, max). For example attribute multiplicity (1, 2) is for a mandatory attribute, and the feature can have up to 2 of this attribute. Feature Catalog example for S-111 in figure 2.

In the first part of the S-111 Feature Catalog from this example, information about the application and version is given. The second part (<... producer>) gives information about the author. In the third part (<... Simple Attributes>), the attributes are defined. In this case there are two attributes: direction and magnitude of the flow. In the last part (<... Feature Types>), features are defined (in our case only one: flow) and the binding of the two attributes (minimum 1 and maximum 1 of each attribute). Finally, it is also defined here that this feature can be used for points or areas. S-101 charts are saved in ISO8211 format. Example of S-101 chart (part of it) for area of Split is given in the example in chapter 5.

*S-111FC_1.0.0_20180222.xml - Notepad

File Edit Format View Help


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				<S100FC:multiplicity>
					<S100Base:lower>1</S100Base:lower>
					<S100Base:upper xsi:nil="false" infinite="false">1</S100Base:upper>
				</S100FC:multiplicity>
				<S100FC:attribute ref="surfaceCurrentSpeed"/>
			</S100FC:attributeBinding>
			<S100FC:attributeBinding sequential="false">
				<S100FC:multiplicity>
					<S100Base:lower>1</S100Base:lower>
					<S100Base:upper xsi:nil="false" infinite="false">1</S100Base:upper>
				</S100FC:multiplicity>
				<S100FC:attribute ref="surfaceCurrentDirection"/>
			</S100FC:attributeBinding>
			<S100FC:featureUseType>geographic</S100FC:featureUseType>
			<S100FC:permittedPrimitives>coverage</S100FC:permittedPrimitives>
			<S100FC:permittedPrimitives>point</S100FC:permittedPrimitives>
		</S100FC:S100_FC_FeatureType>
	</S100FC:S100_FC_FeatureTypes>
</S100FC:S100_FC_FeatureCatalogue>
```


Figure 2: Example for S-111 feature catalogue

Hierarchical Data Format 5 (HDF5) has been developed for data transfer used for imagery and gridded data. HDF5 is widely used, open source, portable, scalable and has built-in compression.

The model implemented in HDF5 includes an abstract storage model and an abstract data model. The storage model describes the representation for the abstract data model objects. For read/write operations from/to HDF5 files the HDF5 library is used. This library is linked to an application program (written in C, C++, Fortran or Java)

The data model includes: file, group, dataset, dataspace, datatype, attribute, property list and link

for object connection. A HDF5 file can mount another HDF5 file as part of it, similar to mounting in Unix.

An S-100 file consists of groups. Each group is a container for other groups, attributes, position information, metadata, ancillary information and datasets. Datasets are for large amounts of numerical data (example: coverage data). An attribute holds the single-valued information applied to a group or dataset.

4 SCRIPTING LANGUAGE LUA

Lua is a scripting language which is used for describing portrayal in S-101 charts and can also be used for other purposes as shown in the examples. Lua has following attributes: simple, efficient, extensible, portable, and free. In the past years, Lua has become popular in game programming.

It has elements from C and Pascal, programs and scripts are interpreted at runtime, although precompiled implementations also exist. Following basic types are supported in Lua: nil, Boolean, number, string, userdata function, thread, and table.

Starting with version Lua 5.3, two representations for numbers are used: *integers* and *floats*. *Integers* are 64-bit integer numbers and *floats* are double-precision floating-point numbers. Memory place for variables is assigned to variable in the runtime, at value assignment. For diagonal matrices with dimension n x n only n memory cells are used. For triangular matrices (lower or upper) with dimension n x n only n (n + 1)/2 memory cells are used. No memory storage is occupied with zero valued matrix members. Due to this behavior with arrays, Lua programs never crash in case of a wrong array index. Lua can call C functions.

5 EXAMPLES

In this section, three examples are presented of ideas and possibilities of the new standard group. The first example shows the information packing to the hdf5 file. It also shows how to increase the amount of information by using the indexed grid. The second example shows the customization of sailing directions for the specific ship and their presentation on ENC display using Lua. The third example shows how to extract meteorological information from hdf5 file for a given waypoint and time. This example is a continuation of the second example.

5.1 Bathymetric surface description

Bathymetric surface description very rich on details opens up additional possibilities for navigation. The idea of the indexed grid and its use with interpolation is explained in this example. The covered area is divided into a very fine grid. Not all grid points need to be included in the HDF file. The file contains datasets with grid indices and depth value for indexed grid point. The values between existing grid points from the table are interpolated. For important details, more grid points are entered in the table for these locations.

Precision describing of bathymetric surface with 0.3m grid and polynomial interpolation is shown in this example. Bathymetric data in S-102 format is constructed in this example from chart MK-16, Rogoznica-Split [5].

The point grid 0.01” is selected (1853m/6000=0.3088333m). The following attributes for tracking list coverage, shown in figure 3, are extracted from the chart.

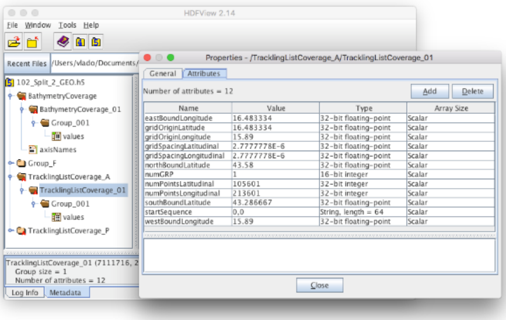


Figure 3: Tracking Grid Coverage Attributes

The attributes numPointsLongitudinal and numPointsLatitudinal are calculated in the following way:

- numPointsLongitudinal = (eastBoundLongitude – westBoundLongitude)/gridSpacingLongitudinal + 1
- numPointsLatitudinal = (northBoundLatitude – southBoundLatitude)/gridSpacingLatitudinal + 1

In this example two TrackingListCoverage tables are defined with the data, table _A and table _P. The first one (_A) is defined with the interpolation type 1 (figure 3) and the second one is defined with the interpolation type 8 (figure 4). This one is used for bathymetric data reach on details in special areas of interest.

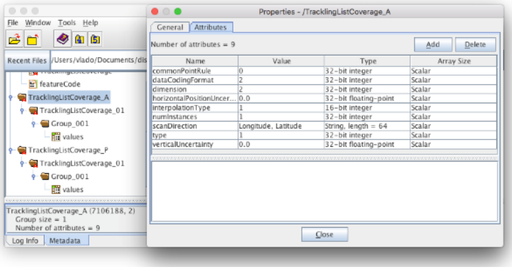


Figure 4: Tracking List Coverage Attributes with Interpolation Type 1

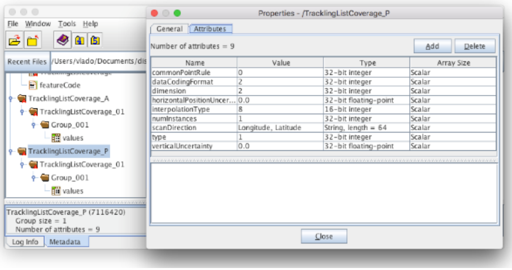


Figure 5: Tracking List Coverage Attributes with Interpolation Type 8

The value tables shown in the figures 6 and 7 have values for points indexed with indices X and Y. The bathymetric values between points in the table are interpolated with the chosen interpolation type. In figure 7, in particular in the cells 330-336, we have a very high resolution rich in details. Using this detail information combined with good interpolation type we have lots of information for planned activities near the shore (e.g. fishing, scuba diving etc.).

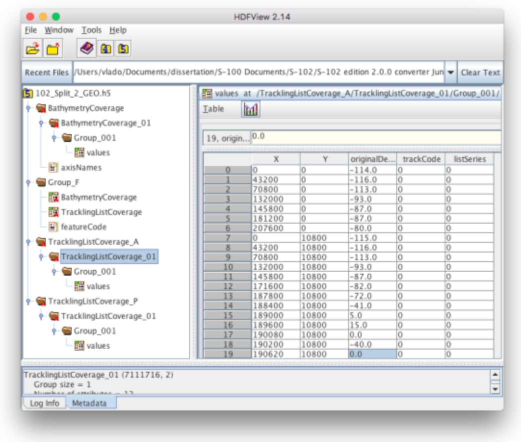


Figure 6: Bathymetric Depth List for A

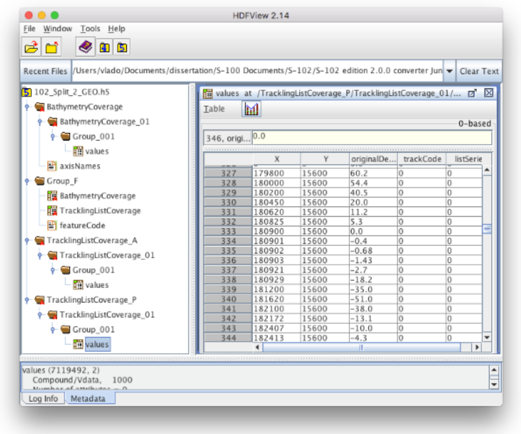


Figure 7: Bathymetric Depth List for P

5.2 Sailing Direction for waterway in Lua

In section 5.2 the example of a passage between Solta and Brac Island, called “Splitska vrata”, is shown. The route through “Splitska vrata” consists of 3 WPTs: WPT1, WPT2 and WPT3.

Instructions are placed on ENC display depending on ship position. The ship approaches WP1 and observing weather condition to WP2 due to large drift to the port side. As the program written in Lua knows the relevant parameters of the ship (pilot card/ship particulars, 2 engines with 3500 kW each), a proposal is given to the display to maintain engine power at 80% each by synchronous propulsion (which is resulting from additional researching).

The ship approach WP2 and drift is in limit of safe tolerance. Approaching to WP3, the ship encounters worse conditions. Due to this, the program recalculates new parameters.

The Lua routine sailing_directions_001 (figures 8 and 9) is user-defined and built in ECDIS on the ship. This routine is called periodically (e.g. every 5s) and each time it checks with the called routine WP_AREA_001 whether the position for the planned actions has been reached.
If so, the routine (programmed in Lua or C) TIME_TO_NEXT_WP_001, not shown in the figures, is called to calculate the arrival time for the next point WP2.

The wind, current and swell at this time are calculated from the meteorological data at this time (routines WP_CURRENT_DIRECTION_AND_ SPEED_001, WP_WIND_DIRECTION_AND_ SPEED_001 and WP_WAVES_HEIGHT_001) and the required propulsion is then calculated from this data (routine SHIP_PROPULSION). The routine DISPLAY_CALCULATED_PROPULSION_001 displays the information at the optimal position on the screen.

5.3 Meteorological forecast written in Lua

Meteorological forecast for wind (direction and speed) is given in hdf5 file. The file has one or more tables. Each row in the table has the following values: grid index (x and y), wind speed and direction.The attributes of each table are UTC time, longitude and latitude limits (see bathymetric tables). Lua function searches in the file the tables for the time immediately before and after the desired time. An interpolation over time and the neighboring grid points gives the expected wind speed and direction.

1. vlado@helix: ~
vlado@helix: ~ (vim) ⌘1 | Default (bash) ⌘2

```
require 'SHIP_PROPULSION_001'
require 'DISPLAY_CALCULATED_PROPULSION_001'
require 'TIME_TO_NEXT_WP_001'
require 'WP_AREA_001'
require 'WP_WIND_DIRECTION_AND_SPEED_001'
require 'WP_CURRENT_DIRECTION_AND_SPEED_001'
require 'WP_WAVES_HEIGHT_001'

boolean in_area_wp1 = false ;
boolean in_area_wp2 = false ;
boolean in_area_wp3 = false ;

function sailing_directions_001(float ship_longitude, float ship_latitude, float ship_speed,
        float wp1_longitude, float wp1_latitude,
        float wp2_longitude, float wp2_latitude,
        float wp3_longitude, float wp3_latitude)

        local boolean synchronous_propulsion
        local float power_left_engine
        local float power_right_engine
        local integer time_to_next_wp
        local float current_direction
        local float current_speed
        local float wind_direction
        local float wind_speed
        local float waves_height
        local float waves_direction
        local float swell

        if WP_AREA_001(ship_longitude, ship_latitude, wp1_longitude, wp1_latitude) then
                if in_area_wp1 == false then
                        in_area_wp1 = true
                end
        end

        if WP_AREA_001(ship_longitude, ship_latitude, wp2_longitude, wp2_latitude) then
                if in_area_wp2 == false then
                        in_area_wp2 = true
                end
        end

        if WP_AREA_001(ship_longitude, ship_latitude, wp3_longitude, wp3_latitude) then
                if in_area_wp3 == false then
                        in_area_wp3 = true
                                                                                39,1-8      Anfang
```

Figure 8: Sailing Directions in Lua, Part 1

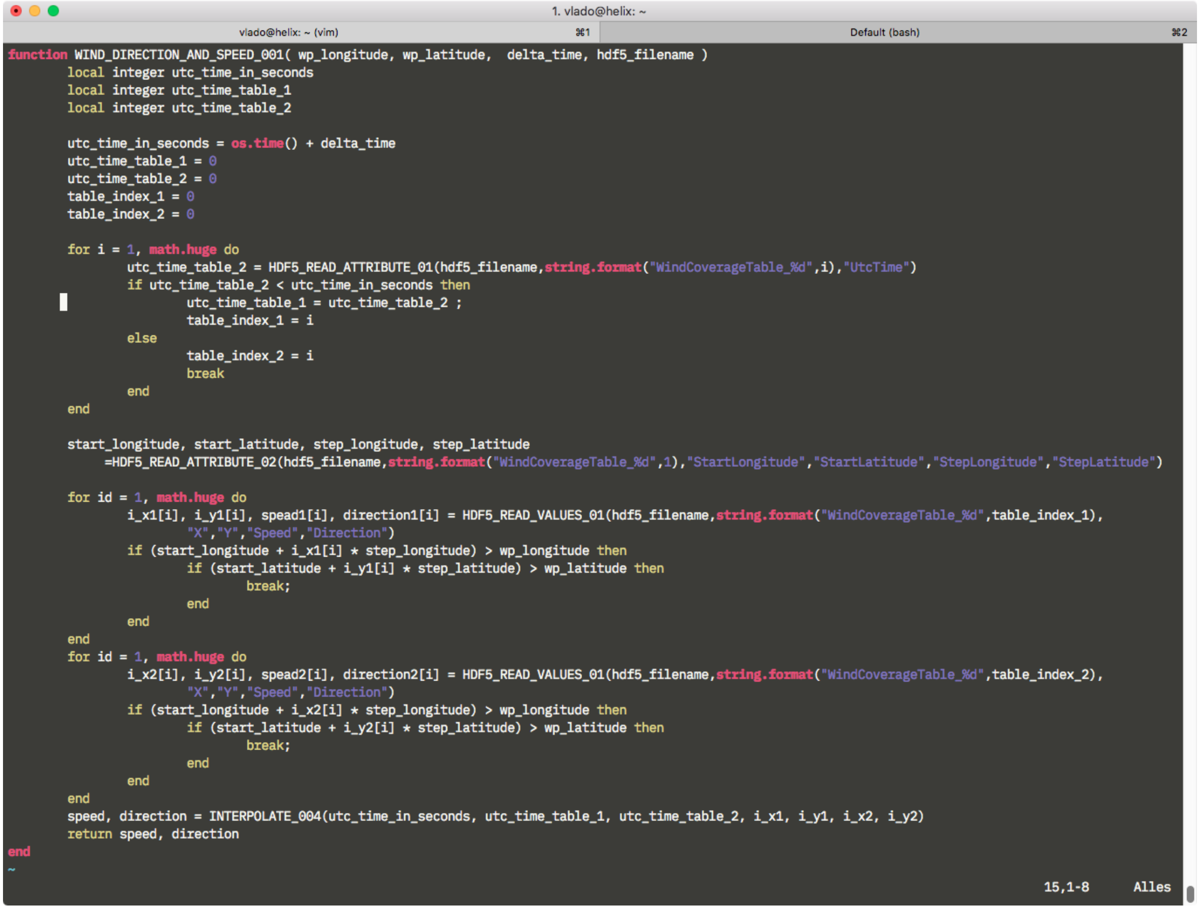
1. vlado@helix: ~
vlado@helix: ~ (vim) ⌘1 | Default (bash) ⌘2

```
        end

        if WP_AREA_001(ship_longitude, ship_latitude, wp3_longitude, wp3_latitude) then
                if in_area_wp3 == false then
                        in_area_wp3 = true
                end
        else
                if in_area_wp3 then
                        in_area_wp1 = false
                        in_area_wp2 = false
                        in_area_wp3 = false
                end
        end

        if in_area_wp1 then
                if (not in_area_wp2) then
                        time_to_next_wp, ship_direction = TIME_TO_NEXT_WP_001(ship_longitude, ship_latitude, ship_speed, wp2_longitude, wp2_latitude)
                        current_direction, current_speed = WP_CURRENT_DIRECTION_AND_SPEED_001(wp2_longitude, wp2_latitude, time_to_next_wp)
                        wind_direction, wind_speed = WP_WIND_DIRECTION_AND_SPEED_001(wp2_longitude, wp2_latitude, time_to_next_wp)
                        waves_height, waves_direction, swell, swell_direction  = WP_WAWES_HEIGHT_001(wp2_longitude, wp2_latitude, time_to_next_wp)
                        synchronous_propulsion, power_left_engine, power_right_engine = SHIP_PROPULSION_001( ship_direction,
                                                current_direction, curent_speed,
                                                wind_direction, wind_speed,
                                                waves_height, waves_direction,
                                                swell, swell_direction)
                        DISPLAY_CALCULATED_PROPULSION_001( ship_longitude, ship_latitude, synchronous_propulsion, power_left_engine, power_right_engine)
                elseif (not in_area_wp3) then
                        time_to_next_wp, ship_direction = TIME_TO_NEXT_WP_001(ship_longitude, ship_latitude, ship_speed, wp3_longitude, wp3_latitude)
                        current_direction, current_speed = WP_CURRENT_DIRECTION_AND_SPEED_001(wp3_longitude, wp3_latitude, time_to_next_wp)
                        wind_direction, wind_speed = WP_WIND_DIRECTION_AND_SPEED_001(wp3_longitude, wp3_latitude, time_to_next_wp)
                        waves_height, waves_direction, swell, swell_direction  = WP_WAWES_HEIGHT_001(wp3_longitude, wp3_latitude, time_to_next_wp)
                        synchronous_propulsion, power_left_engine, power_right_engine = SHIP_PROPULSION_001( ship_direction,
                                                current_direction, curent_speed,
                                                wind_direction, wind_speed,
                                                waves_height, waves_direction,
                                                swell, swell_direction)
                        DISPLAY_CALCULATED_PROPULSION_001( ship_longitude, ship_latitude, synchronous_propulsion, power_left_engine, power_right_engine)
                else
                        REMOVE_DISPLAY_CALCULATED_PROPULSION_001( )
                end
        end
end
~
~
                                                                                54,1-8      Ende
```

Figure 9: Sailing Directions in Lua, Part 2



```
1. vlado@helix: ~
vlado@helix: ~ (vim)    ⌘1    Default (bash)    ⌘2
function WIND_DIRECTION_AND_SPEED_001( wp_longitude, wp_latitude,  delta_time, hdf5_filename )
        local integer utc_time_in_seconds
        local integer utc_time_table_1
        local integer utc_time_table_2

        utc_time_in_seconds = os.time() + delta_time
        utc_time_table_1 = 0
        utc_time_table_2 = 0
        table_index_1 = 0
        table_index_2 = 0

        for i = 1, math.huge do
                utc_time_table_2 = HDF5_READ_ATTRIBUTE_01(hdf5_filename,string.format("WindCoverageTable_%d",i),"UtcTime")
                if utc_time_table_2 < utc_time_in_seconds then
                        utc_time_table_1 = utc_time_table_2 ;
                        table_index_1 = i
                else
                        table_index_2 = i
                        break
                end
        end

        start_longitude, start_latitude, step_longitude, step_latitude
             =HDF5_READ_ATTRIBUTE_02(hdf5_filename,string.format("WindCoverageTable_%d",1),"StartLongitude","StartLatitude","StepLongitude","StepLatitude")

        for id = 1, math.huge do
                i_x1[i], i_y1[i], spead1[i], direction1[i] = HDF5_READ_VALUES_01(hdf5_filename,string.format("WindCoverageTable_%d",table_index_1),
                        "X","Y","Speed","Direction")
                if (start_longitude + i_x1[i] * step_longitude) > wp_longitude then
                        if (start_latitude + i_y1[i] * step_latitude) > wp_latitude then
                                break;
                        end
                end
        end
        for id = 1, math.huge do
                i_x2[i], i_y2[i], spead2[i], direction2[i] = HDF5_READ_VALUES_01(hdf5_filename,string.format("WindCoverageTable_%d",table_index_2),
                        "X","Y","Speed","Direction")
                if (start_longitude + i_x2[i] * step_longitude) > wp_longitude then
                        if (start_latitude + i_y2[i] * step_latitude) > wp_latitude then
                                break;
                        end
                end
        end
        speed, direction = INTERPOLATE_004(utc_time_in_seconds, utc_time_table_1, utc_time_table_2, i_x1, i_y1, i_x2, i_y2)
        return speed, direction
end
~
                                                                                    15,1-8        Alles
```

Figure 10: Meteorological forecast in lua

6 CONCLUSION

The new standard group S-100 describes powerful possibilities for coding of several types of data used in navigation. With the scripting programming language Lua, new information portrayal strategies for ENC displays can be defined. The displayed information can also depend on ship properties, as shown in section 5. It helps the officer to make better decisions in a shorter time. Different kinds of information structured in the same manner (charts, bathymetry, meteorology, rules, currents, waves etc.) used for nautical purposes also makes it easier for the information to be interpreted by machines (computers), which is an important step in the development of self-learning artificial intelligence based systems used for control of autonomous vessels on waterways. Also described within the standard is how new features and attributes can be defined without making changes to existing ones. This makes development of new device and dataset generations possible without risking that old devices will not work with new data records.

REFERENCES

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WOMEN SEAFARERS IN THE ADRIATIC REGION

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ABSTRACT

The ship and the shipping industry in general have become a more open environment for women; currently many women officers and masters work on merchant navy ships. Globally, a small percentage of women are employed onboard ships, most working as hotel staff on passenger ships. As it is estimated that by 2025, there will be a shortage of more than 140,000 ship officers, it is a justified call for maritime institutions, both administrative and educational, as well for shipowners to concentrate its activities to promote the employment of women onboard ships and, consequently, also to other jobs in the maritime industry. The article highlights the state of employment of women seafarers in the European Union, the state of education and employment of women seafarers in Slovenia and the Adriatic region, and propose guidelines to increase interest in the maritime profession among the female population in the local environment.

Keywords: Women seafarers, Education, Employment

1 INTRODUCTION

It was long considered that professions in the maritime sector are reserved exclusively for men, particularly as seafarers have historically been superstitious and women on ships were often though to invite misfortune. Still, it will soon be 90 years since the first woman, of Russian roots, became the master of a ship. Her name was Anna Ivanovna Shchetinina.

However, women have not been employed in the commercial maritime industry in large numbers, though over the last two decades their numbers are increasing onboard; including passenger ships, the number of women globally is now at least up to about 2% of maritime employees[1]. To tackle the projected shortage of seafarers in the coming years [1], the IMO has taken an active approach to promote gender equality in maritime affairs, as reflected in the Women in Maritime Program, a response to UN Sustainable Development Goal 5 "Achieve gender equality and empower all women and girls". Through this initiative, the Busan Declaration[2] was signed in 2013, which encourages the creation of professional networks to improve the gender balance in the maritime industry. These associations support girls and women entering the field through education and then employment in the maritime sector, advocate gender equality, increase the recognition of social responsibilities relating to women in the maritime sector, and promote cooperation, friendship, and understanding through the exchange of knowledge and the dissemination of information [9].

Two networks working towards this end are WISTA (Women’s International Shipping & Trading Association) and WIMAs (Women in Maritime Associations), which bring together and support women in leadership positions in the maritime, trade and logistics sectors, worldwide.

Though we can find a lot of women in management positions in ports and maritime logistics centres today, a woman on a (cargo) ship is still a glaring exception. Working on a cargo ship is a specific profession, which in most cases means a long absence from home, and reduced or prolonged inability to communicate with the loved ones, a circumstance that requires a balance between home and family that is easier for a man to manage than for a woman for the obvious reason that motherhood requires an extensive leave from work. In a study of the impact of motherhood on employment onboard a vessel undertaken in Sweden, 37 seafarers were interviewed [7]. It was and revealed that the majority of respondents decided to end their career on the ship, only five continuing to work on as ship’s officers after maternity leave, two of their own volition, two due to circumstances (lack of financial support) and one who returned to the profession after her children were grown. In general women are considered to be active seafarers until they conceive; afterward, they find work on land, in

[1] http://www.imo.org/en/OurWork/TechnicalCooperation/Pages/WomenInMaritime.aspx

[2] http://www.imo.org/en/MediaCentre/HotTopics/women/Documents/BUSAN%20DECLARATION(Revised1)%20(3).pdf

maritime agencies, maritime administrations, and in MET institutions.

Another challenge experienced by seafarers in an exclusively male occupation is covert gender discrimination, which includes veiled customs and practices in an organization that appears neutral, but holds women back and prevents them from reaching their full potential [9]. This includes the unnecessary emphasis on rewarding and respecting typically masculine virtues and actions rather than feminine ones. A particularly pressing problem is sexual harassment [10][12]. Recently, the #MeToo activist movement launched a campaign among Swedish women seafarers, more than 1,000 of whom divulged that they had experienced sexual harassment onboard[3]. Research has also shown that women working in predominantly male occupations often experience one form of sexual harassment, especially women in lower positions such as apprentice mates or junior officers [12]. Kitada [6], in her research, explored women seafarers' behaviour to manage or prevent such situations using different strategies to avoid being seen as sexual objects but rather as equal co-workers. Women frequently adopt a style of dress that looks less feminine or express their feelings and emotions less; some choose a rougher way of communicating, and so on.

In some cultures female seafarers are still undesirable to shipowners, and even after obtaining the appropriate education it is difficult for them to get a job on a ship [5][13]. Yet, ironically, female seafarers are considered to have better leadership skills than they think, as demonstrated by a study using the Multidimensional Leadership Questionnaire (MLQ-5X) method by which female and male maritime officers' assessed their leadership skills [8].

Nevertheless, according to the European Maritime Safety Agency, in 2017 there were almost 3,700 women officers and masters with valid certificates (based on data collected from 26 EU Member States). Fewer than 20% of them had a Certificate of Competency to work in the engine department, the rest were deck officers or masters [4]. However, given the projected growth trend, statistics still indicate that the share of women in maritime affairs will remain at around 2% globally in the future.

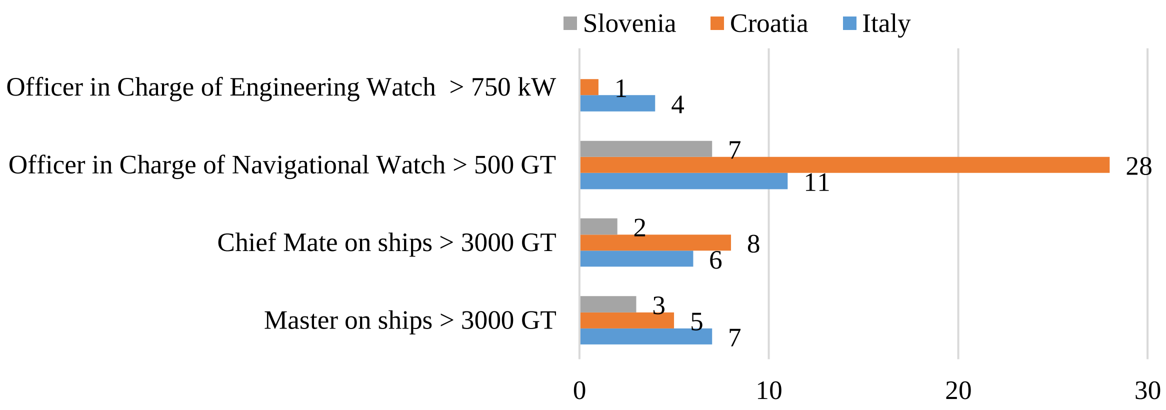
2 STATE OF WOMEN SEAFARERS IN ADRIATIC REGION

In Slovenia, the doors of the naval school were opened for women as far back as 1947. The employment of women on merchant ships opened immediately after World War II, as women proved during war that they were able to fight and lead even under challenging conditions [11]. In the years following the post-war period, to the present day, a small number of women have attended maritime school; only a few of them completed an apprenticeship on a ship, as the working environment was considered unsuitable for girls and women.

Since 2000, 71 women have completed their nautical studies and only one completed marine engineering on a Faculty of Maritime Studies and Transport, University of Ljubljana. The nautical studies and marine engineering are basically geared towards preparing students to work on a merchant navy ship. Nevertheless, only a handful of graduates continue their training onboard as deck or engine trainees. According to the data received from the Slovenian Maritime Administration, in the last two decades, the number of women who passed the exam for obtaining the STCW certificate Officer in Charge of Navigational Watch > 500 GT was 13, and Chief Mates on ships > 3,000 GT was 6. The title Master on ships of 3,000 and more was obtained by 6 women.

Slovenia has not registered any women authorized to work in the engine department.

The two neighbouring coastal countries, Croatia and Italy, face a similar situation. **Graph 1** shows the number of seafarers who currently have valid STCW Certificate of Competency (CoC) in the countries in the Adriatic region, which allows us to determine the number of active seafarers from this area[4].



Graph 1: Number of Women Seafarers with valid CoC in the Adriatic region

[3] https://shippingwatch.com/carriers/article10219785.ece

[4] The data were obtained at the request of the authors by the Maritime Administration of Croatia and Italy.

Regardless of the low number of seafarers in Slovenia, the share of women of all seafarers in Slovenia is higher than in Croatia or Italy. **Table 1** shows the number of all valid CoC at the state level (including both women and men) in 2017 [4] and the share of women with valid CoC, data obtained in 2020. Assuming that the ratio has not changed in three years, we can conclude that in Italy, the share of women officers' on ships is only 0.5%, in Croatia 1.1%, and Slovenia as much as 10%.

Table 1: Share of women seafarers in individual countries

	All seafarers	Rate of Women seafarers
Italy	No.	%
Master > 3000 GT	932	0.75
Ch. Mate > 3000 GT	126	4.76
OOW > 500 GT	2678	0.41
OEW > 750 kW	1609	0.25
TOTAL	5345	**0.5**
Croatia		
Master > 3000 GT	521	0.96
Ch. Mate > 3000 GT	172	4.65
OOW > 500 GT	1763	1.59
OEW > 750 kW	1367	0.07
TOTAL	3823	**1.1**
Slovenia		
Master > 3000 GT	30	10.00
Ch. Mate > 3000 GT	3	66.67
OOW > 500 GT	62	11.29
OEW > 750 kW	17	0.00
TOTAL	112	**10**

3 INITIATIVES TO INCREASE THE NUMBER OF WOMEN ON SHIPS

In order to increase the number of women officers on board ships, a high degree of responsibility must be assumed, primarily by the MET institutions. Their role is mainly to promote gender equality and cultural awareness, to encourage a mindset that eliminates gender bias and overcomes cultural differences between people, and that this becomes part of the institution's curriculum [3]. Unfortunately, this is only an idea that has not yet come to life in reality. In a study conducted at five maritime faculties or academies, study plans and curricula of undergraduate Nautical programs were analyzed [2]. The analysis showed that the study programs follow the instructions of the STCW Convention but do not include topics dealing with gender inequality or cultural differences in a broader sense, including age, gender, religion, sexual orientation, etc.

A similar analysis was carried out by authors from the Faculty of Maritime Studies and Transport, University of Ljubljana. The review of the curricula of the subjects of the Nautical study program, no topics were found that would address issues of gender equality on ships or cultural differences in a broader sense. In the subject Maritime Personnel Management to which these contents would fit, the topics do not include the issue of women seafarers on board and the barriers they face at work. These topics are a matter for informal discussion outside the classroom. As the Swedish study concluded: *»One of the most prominent findings to emerge, was that there seems to be a general 'gender blindness' in maritime education, perhaps as a result of the fact that the maritime industry historically has been largely dominated by men. This is not uncommon, especially in technically-oriented education and natural sciences.«* [2].

Another approach to increase the number of women on ships are role models [9][3]. In the maritime sector there are a number of successful women in management positions who could encourage girls to study maritime affairs, and the promotion of these women at national or EU level is essential. In Slovenia, the maritime profession should be promoted as early as in primary schools, as many social workers who direct students to continue their education are not familiar with this profession, which is particularly true in Slovenian regions that are not located by the sea. However, the promotion of the profession is also necessary in the media in order to reach the general public and to establish itself in the long term in people's subconscious. The aim of promotion is to break the taboo that working on a ship is a male profession to which women have no access.

In addition, the literature mentions the importance of mentors on ships who, with advice and help, positively encourage individuals to express their work potential. Female mentors in particular are indispensable in helping young women on board to start their careers, which would also be an incentive for women to make it easier for them to decide on an internship on board [9].

4 CONCLUSION

This year the Celebrity Cruises embarked on a historic voyage that took place on 8 March 2020 with an all-female bridge team and women officers across many areas. They concluded this event with the prediction that in the near future, the number of women in the fleet will increase up to 19%[5]. This is positive news, which announces that progress is also being made in maritime affairs and that gender diversity on the bridge is only a matter of time. Positive experiences can also be brought back from the army and the police, where the doors of employment for women opened years ago, which in the long term has had an impact on the perception of the professions themselves. And it will be the same in the maritime sector. The future seems bright, it is only up to

[5] https://www.seatrade-cruise.com/news/celebrity-cruises-make-history-all-women-bridge-and-officer-team

us to focus our energy on promoting it and encouraging women to choose this profession in the first place. Last but not least, shipping companies must be aware of the importance of crew diversity, because only in this way we can make a positive contribution to safe ship operation and a cleaner sea.

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DEVELOPMENT OF PORT COMMUNITY SYSTEMS IN EASTERN ADRIATIC PORTS

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ABSTRACT

Ports and terminals are developing new operational communications platforms – port community systems (PCS) to ensure efficient transfer of information between the multiple systems operated by stakeholders in the transport chains and to provide a higher level of automation and productivity in port technological processes. The purpose of the research is to define the general guidelines for the development of functional modules of PCS and, in the specific case, in the port of Koper. Based on the findings, a comparison of the required development of the functional modules of the PCS at the ports of Ploče and Bar is elaborated, with an emphasis on the specific needs of both ports. The aim is to identify the differences in the operation of PCS arising from different administrative requirements of local authorities and due to the different technological processes of receiving, storing and dispatching cargo through ports. The article highlights the potential and impact of upgrading the PCS with additional functional modules to ensure higher productivity at the ports and within the port community. The findings of the legal and business baselines detected at the port of Koper and suggestions for improvements in the southern ports of the eastern Adriatic coast are given. The research brings new insights into opportunities and limitations deriving from a unified modular development of PCS to achieve faster and more efficient implementation in port systems, even though there are differences in technological and administrative operations.

Keywords: port community system, port community, port processes, productivity, electronic data exchange

1 INTRODUCTION

One of the most important links in the logistics chain, which play a key role in world trade market are seaports [26]. Seaports represent a link between sea and land transport, which gives them an important role in ensuring efficient cargo handling. An important factor in ensuring efficient port services is the quality of exchanged information about cargo between seaports and other stakeholders in the logistics chain. One of the factors that ensures a well-managed data exchange on cargo is undoubtedly the establishment of a Port Community System (PCS), which represents a common platform for exchanging data between a seaport and its stakeholders.

A PCS is a common software platform that unites the entire port community, which is composed by different stakeholders and allows them to exchange information on cargo in real time. Members of the port community are terminal operators, freight forwarders, state institutions (police, customs, phytosanitary and veterinary inspections, maritime administration, port authority etc.), shipping agencies and others companies. The advantages of the PCS are the ability to optimize and improve different technological processes with data stored in a common platform [2].

Seaports of the eastern coast of the Adriatic Sea represent one of the most important entry points for trade routes of the Southern and Eastern Europe. The introduction of electronic data interchange between seaports and their stakeholders has an important impact on the execution of technological processes and could play in the future a key role in modernizing operations in the ports of the Eastern Adriatic. An efficient data interchange system enables seaports to dispose with a high-quality datasets, that enables efficient use of port infrastructure and superstructure, which ultimately leads to savings in handling time, energy, to a process optimization, but also improved security and decreased environmental impact [24].

The research of PCS systems of the three eastern Adriatic ports represents a starting point for faster adaptations of PCS systems in less developed port communities and possibilities for unification of PCS systems in ports of the eastern coast of the Adriatic Sea. This could have a positive impact on businesses for many stakeholders who collaborate with seaports of the Eastern Adriatic and also for the seaports themselves in B2G (business-to-government) integration. The research hypothesis states that the PCS systems in the three Eastern Adriatic ports of Bar, Ploče and Koper are differently developed, where such differences may represent in the current development phase an opportunity to identify possibilities for future unifications.

2 PCS SYSTEMS IN THE PORTS OF BAR AND PLOČE

Considering the port traffic, the ports of Ploče and Bar could be defined as smaller ports in the southern part of the Adriatic Sea. Both ports are differently organized, Luka Bar is managed directly from the company Luka Bar, a.d., port of Ploče is managed by the Port of Ploče Authority, which is in charge of awarding terminals in concession [12].

Over the last decade, ports have started investing in the modernization of port infrastructure, superstructure and informatization of business processes through various projects supported by governmental institutions. Through the project "Trade and Transport Integration" (ITT), which started in 2006, the port of Ploče carried out the modernization of its information systems, of the container terminal and of the dry bulk terminal as well as it built the main entry gate for trucks. At the same time, based on a positive trend in the growth of liquid cargoes, an independent project was conducted to construct a berth for oil and natural gas. [10]. The port of Bar has modernized its port infrastructure and superstructure through various development projects, most of which were co-financed by the European Union. Some of the programs through which the port of Bar has managed to modernize are ADRION, MED p, SEE, FP7, IPA Adriatic and others [13]. Successfully concluded projects, but also the on-going one, cover in particular the following fields: infrastructure, superstructure and informatization of business processes.

Both seaports have developed own PCS systems through various development projects. In the port of Bar, the PCS system was developed and handed over in use in 2015, where the development was co-funded through the project Adriatic - Danube - Black Sea multimodal platform (ADB Multi-Platform) that took place under the SEE program (co-funded also with IPA funds). The port of Ploče carried out the informatized of the port and the establishment of the PCS system through the ITT project, which was financed mostly by the World Bank, the Government of the Republic of Croatia and the Port of Ploče Authority.

2.1 PCS system Luka Bar

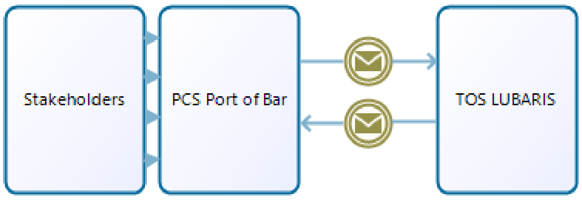
The development of the PCS system in the port of Bar began in 2015, when the project team completed the ADB Multiplatform project. The project was co-founded by the EU as part of interstate cooperation Southeast Europe (SEE program, IPA funds), between 2012 and 2014. The ADB Multiplatform project involved 23 project teams from ten different countries (Italy, Slovenia, Croatia, Hungary, Bulgaria, Romania, Greece, Serbia, Albania and Montenegro). The PCS project for the Port of Bar was approved on the third call for strategic projects under the South East Europe Program, facing participation of non-yet EU partners to which Pre-Accession Assistance (IPA) funds were granted. The main goals of the strategic project for the development of the PCS system were [14]:

- develop a PCS system and its integration with the existing TOS LUBARIS system[1];
- upgrade the TOS LUBARIS system to enable data exchange with the new PCS system.

The aim of developing the PCS system in the port of Bar was primarily to eliminate the inability of TOS LUBARIS to communicate with stakeholders of the port community, which consists of the Ministry of Transport and Maritime Affairs, Ministry of Sustainable Development and Tourism, shipping agents, forwarders and customs. The developed PCS system is a web based platform, which allows exchanging data between stakeholders and the TOS LUBARIS operating system via EDI (Electronic data interchange) messaging [2].

2.1.1 PCS system architecture

The architecture of the PCS system consists of two parts, the main part is the central system that holds the main functionalities and the message system with the role of exchanging messages with the external port systems (figure 1). The central part of the system is a common platform aimed to gather stakeholders' data and, sharing data to perform technological processes.



Source: authors

Figure 1: PCS system architecture in the port of Bar

The communication part of the system that takes care of exchanging messages between the PCS system and external systems uses XML (Extensible Markup Language) structured messages. The current configuration of the PCS system allows data exchange only with the Terminal Operation System (TOS) LUBARIS. Between the systems a two-way communication is established that supports exchanging 12 different types of messages. The architecture of the PCS system is designed to allow adding new external system in use by the port community in an easy manner.

[1] LUBARIS is a terminal operating system (TOS) for collecting data on dangerous goods, monitoring movements and making storage documents [21].

2.1.2 PCS system functionalities

The PCS system disposes of a variety of functionalities that provide information support for various technological processes in various fields, depending on the needs of each stakeholder. The technological processes that are supported by the PCS system are vessel and cargo announcement, work ordering and planning, managing stocks, etc. By setting up the PCS system, information support for technological procedures has been guaranteed, which, through developed functionalities, enables individual stakeholders in the port community to access and exchange data in an easy way. Accessing and retrieving of all the data in PCS system is ensured through functionalities developed in relation to the needs of individual stakeholders in the port community. The functionalities currently developed and in use are [11]:

- Service requests
  - The functionality allows freight forwarders to create vessel and cargo announcements and ordering services.
- Work orders
  - The functionality allows ports terminals to plan and execute internal procedures (e.g. planning).
- Stocks
  - Allows terminal operators to trace cargo and supports warehouse management;
  - Allows customs to monitor stock records.
- Vehicle use
  - Functionality developed for the Car terminal to trace and manage stocks, adjusted to the needs of handlings operations.
- Container use
  - Functionality developed for the Container terminal to trace and manage stocks, adjusted to the needs of handlings operations.
- Vessels
  - Functionality developed to support vessel announcements done by shipping agents as well as changes related to vessel arrivals.
  - Allows customs insight to data on vessels announcements.
  - Manages pilotage plans.
- Truck module
  - Enables terminal operators to plan and schedule truck arrivals.

The execution of technological processes is based on obtained input / output data, which is exchanged between the PCS system and the TOS LUBARIS. Technological procedures supported by the PCS system are cargo announcement and dispatch, vessels announcement and pilotage, work planning and truck arrivals planning and managing trucks parking lots. Table 1 reports data exchanged between stakeholders to support technological process.

Table 1: List of data exchanged in relation to technological processes

Stakeholder	**Technological process**
Message type / direction	**Message content**
Forwarders	Unloading / loading of cargo
Order / PCS to TOS LUBARIS	Main data are: Order type (load / discharge); Transport mode; Freight owner and description; Freight quantity; Customs documents; Customer and other identification data.
Storage document / TOS LUBARIS to PCS	Main data are: Document type (add stock / unstock); Storage area; Freight quantity; Order no. and other freight data.
Agents	Vessel announcement and pilotage plan.
Vessel announcement / PCS to TOS LUBARIS	Vessel name; IMO code; Estimated Time of Arrival (ETA); Agent; Owner; Vessel type; Cargo description; Cargo quantity; Berth; Crow list and other data.
Vessel confirmation / TOS LUBARIS to PCS	Vessel voyage number; Estimated Time of Departure (ETD).
Pilots (Port of Bar - Pilots)	Mooring / unmooring of the vessels.
Berthing / TOS LUBARIS to PCS	Actual Time of Arrival (ATA); ATD Actual Time of Departure; Berth.

Source: authors and [11]

Only part of the functionalities implemented in the PCS system exchange data actively with TOS LUBARIS, the rest works independently. Functionality data that is not shared with other systems is available to all stakeholders with the option of later integration with external systems. Systems that are limited only to the PCS system and which hasn’t had any integrations yet are "Work orders" and "Truck module". The role of customs as a stakeholder in the port community is limited to supervision, because the integration with the customs system is not currently established. Customs just views the stock records of goods, which simplifies entry and exit control procedures.

With the introduction of the PCS system, the port of Bar followed trends set up by modern ports, which strive to increase their flexibility in order to obtain new cargo traffics. Such flexibility concerns in particular the ability to accommodate a variety of cargo types, but also the need to ensure a fast flow of cargo through the port. One of the advantages of developing the PCS system was the integration with the existing infrastructure on the truck gate. The integration includes recording of data on actual arrival and departure of trucks and sharing of such data with the stakeholders of the port community.

2.2 PSC system Port of Ploče

The PCS system in the port of Ploče was developed as part of the project "Integration, Trade and Transport (ITT)". The goal of the ITT project was to upgrade the port's infrastructure and superstructure, to make the port an important part of the international logistics chain that gravitated to the then-existing V.c Pan-European corridor [8]. The purpose of introducing the PCS system was to establish a faster and simplier data interchange (data related to technological processes carried out around and within the port) between stakeholders of the Ploče port community. The PCS system development project for the port of Ploče was co-founded by the Ploče Port Authority through financial resources obtained from the World Bank. The development of the PCS system followed the needs of the port community and, according to the requirements of the latter, developed the functionalities of the PCS system [17] [22]. The port community in the Port of Ploče consists of the Ploče Port Authority, freight forwarders, shipping agents, terminals (Ploče Port NTF, ATT, Passengers terminal, Oil and liquid terminal), customs and port security [18].

2.2.1 PCS system architecture

The design of the PCS system Ploče is based on a common platform that enables stakeholders to exchange data electronically. The data exchange technology is based on the EDI messaging system in XML format. The communication protocol is set up so that messages are exchanged internally, for the purpose of providing data to the functional modules of the system and to a smallest extent with external systems (figure 2).

Source: authors

Figure 2: Architecture of the PCS system in the port of Ploče

The content and form of messages vary depending on the needs of each technological process. PCS system Ploče knows 50 different message formats for data exchange purposes. A large number of messages derive from the architectural design of the system, where for each action the functionality (order, acceptance, cancellation, printing, rejection, etc.) the system trigger creates messages. In such an architecture, it is necessary to divide the messages into two groups, namely, messages that are directly related to technological processes and internal, related to the operation of the application itself. The architectural design of the common PCS platform in terms of input and data sharing for the port community means that everyone uses the same software. Depending on the stakeholder role, it is possible to use only certain functionalities of the PCS system, while other functionalities are disabled.

2.2.2 PCS system functionalities

The functionalities of the PCS system were developed according to the needs of the stakeholders of the port community of Ploče. Based on the requirements, the necessary functional modules were developed for each group of stakeholders, through which they started to informatize the existing technological processes that take place outside and inside the port. The areas of technological processes carried out in the port of Ploče have been supported by the following functional modules, depending on the needs of these processes: [22]:

- Vessel announcement
  - Functionality to support sending vessel announcements and related documents by shipping agents and changes related to vessel arrival.
- Orders
  - Ordering handling services for different cargo groups (liquid cargo, general and dry bulk cargoes).
- Stock records
  - Checking stocks of cargo at terminals;
  - Provides customs with access to cargo records.
- Customs
  - Provides customs with insight into ship announcements and attached documentation related to individual ship visits.
- Trucks (truck announcements).
  - Announcing and monitoring truck arrivals.
  - Truck parking management, which includes billing.
- Railway
  - Monitoring and recording announcements of railway wagons.
  - Recording cargo stocks.

The functional modules provide faster executions of technological processes to the entire port community through a fast and reliable way of exchanging data necessary to receive or dispatch cargo through the port. The information collected in the PCS system that is entered by various stakeholders, plays a key role in enabling effective planning and effective implementation of technological processes. Table 2 shows the set of key data required for each technological process, as well as the role of the port community stakeholder that shares the data. The use of cargo data collected in the PCS system is available simultaneously for different technological processes, which ensures the establishment of a network system where stakeholders represent clusters, while links between them represent veins through which data is shared [9].

Table 2: Data exchange for the technological process purpose

Stakeholder	Technological process
Message type / direction	**Message content**
Forwarders	Unloading / loading of cargo
Order / Internal PCS message	Main data are Order type (load / discharge); Transport mode; Freight owner and description; Freight quantity; Customs documents; Customer and other identification data.
Storage document / Internal PCS message	Main data are Document type (add stock / unstock); Storage area; Freight quantity; Order no. and other freight data.
Truck announcement / PCS to ECCOS	Actual Time of Arrival (ATA); ATD Actual Time of Departure; Berth.
Agents	Vessel announcement and pilotage plan
Vessel announcement / Internal PCS message	Vessel name; IMO code; Estimated Time of Arrival (ETA); Agent; Owner; Vessel type; Cargo description; Cargo quantity; Berth; Crow list and other data.
Vessel confirmation / Internal PCS message	Vessel voyage number; Estimated Time of Departure (ETD).

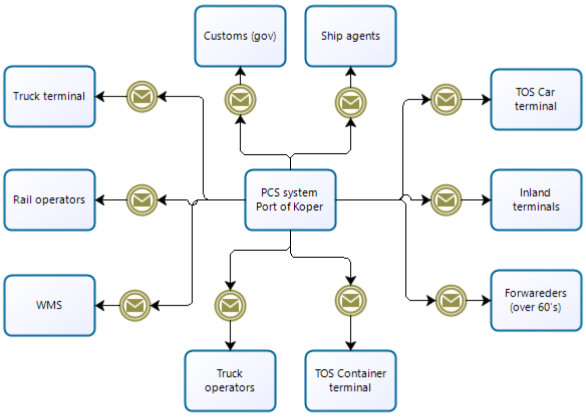
Source: authors and [9]

The PCS system of Ploče is currently designed in such a way that all functional modules are part of a common platform. Stakeholders have access to the functional modules, based on the role in which they perform an operation and the technological processes in which they participate. The design of the system enables that the stored data is accessible to all functionalities, through which information support to technological processes is assured.

Some functionalities of the PCS system has been developed to exchange data with the port infrastructure elements. In the port of Ploče, a communication system with a truck entrance to the port is currently being established, which was built in parallel to the development of the PCS system. Establishing communications with the truck entrance infrastructure is a step towards a smart port. The integration between the PCS system and the infrastructure allows the specific infrastructure element to be managed by EDI messaging systems. In the case of the port of Ploče, data is exchanged between the functional module Truck and the ECCOS system, which is intended for the management of ramps at the truck entrance.

3 PCS SYSTEM BAR AND PLOČE COMPARED TO PCS PORT OF KOPER

The PCS system in the port of Koper is one of the most advanced systems in the region and technical and technological knowledge is also being implemented in other ports in the Mediterranean. In addition, the port of Koper considering traffic data could be considered as one of the most important ports in the Mediterranean. Thus, a comparison of the developed functional modules of PCS systems between the Port of Koper and the PCS systems in the port of Bar and the port of Ploče was performed. The analysis of the PCS system in the port of Koper shows that it covers all technological processes that take place within and around the port system. The PCS system in the port of Koper provides communication with more than 60 stakeholders, who make up the entire port community (figure 3).



Source: authors

Figure 3: Architect of the PCS system currently developed in the Port of Koper

The exchange of information on cargo to support technological processes takes place via EDI with customs administration, shipping agents, truck terminal, railway operators, road carriers, freight forwarders, hinterland terminals (Cargo centre Graz and Adria Terminali Sežana), container terminal TOS, car terminal TOS, warehouse storage system WMS. The exchange of messages between stakeholders and the PCS system of the port of Koper provides data on cargo to functional modules, such as ship announcement, cargo announcement, truck announcement, release of goods in free trades, etc. and ensures fast and efficient reception and dispatch of various cargo. The efficiency of the PCS system is reflected in the fact that on average 63,000 tons of various cargo are handled daily [23].

Compared to the port of Koper, the port of Bar has a 15 times smaller daily throughput, while the port of Ploče has a 7 times smaller daily throughput [1][19]. Despite the lower daily throughput, the ports of Bar and Ploče execute the technological procedures with the support of functional modules of the PCS system. A comparison of the set of implemented functional modules and integrations of the PCS system of the port of Bar and the port of Ploče in comparison to the port of Koper shows a significant difference in the scope of covered functionalities and the need and opportunities for further upgrading of the PCS system (table 3).

Table 3: Comparison of basic functional modules of PCS systems by ports

Functional module	PCS system		
	Port of Bar	Port of Ploče	Port of Koper
Cargo announcement	●	●	●
Vessel announcement	●	●	●
Exchange of storage documents	●	●	●
VBS system			●
Rail waggons announcement		●	●
Work orders			●
Integration with customs			●
Integration with rail carriers			●
Integration with a single maritime window			● [2]
WMS			●
Integration with cargo scales			●

Source: authors

4 DISCUSSION

The comparison of PCS systems shows that the southern Adriatic ports have implemented functional modules that provide information support for basic technological processes, such as cargo arrival / departure order, ship arrival announcement, warehousing and to a lesser extent part of the connection to the VBS system. The comparison shows that the southern Adriatic ports have certain reservations regarding integration with external systems, such as the national single window, the customs system and railway carriers.

With the introduction of the PCS system, the ports in question primarily carried out updates to the communication infrastructure, which ensures uninterrupted data flow (EDI) and the infrastructure of the truck entrance to the port. The modernization of the truck entrance was carried out in order to establish communication between the PCS system and the superstructural elements, such as locks, OCR (Optical Character Recognition) and data displays. Communication between the elements of the truck entrance and the PCS system provides an automated process of entry and exit to the port, where on the basis of the data the controls of entrance in the port are performed. [16][20][15].

As part of its further development, the Port of Bar is active on various projects, through which it planes to further modernize the port infrastructure and superstructure [13]. In the field of PCS system and B2B (business to business) operations, the port has made a big step towards modernization, which enables the contribution to the optimization of works planning and implementation of technological processes. At national level, Montenegro is carrying out activities related to the introduction of the National Maritime Single Window (NMSG) [6]. Integration with NMSG will certainly be one of the major upgrades of the PCS system.

The PCS system in the port of Ploče is currently set up as a single platform, which is in the upgrade phase from the existing obsolete Silverlight technology. A system overhaul is underway to replace the existing outdated Microsoft Silverlight technology with the new HTML5 web technology and change the PCS system architecture. Internal communication between functional modules is abandoned and replaced by execution within program code. With the new system, the EDI messaging system will be exclusively intended for communication with external systems. One of the important goals is integration with the National Single Window (NSW).

The establishment of a more comprehensive PCS system brings the port closer to the introduction of paperless technological processes and the use of standardized communication protocols, which allows flexibility in further integration with external systems, both private and state stakeholders [25]. Despite the lower throughput compared to other Adriatic ports, the southern Adriatic ports of Bar and Ploče have established a PCS system, which allows them flexibility in the implementation of technological processes. The establishment of the system at a later stage of development will allow ports to facilitate integration with systems such as EMSA (European Maritime Safety Agency) [3], national maritime single window [5], customs and tax central system ECS (Export Control System), ICS (Import Control System) and NCTS (new computerised transit system) [4] etc.

5 CONCLUSION

Regardless of the amount of annual throughput, the ports of the eastern Adriatic have begun to develop PCS systems with the aim of establishing platforms that will enable the exchange of B2B and B2G data. The development of basic functional modules of the PCS system, such as cargo and vessels announcements are not related to quantity of annual traffic but such step appears to be fundamental if a port wants to optimize the basic technological processes related to the cargo handling. The architecture and development technologies differ from port to port. The differences stem from the requirements that the port places to the selected (IT) supplier. A general goal that is followed when setting up a PCS system, is that the PCS shall ensure efficient data

[2] Implementation between the central piercing system and the national single window (NEO) is under development.

exchange between stakeholders and help to optimize technological processes as much as possible.

When developing a PCS system, it is important that ports are oriented toward an integration with the port infrastructure, which means a step towards the development of a smart port. The ports of the eastern Adriatic have already started certain activities in this direction, by establishing communication between PCS systems and the truck entrance, trucks and railway cargo scales. The analysis highlights a significant discrepancy in the development of PCS systems, which can confirm the research hypothesis. PCS systems in the ports of Bar and Ploče will need to be upgraded in order to achieve other advantages of using various functional modules already in use in the port of Koper, such as paperless business between all stakeholders, integration with government agencies and external institutions (e.g FURS). It is advisable to look for possibilities of unifying the operation of functional modules by ports, in order to facilitate operations for various stakeholders who ensure the operation of supply chains through the ports of the eastern Adriatic.

The future development of PCS systems could be focused on more intensive upgrades that would ensure communication with the hinterland infrastructure (rail, road), which would further contribute to a more efficient planning of technological processed, by obtaining data on arriving cargo.

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ENVIRONMENTAL PROTECTION AND SUSTAINABLE PORTS

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ABSTRACT

This paper deals with sustainable development of the ports and special attention is given to environmental issues. The risk of pollution caused by ships depends largely on ship-owner as well as on ship master, but port authorities and governments can also reduce the risk of pollution by enforcement of international standards and charging policies. In 1993, The European Sea Ports Organisation (ESPO) was created. The European port sector has been monitoring selected environmental management indicators since 1996 as part of joint ESPO - EcoPorts initiatives. ESPO environmental report for year 2019 included set of indicators related to the Environmental Monitoring Programs of European ports. In 2019, the data were obtained from 94 ESPO-member EU/EEA ports that completed the online EcoPorts' Self-Diagnosis Method (SDM). The indicators for the evaluation of the ports were: environmental management indicators, environmental monitoring indicators, top environmental priorities and green services to shipping. Transparency was the top priority environmental management indicator, while waste was the most frequently monitored environmental indicator in 2019. Environmental priorities of the European port sector were strongly focused on air quality, energy consumption and climate change. Green services to shipping included three categories of indicators: the provision of Onshore Power Supply (OPS), the provision of Liquefied Natural Gas (LNG) bunkering facilities and Environmentally Differentiated Port Fees. The ESPO new tool for European ports is PortinSights, the digital platform includes throughput data, environmental data (EcoPorts) and governance data.

Key words: shipping, ports, sustainable development, marine environment, ESPO, indicators

1 INTRODUCTION

According to Michael Porter, professor at Harvard University, the conflict between environmental protection and economic competitiveness is a false dichotomy based on a narrow view of prosperity sources and a static view of competition. Porter states that strict environmental regulations do not inevitably hinder competitive advantage against rivals; indeed, they often enhance it. Turning environmental concern into competitive advantage demands regulations establishment that stresses pollution prevention rather than abatement or cleanup. [1]

One of the most important legal instruments of marine pollution prevention is the IMO (International Maritime Organisation) *International Convention for the Prevention of Pollution from Ships (MARPOL)*. MARPOL includes regulations aimed at preventing pollution from ships, including air pollution, oil, sewage, garbage, hazardous and noxious substances pollution.

Other important IMO conventions relating to prevention of marine pollution are: *International Convention on the Control of Harmful Anti-fouling Systems on Ships* (AFS), 2001 and *International Convention for the Control and Management of Ships' Ballast Water and Sediments*, 2004.

In line with Annex VI of MARPOL Convention, the sulphur limit for marine fuels used in SECAs (the Baltic Sea, the North Sea and the English Channel) is set at 1.0% until 31 December 2014, to be lowered to 0.1% as from 1 January 2015, and to 0.5% from 2020 in other EU waters. [2] As a result, emissions of sulphur dioxide from shipping in Europe are expected to come down by more than 80 per cent. [3]

At the core of the UN (United Nation) Decade for Action (2020-2030) is the need for action to address the climate changes. 17 Sustainable Development Goals were adopted by UN Members in 2015, as part of the 2030 Agenda for Sustainable Development. The 17 Sustainable Development Goals (SDGs) demand a transformation of all sectors of the society including shipping and ports.

2 SUSTAINABLE PORTS

The profit is not single measure of port success but other two pillars of sustainable development can also be used as port success measures: social and environmental accomplishments. The environmental impact of ports is an important topic, because it causes not only environmental losses but also economic losses. The more sucessful port is, the bigger the number and size of the ships are. The bigger ship is, the higher the risk of pollution is. Even if all ships try to follow the best practices for pollution prevention, increased shipping and port activities can result in increased overall impacts on marine and coastal environment. The risk of pollution caused by ships depends largely on owner as well as ship master, but port authorities and governments can also reduce the risk of pollution by enforcement of international standards and charging policies. Port authorities also try to meet social and environmental obligations while embedding environmental and corporate social responsibility (CSR) concepts in port management systems.

ISO 14001:2015 specifies the requirements for an environmental management system that an organization can use to enhance its environmental performance.

ISO 16304:2013 applies to the management of ship generated waste regulated by MARPOL that is discharged at ports and terminals. It also covers principles and issues that should be considered in the development of a port waste management plan (PWMP), its implementation and port reception facilities (PRF) operations. Adequate oil, waste and sewage port reception facilities are important factor in preventing environmental problems.

EU Eco-Management and Audit Scheme (EMAS), is a premium management instrument developed by the European Commission for companies and other organisations to evaluate, report, and improve their environmental performance.

Port Environmental Review System (PERS) is a certificate assessed by Lloyds register and it helps port to develop their environmental priorities. PERS is the only port sector specific environmental management standard and it is developed by ports.

Port development projects that generate environmental concern are subject to environmental impact assessment (EIA) methodologies to assess the potential impact on marine and terrestrial habitats (UNESCAP, 2009). [4]

There is a lot of competition among the neighbouring ports, and effective actions of improvement require regional agreements. For this reason, the regional memorandums of understanding on port-state control have an important role in managing ports impact on marine environment. [5]

3 ESPO

Port Working Group, the group that consisted of port authority representatives from Europe's major ports, was established in 1974. In 1993, European Sea Ports Organisation (ESPO) was created. The mission of the ESPO is to influence public policy in the European Union in order to achieve a safe, efficient and environmentally sustainable European port sector.

The ***ESPO Green Guide****; towards excellence in port environmental management and sustainability* introduces a common framework for port authorities to respond to their environmental challenges under 5Es; Exemplify, Enable, Encourage, Engage and Enforce. As mentioned within the Guide: "The European port authorities aim to continuously work towards improving their environmental performance through focused action on:

1. Exemplifying; Setting a good example towards the wider port community by demonstrating excellence in managing the environmental performance of their own operations, equipment and assets;

2. Enabling; Providing the operational and infrastructural conditions within the port area that facilitate port users and enhance improved environmental performance within the port area;

3. Encouraging; Providing incentives to port users that encourage a change of behaviour and induce them to continuously improve their environmental performance;

4. Engaging with port users and/or competent authorities in sharing knowledge, means and skills towards joint projects targeting environmental improvement in the port area and the logistic chain;

5. Enforcing; Making use of mechanisms that enforce good environmental behavior by port users where applicable and ensuring compliance." [6]

4 ESPO ENVIRONMENTAL REPORT FOR 2019

The ESPO commissioned the first environmental survey on ports in order to assess port response to the recommendations of the **ESPO Environmental Code of Practice** (ESPO, 1994). This first **Environmental ESPO Questionnaire** provided an overview of the most important environmental problems in ports.

ESPO environmental report for 2019 included set of indicators related to the Environmental Monitoring Programs of European ports. The data were obtained from 94 ESPO-member EU/EEA ports that completed the online EcoPorts' Self-Diagnosis Method (SDM).

The indicators used in the evaluation of the ports were: **environmental management indicators**, **environmental monitoring indicators**, **top environmental priorities** and **green services to shipping**.

The **environmental management indicators** included:

1. Existence of a Certified Environmental Management System – EMS (ISO, EMAS, PERS).
2. Existence of an Environmental Policy,
3. Environmental Policy makes reference to ESPO's guideline documents,
4. Existence of an inventory of relevant environmental legislation,
5. Existence of an inventory of Significant Environmental Aspects (SEA),
6. Definition of objectives and targets for environmental improvement,
7. Existence of an environmental training programme for port employees,

8. Existence of an environmental monitoring Programme,
9. Environmental responsibilities of key personnel and
10. Publicly available environmental report.

Transparency (Publicly available environmental report) was high priority environmental management indicator. About 87% of the ports communicated their environmental policy to the stakeholders and 82% of them made it publicly available on their websites.

Environmental monitoring indicators were: waste, energy consumption, water quality, water consumption, air quality, noise, sediment quality, carbon footprint, marine ecosystems, terrestrial habitats and soil quality. In 2019, waste was the most frequently monitored indicator (79%), and it was followed by energy consumption (76%) and water quality (71%).

Ship and port waste is very important issue. The ***EU Directive on Port Reception Facilities for ship waste*** can help stakeholders to cope with marine litter problem.

Since 2018, three new indicators related to climate change have been included in the report: operational challenges due to climate change, steps to strengthen the resilience of its existing infrastructure to adapt themselves to climate change, taking climate change into consideration for the development of their future infrastructure projects. This is the evidence that climate-proof infrastructure has become the top priority issue.

In 2019, **top 10 environmental priorities** were:

1. air quality,
2. energy consumption,
3. climate change,
4. noise,
5. relationship with the local community,
6. ship waste,
7. garbage/port waste,
8. port development,
9. dredging operation,
10. water quality.

The top three positions of climate regulations, gas emissions reduction and climate-proof infrastructure in the list proves that these issues are the most important environmental priorities of the European port sector.

Green services to shipping included three categories of indicators on efforts of port managing bodies: the provision of Onshore Power Supply (OPS), the provision of Liquefied Natural Gas (LNG) bunkering facilities and Environmentally Differentiated Port Fees (for companies and ships going beyond regulatory standards).

It is very important for the ports to have **an inventory of relevant environmental legislation,** an Environmental Policy, the documentation of environmental responsibilities within the port authority (especially in the event of an accident or incident), regular environmental training program as well as to produce publicly available environmental report. [7]

5 ECOPORTS AND PORTINSIGHTS

EcoPorts, the environmental initiative of the European port sector, started in 1997 as a separate initiative of a number of proactive ports. It has grown into a big network of ports, working on the improvement of their environmental performance. EcoPorts has been fully integrated into the ESPO since 2011.

The European port sector has been monitoring selected environmental management indicators since 1996 as part of joint ESPO - EcoPorts initiatives. The aim of the initiative is to monitor the trends that would highlight tendencies and assist both the sector and policy makers.

The ESPO new tool for European ports is **PortinSights**, the digital platform includes throughput data, environmental data (EcoPorts) and governance data (www.portinsights.eu). [6]

6 CONCLUSION

The profit is not only measure of port success but social and environmental accomplishments can also be used as measures of port success. Ports and ships are serious contributors to global pollution, and they also affect the quality of life in general. The risk of pollution caused by ships depends largely on owner as well as on ship master, but port authorities and governments can also reduce the risk of pollution by enforcement of international standards and charging policies.

In 1993, European Sea Ports Organisation (ESPO) was created. The mission of the ESPO is to influence public policy in the European Union in order to achieve a safe, efficient and environmentally sustainable European port sector.

The ESPO publishes environmental reports every year. ESPO environmental report for year 2019 included set of indicators related to the Environmental Monitoring Programs of European ports. The indicators for the evaluation of the ports were: environmental management indicators, environmental monitoring indicators, top environmental priorities and green services to shipping.

Transparency (Publicly available environmental report) was the top priority **environmental management indicator**. **Environmental monitoring indicators** included: waste, energy consumption, water quality, water consumption, air quality, noise, sediment quality, carbon footprint, marine ecosystems, terrestrial habitats and soil quality. In 2019, waste was the most frequently monitored indicator.

Environmental priorities of the European port sector were strongly focused on air quality, energy consumption and climate change.

Green services to shipping included three categories of indicators: the provision of Onshore Power Supply (OPS), the provision of Liquefied Natural Gas (LNG) bunkering facilities and Environmentally Differentiated Port Fees.

The European port sector has been monitoring selected environmental management indicators since 1996 as part of joint **ESPO - EcoPorts** initiatives. The ESPO new tool for European ports is **PortinSights**, the digital platform includes throughput data, environmental data (EcoPorts) and governance data.

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METAPHORS RELATING TO THE HUMAN BODY IN TRANSPORT TERMINOLOGY

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ABSTRACT

The aim of this paper is to explore the use of metaphors related to the human body in texts about transport. Using glossaries that are available in digital form, the author uses discourse analysis to obtain examples of metaphorical meaning. The results are then explained within the transport and logistics setting. The analysis points to the fact that the field of transport contains many metaphors relating to human body parts, such as: the head, arms, legs, neck and skeleton. It is also discovered that the use of metaphors in texts about transport presents a very powerful rhetorical device used in coining new words. In the pedagogical context, students are fond of metaphors, as they make the world vivid and they like to link the meaning of a word with the concept it derives from, particularly with the human body.

Keywords: metaphor, human body, discourse approach

1 INTRODUCTION

Language or the linguistic examination of a specialised corpus has become an unavoidable activity among teachers and researchers involved in teaching specialised genres. The reason for this lies in the fact that in the modern world genres are evolving at a rapid pace and language requirements are changing under the impact of new social and cultural changes. For example, the language of members of the transport discourse community has been affected by new technologies, digitalisation and globalisation, which is primarily reflected at the level of semantics. Lowe (2002) observes that rapid developments in sophisticated haulage and transport operations have brought with them many new generic and specialised words, abbreviations, “buzzwords” and specialised terms interpretable within the transport context. Although specialised discourses and texts, particularly of a technical nature, have to be precise and unambiguous, the metaphor, as a stylistic and rhetorical figure of speech, has settled into these discourses. The main essence of a metaphor is to link a real concept between two occurrences or entities that resemble each other. Moreover, metaphors are not only about comparing and linking between a target and a source concept – it is in human nature to explore, play with words, think about the meaning of things and associate them on the basis of related concepts (some conventional metaphors, such as thinking of the mind or life as a machine). One of the basic capacities of the metaphor is to understand the relationship between the source and target, a set of correspondences, or mappings, between the constituent elements of the source and those of the target (Kövecses, 2010). Metaphors are embedded in various technical and specialised discourses and their application in the classroom may help learners to identify and grasp the meaning of a technical term. Examples are: *ship's husband* or *sister ship* related to the domain of shipping or “way as a method” in mathematical discourse (Cameron, 2003). As regards the metaphors relating to the human body in transport that are explored in this paper, the way they contribute to a better understanding of the target word will be investigated. The transport world abounds in many complex words denoting a myriad of new sophisticated trailers, and hauling devices. The role of a metaphor where the nature of the vehicle is connoted with the human body, such as in *belly* (a space for placing cargo), *piggyback* (the action of transporting freight on the back of other vehicle), is to add a rhetorical and depictive flavour to specialised words. In other words, metaphors “humanise” (McClure, 2009) technical discourse, making it richer, creative and easier to understand. Likewise, as regards transport discourse, it might be assumed that a metaphor relating to the human body facilitates the expression of features of vehicles and mechanisms in terms of their design, means of transport, performance and duration. Thus the main objective in this paper is to explore the use of metaphors in the domain of transport in transport dictionaries.

2 METAPHORS IN TECHNICAL DISCOURSE

A technical metaphor is categorised as “subject-specific language” constructed through metaphorising non-technical language (Cameron, 2003). The very concept of technical discourse refers to a kind of specialised language used by members of a specific discourse community that employs general and specialised vocabulary, often closed to those who are not members of the community. This notion of the language representativeness of a discourse community and the types of genres at the macro level and micro level are developed and explored by famous linguists who emphasise the constraints of the vocabulary of technical genres (Swales, 1990), whereas non-specialists might feel like outsiders in specialised discourses (Bhatia, 1993). However, having in mind the multidisciplinary nature of science and speed at which new words are generated in the field of transport, the understanding of technical genres must be interpreted from the point of view of the circumstances in which they emerge (Roldán-Riejos & Ubeda, 2006). Some studies support the idea that metaphors contribute to the interpretation of technical and scientific communication and trigger imagination and mental images that are of relevance for creating meaning in that domain (Roldán-Riejos & Cuadrado, 2015). This study supports the hypothesis of metaphor-based scientific and technical communication, and especially of the importance of the role of visual mental imagery in the construction of meaning in this specific field. As regards the use of metaphors in the discourse of transport, the author has not found any relevant papers dedicated to this subject, but the metaphorical use of the discourse of transport and logistics was partially mentioned in one of the author's earlier papers (Dževerdanović, 2014).

3 METHODOLOGY

The approach taken in this paper relies on quantitative and qualitative methods. On the basis of an exploration of available online dictionaries, concepts relating to the human body were manually searched for and identified. Thus, one of the first steps in the analysis was to establish whether the term conveys a literal or figurative meaning, which required the help of professional transport books, subject experts in the transport field, and general and specialised dictionaries. Thanks to the availability of transport dictionaries in digital form, the target keywords were searched for in PDF files with the PDF reader's search function. The selected words were body parts (head, neck, body, eyes, hands, arms, life). Dictionaries and additional resources in the form of glossaries used for empirical analysis are representative for the field and are also available on the internet (Lowe 2002; Cavinato 2000). In order to interpret the calculated data, an interpretative method was used. This required consultations with subject teachers and books on transport (Daganzo, 2005; Waters, 2003).

In the analysis of the digital material dealing with transport, it was established that out of 10,000 entities, about 1,000 metaphors relate to the human body. Of course, not all the entities referring to the human body are metaphors. For example, the noun head is the basis for many spatial and physical metaphors, where the noun head refers to a central, leading part, as in instrument head. It is the same with the noun foot, that appears as many as 120 times (as in a twenty-foot equivalent unit denoting a measure of length). Therefore, attention has to be paid to differentiate between literal or figurative meanings or between a metaphorical and nonmetaphorical use of language.

Mappings or, in simple words, resemblances that constitute metaphors in our empirical analysis of transport dictionaries, are connoted with the concepts of structure, rigidity, strength, robustness, speed, and means of transport. The searched-for node words were neck, nose, head, body, arms, fingers, skeleton, legs, knees, foot, belly, backbone and eyes. The results are presented in the next section of the paper.

4 RESULTS

Head metaphors in the discourse of logistics are scarce. As already mentioned, the examples found mainly refer to the main operative part of the operational transport vehicle equipment (headlamps, headlights). However, there are two interesting examples – *headache rack* and *deadheading*. The meaning of the first example relates to the kind of transport where a certain cargo, such as pipes or specific slender cargoes, is carried extended and therefore protrudes above the cab of the trailer. It may be assumed that carriage of this kind of cargo requires special care. It is to be assumed then that a risky transport of part of the cargo that extends over the cab of a trailer poses a risk to the participants in the transport and the carrier, and is connoted with something that causes trouble and a headache. On the other hand, *deadhead* is related to passage without cargo or passengers, which most possibly relates to a boring or stupid person (hence "without brain, brainless or empty-headed").

Metaphors with *neck* are used to denote constraints or obstacles in a transport process, such as a traffic jam. Moreover, conceptual metaphors with *neck* are related to some kind of trouble and anger (Kövecses, 2010). In our corpus, the neck-related metaphor is *bottleneck*, referring to problematic goods or an obstacle to use a capacity. The similar meaning of a physical narrowing of the neck, for example, that of a vehicle, is found in *neck-in*. Here, the metaphor is based on physical resemblances between the target and the source word, but a human trait is found in the concept of a physical obstruction in the neck ("narrowing of the neck canal or a crick in one's neck").

The metaphors encompass material, physical, cultural and mental things that we find in humans. One of the most conventional metaphors implying movement and the dynamics of life is "life is a machine". In a physical sense, the human body resembles a machine with all the necessary elements, which must work in harmony. These metaphors found in transport in this paper are, for the most part, based on the resemblance between a machine (truck, trailer) and the human body. Thus, "to drop it on the nose" – used in transport discourse – is literally compared to a clumsy fall of a human (the comparison here is with a trailer dropping when uncoupled from the transport body and probably related to the *nose* part of a transport body, as in aircraft) .

There is no doubt that the fundamental part of every transport vehicle is the *body*, types of which vary according to the transport purpose and trade (*bottlers body*, *grain body*, *log body*, *panel body*, *platform body*, *demountable body*, *express body*, *dump body*, *skeleton trailer*). The action of dropping and falling, already mentioned, is given in *drop the body* and the metaphor here is a comparison with the human body's capacity to bend or tilt when dropping something (garbage or waste). The human body is certainly the vital element in human anatomy, where the *backbone* (as with vehicles) stands for the most important load-bearing element.

The most common component of the conventional metaphors is personification, where characteristics of human beings are attributed to nonhuman entities. Illustrative examples of this kind found in the corpus are *kneeling or kneeler* (referring to the capacity of some buses to kneel, that is, to reduce the height of their floors so as to make it easier for elderly and disabled people to get on or off).

Arms, legs and *fingers* are the most exploited terms in the discourse of construction and transport. They refer to additional or adjacent parts and elements of a construction site, of a crane, jetty, davit (or shore facilities), and of transport equipment in cargo-handling operations.

In transport glossaries, *fingers* relate to the protruding parts of a pier or jetty used to load or unload goods at specialised passenger terminals. Among the many conventional metaphors relating to hands as a part of the human body is the expression to "have one's hands full" (Kövecses, 2010). In our corpus the noun *hand* is not found in an idiomatic meaning – the noun *hand* in compound phrases is mainly used to denote a mechanism that is started manually as in *hand car* or *hand-held* terminal (a scanner that is held in the hand). However, the terms *on-hand*, as in *on-hand* balance or *on-hand* inventory or *hand stock*, may be said to contain a metaphorical meaning as they imply the quantity of goods that a company can rely on, have in stock and under control, as in "to have in hand" (to assume or keep under control). Unlike the previous term which implies abundance, the adjective *hand-to-mouth* is taken from commonly used language. This adjective refers to a difficult way of life (*hand-to-mouth* existence). However, in transport discourse, the term corresponds to bulk purchase of products due to a possible recession or financial crisis.

The noun *leg*, or the plural form *legs*, is only used as a part of a structure or support, as in *folding legs* or *landing legs* in a trailer or semi-trailer.

An example of cultural peculiarity is *at arm's length*, embedded in the general language and transferred to the language of transport technology, where *arm's length* refers to the relationship between the two parties (usually purchaser and seller) which is only founded on price and the delivery of goods.

Also, of relevance to human features and physical capacities is the term *fitness* – in transport discourse it is applied to determine the financial position of a company.

As regards the process of cargo carriage, one of the human-related metaphors pertaining to women and connoted with a specific way of transport is the term *belly*. In general language, the term belly refers to, among other meanings, a womb or uterus. A generic meaning was therefore conceptualised and has entered the world of transport, where it refers to the section for the carriage of cargo in a jet aircraft.

Finally, each transport unit or product has its *life* and duration. Illustrative examples of life-related metaphors, implying the duration of a product found in our corpus are compounds such as *life-cycle assessment* or *life-cycle analysis*. The "life time" of a product is important in an economic and environmental sense in transport and thus the *shelf-life* means the usable time of a product or beneficial time of an asset during its *life-cycle*.

The time for which a product can be used or exploited is called its *useful life* as opposed to its *depreciated life*. In light of such examples, the term used to denote the end of a product's limited life or the finite duration of a product which is usually determined by the manufacturer is a *lifed item*. Furthermore, a product or asset becomes obsolete and reaches the stage where planning has to be carried out for *end-of-life* products, whether by sale or by other methods.

The metaphor of family, origin or ancestry is very common, as humans belong to families: society is regarded as a family and a country as a parent (Kövecses, 2010). Metaphorical use of the word *parents* in technology or equipment denotes a product or transport vehicle that belongs to the same origin, i.e. manufacturer or producer with the licence. This is what connects the term *parent* from the general language with the transport terms *parent equipment, parent part, parent product, parent company, parent item* and *parent component*.

Finally, an interesting example of a metaphor not directly related to human body but to experiences characteristic of humans is *kissing*. In our context the target activity (the tyres of vehicles are rubbing against each other) is described with the metaphorical source domain (*kissing*), therefore, the state of the source domain is transferred onto the target.

5 CONCLUSIONS

This empirical study attempts to highlight examples of the metaphorical use of body-related parts or human characteristics in transport. Digital transport dictionaries facilitate the use of search engines within text files. However, the reading of each entity was required as not all the words containing body-related words are metaphors. Based on the idea that specialised and technical languages are recognisable for specialised vocabulary and metaphors, this paper focuses on establishing conceptual relationships between human body metaphors and transport items.

The metaphors found in our materials are mainly based on visual resemblances, where human body parts are compared to structural parts of vehicles and modes of transport and their features (health, fitness, robustness, strength, durability, life, decay).

Finally, a metaphor is a linguistic tool that calls for knowledge of the world or professional culture in which it is embedded. It might well be concluded that, from a linguistic point of view, the use of metaphors may be contradictory. On the one hand, the metaphorical use of language may be a way to keep the discourse of a particular discourse community members closed to other "intruders", while on the other it may impede understanding between the members themselves. However, the point of the metaphorical use of language is to make the use of the target domain understandable through the source domain. In the case of transport discourse, human body metaphors, along with life metaphors, help to conceptualise the transport world in its specific context.

As was stated at the beginning of the paper, students are fond of metaphorical use of language. Classroom activities can be designed so that the students are asked to extend and explore the meanings of words, to be creative and imaginative in connecting the source and the target word. In pedagogical contexts, establishing metaphors in any specialised or technical language might arouse students' imaginations and interest for the discourse or selected genres under investigation.

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HOW MANY WORDS DO SEAFARERS NEED FOR ADEQUATE READING COMPREHENSION OF CHARTER PARTIES?

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ABSTRACT

The article tends to shed light on the issue of proper reading comprehension of Charter Parties, primarily for non-native English speakers. For this purpose, we examined some of the most used BIMCO Charter Parties, with the total of 103,407 words. Using some of the latest corpus linguistics methods and software, we are examining the volume and type of vocabulary in the Charter Parties and the number of general English and academic words needed to achieve the recommended 95% and 98% of the corpus' words, respectively. The article also provides recommendations for the development and use of specific word lists the learning of which would make these goals achieved more easily.

Keywords: Charter Party, word list, reading comprehension

1 INTRODUCTION

Apart from being a considerable commercial activity with huge turnover figures, maritime transport has also been a global activity of multicultural and multilingual nature [1]. As of the foundation of the International Maritime Organization (IMO) in London in 1948, English has been the official language of formal maritime documents and communication. One of those official maritime forms, essential in overseas transport of today, has been the focus of our research attention.

This paper deals with the vocabulary of Charter Parties, named by the late Middle English term derived from French *charte partie* i.e. from Medieval Latin *charta partita* ("divided charter"), meaning one written in duplicate on a single sheet, then divided in such a way that the two parts could be fitted together again as the proof of authenticity [2].

CPs as a genre and their linguistics analysis are intriguing due to very specific discourse communities they combine – maritime and legal. On the other hand, their formal significance does not fall behind, since they present a valid legal document of an ever developing and prestige maritime industry [2]. In line with this, their adequate reading comprehension is of utmost importance, especially to non-native English speakers, which brings us to the key question of our research: *How many and what kind of English words do we need to adequately comprehend a Charter Party?*.

2 WORD LISTS AND READING COMPREHENSION

The relationship between the reading comprehension of a text and vocabulary mastering has been focused and perceived in new ways by many linguists and researchers in the past several decades. This has especially been the case in English for Special Purposes (ESP), where vocabulary plays an essential role in technical texts for professionals. The fact that these vocabularies are rather area-specific and differ from general English in the frequency of specific terminology, results in the creation of more and more field-oriented word lists.

In setting the goals for adequate comprehension of a text, there are two available thresholds researchers are led by. Laufer [3] sets the threshold of 95% of known vocabulary in the texts, while Nation [4] advocates for 98% of the text vocabulary in order to have ideal understanding of the text while reading, with the remaining 2–5 % being understood or guessed from the context. The goal being set, adequate word lists have proven the best and easiest means for achieving it.

The first list playing an important role and starting point for this kind of research was the West's General Service List (GSL) from 1953 [5]. It comprises 2,000 word families (headwords with all its inflectional forms and derivatives), obtained from the corpus of 5 million words. The lasting significance of the list is confirmed by the fact that much of subsequent research has been conducted against it. For example, the most influential Academic Word List (AWL) of Averil Coxhead [6] was developed in 2000 upon GSL, thus they have been used in pair in examining text coverages, so this will be the case with a part of our research, as well. For more detail, the idea behind AWL was to extract the list of the most common vocabulary for various scientific areas, outside of the first 2,000 most frequent English words (GSL). Obtained from the corpus of 3.5 million words of various academic texts, the final AWL contains 570 word families and covers approximately 10% of an academic text vocabulary.

In addition to the two above mentioned authors and their lists, there is another most-influential author and authority in this kind of research. In 2004, Paul Nation obtained 14 lists of 1000 words each from a 100-million British National Corpus (BNC), as a solid base for both the learning and testing of English knowledge. In order to make his lists even more contemporary, in 2012 he came up with a new set of 25 lists[1], which included also the Contemporary American English (COCA) or the total corpus of 450 million words of various written and spoken English areas. Also, he added four accompanying lists of the most frequent proper names, abbreviations, marginal words and transparent compounds.

In addition to the afore mentioned two lists (GSL and AWL), we are going to use the Nation's list for analyzing the type and amount of English words needed for reaching the adequate reading comprehension of our target corpus – Charter Parties.

3 CORPUS

Charter Parties of today, representing a written contract signed by the shipowner and the charterer (or their agents) for the hire of a ship partly or in full, for a certain time period or voyage, are more or less standardized forms – a genre. Earlier, there was a large number of similar documents the clauses of which often lead to misunderstandings and disputes. Therefore, for practical and legal reasons, standardized forms have been developed, some of which have existed since the late XIX and the beginning of XX century [2].

Standardized CP forms are issued by renowned maritime institutions. In recent times, the most recognized one is the Baltic and International Maritime Council (BIMCO) established in 1905, which examined the majority of the existing Charter Parties and gave and has been giving its recommendation for the most applied CP forms in the shipping of nowadays.

Based on the research conducted and some expert advice, we comprised our corpus of some of the most used and recommended BIMCO Charter Parties, both as sample copies and worked-out forms. The forms included in the vocabulary analysis were (for efficiency reasons, we are stating their official code names): GENCON (As Revised 1922, 1976 and 1994), GENTIME, SUPPLYTIME 2005, LINERTIME, BALTIME 1939, BARECON 2001, HYDROCHARTER (last amended 1997), ROPAXTIME, YARACHARTER, NUVOY 84, along with some additional clauses of work-out forms (e.g. Rider Clauses or Riders, or some explanatory ones). The idea was to include CPs for various purposes and types of vessels, bearing in mind the frequency of their use and diversity of vessels they apply to. The collection, selection and preparation of the relevant corpus resulted in 103,407 running words – tokens.

4 METHODOLOGY

The development of information technologies has brought new possibilities to corpus linguistics methods regarding both quantitative and qualitative analysis of real life texts. The method applied in this research was the so-called Lexical Frequency Profiling (LFP) [7] used for measuring vocabulary levels in a certain type of texts and classify it according to the lists assigned. For this type of analysis, we used the software developed by Anthony Laurence – AntWordProfiler 1.4.0w [8]. We also used AntFileConverter by the same author [9] in order to prepare the corpus for the analysis, which anticipates the conversion of the texts into plain text format. Additional “cleaning” and adjustment of the corpus is always needed in order to remove errors, references, tables, some proper names, diagrams and similar, in order to obtain a corpus that would be as “clean” and as appropriate as possible for the specific software analysis.

As mentioned earlier, in the analysis, we used GSL and AWL for comparison reasons (as they are generally used together in this type of research), but we also used the Nation's BNC/COCA word lists in order to obtain the level of general English words needed for reaching 95% and 98% of the coverage, respectively. Also, considering that all the lists are available as headwords, there is another software applied in this type of research – Familizer + Lemmatizer v2.0 [10] used for expanding the lists to all-member format and making them applicable for the LFP software analysis. The unit of measurement in this kind of research is most frequently word family, thus this will be the case with our analysis and results – a *word* here would stand for a headword with all its inflectional forms and derivatives. The rationale behind this kind of unit of measurement is the learning burden, i.e. effort one needs to put into learning a word, which is significantly reduced (it is much easier to understand a “new” word) if you are familiar with the headword or another word related to it.

5 RESULTS

The results obtained through the afore-explained methodology are presented in the form of tables.

5.1 Coverage of GSL and AWL in the corpus of Charter Parties

Table 1. shows the coverage of GSL and AWL in our target corpus of Charter Parties (CCP).

Table 1: Coverage of GSL and AWL in CCP

Word lists	Tokens	Coverage (%)
GSL	82,264	79.55
AWL	7,048	6.82
–	14,095	13.63
Total	103,407	100

If we compare our results to previous research, we can see that the share of general-purpose words in this genre (79.55%) falls within the range of 78% – 92% cited for ‘various written texts’ [11], but is rather bigger that the coverage of 70% – 71.9% in various academic texts, as reported by Coxhead [6]. This also means that, with the knowledge of 2,000 most frequent English words only,

[1] Available at: http://www.victoria.ac.ny/lals/about/staff/paul-nation

approximately every fifth word would not be familiar, which would make the reading/understanding of the text very difficult.

Also, the results point to somewhat lower coverage with academic words (6.82%) compared to the expected average of around 10% [6] in typical academic texts, such as research articles and textbooks (e.g. 10% in medicine [12], 11.17% in applied linguistics [13], 9.47% in pharmacology [14], etc.). Interestingly, it is even lower than the one reported for marine instruction books, which are extremely technical in nature [15]. It is still, understandably, higher than in typically non-academic genres, such as newspapers, where the AWL coverage is 4% [16]. To a large degree, the AWL covers words belonging to formal register [16], which is why some coverage of it is expected in all types of formal texts. Taking this into account, if we take a step further and divide GSL in the first and second 1,000 words and examine them as such (74.7% + 4.9%), we can confirm the importance of AWL share here, since it covers a bigger share of the text than the second 1,000 most common English words (6.82% to 4.9%) and that is considering only the words not belonging to GSL. Therefore, the coverage we found is still substantial enough that we may conclude that teaching/learning AWL would be a necessity during the studies of both – English for Maritime Purposes (EMP) and English for Legal Purposes (ELP), as it is generally the case with English for any academic purpose.

If we consider the cumulative coverage of GSL and AWL (79.55% + 6.82% = 86.37%), it fits within the average of 86.1% found in academic texts (Nation, 2000: 27). Although the AWL share was somewhat lower than in a typical academic text, we can say that, according to the cumulative coverage of GSL with AWL, Charter Parties can compare to the academic texts of various areas.

For the purpose of illustration, we used another option of the AntWordProfiler, which is one of the advantages of the programme compared to the others used. In the excerpt taken from our corpus, the words marked red represent the first 1,000 words of the GSL, whereas those marked green are from the second 1,000 GSL words. The words marked blue belong to formal academic vocabulary, as represented by AWL, while the rest of the words remain black.

Hire shall not contribute to General Average. Should adjustment be made in accordance with the law and practice of the United States of America, the following provision shall apply:
"In the event of accident, danger, damage or disaster before or after the commencement of the voyage,resulting from any cause whatsoever, whether due to negligence or not, for which, or for the consequence of which, the Owners are not responsible, by statute, contract or otherwise, the cargo, shippers, consignees or owners of the cargo shall contribute with the Owners in General Average to the payment of any sacrifices, loss or expenses of a General Average nature that may be made or incurred and shall pay salvage and special charges incurred in respect of the cargo.
If a salving vessel is owned or operated by the Owners, salvage shall be paid for as fully as if the said salving vessel or vessels belonged to strangers. Such deposit as the Owners, or their agents, may deem sufficient to cover the estimated contribution of the cargo and any salvage and special charges thereon shall, if required, be made by the cargo, shippers, consignees or owners of the cargo to the Owners before delivery".

Both-to-Blame Collision Clause
If the Vessel comes into collision with another ship as a result of the negligence of the other ship and any act, neglect or default of the Master, mariner, pilot or the servants of the Owners in the navigation or the management of the Vessel, the Charterers will indemnify the Owners against all loss or liability to the other or non-carrying ship or her owners insofar as such loss or liability represent loss of or damage to, or any claim whatsoever of the owners of any goods carried under this Charter Party paid or payable by the other or non-carrying ship or her owners to the owners of the said goods and set-off, recouped or recovered by the other or non-carrying ship or her owners as part of their claim against the Vessel or the Owners. The foregoing provisions shall also apply where the owners, operators or those in charge of any ship or ships or objects other than or in addition to the colliding ships or objects are at fault in respect of a collision or contact.

Figure 1: Coverage of GSL and AWL in a CP excerpt

5.2 Coverage of BNC/COCA word lists

As mentioned earlier, the rationale behind the first part of the analysis and research was to obtain comparative results on the lexical profile of CPs. Nevertheless, if we wish to answer the question about the quantity of (general) English words we need for adequate reading comprehension of this type of both maritime and legal forms, we need to use the Nation's BNC/COCA word lists (Table 2.).

Table 2: Coverage of BNC/COCA lists in CCP

BNC/COCA word lists	Coverage (%) (with word lists of proper nouns, compounds, abbreviations and marginal words)
2,000 (+ proper., comp., abbrev. and marginal w.)	79.59 (80,59)
3,000 (+ proper, comp., abbrev. and marginal w.)	90.74 (91,74)
4,000 (+ proper, comp., abbrev. and marginal w.)	93.10 (94.1)
5,000 (+ proper, comp., abbrev. and marginal w.)	94.7 (95.7)
6,000 (+ proper, comp., abbrev. and marginal w.)	95.8 (96.8)
7,000 (+ proper, comp., abbrev. and marginal w.)	96.2 (97.2)
8,000 (+ proper, comp., abbrev. and marginal w.)	96.8 (97.38)
9,000 (+ proper, comp., abbrev. and marginal w.)	96.61 (97.61)
10,000 (+ proper, comp., abbrev. and marginal w)	96.79 (97.79)
11,000 (+ proper, comp., abbrev. and marginal w)	96.84 (97.84)
12.000 (+ proper, comp., abbrev. and marginal w)	97.01 (98.01)
22,000 (+ proper, comp., abbrev. and marginal w)	97.47 (98.47)
25,000 (+ proper, comp., abbrev. and marginal w)	97.47 (98.47)

We started our results with the first 2,000 BNC/COCA words, where we can see that the coverage (79.59%) is almost identical to that of GSL (79.55%). This result might be influenced with "legalese" which tends to be more formal, even archaic to a certain extent, and therefore close even to "older" corpora such as those used for GSL [5]. Also, we calculated the cumulative coverage for the additional four Nation's lists, since they are also used in these kinds of analyses. Together, they amount to precisely 1% in our target corpus (0.39% + 0.13% + 0.35% + 0.13), thus we included them in the optional results given in brackets.

The overall results are interesting, since there is a huge gap between the two thresholds. The lower one of 95% [3] is reached as early as with 5,000 general English words with the most common proper nouns, abbreviations, transparent compounds and marginal words, and with 6,000 without them. This would be somewhat over the general vocabulary quantity reported for, for example, the reading comprehension of novels or newspapers (4,000 general English words with proper nouns [17]. On the other hand, the ideal level of 98% [4] is reached at the level of 12,000 most common English words together with the four additional lists mentioned, and without them it is not achievable even with 25,000 English words. In this case, we can say it is not reachable at all, considering that the results remain unchanged in the last several available hundreds of words (22,000 to 25,000). This would be far beyond the quantities reported in analyzing some general corpuses such as novels and newspaper [17], where 98% is reached with 9,000 and 8,000 respectively. This does not come as a surprise, since general and technical corpuses are not expected to be evenly covered by general English word lists. The purpose of technical word lists is therefore to make up for the gap between the first several hundreds of general English words, which would be common to every English text, and the desirable reading comprehension level.

If we compare the coverage to other results available to the best of our knowledge, we can say that this type of text is generally of a fair difficulty. Namely, it is not as demanding as some other maritime genres, especially, for example, instruction books and manuals, where 95% is reached only at the level of 12,000 [15], while it is similarly demanding compared to, for example, engineering textbooks, where 5,000 words would be sufficient for reaching the satisfactory threshold level [18].

Also, we can note here that the first 3,000 general English words cover as much as 93.10% of our corpus, whilst the subsequent 19,000 (and more) cover only about additional 4.5%. As in other technical areas, this would justify the creation of a specialized word list which would make even the ideal goal of 98% easily reachable with the basic 2,000 English words. It would certainly be of great assistance to seafarers, especially senior deck officers, but also agents and lawyers dealing with Charter Parties. This speaks in favour of the fact that Charter Parties are often accompanied with a set of words with their legal interpretation for the very document, in order to avoid any ambiguity or misinterpretation. The required accuracy is a reason more for heading for the ideal reading comprehension.

Again, for illustrative purposes, Figure 2. presents the same excerpt from above with different colours for various levels of general English vocabulary. The legend would be as follows: red – 1st 1,000 words, green – 2nd 1,000 words, blue – 3rd 1,000 words, pink – 4th 1,000 words, violet – 5th 1,000 words, orange – 6th 1,000 words.

Hire shall not contribute to General Average. Should adjustment be made in accordance with the law and practice of the United States of America, the following provision shall apply:
"In the event of accident, danger, damage or disaster before or after the commencement of the voyage,resulting from any cause whatsoever, whether due to negligence or not, for which, or for the consequence of which, the Owners are not responsible, by statute, contract or otherwise, the cargo, shippers, consignees or owners of the cargo shall contribute with the Owners in General Average to the payment of any sacrifices, loss or expenses of a General Average nature that may be made or incurred and shall pay salvage and special charges incurred in respect of the cargo.
If a salving vessel is owned or operated by the Owners, salvage shall be paid for as fully as if the said salving vessel or vessels belonged to strangers. Such deposit as the Owners, or their agents, may deem sufficient to cover the estimated contribution of the cargo and any salvage and special charges thereon shall, if required, be made by the cargo, shippers, consignees or owners of the cargo to the Owners before delivery".

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Figure 2: Coverage of BNC/COCA lists in a CP excerpt

We can notice that all the words from this excerpt fall into the first 6,000 general English words. We should note here that our intention was to detect a short excerpt which would reflect the communicative intention of both discourse communities, maritime and legal. Also, as we can conclude even from our short excerpt, the types of vocabulary (maritime, legal, general) are not evenly distributed throughout the CP texts. For example, we have almost strictly legal sequences, such as the clauses on indemnification, payment, insurance etc. On the other hand, we also have clauses dedicated to drydocking, maintenance, crew, ship condition etc., with more EMP vocabulary, although the tenor remains legally formal throughout the document.

5.3 Some limitations and additional notes

Another important point here regards the semantic distinction between various (professional) registers. For example, the word "average" has a well-known meaning in general English referring to a mean value of something. In maritime English, however, such as in this particular excerpt, the collocation "general average" refers to the total loss or damage to the vessel. Therefore, when it comes to English for maritime purposes, we always need to be careful and not take the words for granted. One simply needs to be familiar with this technical register, regardless the level of general English knowledge. Otherwise, we can be misguided by "familiar" words from general English, which, in this specific discourse context, have new meanings, often not easily or not at all relatable to the general one. This brings us to attempt to overcome this limitation of the research by trying to reach the higher recommended threshold of 98% [4]. We are in favour of, therefore, the higher level of known words, since some of the words detected as belonging to a certain level of general English, practically should not be counted as such, since their meaning in maritime (logistics) register is completely different and new.

In our research, we were also faced with the lack of similar research in this specific area. Although word lists are not a new phenomenon in foreign language teaching/learning, there are no maritime English word lists, to the best of our knowledge, or applicable legal word lists we could test against our target corpus. In particular, we were not able to find any available published word lists of the kind produced by a LP software, especially not related to maritime law or hire contracts, for example, regardless the common tendency to deal with these two specific professional registers. Since the purpose of developed WLs is to make the teaching/learning of key vocabulary as efficient as possible, it would be of good use here if there was a word list developed especially for Charter Parties. In addition to the first 2,000 or 3,000 words (as recommended by the leading authors in the area), with this specific list, reaching of any of the two recommended thresholds would be a much easier task.

Also, if we take into consideration that our excerpt, for example, was fully covered by the first 6,000 word families, while the entire corpus (103,407 tokens) could not be covered even with all the available general English words lists (98.47% at the most), a substantially bigger corpus might be able to bring us somewhat different results. Moreover, we tried to select the most frequently used CPs, as recommended by experts, still more types could be used in the corpus creation in order to make the research, or prospective word list, more comprehensive.

6 CONCLUSION

The aim of our research was to provide a lexical profile of Charter Parties as a very important form of contract used in maritime transport. Using a most modern software solution for the purpose, we were also able to answer the question on the quantity of required general English vocabulary one would need to adequately follow and understand this kind of written documents. Firstly, we came up with the conclusion that with the knowledge of 2,000 most common English word families, such as those provided by GSL [5], together with 570 most common academic words provided by AWL [6] would leave the reader with approximately every fifth word unknown, which would make an unacceptably low level of reading comprehension. Furthermore, we analyzed the corpus against available and most recommended general English word lists (Nation's BNC/COCA lists). The resulting conclusion is that one would need to know at least 5,000 – 6,000 English word families to adequately understand this type of text while reading. More favourably, it would require as many as 12,000 with additional lists provided by Nation for ideal reading comprehension of a CP text (98%), otherwise this threshold is not reachable at all. Moreover, some knowledge of English for maritime purposes would be a must, since a certain share of general English vocabulary has gained new meanings in maritime English, either individually or in collocations.

This brings us to another conclusion and recommendation. It would certainly be of great assistance if there was a specific word list created for CPs themselves, or for the area of maritime law, which would, together with the most frequent 2,000 – 3,000 English words, reach the threshold of 95% [3] or the ideal goal of 98% [4] more easily, therefore significantly reduce the learning burden. We certainly hope here that we have provided a modest contribution to a clearer picture of the requirements imposed not only on seafarers (senior deck officers), but also on agents and lawyers who often find themselves faced with the demanding task of proper understanding and interpretation of a Charter Party – a very specific genre pertaining to merged discourse communities, additionally burdened by legal liability.

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THE POSSIBILITIES OF NEW TECHNOLOGIES IN NAUTICAL TOURISM IN THE REPUBLIC OF CROATIA

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ABSTRACT

This paper aims to analyze the potential of contemporary technologies implementation in Croatian nautical tourism. Growing nautical sector in Croatia makes the investments in modern technologies profitable including its niches of yachting and recreational boating services. In Croatia, there are several thousands of vessels in charter and more than a hundred ports of nautical tourism. An overview of observed sector trends regarding the possibilities of implementation of new technologies is given, especially autonomous vessels technologies and green technologies. It can be concluded that Croatia has excellent potential for further development of nautical tourism concerning new technologies.

Keywords: nautical tourism, recreational boating, competitiveness, autonomous vessels, green technologies, the Republic of Croatia

1 INTRODUCTION

Nautical tourism is part of tourism sector offer that marks distinguished records of development in Croatia. Most of the Croatian's GDP is based on the tourism and because of that, a lot of effort is put into creating attractive tourism products both from the government officials as well as stakeholders working in the tourism economy.

The tourism as a branch of economy that includes exploitation of whole state's potential including nautical tourism potential. Croatia has an excellent capability for nautical tourism development due to the fact that it has 1244 islands, islets, cliffs and reefs in total (78 islands, 524 islets, 642 cliffs and reefs) [18]. Indented Croatian coastline and natural beauties offer numerous activities for nautical tourists. Further improvement of nautical tourism could enrich current tourist offer of the Republic of Croatia.

The analysis of the current state of nautical tourism indicates growth trend in the past several years. Every year, more and more recreational boaters come to Croatian coastline to spend their leisure time. Consequently, the rise in number of yachts and sailing boats is visible both for transit and stationed moorings. Due to the mentioned growing indicators, new nautical ports are built constantly and legislation is changed in order to capitalize possible income.

In order to assure leading Croatian position in the future concerning the nautical tourism, observation of technological advancements is necessary. With high-rate of technological innovations, many of which are being introduced into modern yachts and sailboats, nautical ports strategies and goals should be oriented towards possibilities of implementation of contemporary technologies that could facilitate future trends in nautical tourism with special emphasis on sustainability and investments in green technologies.

2 CURRENT STATE OF NAUTICAL TOURISM IN CROATIA

The foundation elements for prosperous industry of nautical tourism are those related to nature, infrastructure and superstructure of the state. Sea and coastal area are the most important natural resources for nautical tourism development. The abundance of natural bays and islands represents attractive elements for navigation and sojourn for tourists in nautical tourism. Indentation of the coast provides natural shelters and rich navigation opportunities [14].

Due to the Croatian geo-traffic position, coast characteristics, mild climate and favorable winds conditions for the recreational boating, Croatia has been positioned as one of the most desirable nautical destination in the world. This is indicated by the constantly growing result in the sector of nautical tourism. On the other hand, yachting and boating in Croatia has been marked by the periods of stagnation in the last decade concerning the capacity of marinas and berths for mega yachts although the demand for different size berths is quite notable [4].

2.1 Ports of nautical tourism

Croatia has 167 nautical ports on the coast of which 78 are marinas, 75 are anchorages, 9 moorings and 5 boat storages [3]. Ports of nautical tourism are classified into different types according to the *Ordinance on the* *categorization of nautical tourism ports and the classification of other facilities for the provision of berth services and accommodation of vessels* [16]. Types of ports of nautical tourism are determined by the service they provide and are classified as follows [16]:

- marina,
- nautical anchorage,
- nautical mooring,
- landfill of vessels,
- dry marina.

A marina is a part of sea (or water) and shore built and arranged for the provision of berth, accommodation of tourists on vessels and other services intended for the needs of tourists including drink, beverage and food services. Nautical anchorage is a part of sea (or water) suitable for safe anchoring of the vessels. Nautical mooring is defined as the sea (or water) and shore area used for berth services. A landfill of vessels is an arranged part of the land which is used for the disposal of vessels on land and the provision of services, including transport and other utilities. Nautical tourists are not allowed to enter vessel landfill and preparation for navigation is also prohibited in these areas. Dry marina is an arranged land intended for the accommodation of vessels on land and for the provision of transport and vessels lifting/launching services. Tourists are allowed to stay in dry marina and preparation of the vessel for the navigation is not prohibited [16].

For the classification of the port of nautical tourism it is necessary to fill in different types of paperwork, to obtain licenses and to adequately arrange infrastructure and suprastructure. It can be acknowledged that classification of different types of nautical ports is needed in order to diversify the market supply of the ports for the vessels in nautical tourism. Different aspects and features of the port can offer variant predispositions for the further development of the desirable type of nautical port and introduction of contemporary technologies in its functionality.

Table 1: Ports of nautical tourism in Croatia

County	Total	Anchorage	Mooring	Marinas
Primorje-Gorski kotar	30	9	3	18
Zadar	45	31	2	12
Šibenik-Knin	30	15	-	15
Split-Dalmatia	31	15	1	15
Istria	13	-	1	12
Dubrovnik-Neretva	13	5	2	6
Republic of Croatia	162	75	9	78

Source: created according to data of the Croatian Bureau of Statistics [3]

Table 1 shows the number of nautical tourism ports in Croatian counties an in Croatia. Most of the ports, 45 of them, are located in Zadar County. It is also important to mention that there are five boat storages in Croatia, three in Primorje-Gorski kotar County and two in Zadar County[1]. Ports of nautical tourism in the Šibenik-Knin County have recorded highest income of 31 million euro[2] in 2019, contributing the most in the total income of nautical ports [3].

Table 2: Capacity of nautical ports

Year	2015	2016	2017	2018	2019
Number of moorings	17351	17428	17067	17274	18179

Source: created according to data of the Croatian Bureau of Statistics [3]

Table 2 shows the number of moorings in the ports of nautical tourism from 2015 to 2019. In 2019, there were 18179 moorings in the Republic of Croatia, most of which were located in the Zadar County (4202) [3]. Private and state owners of marinas invest millions of euro in their marinas in order to increase their size and capacity and to add additional value. They largely invest in secondary or auxiliary services such as accommodations, restaurants, service and sailing centers. Majority state owned ACI (*Adriatic Croatia International Club*) is currently the biggest chain of marinas in the Croatia with 22 marinas located along the Croatian coast [1]. Other nautical ports are under concession regime and are governed by privately-owned companies.

The Adriatic Sea together with the Croatian coastline is visited by approximately 60000 yachts, sailing boats and other types of vessels every year, and by more than 300000 nautical tourists [4]. In 2019, there were 12100 permanently moored vessels in nautical ports, (5613 motor yachts, 5935 sailboats and 552 other types of vessel). The number of vessels in transit was 202412 (58892 motor yachts, 131373 sailboats and 12417 other types of vessels) for the same year [3].

2.2 Economical aspects of nautical tourism

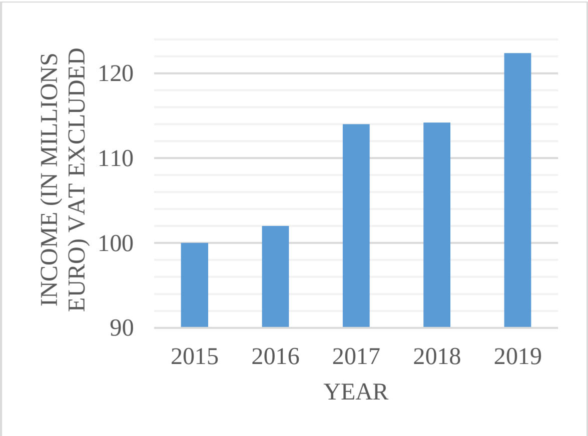
Tourism has become one of the key factors for economic growth of Croatia due to the fact that tourism revenue amounted to 19.8% of the Croatia's GDP in 2018. In 2017, that share was 19.6% and in year 2016 it was 18.01% of GDP. The year of 2019 was record year for Croatian tourism with more than 20 million tourist arrivals [15]. The share of nautical tourism in the sector of tourism amounts to around 113 million euro per year. The real contribution of nautical tourism to the tourism branch is around 667 to 800 million euro, if all economic entities of nautical sector are included (such as charters, restaurants, shops, catering services, ship repair companies) [9]. It is clear that there is an increasing trend of tourist turnover over the past few years which was the result of strategic document implementation *Tourism*

[1] Number of boat storages are not included in total column in Table 1.

[2] 1 EUR = 7.5 HRK

Development Strategy of the Republic of Croatia until 2020 issued by the Government of the Republic of Croatia [4] as well as the result of other contributing factors such as politics, legislation as well as foreign and domestic investments. Though nautical tourism in Croatia is still mostly categorized as seasonal due its dependence on weather conditions, the seasonal character has been changed. The season is extended to pre-season period and post-season period now thus enabling more profit and returnable investments [10]. Recent increased investments in nautical tourism in Croatia and construction of the nautical ports can be observed from an economical view due to the high rates of profitability that are connected with the positive income of other tourist niches. Reason for the mentioned is because boaters, and generally speaking nautical tourist, are on average better consumers than "classic tourists" [10, 5].

Nautical tourism is observed as one of the most dynamic type of recreational tourism due to its multiplier effect that can be recognized both in regular nautical experience and activities related with them vertically and horizontally. Vertically relevance can be seen in the business of shipbuilding (vessels for nautical tourists). Horizontal effect is associated with excursion tourism, diving tourism, servicing, etc. [12]. Nautical tourism has a significant contribution in creating a tourist offer of a country. Numerous types of yachts and sailing boats are being built and new technologies are being adopted in vessels architecture thus developing a constant need for sophisticated marinas and berth options. That technological advancement is encouraging local population and nautical country officials to invest in this type of tourism, increasing the possibility of employment for domicile population in this high valued tourist branch.



Source: created according to data of the Croatian Bureau of Statistics [3]

Figure 1: Total income realized in nautical ports in Croatia from 2015 to 2019

Figure 1 shows the income of the nautical ports in Croatia from 2015 to 2019. In 2015, the income was 100 million euro. The year after, it was 102 million euro and it represents an increase of 2%. Most of that income was realized by the renting of the moorings. In 2017, the income was 114 million euro, what represents an increase of 11.8% from 2016. Year of 2017 was a very good year for nautical tourism ports due to the highest percentage of increased gain over the past several years. This growth was even bigger after 2017. In 2018, the income was 114.2 million euro. Year of 2019 was a record year with the income of 122.4 million euro [3]. It is clear that increasing growth trend is elevating Croatia on world chart of nautical tourism. There are several reasons for that [11]:

- hospitality of the local population,
- beautiful nature scenes, mild climate and pristine sea,
- investments in ports of nautical tourism,
- enrichment trend of ports of nautical tourism with modern facilities.

Estimation of nautical tourism income is based on the revenues generated by [8]:

- vessels on a permanent annual berth in nautical tourism ports,
- transit berths,
- seasonal berths,
- nautical berths in the part of the port opened for public transport,
- maintenance and repair of the vessels and vessel engines,
- renting vessels,
- cruise vessels,
- different fees (vessel's registration, accommodation taxes, etc.),
- concessions,
- sales of the motor fuel.

Table 3: Income per year (in thousands of euro, VAT excluded) by type of income in nautical ports from 2015 to 2019

Type of income	Year				
	2015	2016	2017	2018	2019
Stationed moorings	55 487	56 367	59 907	64 474	67 227
Transit moorings	13 761	15 527	17 032	18 346	19 670
Maintaining services	7625	8026	8782	9301	9244
Other income	23 582	22 601	25 481	22 485	26 325

Source: created according to data of the Croatian Bureau of Statistics [3]

Table 3 shows income per year (in thousands of euro) by type of income in the nautical ports from 2015 to 2019. It can be clearly seen that renting of moorings (stationed and transit moorings combined) is the most profitable source of income for the ports of nautical tourism. In period 2015-2019, stationed moorings generated more that 50% of the total income.

3 MODERN TECHNOLOGIES IN NAUTICAL TOURISM IN CROATIA

Nautical tourism in Croatia is annually generating enormous amount of income making it one of the most profitable branches of the tourism economical sector. Croatian government is trying to ease legislation regarding the nautical tourism in order to attract investors for further development of nautical sector by endorsing acts and strategies that are fundamental incentives for progress in this niche of tourism. It can be stated that current position of nautical tourism is attractive and fertile enough to put long-term perspective of the nautical sector in Croatia into account. With that acknowledged, it is safe to say that investments in contemporary technologies, such as new types of vessel concepts as well as application of futuristic green technologies, represent the future solutions for competitiveness in nautical sector.

3.1 Autonomous vessels concept

Interest in autonomous vessels is steadily occupying the world's biggest investors, innovators, companies as well as European institutions. With the increasing development of new technologies, such as sensors and networks, the utilization of new technologies is becoming more and more significant. It is already known that this type of technology has already been applied in the shipping industry. It stems initially from Norwegian company Kongsberg and their vessel project "Yara Birkeland" [13].

To start with, it has to be acknowledged that this type of technology is quite expensive and it may take years even to make plans for possible implementation of this technology. Secondly, this concept is currently applied only on bigger ships compered to average length of a pleasure craft or a sailing boat (length of vessel "Yara Birkeland" is around 80 meters [13]).

To take into consideration application of this technology, it ought to be implemented on smaller vessels that could be used in ports of nautical tourism. Such vessels could be used to transfer tourists from their main vessel to the shore or to use that vessel for excursions on nearby islands. Croatia has a perfect setting for that kind of futuristic view due to the fact that it has indented coastline and mild weather conditions but infrastructure should undoubtedly be optimized for this kind of endeavor. It should also be emphasized that tourists tend to rent a skipper with the vessel while renting the vessel for their nautical experience. Skipper is a person in charge of the rented vessel but he/she is also responsible for the well-being of the tourists as well as the vessel. Autonomous vessel concept is in somewhat contradiction with the concept of vessel with the skipper if it is taken into account that skipper on the vessel represents some kind of an "folklore" or a custom that is usually associated with the whole experience of recreational boating.

Another term connected with the term autonomous vessels is resource efficiency. This concept is connected with increasing renewable energy sources on board the recreational vessels and yachts. This could lead to more optimized and self-sufficient vessels, reduced energy bills and new jobs in this market niche. This kind of innovative concept could also reduce energy consumption and improve the waste management system thus reducing the littering of the sea [6]. It is safe to say that this kind of technology is in close relation to the green technology concept.

3.2 Future of green technology application

Croatia has a potential for the future development of the nautical tourism but this potential has to be used in a sustainable way. This type of tourism should be considered on a long-term basis not only regarding economic and social indicators but also environmental indicators [10]. Green technology is a type of contemporary technology idea that has focus on protection of the environment. It is of the utmost interest for all shareholders involved in the nautical tourism to maintain sea and coastline clean and to reduce the risk of pollution that could, in other way, have hazardous effect both on the sea environment as well as on economy and society.

Yachts and recreational vessels mostly use internal combustion engines. Various gases and particles are emitted in the air by burning of fossil fuels (oils) in these engines. Also, there is a risk of oils leakage into the sea. Since the main purpose of the nautical tourism is directed towards the usage of the vessels on the sea, tendency should be to introduce alternative marine fuels that are environmentally more acceptable. Some authors stated that there is a possibility to use LNG and LPG as alternative fuels or more futuristic energy sources such as electricity, solar power, wind power or biomass [17]. Vessel operating on electrical power has already been introduced on the market by the Swedish electric boat manufacturer "X Shore". This type of vessel does not emit gases because boats engine operates on batteries [7]. It is important to acknowledge the value of this kind of incentives and their future application in the recreational boating. It will take time until manufacturing process of environmentally friendly vessels is introduced on larger scale as well as their adoption in the nautical ports. New electric chargers facilities have to be built in order to introduce more electrical power vessels into operation.

It is necessary to understand the importance of Croatia's government involvement in the processes of modernizing and developing green technology concepts. Several acts and strategies are used for the optimization of nautical tourism, as well as optimization of environmental solutions. The acts are: *Tourism Development Strategy of the Republic of Croatia until 2020* [4], *Nautical Tourism Development Strategy for the period 2009-2019* [8] and *Action Plan for development of the Nautical Tourism* [2]. One of the main goals is to increase the capacity and quality of the nautical tourism by introducing green technologies and other innovations hence creating an effective system of environmental protection while also increasing boating consumption [10]. The above mentioned is the foundation for the sustainable and "greener" nautical economy. Future development of the nautical sector should be taken into account together with new technologies and environmental standards implementation in order to protect natural values, biodiversity and environment [8]. The improvement of waste management systems, including collection of waste waters from recreational boats, yachts and cruisers, is very important issue in nautical tourism that should also be taken into account [4].

4 CONCLUSION

Nautical tourism has a significant share in the Croatian tourism hence it represents power driver for development of Croatian maritime and economic system. If annually growing activity of tourists, both in nautical tourism as well as in tourism generally, is taken into consideration, it is clear that Croatia has a great potential for further positioning among the leading tourist nations. Nautical tourism in Croatia is in relatively early stage of development, but nevertheless new records are set every year in terms of recreational vessels and nautical tourist arrival.

Since Croatian government recognized nautical tourism as part of vital offer than can be provided to the tourists in order to expand their experience, several legislation and strategies are adopted to establish prosperous and sustainable development of this tourist niche. On the other hand, some goals from the strategies are not carried out in complete manner. Many crucial aspects of Croatian nautical tourism should be improved. Those aspects should be revised by the professionals in order to fully adapt strategies for future more and more competitive market. Croatia has a chance to position her competitiveness on the future nautical tourism market by introducing new technologies while respecting environmentally friendly principles.

The implementation of new technologies is undoubtedly expensive and time-consuming process but it has potential to put Croatia ahead of its competition, if it is accompanied by attraction of investors (foreign and domestic) and adequate legislation.

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COMPARISON OF ENVIRONAMENTAL POLLUTION OF LAND TRANSPORT MODES IN GREEN SUPPLY CHAINS THROUGH PORT OF KOPER

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ABSTRACT

Environmental pollution is increasingly becoming a major global problem. Consequently, companies and policymakers are facing top-down pressure to reduce their impacts of logistics activities and make transport greener. The main objective in greening the transportation chain is the optimal use of the various modes of transport in complex transport chains, in order to achieve higher efficiency and greater environmental sustainability. Sustainability is shaped by socio-economic, demographic, and environmental megatrends, which causes the major shift in economic, social, and environmental areas to transform societies, companies, and people. European Union set the goals to shift 30% of the road freight transport over 300 km to other, more environmentally friendly means of transport (such as rail and waterborne), by the year 2030, and more than 50% by 2050. This article overviews upcoming trends of green intermodal chains, initiatives in green railway and truck transport, and how outstanding is the share of their impact in the transport chain as a whole. Thus, the paper outlines the information what is the impact of railway transport mode as an environmentally efficient transport in organizing intermodal transport chains from northern Adriatic port, Port of Koper, to the main hinterland European markets. Four scenarios are simulated according to throughput development plans and eventual rail modernization, exposing the relevance of investments in rail infrastructure from the sustainable transport point of view.

Keywords: Supply chain, land transport, green transport, transport mode simulation, carbon footprint

1 INTRODUCTION

The world population is currently estimated at 7.6 billion people. Projections show that it will increase by 50% by 2100. The increased population also means a greater need for transport services either after the transport of passengers or the transport of goods. Transport will maintain its vital role in the future, as one of the key factors for maintaining the economic well-being, as well as the social well-being of each country. Despite the great progress made in terms of increasing efficiency and distribution activities over the years, transport will continue to produce harmful effects on the environment in the future. The consequences are manifested through many climate changes such as rising temperatures, rising atmospheric CO_2 concentrations, changing rainy seasons, rising sea levels, biodiversity loss, increasing ocean acidification, more frequent extreme events such as floods, droughts, and heatwaves. Many areas around the world are already experiencing global warming at the regional level, where about 20-40% of the world's population is exposed to temperatures at least 1.5 °C higher for a shorter period than one season [1]. The rise in temperature has consequently already affected significant changes in the adaptation of human and natural systems.

The European Union is responding to climate change mitigation with action plans on how to limit emissions within a given timeframe. For example, it has set itself the goal of making progress in the field of transport by 2030 through technical and sociological measures such as cooperation with key stakeholders such as policymakers, standardization, collaboration, and integration of the user perspective into the development and integration research process. Many existing strategies and published action plans address these issues in full or only in the area of individual passenger or freight transport. Such initiatives are driven by the research community, industry, or governments (policymakers), but rarely from a user perspective. European Union countries will have to reduce their greenhouse gas emissions by at least 20% by 2020 and by 60-80% by 2050 compared to 1990 emissions. In order for the transport sector to be able to contribute as much as possible to achieve the set emission reductions, it is essential to increase the efficiency of transport chains and introduce increasingly green technologies.

In looking for greener transportation, rail is very important, especially because it is usually more environmentally friendly compared to the road. Consequently, rail freight transport forms an important component in many countries' policies, especially in the EU. Albeit to all advantages of rail transportation, prioritization has not been made in praxis. The reason lies in many technical and administrative barriers that concern the incompatibility of the various rail systems within each other [2]. Such a discordance mainly incorporates issues as electric traction systems, signaling systems, customs procedures, work regulations, etc. In order to make rail transportation happen in a greater percentage, those issues will have to be dealt with in an effective way.

2 LITERATURE REVIEW

Climate change and environmental problems are key issues that governments around the world are trying to address by introducing new, stricter legislation with the aim of reducing the negative impact of industry and transport on the environment.

Individual companies are trying to respond to current environmental problems by implementing green supply chain (GSC) management models based on supply chain management with an add-on that takes into account efficiency and environmental impact [3] [4]. The European Commission for Large Volumes of Cargo, supports the idea of green transport corridors, first mentioned in the 2001 White Paper [5]. Later on, the concept of green transport corridors (GTC) was presented in a revision of the White Paper entitled “Freight Transport Logistics Action Plan”, which focused on “shifting” freight to greener modes of transport such as inland waterways as a complement to road transport and short sea shipping. The concept of GTC was further developed in the 2009 “TEN-T Green Paper” and later in the 2011 “TEN-T Policy Review”, and finally in the 2011 White Paper entitled “A sustainable future of transport”, where the European Commission presented the final concept of GTC as transport routes between major transshipment points over relatively long transport distances. Such transport routes are expected to have a reduced impact on the environment and climate change in the future while increasing the safe and efficient implementation of sustainable logistics solutions in the transport area. GTC thus promotes green logistics solutions, intermodality, information and communication infrastructure, common regulations, and strategically placed transport hubs [6]. The theoretical basis of GTC is related to sustainability aspects, multimodality, supply chain concepts, and their networks [7] [8] [9]. As the concept of GTC was defined at the political level, there were some different implementations of such corridors. Thus, the Baltic Sea Region (BSR), the EWTC - East-West Transport Corridor connecting the southern Baltic with the Black Sea, was established; Scandria, which connects Scandinavia and the Adriatic, RBGC - Rail Baltica Growth Corridor connecting the countries of the Baltic Peninsula with the Central Railway System; NECL-North East Cargo Link-Nordic green transport corridor between Norway, Sweden, Finland, and Russia.

In the field of the mentioned corridors, numerous studies were carried out on how to green the corridors, which differed from each other as they addressed the problem from different aspects (powertrains, fuels, transshipment machinery, vehicles, navigation technologies). Nevertheless, in all studies, they formulated common goals such as co-modality, efficient transshipment infrastructure, innovative transport units and vehicles, and innovative Information and Communication Technologies. When reviewing studies in the field of GTC of the TEN-T network, we find that there is a great fragmentation of these and the consequent lack of comprehensive organization and a clear, standardized structure of informing the user about the effects of GTC.

3 MATERIALS AND METHODS

The research basis on the research dilemma of how the operational policy of the transport process is reflected in a sustainable footprint. Therefore, research is based on the following research questions:

- what is efficient transport in organizing intermodal transport chains from northern Adriatic port, Port of Koper, to the main hinterland European market, and
- how can hinterland infrastructure modernization affect sustainable intermodal transport development?

The analysis is considering destinations of main hinterland European markets from Port of Koper to Debrecen, Erd, Banska Bistrica, Kladno, and Usti nad Labem that are not so often used in the researches but represent important business points in central Europe. Consequently, six services and connections from Port of Koper with various transport modes are analyzed from different perspectives, considering freight rates, pollution, and energy consumption. All environmental calculations from transport activities and energy efficiency of the intermodal chain have been carried out with EcoTransIT World calculator [10], although there are also other environmental calculators on the market (NTMCalc, DHL Carbon calculator). The basis for the calculation of emissions in EcoTransIT calculator is standard guideline EN 16528 (Methodology for calculation and declaration of energy consumption and greenhouse gas emissions of transport services) [11], which gives a very good foundation for transport industries evaluating their emissions. For the calculation of emissions with rail, the container train of 1,000t was chosen as train type. The electricity of class EU UIC 2 was chosen as traction with a load factor of 80% and 0% empty trip. The parameters for truck transport were diesel truck with EURO 6 emission standard and class 26-40t with load factor 80% and 0% empty trip. The weight was set at 14 t/TEU. The focus of the analysis was on inland transport by truck or train or combination of both, including container manipulation at the terminal.

For a better understanding of what are the environmental impacts or how could some government decisions occur in a real environment, if the containers are transported by rail or truck, we have envisioned different scenarios simulating real and theoretical conditions. Quantity of containers in Scenario is settled with the 10 TEU (20 - foot transport equivalent unit) throughput in Port of Koper. With formed scenarios, it is easier to make projections of “what-if” situations and better react to consequences possible. The design of these is very suitable as the accessibility of rail and road transport is changing. Therefore, the study consists of the following scenarios:

- **Scenario 0:** is describing the real current state where 47% of containers are transported by rail and 53% by the truck. It is deemed that rail is at full capacity and can no longer take the additional load. The same proportion is used for pollution level calculations to all analyzed destinations.,
- **Scenario 1:** it is deemed that the second rail track is already finished. All containers to the selected destination are transported by rail only. Scenario 1 is theoretically based and, in practice, almost undoable. Therefore, it serves only for a better understanding of other real scenarios.
- **Scenario 2:** is envisaging that the quantity of the containers shipped from Port of Koper to European hinterland markets as planned by the port for the next years to double container throughput till 2030. At the same time, we assume that demand for all destination studied, increase equally. There is still single-track line, so modal share changes to 23.5 % by rail and 76.5 % by truck, as all new container flows to central Europe would be transported by truck only. Scenario 2 is theoretically based and, in practice, almost undoable, especially when considering current road infrastructure capacity. Therefore, scenario 2 serves only for a better understanding of others to some extent, still real scenarios.
- **Scenario 3** is envisaging that the quantity of the containers shipped from Port of Koper to the hinterland European markets as planned by the port for the next years to double container throughput till 2030. There is a two-track rail line in service. It is assumed that increased throughput of containers will be transported by rail (76.5%), but at the same time, we take into account that for the commercial reasons road transport will still be present with 23.5%, especially in cases of fast supply chains deliveries. According to situations in other European ports, this could be a real scenario at the end of this decade.

4 RESULTS

The analysis of different scenarios of future transport growth and transport share between road and rail confirms generally known the fact that rail is greener than the truck. Further comparison of Scenario 0 with Scenario 1 (Table 1) reveals differences in pollution and the energy efficiency of the transport. A more detailed comparison for main hinterland European markets shows that in Scenario 0 transporting 20’ container consumes between 44% - 77% more energy than Scenario 1. Results obtained with EcoTransITworld calculator indicate that Scenario 1 consumes 31% less energy to Debrecen and Erd, 33% less energy to Banska Bistrica, and 44%, 39%, 40% less energy to Presov, Kladno, Usti nad Labem respectively (Figure 1). It is worth mentioning that transport by rail (Scenario 1) can be considered as indirect as truck needs to be used for last-mile delivery to fulfill door to door service. Having that in mind, we need to consider energy consumption for transshipment manipulation at the intermodal terminal, which requires 550 MJ, 347 MJ, and 295 MJ for every container move (load/unload) in Port of Koper, Budapest, and Dunajská Streda respectively. Comparing the pollutants of destinations reveals that Scenario 1 emits 64%, 63%, 70%, 72%, 63%, 63% less CO_2 emissions than Scenario 0 to Debrecen, Erd, Banska Bistrica, Presov, Kladno, Usti nad Labem respectively. Analyzing GHG emissions as CO2e and CO2 shows almost identical behavior to Debrecen, Erd, Banska Bistrica, Presov, Kladno, Usti nad Labem with emissions lower in Scenario 1 for 64%, 63%, 70%, 72%, 63%, 63% respectively.

Further inspection of pollutant data reveals substantial irregularity at Non-methane hydrocarbon (NMHC) where the transport in Scenario 0 for Debrecen, Erd, Banska Bistrica, Presov, and Usti nad Labem emits 92%, 92%, 93%, 93% and 93% more than in Scenario 1 respectively. Kladno is the only destination where the emissions of Non-methane hydrocarbon (NMHC) with 86% are not so high compared to others. Although being the half smaller quantity of containers transported by truck in Scenario 0, the pollutants where Scenario 1 is performing worse is sulfur dioxide and PM_{10}. It can be observed that transport in Scenario 0 emits 25% less SO_2 to Debrecen and 9% less to Presov, 28% less SO_2 to Erd, 19% less to Kladno, 24% less to Usti nad Labem and 8% less to Banska Bistrica. Comparing pollution with particulate matter (PM_{10}) reveals that Scenario 1 to Debrecen emits 49% more, to Erd 51% more, to Banska Bistrica 44% more, to Presov 35% more, to Kladno 48% more and 49% more to Usti nad Labem. Similar to other pollutants mentioned earlier, Scenario 0 emits 38%, 34%, 49%, 49%, 25%, 45% less nitrogen oxide (NO_x) than Scenario 1 to Debrecen, Erd, Banska Bistrica, Presov, Kladno, Usti nad Labem respectively. It is deemed that the most energy used on the transport to end destination happens in Slovenia because it is a mountainous country while other destination cities (Debrecen, Erd, Banska Bistrica, Presov) are flatter.

In Scenario 1, a full quantity of containers is transported with the rail only generating importantly lower GHG emissions. Thus, there is a strategical meaning for Slovenia to produce lower carbon emissions by supporting green technologies while being a part of the bigger environmental policy of the TEN-T network

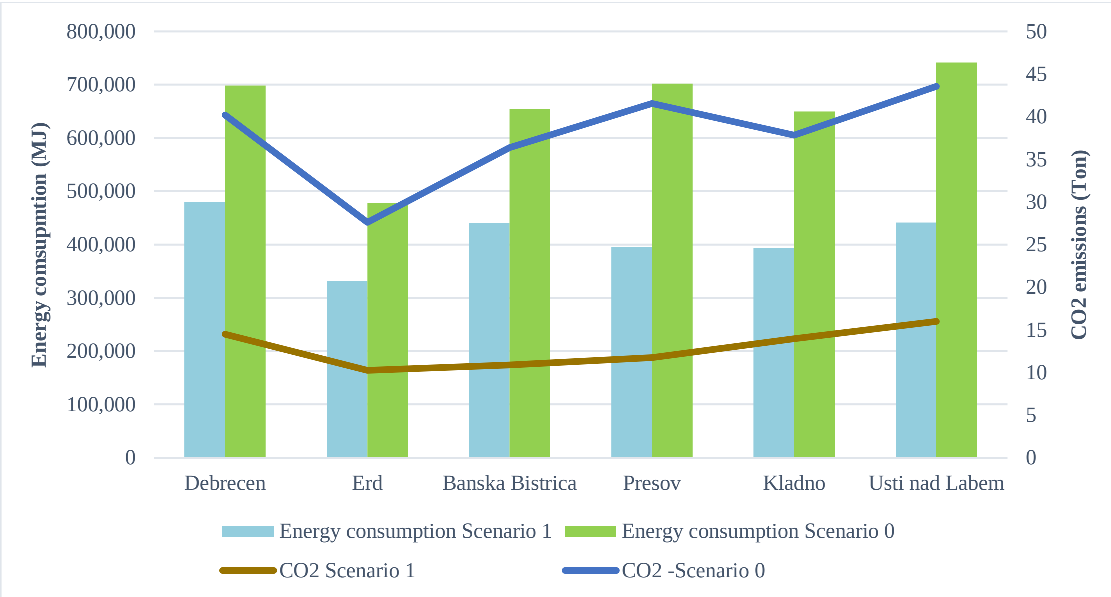
Table 1: Energy consumption and pollution in Scenario 0

Scenario 0	Debrecen	Erd	Banska Bistrica	Presov	Kladno	Usti nad Labem
Energy consumption [TJ]	698	477	654	702	649	741
CO_2 emiss. [T]	40	28	36	42	38	44
GHG emiss. as CO_2e [T]	42	29	38	43	40	45
Nitrogen oxides [kg]	34	23	29	34	36	36
NMHC [kg]	10	7	10	11	10	12
SO_2 [kg]	29	21	24	27	26	32
PM10 [kg]	2	2	2	2	2	3

Source: (own source)

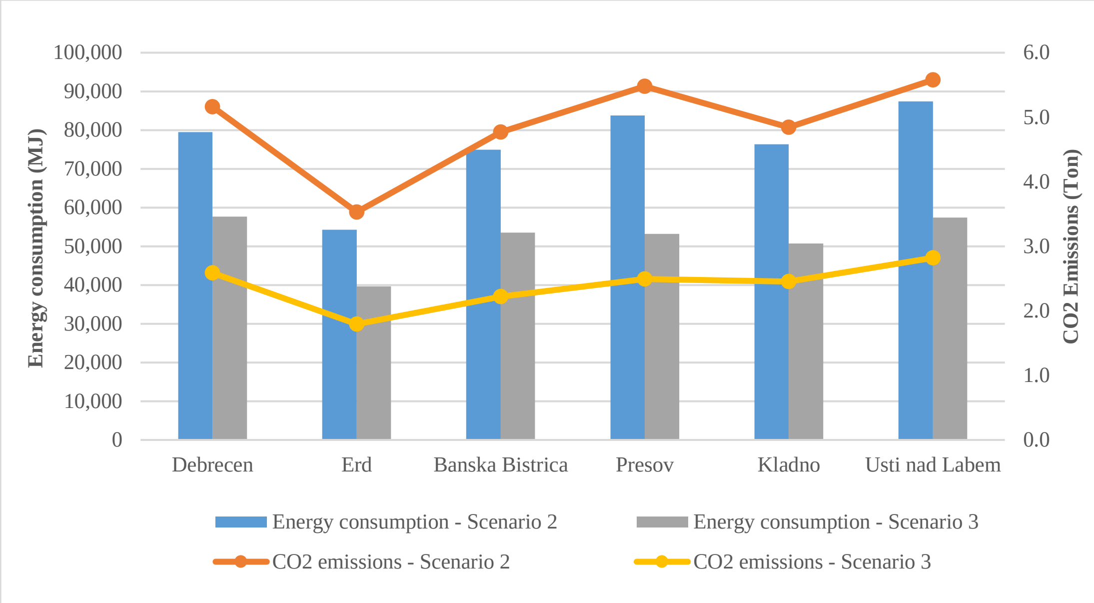
Comparing Scenario 2 with Scenario 3 (no additional measures as doubling the rail capacity vs. double-track rail) shows, that higher emissions in Scenario 2 are mainly at the expense of larger share of containers carried by truck transport, as the only option to achieve growth in container throughput in next years. The analysis of Scenario 2 highlights the importance of building second rail-track from environmental point of view.

Comparison of energy consumption shows that transport to the analyzed destination in Scenario 3 consumes 27%, 27%, 29%, 37%, 34%, and 34% less than Scenario 2 for Debrecen, Erd, Banska Bistrica, Presov, Kladno, and Usti nad Labem respectively (Figure 2). Both pollutants, CO_2 and GHG emissions as CO_2e are behaving nearly identical, so there will be studied only CO_2 data. As mentioned above, CO_2 emissions of Scenario 3 are smaller for 50%, 49%, 53%, 55%, 49%, 49% to Debrecen, Erd, Banska Bistrica, Presov, Kladno, and Usti nad Labem respectively. Detailed inspection of NO_x shows that emission to Debrecen in Scenario 3 is smaller for 32%, to Erd for 30%, to Banska Bistrica for 40%, to Presov for 41%, to Kladno for 22%, to Usti nad Labem for 38% (Figure 3). The biggest plunge from all pollutants compared between Scenario 2 and Scenario 3 has been observed with Non-methane hydrocarbon (NMHC) where the emission of Scenario 3 to Debrecen and Erd are smaller for 65%, to Banska Bistrica and Presov for 66%, to Kladno for 62% and Usti nad Labem for 66%. The slightly higher emissions in Scenario 3 compared with Scenario 2 can be found with Sulfur dioxide (SO_2), where for Debrecen emissions are 28% higher, to Erd 32%, to Banska Bistrica 8%, to Presov 9%, to Kladno 20% and to Usti nad Labem 27%.



Source: (own source)

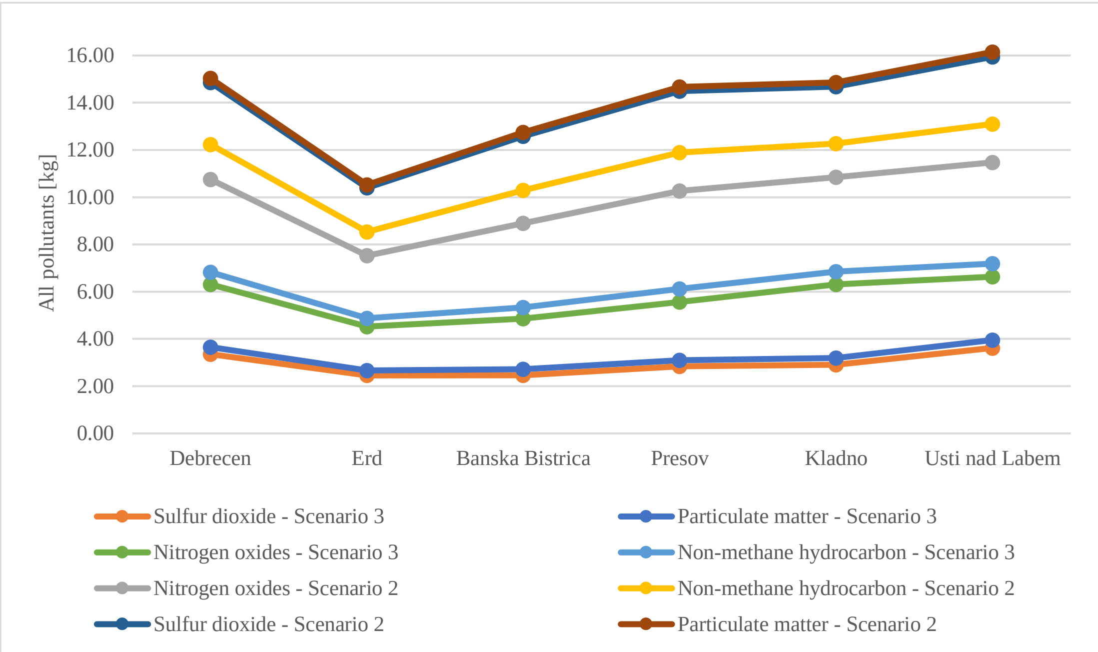
Figure 1: Comparison of energy consumption and CO_2 emissions for Scenario 0 and Scenario 1



Source: (own source)

Figure 2: Comparison of energy consumption and CO_2 emissions for Scenario 2 and Scenario 3

Similarly, it is observed with particulate matter (PM10) where values for Scenario 3 are higher to Debrecen for 62%, to Erd for 65%, to Banska Bistrica for 54%, to Presov for 42%, to Kladno for 61% and to Usti nad Labem for 63%. According to obtained results in Scenario 3, pollution plunged dramatically even when comparing it to Scenario 0 due just to a 25% reduction in using trucking for inland transport to or from Port of Koper.



Source: (own source)

Figure 3: Comparison of SO_2, NO_x, NMHC and PM10 emissions for Scenario 2 and Scenario 3

5 DISCUSSION

The combination of twelve intermodal transport possibilities from Port of Koper to main hinterland European markets of three countries (Slovakia, Czech Republic, and Hungary) demonstrates different decision options which transport mode to choose considering time pollution and cost. The comparison points out that the best choice to transport containers from Port of Koper (Slovenia) to the intermodal terminal of hinterland markets is with rail service. Such transport is greener (less energy consumption, CO_2 emissions, GHG emissions as CO_2, NO_x, NMHC, SO_2, and PM_{10}) than truck transport. Although being the greener and more suitable transport on larger distances, using truck transport should be preserved in minimal shares predominantly from commercial reasons, using it for fast deliveries in supply chains. Besides to ecological component, transport time should also be considered when contemplating which transport is better from environmentally economically and time perspective. Truck transport uses one day, and rail transport up to 3 days. From this, we can deduce that truck transport is more flexible than rail, which is the reason to deploy truck transport for a short distance or last-mile delivery.

Comparing the transport rates in table 2 for rail and truck transport can be seen that in most cases rail is slightly more costly than a truck. Although the difference being small, for instance, 50€ (Rail VS. Truck) for Debrecen, the monetary difference in relation to time may represent a significant shortcoming that should be addressed in the future. The European Union is aware of it and it already started with revitalizing the railways introducing GTC which were introduced at the same time at the freight transportation logistics plan in 2007. The benefits of the green corridor policy should be felt most by small and medium-sized enterprises in the logistics sector [4]. In 2014, the EU launched green corridor managers as a tool in formulating concepts in planning, financing and work processes. It will be necessary to wait some time to see the effects of the new initiatives.

Table 2: Transport rates for rail and truck to the studied destinations

Koper to	Transport route	Final destination	Rail vs. truck rate in 2018 (%)
To HU	Koper via BUD	Debrecen	94.51
To HU	Koper via BUD	Erd	102.22
To SK	Koper via D. Streda	Banska Bistrica	127.18
To SK	Koper via Kosice	Presov	112.96
To CZ	Koper via Praha	Kladno	122.87
To CZ	Koper via Praha	Usti nad Labem	115.00

Source: (own source)

However, any policy affecting rail transshipment does not apply exclusively to rail, but also to other modes of transport. Many European policies and interventions are based on EU-funded research, which is later developed and carried out in line with policy in order to understand freight rail policy better.

The results show the ecological justification of the development of the second rail-track, and the shift of the largest possible share of containers to the railway. In addition to energy efficiency, significantly lower CO_2, NO_x, and SO_2 emissions are also important.

6 CONCLUSIONS

The choice of means of transport in the green supply transport chain is becoming an increasingly important factor. This research studies the choice of land transport from Port of Koper to the main hinterland markets of the EU. Transport operators often have very limited options as the transport mode is usually defined by the type of product and the distance that must be covered. Although being limited, their choice can significantly impact on the environment. The study compared rail transport and truck transport simulating different scenarios considering current and future development of infrastructure and container quantity. The study reveals that rail emits between 17-24 % less CO_2, 35-62% less NO_x, and consumes between 41%-55% less energy as truck transport. It has been shown that with no infrastructure measures taken as doubling the rail capacity, the environmental consequences will be seen in approximately 1.25 times heavier environmental pollution. On the other hand, investment in second rail track from Port of Koper and rail network modernization in Slovenia (in total worth between 1.3 to 1.5 billion EUR) where the container throughput would increase to 2 MIO TEU could save 4.8 TJ of energy (average for studied destinations) and decrease the carbon footprint by 499,453 tons (average for studied destinations).

Current research highlights that there is potential to improve the environmental performance of rail transport, especially in optimizing the infrastructure (second rail track in Slovenia), management of train compositions, and multimodal green corridors. The latter is more difficult to manage due to the larger number of transport operators. Further research on making the rail more competitive lies in improving the service of first and last mile, which can be done with improving the multimodal nodes in combination with information telecommunication technology. The current paper presents the basis for further research of implementation and evaluation on levels of green land transport and, at the same time basis for models of efficient decision-making intermodal transport.

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REVISION OF RISK ASSESSMENT METHODS FOR LNG TERMINAL SITE LOCATION

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ABSTRACT

During the process of LNG (Liquefied Natural Gas) site design (either off- and on-shore) one of the key factors are hazard identification and risk mitigation for potential spillage of liquified gas. From the very beginning of LNG 'career' in transport, this cargo has been treated especially carefully by safety engineers. The authors in the article present methods of risk evaluation with special care for consequences evaluation using different methods for a newly designed LNG terminal.

Keywords: LNG risk, consequence evaluation, HAZOP, FMA

1 INTRODUCTION

In the process engineering science and design of complex technical systems risk evaluation and assessment is a crucial step in means of new process design. In every branch where the liquefied fuel cargo (low flashpoint liquids or gases) is concerned apart from modeling tools like HAZOP, FMA, or FTA there is a need for detailed case modeling with the specific design criteria. HAZOP and relevant methods are practically very useful in many applications [16], [17], but as an empirical method must be followed by other concepts [18]. FTA literally has been adopted in many applications to mention [14] and [15]. Liquefied natural gas is transported by sea under pressure (usually small P_a~250 mbar) in fully enclosed cargo tanks. Another rising concern is using the LNG as fuel [19], where growing demand for this type of shipping leads to the needs of risk estimation and evaluation. In the article both the classic approach and computer simulation methods are presented. As a main cause of most accidents grounding and collisions are prevailing and has been investigated in [4],[10] and [5]. Consequence modeling as a complex phenomenon was followed in [6],[7],[8]. Usage of the described methods was to mention in [12].

2 THE CLASSIC APPROACH TO HAZARD EVALUATION

Typically, the identification of hazards in the LNG industry involves the use of formalized methods such as HAZOP (Hazard and Operability Study). This method allows the generation of hazards based on the analysis of deviations from standard operations and design. These may include mechanical/technical deviations, human error, or a combination of several factors. The key factor determining the usefulness of a given method of hazard identification is its openness to the creation of scenarios connecting the chains of events and time series. An example of the Hazop table - a single scenario sheet is shown in Figure 1. Some extension of the HAZOP method is the hazard analysis, where both exposure factors and the probability of failure need to be determined. In the next step, adding the analysis of consequences, we obtain a simplified version of QRA (Quantitive Risk Analyses). However, HAZOP does not allow for risk modeling - therefore it is necessary to add this element to the analyses. Some approximations are EPA regulations (US Environmental Protection Agency) included in RMP plans - (risk management plan) which defines LNG leakage for 10 minutes from leakage with a diameter of 50 mm. Such a risk, however, is not the only one possible and according to [1] it is necessary to take into account leakages with diameters:

- 10 or 25 mm - small leaks highly likely to occur during the life of the installation;
- 50 mm - serious leakage unlikely to occur during the life of the installation;
- 100-250mm - very serious leakage unlikely to occur during the life of the installation, but the analysis of historical data includes such leakages;
- FBR (Full bore rapture) - complete unsealing, an extremely rare phenomenon more likely for the pipeline than for the LNG tank. For cryogenic tanks, this is only possible in the event of the failure of multiple safety systems.

Causes	Consequences	Severity	Likelihood	Risk Ranking	Safeguards	Recommendations
Collision of a non-LNG vessel onto the LNG jetty/trestle	Interruption of business due to damage of the jetty or trestle	High	Medium	Medium	1. Jetty located within a regulated/monitored water way	A tug is the considered one of the more likely vessels to strike the trestle. Consider a load calculation for a trestle strike from a tug, and design the structure to handle this load.
					2. Navigation lights on the jetty and dolphins	Consider conducting a trestle/vessel collision analysis.
					3. Tugs available to assist ships to minimize collisions, as needed (if LNG vessel is present)	—
					4. Emergency shutdown of the LNG pipelines	—

Figure 1: Example table of HAZOP exposures. For: [1]

In the case of security design, the duration of the leakage and the amount of LNG evaporated is crucial. The most common safety feature is an automatic hydrocarbon detection system coupled with an ESD (emergency shutdown system) shutting down a section of the installation, thus limiting the amount of leakage. Such a system usually successfully cuts off a leak within 3-5 minutes. Frequencies of occurrence are most often obtained from historical data. It works quite well for systems like pumps or valves. However, for cryogenic tanks, there are not enough failures. In this case, it is recommended to use FTA (Event Tree Analysis) methods. The existing leakage probabilities described in the sources [2], [3] determine the individual values for the given elements of the installation. Some approximation for the frequency of failures is formula [1]:

$$F_{full} = 8.0 \times 10^{-6}(1 + 1000D^{-1.3})d^{-1.42} \quad (1)$$

Where: F_{full} is the total cumulative frequency of leakage $\geq d$ (per meter of pipeline per year), D is the pipe diameter (mm) and d is the damage diameter (hole) (mm). For example, if there is a leakage of 50 mm in diameter in a 400 m long pipe, the frequency will be: F_{full} = 4,38x10^{-7} (m/year) which seems to be a very small value but it should be remembered that on an LNG vessel the pipelines with a diameter of D=400mm are about 1km, which gives the frequency of leakage about F_{full} = 4,38x10^{-4} (year).

Other methods such as FTA (Fault tree analysis) or ETA (Event tree analysis), where the so-called initiating event is additionally introduced, are also used in more advanced analyses. Analyzing the study [4] in which the risk of LNG tank damage was studied, the values of individual frequencies of occurrence of damage to its key elements were obtained (Table 1).

Table 1: Frequency of events related to LNG tank damage[1].

Large LNG spill caused by	Frequency/year
mechanical damage to the integrity	8.8×10^{-6}
overfilling	1.2×10^{-5}
hypertension	6.5×10^{-7}
too low pressure	2.9×10^{-10}
interruption of the power line	2.6×10^{-6}
interruption of the output line	2.8×10^{-5}
The cumulative frequency for the tank	5.2×10^{-5}

Event Tree Analysis (ETA) modulates quite accurately how failure spreads, which factors amplify and which mitigate the potential effects. However, the analysis of consequences is based on the potential number of victims (PLL-potential loss of lives) given for: [2] in Table 2:

Table 2: Potential number of casualties (PLL) concerning the number of ship operations per year for LNGC [2]

Category of accident	PLL (victims for a year)
Collision	4.42×10^{-3}
Grounding	2.93×10^{-3}
Impact	1.46×10^{-3}
Fire and explosion	6.72×10^{-4}
During transshipment	2.64×10^{-4}
Total	9.74×10^{-3}

3 EVALUATION OF THE CONSEQUENCES

The assessment of consequences is based on an analysis of the phenomena resulting from the leakage of a tank, armature, or pipe (pipeline). These phenomena are as follows:

- Dispersion;
- Flashfire (fire - ignition of an air-fuel mixture);
- Pool Fire (surface fire - fuel burns in layers);
- Jet fire (fire of combustible gases escaping under pressure);
- Explosion BLEVE.

LNG is a highly flammable and explosive substance with a flashpoint of 650°C, rapid flame propagation, high rate of combustion (about twice as fast as petrol), and high flame temperature. Combustion is highly radiant, it easily creates a large fire surface, with the characteristics of turning back and re-explosion. Liquefied natural gas on ships is stored at low temperature (-162°C) and atmospheric pressure. After a possible leakage of liquefied natural gas, the initial LNG evaporates rapidly to form mixtures with air (outside the boundaries of UEL/UFL). In reaction to the surrounding air, it creates a cold vapor mist and condensate in the air. It is then diluted and heated to form a cloud of combustible gas with the air and reaches explosive concentrations between LEL and UEL (5% - 15%), which can lead to a vapor cloud explosion on contact with fire.

Boiling Liquid Expanding Vapour Explosion (BLEVE) is an explosion caused by a sudden leakage of LNG at a temperature above its boiling point at normal atmospheric pressure, resulting from thermal or mechanical damage to a tank. A BLEVE explosion is usually not a typical physical explosion, but a hybrid of a physical and chemical one [20].

When the tank shell (or other leakages) is damaged, the gas phase expands, rapidly reducing the pressure above the liquid, resulting in a rapid boiling of the LNG. In the case of ignition of escaping vapors, the combustion heat heats the tank, leading to a rapid increase in internal pressure (the second-factor increasing evaporation). When the pressure increases, the tank shell finally bursts (physical explosion) and the liquid released to atmospheric pressure suddenly becomes gaseous and expands 600x (600 times) its volume. The resulting cloud of CH_4 and air mixture is extremely explosive (chemical explosion).

The very effect of a given type of accident (fire, explosion) must be superimposed on the probability of arson of a gas cloud/leakage/unsealing. Besides, the ignition efficiency must also be assessed. The ignition probability value for flare is 1.0, for ship it is about 0.5, for medium voltage line about 0.2, for office 0.01. These values are eliminated by prohibiting the use of fire, electronic equipment, etc. on the LNG terminal.

The analytical method for assessing the radius of the danger zone is based on the equation[15]:

$$R = C_s(NE)^{\frac{1}{3}} \tag{2}$$

Where R- radius of the danger zone (m), E- explosion energy (kJ) at $E=V \cdot H_c$; V is the volume of combustible gas in reaction (m^3) H_c – Energy density (kJ/m^3) – for methane H_c=39860 kJ/m^3; N - - energy efficiency coefficient of combustion usually assumed at 10%, Cs is an empirical constant depending on the level of destruction of the fireball. Based on the calculation of the potential PERC failure, we assume that 5.2m3 LNG will get on board and evaporate, which gives us V=3.120m^3 of methane (CH^4), assuming N=0.1 and CS has given in Table 3.

Table 3: Evaluation of the LNG vapor explosion after the LNG spill on the gas carrier manifold.

E (kJ)	Level of damage	Cs	Damage to equipment	Losses in people	Damage radius (m)
1,24E+08	1	0,03	Severe damage/destruction of equipment	1% mortality from respiratory burns >50% percent impact of debris >50% cracked eardrums.	~7m
	2	0,06	Damage to facades and roofs	1% of the shrapnel impact 1% cracked eardrums	~13m
	3	0,15	Broken windows.	Shrapnel impacts	~35m
	4	0,4	Broken windows (10%)	-	~90m

4 CFD MODELLING

Computer numerical CFD (Computational Fluid Dynamics) fluid modeling is based on the mechanics of liquids and gases in continuous media. The following elements should be defined::

1. Liquid density $\rho = \lim_{\Delta V \to 0} \frac{\Delta m}{\Delta V}$
2. Specific gravity $\gamma = g\rho$
3. Specific volume $w = \frac{1}{\rho}$
4. The compressibility of a fluid (the ability to change its volume at a given temperature and pressure) is measured by the compressibility factor βp (1/Pa): $\frac{dV}{V} = -\beta_p dp$
5. Thermal expansion - the ability of a fluid to change its volume at a change in temperature (at constant pressure):$\frac{d\rho}{\rho} = -\beta_T dT$
6. Diffusion (molecular) in fluids - a process of molecular concentration compensation: $I_A = -D\frac{dc_A}{dl}$
   where I_A – the diffusion flux rate of component A, c_A – the mass concentration of component A, l – distance, D - coefficient of proportionality of molecular diffusion
7. Viscosity - the ability to transmit tangential stresses when its components move with each other at different speeds:
8. $\tau = \frac{T}{A} = \pm\mu\frac{dv}{dn}$
9. where T is the force tangential to the surface A, derivation dv/dn is the angular deformation rate, μ dynamic viscosity index (only for Newtonian liquids).
10. The ratio of dynamic viscosity ratio to fluid density is called kinematic viscosity ratio ν (m^2/s): $v = \frac{\mu}{\rho}$

Surface tension - the effect of molecular forces at the phase boundary. They result from the fact that the forces of interaction between liquid particles are greater than the forces of interaction between liquid and gas. A film is then made on which certain forces act. The measure of this force is the coefficient of surface tension or directly the surface tension σ, i.e. the ratio of the tensioning force F to the cross-sectional length of the film L, on which the force F acts: $\sigma = \frac{F}{L}$

Real and perfect fluids. In order to facilitate mathematical description of physical phenomena in fluids, simplified models of liquids and gases are often used in considerations, e.g.:

1. A non-sticky liquid in which tangential forces are disregarded when moving the medium: $\mu=0$;
2. Non-compressible liquid: $\rho=0$;
3. Perfect fluid, in which viscosity and compressibility, thermal expansion and surface tension are omitted
4. Ideal gas in which molecular volume, cohesion strength and viscosity are not taken into account. This gas meets the Clapeyron equation: $pV = nRT$
5. A thermodynamically perfect gas which meets the Clapeyron equation but is a viscous medium.

The Navier-Stokes equation is a general equation for fluid/real gas movement. It describes the principle of preserving mass and momentum for a moving fluid/gas. Changes in the momentum of a fluid element depend only on the external pressure and internal viscosity forces of the fluid or the pressure of the gas. The vector form of the Navier-Stokes equation takes the form of:

$$\frac{dv}{dt} = \mathbf{F}_{jm} - \frac{1}{\rho}\text{grad}\, p + \nu\nabla^2\mathbf{v} + \frac{\nu}{3}\text{grad div}\,\mathbf{v} \qquad (3)$$

In practice, time-dependent series must be calculated and the solution of these systems is feasible through numerical methods (analytical calculations are impossible) and dedicated CFD software (computational fluid dynamics). Stages of solving Navier-Stokes equations in the form of a simplified algorithm:

1. Identify the factors causing the flow:

- pressure difference,
- movement of the surface bounding the system,
- mass forces.

2. Choose the coordinate system and the equation form appropriate for this system, build a numerical model of the shape of the analyzed (terrain),
3. Determine the general form of the relationship between the components of gas/liquid velocity and pressure:

- determine the stationarity of the flow,
- determine the expected flow direction (v≠0)
- determine the coordinates of the non-zero components of the speed and pressure.

4. Specify the boundary conditions and/or initial conditions e.g.:

- no slippage on the contact surface liquid-solid (not applicable to gas),
- no tangential stress on the free surface of liquid/gas, equal speed and stress on the interphase surface liquid-liquid,
- symmetry condition (for the condition of symmetry dv/dt=0) the liquid/gas is stationary at the start of the process or is moving at a preset initial speed.

5. Simplify and solve the system of continuity equations and Navier - Stokes.

As a result of such an implemented algorithm, we can obtain both 2 (2D) and 3 (3D) dimensional models of leakage effects and transfer the behavior of gas and possibly fire/explosion imposed on the local terrain infrastructure and other elements. 2D models are often sufficient for the initial design and variable operating conditions. An exemplary layout for a 2D model is shown in Fig. 2. For the purposes of the detailed design, 3D models are necessary - see Figure 3 and 4.

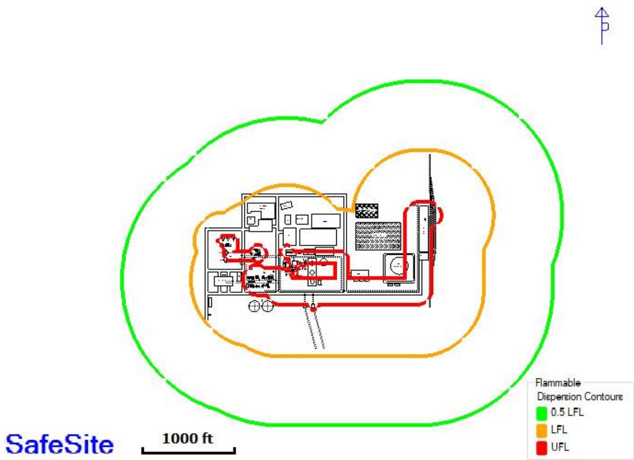

Figure 2: Modeling effect 2D CFD (source – web page: SafeSite – Baker Risk)

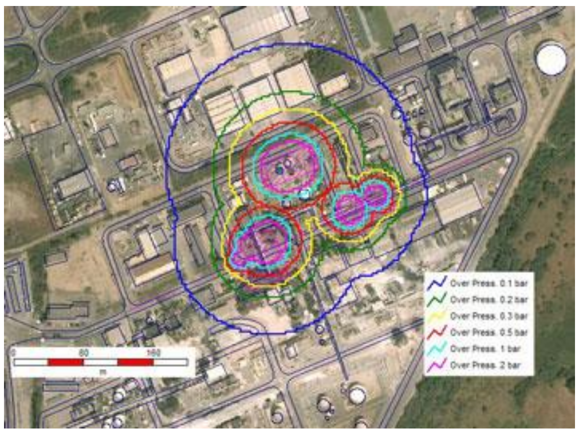

Figure 3: Modeling effect 3D CFD (source: DNV web page Phast - dnvgl.com)

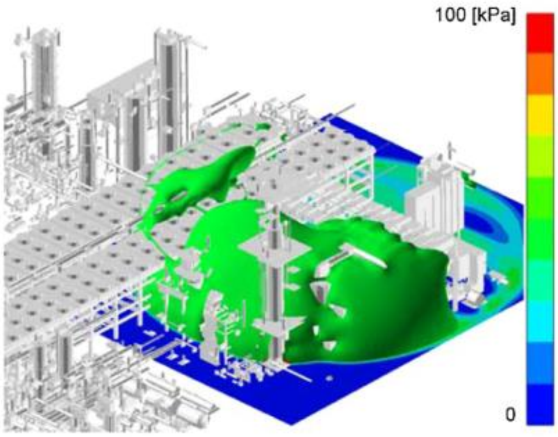

Figure 4: Modeling effect 3D [3]

5 GUIDELINES, STANDARDS AND RECOMMENDATIONS

IMO, SIGTTO, OCIMF, classifier, and other local recommendations apply to LNG sea terminals. However, it should be noted that there are no international standards for the whole, e.g. for risk modeling. Therefore, IMO standards [11] are applied (such as Formal Safety Assessment - FSA Liquefied Natural Gas (LNG) Carriers) for risk assessment for the offshore part and fire protection standards for the onshore part. Many standards and guidelines are taken from US institutions, e.g. US Federal Law 49 CFR Part 193, which refers to the design standards published by the National Fire Protection Association NFPA 59A (Standard for the Production, Storage, and Handling of Liquefied Natural Gas). This standard defines the area around the terminal that must be under fire protection control, i.e. where the radiant heat intensity does not exceed 5 kW/m^2 or is available to the civilian population. n addition, there is a zone where the radiation will not exceed 37.5 kW/m^2 n addition, there is a zone where the radiation will not exceed. A zone shall also be designated for vapor dispersion in which the concentration of the resulting hydrocarbon vapors does not exceed half of the LFL. However, these criteria are often criticized for various reasons, e.g.[8]:

1. Anthropomorphic diversity of people in terms of their ability to escape
2. The recommended methodology for Process Safety Management (PSM) as described in recommendations PSM 29CFR 1910.119 by the American Institute of Chemical Engineers (AIChE) and the Occupational Safety and Health Administration (OSHA) is not considered. It is used in the case of chemical plants.
3. The effect of LNG dispersion in the air related to mixing with oxygen under the influence of positive wind pressure in the basins should be taken into account when modeling the dispersion zone.
4. The effect of mixing LNG with oxygen for modeling the dispersion zone should be considered by the LNG carrier hull.
5. Use of LFL instead of half of LFL for modeling the dispersion zone.
6. Use advanced impact models such as DEGADIS, FEM3A, or LNGFIRE3. The latest version of NFPA59 from 2009 already allows this. Previously, only DOT and FERC models were considered.

Table 4 summarizes the standards and guidelines applicable to the issues discussed in the scope of supervision over the construction, design, and operation of LNG terminals.

Table 4: Standards and guidelines apply to the supervision of the construction, design, and operation of LNG terminals.

Standard/guideline	Description
49CFR Cz. 193	LNG facilities, requirements for construction and equipment, qualifications, training and protection
33CFR Cz. 127	Offshore LNG Installations
NFPA 59A	The standard for production, storage, and processing of LNG
EN1473	The standard for the equipping of onshore LNG plants. The standard introduces a risk management approach
EN1160	The standard for LNG facilities
EEMUA 14743	Guidelines for the construction of LNG cryogenic tanks
33CFR 160.101	Guidelines for the management of maritime safety
33CFR 165.20 & 33CFR 165.30	Regulations for restricted maritime access areas
MSC 83/INF.3	Risk analysis methodologies for LNG terminals and vessels

6 SUMMARY

The design of the new or expanding existing LNG terminal is always a demanding and wide approach. Having in mind national or international criteria is not always ‘the only way’ and new specific approaches must be applied by engineers. The necessity for this article was to summarize the existing methods and show their combinations in LNG terminal design in safety of processing areas.

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DEMAND RESPONSIVE TRANSPORT POLICIES FOR RURAL AREAS OF SIX CENTRAL EUROPEAN COUNTRIES

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ABSTRACT

The mobility challenges of rural areas stem from dispersed destinations, low population density and lower GDP levels, which create fundamentally different conditions for the provision of public transport services than in urban areas. The lack of sustainable mobility concepts is an obstacle for any development strategy implemented in rural and mountainous areas. One of the measures to improve accessibility is the concept of demand responsive (public) transport (DRT). DRT, as a user-oriented and flexible mode of passenger transport that adapts to the needs of its user groups, has been around for some time. Experimental flexi-route, dial-a-ride and community cars and bus schemes first appeared in the UK as early as the 1960s. From the beginning, DRT was associated with areas of low demand and areas without public transport services. It is only with today's Information and Communication Technologies (ICT), real-time routing and the increasing availability of smartphones, that technical restrictions and barriers to implementation have been removed and DRT is seen as one of the future measures for the provision of mobility services in rural and semi-urban areas.
Within the EU-funded project "SMACKER" DRT policies in six countries of Central Europe were analysed. The analysis showed that there are policies and laws that enable DRT. However, these services are still at an experimental stage and there are few examples of implementation in rural areas. Further development of DRT for rural areas can be an opportunity to ensure sufficient mobility choices for areas where public transport is inadequate.

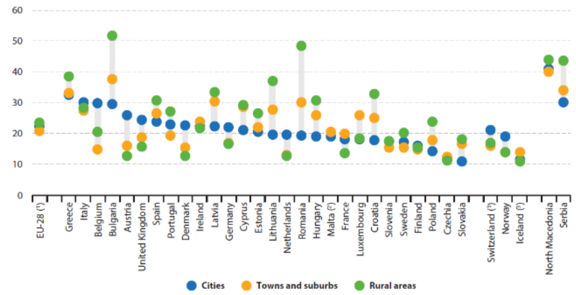
Keywords: Mobility, Demand Responsive Transport, Rural Areas, Public Transport, Central Europe, Transport Policy

1 INTRODUCTION

Predominantly rural areas make up half of Europe and represent around 20 % of the population. Most of the rural areas are also among the least favoured regions in the EU, with a GDP per capita significantly below the European average (European Commission, 2020). European cities, home to 70% of the EU population, generate more than 80% of EU GDP (Zavaglia, 2016).

Importantly, rural areas are affected by a consistent demographic change, which is mainly driven by the asymmetric distribution of economic activities between rural and urban areas (Porru, Misso, Pani, & Repetto, 2020). Access to health care, education, work and other services (e.g., shopping centres) for people living and working in rural areas is a key issue (Velaga, Beecroft, Nelson, Corsar, & Edwards, 2012). As Porru et al report, business headquarters, workplaces, and universities are usually located in large cities, leading rural inhabitants (in particular, young adults) to make a fundamental choice: move to the city or stay in the village, in the latter case by dealing with additional efforts to reach their destinations of interest. The depopulation of rural and semi-rural areas results in scarcely populated areas where proper public transport (PT) is difficult to provide due to low demand.

When it comes to mobility, its primary function is to provide access to educational and employment opportunities; health and social services; family and friends; healthy, fresh, reasonably priced products and other goods, etc. Low access to mobility can reduce opportunities to participate in society. (Kenyon, Rafferty, & Lyons, 2003). Lack of access to adequate transport – private or public which is acceptable, accessible, affordable and available and which can meet the economic and social needs of the individual or the community – is strongly linked to social exclusion (ibid). This clearly explains why governments regard public transport as a basic need for all inhabitants and include its provision in their law or national and regional policies (De Jong, Vogels, van Wijk, & Cazemier, 2011). This is especially important for rural areas for lack of adequate transport disproportionately affects people and communities who are at risk of, or who currently experience, exclusion – for example, rural dwellers, residents of urban 'sink' estates, older people, lone parents, people with disabilities, people who are unemployed and people on a low income. (Kenyon, Rafferty, & Lyons, 2003). Rural residents are at higher risk of poverty or social exclusion that residents of urban areas (Figure).



Source: Eurostat regional yearbook 2019 edition (European Commission, 2019)

Figure 1: People at risk of poverty or social exclusion, 2017 (% share of total population, by degree of urbanisation)

Yet rural mobility has received far less attention from policy-makers than urban mobility and there is a serious lack of conventional transport and of various shared mobility options that are being deployed in many urban areas (European Network for Rural Development, 2019). One of the reasons can be linked to economic reasons – namely in rural areas, with a density of no more than 200 inhabitants per km2, public transport is often cost-inefficient due to few passengers and long distances between stops (De Jong, Vogels, van Wijk, & Cazemier, 2011). The PT service can end up being underused, consequently generating unsustainable costs (Porru, Misso, Pani, & Repetto, 2020) resulting in poor provision of public transport because of its high costs. Consequently the reality for many rural areas is few buses, even fewer train stations and an almost total dependence on cars (European Network for Rural Development, 2019). Many people cannot imagine their life without car even in the relatively densely populated regions of Europe, for lack of adequate public transport (Sitányiová, Masarovičová, Berselli, & Nicolini, 2018).

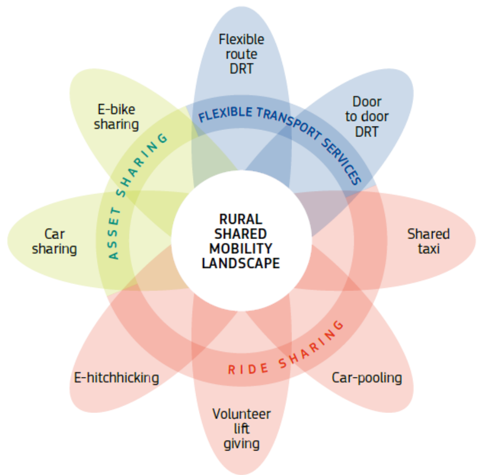
2 DEMAND RESPONSIVE TRANSPORT - DRT

Over the years, many different approaches for providing public transport in low-density areas have been tested. It appears that a well-managed combination of factors in the public transport system is necessary in order to achieve success (De Jong, Vogels, van Wijk, & Cazemier, 2011). An improvement in the affordability, accessibility, acceptability and availability of private and public transport could increase use and thus decrease mobility-related exclusion (Kenyon, Rafferty, & Lyons, 2003). Public transport regulators worldwide are now taking a pro-active approach and embracing innovative, people friendly public transport solutions, such as Demand Responsive Transport (Logan, 2007), that may be economically viable and efficient while at the same time environmentally friendly (Sitányiová, Masarovičová, Berselli, & Nicolini, 2018).

But what exactly is demand responsive transport? When it comes to public transport, the organization of it can broadly be separated into two groups: scheduled transport and demand responsive (flexible) transport. Scheduled transport is public transport that runs via a pre-set schedule, independent of the amount of passengers that travel on that particular day, time and route (De Jong, Vogels, van Wijk, & Cazemier, 2011). On the other hand, demand responsive transport (DRT) is a flexible mode of transportation that adapts to the demands of its user groups (day-to-day operations are determined by the requirements of its users) (Interreg Europe, 2018). Typically this involves users contacting a booking service (web, app, phone), which will then plan a route for the day to pick-up users and take them to their required destination (ibid). With qualities of bus and taxi, the term covers a wide range of vehicular transport solutions; from traditional 'dial-a-ride' services that provide social transport booked by phone, to new transport services that allow journeys to be booked through a mobile app (ARUP, 2018)

DRT is not a new concept. In developing countries, informal 'paratransit' systems are often a key form of urban transport. Within the context of a developed country, until recently DRT had found most success as a rural community transport solution, used where conventional bus services do not exist, often due to their financial instability and requirement for heavy subsidisation (ARUP, 2018). DRT, digital or otherwise, is generally implemented as a niche service to provide for particular journey or passenger characteristics without consideration of modal integration or macro transport outcomes (ibid).

Flexible transport systems bring a promising approach to improving the efficiency and performance of passenger transportation services in rural areas. They provide passengers with flexibility in choosing routes, times, modes of transport, service provider or payment systems (Porru, Misso, Pani, & Repetto, 2020).



Source: (European Network for Rural Development, 2019)

Figure 2: Mix of modes and services complimentary to conventional route-based public transport for rural communities

Obviously the DRT alone is not an answer to all mobility related problems, but a mix of modes and services designed specifically for rural areas in addition to conventional route-based public transport (predominantly operated by buses) might be the answer as proposed by European Network for Rural Development (figure above).

The literature reveals, however, that these (DRT) solutions are seldom supported by robust, formalized policy. (Logan, 2007).

3 MOBILITY POLICIES FOR RURAL AREAS

In the European Union, transport and mobility play a fundamental role. This is reflected in the EU's transport policy that endeavours to foster clean, safe and efficient travel throughout Europe, underpinning the right of citizens, goods and services to circulate freely within the single market (European Commission, 2019). The disparity between urban and rural areas is also well recognized and various policies are in place – from rural development policies, regional policies to policies dealing with transport and mobility (European Commission, 2020).

The European policies are reflected in EU macro-regional strategies that address common challenges faced by a defined geographical area relating to Member States and third countries located in the same geographical area. The four macro-regional strategies concern 19 EU member-states and 8 non-EU countries:

- The EU Strategy for the Baltic Sea Region (2009) - EUSBR
- The EU Strategy for the Danube Region (2010) - EUSDR
- The EU Strategy for the Adriatic and Ionian Region (2014) – EUSAIR
- The EU Strategy for the Alpine Region (2015) – EUSALP

All the macro-regional strategies listed above are accompanied by a rolling action plan, which is regularly updated in the light of new and emerging needs and changing contexts. All four macro-regional strategies address transport and the improvement of mobility and multimodality of people and goods. Rural mobility is addressed within these themes.

4 DEMAND RESPONSIVE TRANSPORT POLICIES FOR RURAL AREAS OF SIX CENTRAL EUROPEAN COUNTRIES

The transposition of European policies and directives into national policies and laws differs among EU Member States – rural and mobility policies are implemented in different ways. This results in very diverse basic conditions under which demand responsive transport can be implemented, and this should not be neglected. The SMARTA project has conducted an in-depth analysis of the framework conditions for rural mobility in the EU-28 Member States. A number of insight papers have been produced describing the framework (policies, obligations, resources, objectives, etc.) within which rural shared mobility takes place in a given country (SMARTA project, 2020). These insight papers show that practically no European country has an explicit rural mobility policy that combines a vision with practical measures, such as commitments to provide mobility services, specified targets, allocation of responsibilities or the role that local actors can play (European Network for Rural Development, 2019). The work is continued in project SMACKER, funded under Interreg Central Europe programme, which has further investigated DRT-related policies and legislation in six European countries (Hanzic, et al., 2019). Findings for each country are presented below.

4.1 Austria

Austria has a predominantly rural character - more than 80% of the territory is rural, where 66% of the total population lives (SMARTA project, 2020). Austria is facing a population decline in peripheral rural areas, therefore the first Austrian Master Plan for Rural Areas was developed in 2017. It deals with the topics of agriculture, forestry, economy, infrastructure and mobility as well as the digital village. It states that reliable local public transport is essential for the sustainable development of rural areas as places to live and work (Hanzic, et al., 2019). The establishment of mobility networks between small and medium-sized rural centres is considered very important - in rural areas, individual everyday mobility should be made possible by combining different mobility options.

At regional level, policy is administered by the federal states, which also manage the transport umbrella organisations (Verkehrsverbund). These organisations tender and contract all transport services within the region. This includes DRT if the transport association considers it important for the entire public transport network.

The management of mobility at local level is highly dependent on policies at national and regional level. In the transport sector, local authorities play above all the role of co-financers in transport networks and transport associations. Although specific local policies on e-mobility have been identified, this is not the case for policies specifically related to DRT. There are some local examples of transport with DRT characteristics (hailed shared taxi service).

The situation could be related to Austrian legislation, which does not specifically deal with DRT, however it mentions flexible transport operated by a bus operator. Regardless, if the flexible service has no elements of regularity, commercial and public nature, no clear legal definition is given in Austria.

4.2 Czech Republic

In the Czech Republic 34 % of the population lives in rural areas, 30 % live in cities, the rest in intermediate areas (towns and suburbs) (SMARTA project, 2020). The Czech Republic has a decentralized system of government with a national government and 14 self-governing regions (13 regions + capital city of Prague). With the exception of Prague, which is headed by a mayor, all other regions are headed by a regional governor. The administrative units are responsible for development issues in their territories, including education, sanitation, healthcare and environmental affairs (Hanzic, et al., 2019). The country has the highest fragmentation of all EU countries with more than 6,250 municipalities, the majority of which have a population of less than 500 inhabitants (SMARTA project, 2020). In 2013, *The Transport Policy of the Czech Republic for 2014 – 2020 with the Prospect of 2050* was adopted. The document is important because it delegates responsibility for the development of regional transport plans and the organization of integrated regional public transport to the regions. Among the recommendations to regional authorities, the following statement is of particular interest: "Introduction of alternative systems for serving sparsely populated areas (bus on demand and the like)" (Hanzic, et al., 2019).

Regional Czech Republic governments, together with local governments, have full responsibility for regional transport. There is an obligation to organize public transport at regional level, but municipalities have the power to organize transport and mobility on their own territory. This leads to a fragmented organization of public transport based on separate transport systems. Integrated transport systems (i.e. systems that are interconnected in terms of traffic, tariffs and information) are sometimes organized with limited functionalities without significant connections between regions. The approach to the organization of public transport (economic, spatial, modal, integrated) is very heterogeneous, which leads to growth of regional disparities. No policies specifically addressing rural mobility and/or DRT were identified.

Czech legislation addresses the DRT - the Act on Road Transport defines "occasional road passenger transport", which is subject to several restrictions in order to avoid unfair competition with taxi services:

- It is not allowed to collect fares in transport without fixed route schedules.
- DRT can be legally operated only free of charge or based on prepaid fares.
- Bookings can be made only with the central dispatcher office (by phone, online, personally).
- DRT is subject to higher VAT than fixed-route transport.
- Only fixed route-buses can stop at bus stops.

While public transport is highly subsidized, standard taxi services maintain high market prices. The difficulties in a wider use of DRT are related to its positioning between these two opposing sides of the transport systems. The operators and advocates of DRT are striving for more favourable conditions for DRT and its equality with public transport with fixed routing.

In Czech Republic the introduction of DRT is hampered by legislation, although policies on national level stimulating implementation of DRT exist. As in Austria, there are some examples of transport with DRT features (dial-a-bus with fixed schedule).

4.3 Hungary

From a territorial perspective, Hungary can be classified as a predominantly rural country with 66% rural areas, where 32% of the population live (SMARTA project, 2020). The country is characterised by an urban-rural divide. Administratively, the country is divided into 19 counties, the capital Budapest and 23 cities with county level authority. The counties are further subdivided into 3,175 communities organised by settlements (including 2,863 municipalities, 265 towns), while Budapest is further subdivided into 23 Districts.

At national level, several documents deal with national priorities for the transport and mobility sector. The focus is on infrastructure development, improving public transport services and improving regional accessibility (with priority given to the development of sustainable urban and suburban transport and the modernisation or development of local train lines in rural areas). The Territorial and Settlement Development Operational Programme (TSDOP) 2014-2020 supports regional, decentralised economic development. One of the development priorities is "friendly and population preserving urban development", which includes support for the development of sustainable urban transport, the expansion and development of public services and the development of deprived urban areas. These include demand-driven passenger transport services in the area of urban-rural (small town) and rural development with the aim of solving transport problems in small villages and sparsely populated urban areas (i.e. suburbs) (Hanzic, et al., 2019).

Under the Hungarian transport act, minimum level of service is defined: each settlement has to be directly connected to the nearest regional centre and to Budapest with two transfers. Additionally cities with county rights must have direct links to Budapest as well as to their neighbours.

The rural mobility policy of Hungary is mainly an extension of the urban mobility policy and is focused on rural settlements in connection to urban cores.

Within legislation no DRT specifics were identified. Yet a proper DRT service is operated by BKK (Centre for Budapest Transport) in Budapest.

4.4 Italy

Italy is a highly urbanised country, yet rural areas make up a large part of the national territory. These rural areas, which are characterised by an inadequate supply of and access to basic services, account for 60% of the national territory and about 24% of the population (SMARTA project, 2020). Italy has a decentralised institutional structure, which is articulated at different levels: the State (with several central public entities), the Regions, the Provinces/ Metropolitan cities, and the Municipalities (the basic local authorities). This complex structure leads to a complicated system of policies dealing with transport and mobility.

Rules, performance indicators, criteria for setting tariffs, charges and tolls and the minimum content of user rights are defined at national level. In 2014, the Italian government adopted a National Strategy for Internal Areas ("Strategia Nazionale per le Aree interne - SNAI") to combat demographic decline and to revitalise the development and services of the "inner areas". One of the main objectives of this Strategy is to improve the quantity and quality of education, health and mobility services. With regard to mobility, the Strategy aims to encourage the development of new policies that meet the needs of the "inner" population, as well as the restructuring of the organisation of public transport services in inner areas by introducing flexible and financially sustainable service (Hanzic, et al., 2019).

At regional level, governments are responsible for the planning and programming of public transport and mobility services at regional and local level with regard to "minimum services". The services are planned in terms of basin or at the level of the entire region. Independently of this, public transport services are defined at the level of urban and extra-urban areas. For "areas of low demand", specific resources are foreseen, and managed by local communities or, in some cases, by provinces and/or metropolitan cities. Mobility management tasks are often delegated to mobility agencies - the presence and number of mobility agencies varies from region to region. It may be that a single Regional Mobility Agency takes over the tasks or tasks are delegated to several Mobility Agencies within a region. In general, the tasks of these agencies are to improve sustainable mobility in the regional area, to optimize urban and peri-urban public transport services by planning mobility strategies, managing the fare system and keeping citizens well informed.

Demand responsive transport services, if implemented, are planned and procured by the Provinces (or Municipalities), addressing only transport services in specific rural areas.

In Italy, transport-related legislation is managed by the Transport Regulation Authority, which is responsible for regulating the transport sector and for access to the relevant infrastructure and auxiliary services. The authority is an independent administrative authority which operates in full autonomy and in compliance with the principle of subsidiarity and the competences of the regions and local authorities.

In Italy, no specific policies on mobility and transport in rural areas are implemented. Experiments with public transport with demand responsive characteristics are underway, mainly in low density areas and with smaller vehicles.

4.5 Poland

Poland is to a large extent a rural state, 72% of the 38.4 million inhabitants live in rural areas (SMARTA project, 2020). The southern and western parts of the country are characterised by a higher degree of urbanisation, with a larger number of cities, towns and suburbs, while the central and eastern parts have a higher degree of rurality (ibid). Poland has retained much of the centralised control mechanisms and rigid planning processes. Poland's administrative structure is based on three levels of local government: regions (voivodeships), districts (powiats) and municipalities (gminas).

At the national level, the Polish National Transport Policy for 2006-2025 highlights the need for investment in public transport and the need to combat suburbanisation. The Strategy sets national priorities for the creation of an integrated transport system by investing in transport infrastructure, creating favourable conditions for the efficient functioning of transport markets and developing efficient transport systems. In this Strategy, sustainable urban mobility is one of the 10 main areas and its actions should aim at increasing the efficiency and attractiveness of public transport. However, nothing is said about rural mobility.

At the regional level, the Joint Commission of Central Government and Local Government provides a forum for connecting national and district level. At the local level, districts and municipalities are the main actors in development, but they are largely "policy takers" - their scope for action is largely determined by rules, regulations and fiscal frameworks established by the national government. Rural mobility and/or DRT are not explicitly mentioned in the policy documents. (Hanzic, et al., 2019).

Taking into account the legislation, the main regulatory instrument for passenger transport services in Poland is the 2010 Public Transport Act, which sets out the legal requirements for the organization of public transport markets, transport planning, and the financing and management of public transport services. Public transport is organized by local government authorities corresponding to the area in which the transport is carried out. Local transport is organized by municipalities and counties, regional transport by regions, while responsibility for the organization of national and international transport lies with the central government.

Within the existing legal and organizational framework in Poland, the most common way of coordinating urban public transport with suburban transport is by entering into bilateral agreements between the city and surrounding municipalities, transferring organizational competencies from the latter to the former in return for covering the deficit of the subnetwork that is the subject of the contract.

The Tele-Bus, the country's first demand responsive transport system, was developed in Krakow in 2007, it provides services for the city and surrounding areas. Other similar services have not been identified (SMARTA project, 2020).

4.6 Slovenia

Slovenia is the fourth smallest EU member state with a predominantly rural character - over 70% of the territory is rural, where 46% of the population live (SMARTA project, 2020). Slovenia's population density is below the EU average (102.5 vs. 117.5), while the population density of nine rural NUTS3 regions averages 84, with one region reaching only 36.7. This is an important factor for rural mobility, as low population density leads to higher relative costs of providing public transport and other services (ibid).

At national level, the issue of mobility is addressed in various strategic policy documents. The Transport Development Strategy of the Republic of Slovenia until 2030 states that special attention must be paid to public transport links between rural and urban settlements. Among the possibilities for improvement, the strategy mentions the development of "dial-a-ride" options (i.e. public transport on demand) and the integration of arbitrary school buses with public bus lines to increase the coverage and accessibility of public transport in rural areas. The Rural Development Programme for the period 2014-2020 must be mentioned as it is important for overall rural development and investment from EU funds. It includes the issue of accessibility of rural areas, which provides for the eligibility of projects focusing on the development of sustainable transport methods. There is no regional level of government, and the management of mobility in individual areas is highly dependent on policies at local level. In recent years, Slovenian municipalities have developed local Integrated Transport Strategies (ITS) that stem from the Sustainable Urban Mobility Plans (SUMPs) but are adapted to the Slovenian context. Integrated Transport Strategies comprise various measures to be implemented by municipalities in the field of mobility in both urban and rural areas. In most cases, they also include policies and actions to improve the accessibility of public transport in rural areas (Hanzic, et al., 2019).

The Road Transport Act, which was last amended in 2016, forms the main regulatory framework. It defines public road transport as a service of general economic interest (i.e. in the public domain), where the connections between cities are provided by the state. Inner-city connections are obligatory for municipalities with more than 100,000 inhabitants, municipalities with less than 100,000 inhabitants can provide inner-city public transport on a voluntary basis.

The Road Transport Act also permits dial-a-ride services, which differ from standard taxi services. In this context, "dial-a-ride" is defined as an advanced form of public transport service for up to eight passengers, which may only be provided in areas where public transport is not organized or in areas with lower demand for public transport services. The "dial-a-ride" service may be operated in accordance with a predetermined timetable and is performed exclusively upon prior request of the potential traveller. Alternatively, it may be carried out according to a flexible timetable, in which the time and relation of the journey are formed according to the passenger's needs (Hanzic, et al., 2019).

Urban-rural or rural-rural links fall into the category of inter-city public transport and are subject to state jurisdiction. It is generally acknowledged that rural mobility in Slovenia and the provision of rural public transport is not satisfactory. The existing institutional, regulatory and organizational framework is not conducive to improvements in this area. The centralised state jurisdiction in managing rural mobility, which is usually essentially a local matter, is a potential obstacle to a more dynamic and efficient organisation of this public service, which must respond to the specific needs of the rural population (SMARTA project, 2020). he possibilities of integrating the so-called special public transport, in theory meant only for a single category of passengers (schoolchildren, students, workers), with general public transport, adopted in 2013 in the form of amendments to the Road Transport Act, are a step in the right direction. This type of transport does not receive state funding and is based on contractual relations (not concessions). In stark contrast to the above data, 169 municipalities (or 80%) financed special public transport, i.e. school transport. In 2014, only 23 of these municipalities included the possibility for general passengers to use special public transport as general public transport, while in the majority of cases such legally possible integration was not implemented (SMARTA project, 2020).

On-demand services with micro-electric buses are in operation in several Slovenian cities. These services are intended for transfers through city centres for citizens, tourists and other visitors with special electric vehicles. The services can be requested in advance by phone or the vehicles can simply be stopped on the street (Hanzic, et al., 2019). No examples of DRT in rural areas were identified.

5 CONCLUSIONS

The analysis carried out for each of the six countries has shown that all countries address the challenges of transport and mobility at national level. The issue is mainly dealt with within one ministry, which cooperates on this issue with other national ministries.

At regional level, the approach varies considerably. With the exception of Slovenia, all five other countries have a regional level of competence, but their powers in the transport sector are different. In Austria and Italy, the regions and provinces are responsible for or strongly involved in the planning and programming of public transport and mobility services. In the Czech Republic, regional governments have full responsibility for regional transport, while municipalities have to organise transport and mobility on their own territory. Differing views on the organisation of transport, particularly between urban cores and the region, hinder the creation of integrated transport systems and lead to a very heterogeneous organisation of public transport at local level. In Hungary and Poland, policies are mainly centralised and implemented at national level. In Poland, the Joint Commission of Central Government and Local Government provides a forum linking the national and district levels. However, the authorities at local level are mainly "policy takers", as their scope of action is largely determined by rules, regulations and fiscal frameworks set by national and regional governments. In Hungary the local level of government is underfunded and there seems to be little scope for decentralised actions. In Slovenia, the management of mobility in individual areas depends heavily on policies at local level. As there is no regional government, harmonisation at regional level depends on voluntary agreements between municipalities.

Irrespective of this, it is clear that rural mobility has rarely been taken into account in national policies. European and national mobility policy is mainly concerned with urban mobility, but this has changed in recent years. The understanding that local mobility has a strong impact on the local economy, territorial cohesion, social inclusion and environmental protection has extended the focus of mobility policy to rural areas. As Table below shows, several countries already address rural mobility in national strategic documents. When it comes to demand responsive transport, the situation is somewhat worse, as few policies have been identified that deal with DRT.

The situation is similar for the legislative part - only in two countries DRT is specifically addressed (Table below).

Table 1: Comparison of demand responsive policies, legislation and examples in six analysed countries

		Austria	Czech Republic	Hungary	Italy	Poland	Slovenia
Rural mobility policies		x			x		x
DRT policies	National level		x				x
	Regional level				x		
	Local level						
DRT legislation			x				x
DRT examples		x	x	x	x	x	x

Own source

However, the absence of a specific policy or legislation for demand responsive transport is not an obstacle to its implementation. All six countries have policies that provide a sufficient basis for the implementation of DRT, or transport with DRT characteristics, and more are being developed. It is worth noting that in some countries demand responsive transport is already practised in rural areas, while in others it is only practised in urban centres. The project SMACKER (Interreg Central Europe, 2020) is currently carrying out pilot activities with different levels of maturity:

- feasibility studies for the future implementation of DRT in the suburban areas of Prague (CZ) and Gdynia (PL);
- development and testing of app-oriented DRT service to connect tourist centres in areas with low population-density in Murska Sobota (SI);
- to achieve the use of flexible mobility by locals and tourists by making existing (fixed and flexible) services visible, understandable and integrated into tourism in the Osttirol region (AT);
- upgrading of the existing DRT service with IT solutions in the suburban areas of Budapest (HU) and improvement of an existing DRT service by increasing the offer and its flexibility in mountain region of the Bolognese Apennine (IT).

The experience gained from the pilot activities mentioned above will also lead to the further development of policies in the regions implementing pilot actions in the form of regional action plans for better integration of peripheral areas using DRT (Interreg Central Europe, 2020)

Our results supports Porru's findings that the success of public transport in regions with low population density depends on three main elements: the availability of financial resources, cooperation between stakeholders and a flexible supply of scheduled and demand responsive transport (Porru, Misso, Pani, & Repetto, 2020). When all three come together, demand responsive transport can be implemented even without adequate policies or legislation. However, it is much easier to ensure stakeholders' participation and financial resources when rural mobility policy clearly supports innovative measures such as demand responsive transport.

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CURRENT OPTIONS AND LIMITATIONS IMPLEMENTING DEMAND-RESPONSIVE PUBLIC TRANSPORT IN RURAL COUNTIES

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ABSTRACT

In the light of imperative efficiency enhancements to achieve climate protection goals and curb operating losses, this contribution reflects the potential but still not materialized transformation of public transport provision in rural Germany towards flexible integrated transport systems, combining a fixed-route trunk network with public demand-responsive transport (DRT) services. Based on a systematization of present public DRT systems and respective collaborative choice options, centering around public ridesharing services and/or hailed micro-transit, this analysis examines promoting factors and impediments by discussing recent domestic and comparative overseas case studies. From selected findings of this retrospection, the authors seek to conclude on common local settings, a minimum addressable trip pooling demand, and corresponding external conditions such as legal frameworks that incentivize or prevent a public authority from exploring the emerging technological opportunities by incremental DRT in Germany. The authors' approach is set (i) to assure ubiquitous minimum levels of service and (ii) to create the necessary financial and legal freedom for municipal decision-makers to test flexible forms of operation with everyday viability.

Keywords: demand-responsive transport, rural area, flexible integrated transport system, trip pooling, ridesharing

1 INTRODUCTION

The German federal government is aiming for a climate-neutral transport sector by 2050. In order to achieve this, it is imperative, among other things, to be able to travel everywhere with an acceptable expenditure of time and money, even without a car. Nevertheless, in large parts of Germany - not only in rural areas, but also in suburban areas - a de facto dependence on private cars is recognized.

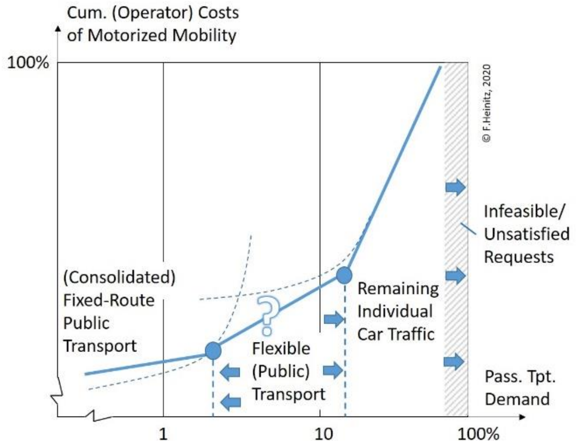
What can public transport do? The provision of (fixed-route) public transport services faces severe, particular challenges in rural areas, primarily because of unfavorable economies of density. Given dispersed settlement areas affected by adverse demographics, the contemporary household activity pattern pursued by highly motorized individuals - anxious to preserve their independence and flexibility, the questionable future of parts of conventional "mass" transit and its operators seems to be clearly mapped out. According to the current legal situation in Germany, local decision-makers may claim for costs "opting out", i.e. refusing to provide certain public transport services. In the vast majority of these cases, however, this is due to the actual or assumed costs associated with the provision of a minimum public transport service on fixed routes.

In what form should a minimum service be established?

Since the 1970-ies, the economic (and environmental) necessity of demand-responsive transport (DRT) services and the deployment of respective enabling technologies has been widely recognized in Western Germany, echoed by a wealth of subsequent state programs, publications, and a patchwork of (temporary) pilot applications, yet without any substantial changes to the transport market. This necessity has been further aggravated in the aftermath of the country's reunification, which added further thinly populated and structurally disadvantaged regions of limited financial resources to the federal territory.

Kutter (2000/2005) in particular suggested an increased support for unlocking potentials through appropriate framework conditions. He also discussed impediments implementing DRT by East German case studies. Back in 2006, a publication of the German Institute for Urban Affairs (DIfU) has called for a functional (service level) specification approach rather than the construction of timetables in local transport plans. Comprehensive DRT was also recommended as means for economic sustainability (e.g. Heinze & Kill, 2008).

Regardless of the compass direction, the past decade's sobering time series of rural and peripheral areas' transit patronage (apart from school transport) further diverged from their pleasingly developing urban and inter-city counterparts. Moreover, comparing affected rural counties with comprehensively served conurbations, the pace of technological advancement and propensity to invest appear to be the slowest and lowest where it is lacked the most - thus deepening fragmentation trends. Proposed some time ago, an intermediate, flexible supply of much-less-than-busload capacity could overcome the dichotomy between the two systems of fixed route scheduled transport and individual car trips (Figure 1).



Source: Heinitz, 2020

Figure 1: Proposed Intermediate DRT Service

Private transport network companies (TNCs) started to address the eminent gap by creating value through digitized platforms, raising the availability and matching empty car seats and trip requests on large scales. Within few years, their market presence and technologic advancement set new, high standards across the globe and as well on the European continent, while the state-owned public transport was not yet in position to come up with equivalent solutions.

Notably, Germany plays a special regulatory role in terms of granting TNC market access in the worldwide comparison. Even in decreed absence of competition, their situation challenges public transport providers to turn to flexible operational models themselves.

2 RESEARCH QUESTIONS AND OUTLINE

Above-stated contradiction between the availability of information-technological prerequisites and their effective implementation became increasingly evident in Germany: Whereas even the automotive industry is taking measures to technically enable collaborative forms of car usage and test the attractiveness of corresponding business models, a comparable transformation of public transport towards an integration of the two paradigms is rather a distant opportunity than everyday reality. Omitted by the TNCs so far, the feasibility of such an intermediate service in a rural setting under public accountability, complementing a scaled-down line network, is not clear per se. This gives rise to further research questions:

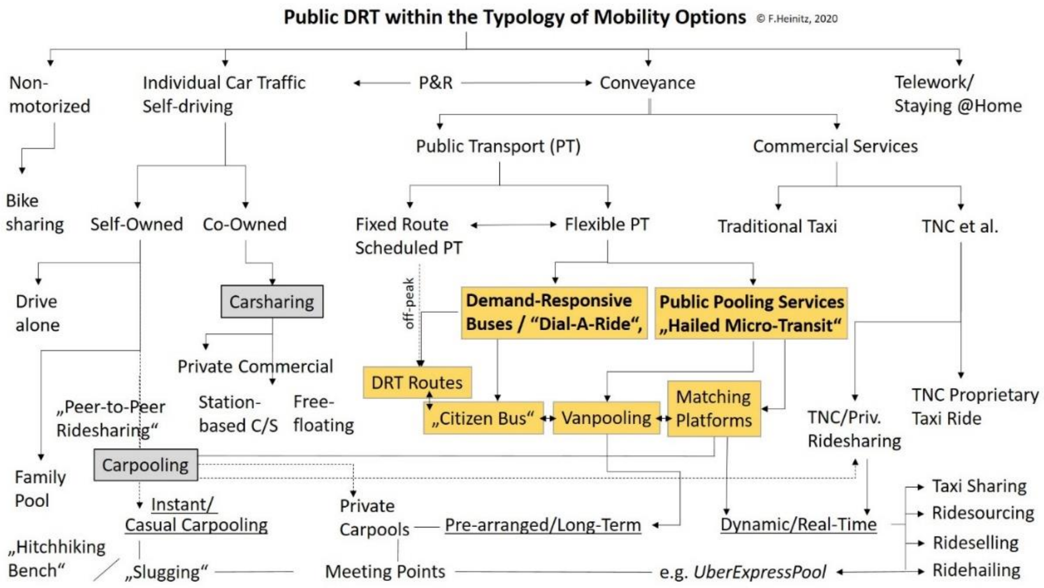
- What characterizes the specific situation in Germany?
- Does DRT, namely ridesharing, comply with the sustainable transport policy's triangular system of objectives (measures of economic, social & ecologic sustainability)?
- Which type of requests and offered rides have real-world suitability specifically in a rural environment?
- Which potentials and obstacles arise in the realization of DRT services?
- Which orders of magnitude of DRT demand can be achieved?
- To what extent is the local transport market receptive?
- How is the prospective market volume narrowed by legal frameworks, technology, preference structures?
- What is the benefit of incremental / partly substitutive DRT services to specific investigation areas?
- With regard to the TNC's market position - will a public, private, or public/private cooperation model for DRT and/or its matching platforms work best?

This contribution refers to a subset of aspects of the underlying investigation. It is organized as follows:

- A brief overlook of the literature on rural DRT
- Typology and systematization of mobility options with emphasis on shared mobility and their relevance for that region type
- Knowledge gained from a meta-study approach, using three *own* case studies; by intention of diverse settings (U.S./Germany East/West, remote-peripheral areas/ rural areas with close interlinkage to a conurbation)
- Generalization of driving forces vs. obstacles for DRT (a summary of analyses in the transport geographic/ legal / technological / economic / ecologic dimensions)
- Conclusions for the scope of a nationally valid strategy for rural areas and further research.

3 PREVIOUS WORK ON RURAL DRT

Carpooling and ridesharing have had a demonstrable effect in the transport, ecology and energy policy dimensions. This has motivated research across the globe to transfer underlying ideas and experiences from metropolitan to remote, thinner populated territories. Irrespective of regional types of the actual operational area, one of the first tasks arising was to address the emerging variety of DRT models and their practical manifestations. With some effort and delay, Germany's research scene attempted to preconceive the integration of new DRT concepts into the long-established conceptual system of fixed route scheduled/dial-a-ride services – leading to a pilot project's awkward quest to assign numbered timetable slots to ridesharing drivers' offered supply in terms of empty passenger seats.



Source:Heinitz, 2020

Figure 2: Public Demand-Responsive Transport within the Typology of Mobility Options

This article picks up on prior insights on success factors and impediments of rural DRT, such as by Steinrück & Küpper (2010). Remarkably, a decade ago that research report still subsumed citizen's buses and institutional ridesharing - besides a reversal of the previous centralization of services with mobile units - as "alternative models" to the flexibilization through dial-a-ride lines.

Also in rural areas, comprehensive DRT centers around the triangle of terms "rent – pool – share" in connection with platform-based matching of supply and demand (e.g. Berrone et al., 2016; Viergutz et al., 2020). Recent notable work, both nationally and across borders, on surveying, estimating, simulating, and discussing the adequate DRT supply and demand potential regarding (sub) spaces and periods of particularly low demand with their economic implications includes

- an approach of a flexible integrated transport system in Scotland by Mounce et al. (2018)
- a case study of mobility as a service in Finland, based on in-depth stakeholder interviews and a SWOT analysis by Eckhardt et al. (2018)
- a report by McCoy et al. (2018) on better overall performing systems - including shared mobility
- a field study of complementary ridesharing by Sommer/Harz (2018) in a rural pilot region in Germany
- implications of DRT for the incumbent public transport (Smith et al., 2018)
- analytical methods in conjunction with cost-effective semi-flexible transport systems by Mehran et al., 2020.

4 DRT TYPOLOGY IN A RURAL CONTEXT

For a further classification of any past / future / transitional forms of appearance of DRT, a systematization of the relevant multi-optional environment, differentiated in a public or commercial sub-tree, was conducted (Figure 2). The relevant forms of appearance by public bodies were highlighted in color.

Fixed-route dial-a-ride services represent the conventional 'scheduled' approach to address low demand.

- This option typically requires a pre-registration of at least two hours, implying a further decline in service levels and combining detour factors with time losses.
- It is a largely exhausted instrument that has been tried for years without holding out the prospect of any growth, perhaps even without a positive effect on the retention of the previous patronage – thus often termed as "entry into complete withdrawal".
- Its cost-saving potential and respective incentives are limited to about one quarter of the total costs, as the municipal labor relations of bus drivers (not 3rd parties) require a full compensation, regardless if the bus service has taken place and by whom it was utilized.

The focus of consideration in the following will be on chances of a paradigm shift resembling to the private sector, that is, public pooling offers by "hailed micro-transit", with their common key properties of

- an organization principle enabling a highly flexible, (full/primarily) demand-driven supply, which can be performed apart from any prescribed lines, timetables, or corridors - for example the *Freyfahrt* pooled shuttle

- the strict dependency of all operations on the exploitation of spatiotemporal scale economies, even at low levels – that is, small vehicle sizes, through ad-hoc trip bundling with digital matching platforms involved.

As if that paradigm shift to the well-arranged and legally founded habitual planning world was not enough, however, in the internet era most academic or administrative distinctions become pointless. Their constituent boundaries are rather poorly defined and perhaps insignificant from the demand perspective, as most different options under legal aspect are just a few clicks away in smart mobility applications supporting the integrative use and customized bundling of many kinds of publicly accessible transport services. Recognizing this, one can either ignore or keep pace with it through a clarification of apparent legal, economic, and practical issues.

5 FINDINGS FROM OWN CASE STUDIES

A small selection of recent (2018-19) anonymized case studies at county level, conducted inter alia by the authors and their institutions and found to be proto-typical, has been scrutinized once again (i) to illustrate the present state of DRT and (ii) to obtain a better understanding of facilitating and impeding mechanism to the two above-mentioned forms of DRT. Prior to summarizing the results of the analysis, selected insights and peculiarities are presented in the following.

5.1 Study 1 – Ridesharing as an additional sub-mode of public transport (U.S., 2018)

The main modal choice options in this aspiring investigation area are private cars vs. public transport (bus rapid transit and light rail) vs. strong but relatively high-priced TNCs. Different forms of ridesharing on suburban commuter relations could be field researched, as they are key to the county's transport development plan. The pressure to act is due to

- apparent capacity limits of the road and parking infrastructure in prospering metropolitan areas
- problems assuring statutory air pollution control and improve climate protection
- unsatisfied mobility needs because of a lack of adequate public transport services.

Combined with technological developments in digitization, ride sharing has revived significantly and, in addition to the growth in absolute numbers, has generated a very wide public perception.

The public transport administration is particularly successful enabling long-term vanpooling agreements.
Political and legal support through the installation of high-occupancy vehicle (HOV) lanes on motorways, clear preference for parking and ferry lines, and generous funding in some areas from the federal to the municipal level have to be acknowledged. Moreover, corporate mobility management of large companies in terms of their legal contribution to air pollution control and cooperation via local transport management authorities contribute to this goal. The result is a customer-oriented, target group-differentiated, innovatively designed and regularly reviewed, professionally and highly motivated volunteer ridesharing program, coexisting with the fixed route network. Taxi companies collaborate to create a fall-back level, e.g. in cases a driver falls ill or the passenger misses the departure because of delays or prior commitments. This "guaranteed ride home" feature fulfils a very important aspect that had previously prevented interested parties from choosing this mode. From the beginning, much attention has been paid to lean cost structures. The administration mainly causes staff and marketing cost. One full-time equivalent is needed for 40 to 50 vehicles and their respective vanpools.

The transit authority's employees see themselves as mobility managers for commuters who are looking for alternatives to driving in their own cars. The administrative costs are approximately 25% of the vehicle operating costs.

These offered rides are purely demand-driven. The remaining operating costs of the vehicle (i.e. without administrative costs and due to preferential use of infrastructure and parking) are fully covered by user fees. This has the advantage of resilience against cuts in public funds, such that they have no (immediate) impact on the creation or continued operation of vanpools. No extra driver's fee is paid; with one and the same driver, on the other hand, it is common practice to waive his share of operating costs. With the financing model described, it has been possible for years to keep the cost threshold for new van pools low and thus enable further growth.

In addition to the management of existing vanpools and their fleets, the funds of the county flow in significant marketing expenses, which are allocated to several programs, customer communication channels and recruitment/retention campaigns. Current user experiences and advice are now being shared in a contemporary form on social media such as the local blogging platform. It goes without saying that there is a lively, sometimes controversial but always informal exchange about opportunities for improvement in the public transport system. The close connection between ride sharing and public transport is also visible at this point. Beyond marketing, the county government closely works with inner-city businesses and private/nonprofit organizations to design significant commuter traffic.

According to the Commute Trip Reduction (CTR) Law of 1991, the measures taken are monitored by means of a reporting system and surveys of employees every two years. This also provides a valuable data basis for planning and efficiency measurements of the vanpooling supply side. The focus is on the acquisition of newly hired company employees. Several self-planning tools are provided to users on the website:

- the cost comparison calculation for commuter relations and profiles in terms of time required

- state & company- co-funded ride matching to support the search for suitable carpooling opportunities
- the use of park-and-ride, where registered carpools benefit from parking ticket authorizations for pre-reserved, free and well-positioned parking spaces.

To allow for further growth, the market of origin-destination relations with relevance for commuters is regularly "browsed" to determine where there are deficits in the public transport timetables networks and cannot be remedied cost-effectively by means of regular services through a line extension, connection or frequency increase. In addition to cost savings, one of the arguments in favor of vanpooling is the gain in comfort through a door-to-door transfer-free journey - in the original tone: "People hate transfers."

5.2 Study 2 – "Citizen's Bus" of uncertain future (Germany, 2018)

In a rural county in Germany, a quite dispersed 19,000-inhabitant community, consisting of a market town and 30 villages, has been operating DRT with model character in the form of a citizen's bus in connection with a mobility center, thus partly extending the county's fixed-route network within the limit of the financial resources. In service for a decade now, it is legally classified a "dial-in local transport", primarily, but not exclusively aimed at people with temporary or permanent mobility restrictions, for whom the use of public transport therefore proves too problematic. The traffic volume in 2017 was 7.232 passengers carried, 3,378 of them children. This corresponds to an average of 33 passengers per school day. For this target group-specific supplementary supply calling near people's doorsteps, the municipality spent an equivalent to about €5 per inhabitant per year in 2017. Related to the determined number of "low-mobiles" (children exempted), the annual budget amounted to €93.

The mobility center, which is located in the municipal administration and can be reached by telephone and in person during normal office hours, also contributes to the public benefit by

- manually matching trip requests with the dynamic routing of the citizen's bus
- ensuring the maintenance of the vehicle
- free travel information and mobility counseling.

The operating license was prolonged by the regional authority mid-2018, taking this opportunity to tighten the concession even further to scheduled paratransit, by

- the restriction to the exclusive carriage of persons with a severely disabled person's pass
- a minimum of one hour's distance from the scheduled public transport
- predefined routes and detailed timetables
- an advance order period of at least two hours.

Under these circumstances, the continuance is doubtful.

5.3 Study 3 – County's fixed-route public transit at its limits (Germany, 2019)

The county, populated by about 100 inhabitants per km^2, was examined in depth twice in five years. It appears to be prototypical for rural Germany. Interestingly, the shrinking and ageing of the population took place more slowly than predicted, while external migration temporarily tended to stabilize the population figures.

Particularly in recent years, the district administration and the regional bus company have been making extraordinary efforts to improve its public transport, which is challenging due to the county's spatial extent, its topography (stub lines to connect deep valleys, winter conditions, etc.), ongoing demographic change, dispersed multi-centric settlement structures and the massive dominance of private car usage. In addition to the regional bus system, parts of the area are served by the federal state's regional railway lines, typically with a two-hour headway in interval timetables and up to 14 operation hours per working day. However, the accessibility of train stations from residential areas is often limited and requires other means of transport. Although only every second calendar day is a school day, the public transport supply for up to 500 access points is primarily geared by the requirements of the substantial, constant school transport demand with its two peaks. To meet the capacity needs and the complex legal regulations, the vehicle technology is accordingly oriented to 12 meter solo buses and a certain percentage of high-capacity tri-axial buses. Only few units of the available 75-vehicle fleet are midi or minibuses. A low single-digit percentage of all departures is marked to be on a 'dial-a-ride' basis without the aforementioned cost effect. The regional bus company's labor force is limited to about 90 full-time equivalents of drivers, while recruiting of new bus drivers is difficult. Besides "mass transit", another 102 vehicles with 680 passenger seats in total have become licensed for public transport. One third of them is related to taxi concessions – which means one vehicle for nearly 4,000 inhabitants. Taxi rides are mostly contracted for financially rewarding ambulance transport and paratransit, but only to a low extent requested by the general public.

Economically, the county's public transport suffers from externally influenced cost structures (particularly payroll costs) and lower than industry-averaged ticket revenue.
There are conflicting demands of student and public transport. Schools are not prepared and refuse to adjust their teaching times in order to optimize the transport offerings. Despite of several subsidization schemes with agreed sums based on target costs in place, soaring deficits can be recognized. Emphasis of the last four-year local public transport plan was on differentiating network tiers. The emphasis was laid on the trunk fixed-schedule bus networks, their integration and introduction of fixed timetables, while the advisory recommended DRT approaches for eight identified low demand & supply areas were mostly omitted although the disadvantages of

the organizational co-product with the school transport outweigh synergies.

6 PROMOTING FACTORS OF PUBLIC DRT

What factors promote demand-responsive transport?

Transport Geography

Adverse demographic change affects the demand and pushes it below a critical threshold for fixed-route supply. The necessity of truncating fixed-route networks and raises the issue of “last mile” access and egress interconnectivity between the stations and the household locations or between local destination opportunities and household locations respectively. On the other hand, the commuter travel demand from the rural areas into the conurbation and back and thus the mileage are growing.

Legal Framework

In general, a raison d'être for DRT can be taken for granted insofar as it is specified and anchored in the local transport plans adopted by the district council. The Passenger Transport Act (*PBefG*) already contains experimental clauses in its current version. As shown in the U.S., low barriers to market entry and the practice of allowing mobility in experimental fields in the interest of higher valued goals and legislations such as air pollution control provides the legal basis for DRT.

Technology

Advancing digitization through the availability and high user acceptance of technologies that lead to deep product differentiation up to the individualization of the former "mass transit" and therefore a drastic reduction of transaction, matching, and fulfillment costs. Ubiquitous access and usage of mobile communication have advanced in rural areas, too. Moreover, the technical capability to run a fully demand-driven system without predefined timetable contributes to the overall system resilience for both extreme demand peaks and absence of supply, i.e. in emergency states.

Economy - User Perspective

Analogous to the drop in total user costs after the liberalization of inter-city buses and introduction of many direct services, the price-sales function is extended to lower willingness to pay regions not yet addressed. For all technology-inspired individuals without permanent car availability, an advantage relative to the value of time can be stated (Matuszak et al., 2018). There are readily apparent network/ scale economics of pooling trips, such as a future minimum cost frontiers when deploying automated vehicles. High-occupancy vehicle lanes and toll exemption lanes, even reverse tolling, provide strong incentive structures to the demand side.

Economy - Supplier Perspective

Moving from fixed-route structures towards functional service level guarantees in rural areas will - depending on the specific contractual arrangements - allow for a cost-effective flexibilization of the supply and grant market entry option for small transport companies.

Ecology & Sustainability

The overall goal conformity with the sustainability’s system of objectives gives reason for support, if substantial net effects of private vehicle kilometers savings, reductions of intra-urban car traffic and/or reductions of required parking space can be achieved. A reduction of serious road accident rates in the most endangered age group and corresponding social costs savings was shown by Kirk et al. (2020). The role of DRT for better resilience in crises with temporarily dysfunctional conventional public transport, such as in the aftermath of the Christchurch earthquake, aroused broad interest.

Stakeholder Influence

As the case studies suggest, the prospect of customized and more affordable mobility for a wider range of users creates a significant level of civic participation and initiative. The chance of a local approach works against the imperative centralization and preserves the control possibilities of the municipalities. A supra-regional networking of stakeholders, integrating the scientific community such as in the U.S., proved to be supportive.

7 IMPEDIMENTS TO PUBLIC DRT

Assessing the insights from investigation areas lagging far behind – which factors are preventing public DRT?

Transport Geography

Under the assumption that DRT will have to focus on remaining, left-over service areas with particularly thin traffic flows, dispersed activity locations and thus insufficient density, far below the critical mass for trip pooling, is expected and remains to be studied.

Legal Framework

The law lays down the provision of fixed-route services with integrated school transport as a rule and the conveyance obligation according to route and timetable descriptions rather than functional service level agreements for transport relation. Legal barriers include the

- intended “regulatory split” (Knieps, 2018) of transport markets between scheduled and on-demand services which prevents, among others, vehicle-related co-productions
- adherence to strict driver licensing and liability rules
- present system of subsidization which mostly exempts non-conventional DRT.

Technology

In terms of the technological readiness to considerable levels of DRT, namely

- ubiquitous broadband mobile network coverage to provide real-time data
- seamless, digitally controlled multi-modal chains
- differentiated road infrastructure product (dedicated lanes, levying of toll)
- appropriate (co-owned) vehicles in sufficient numbers
- simplified transaction by mobile payment services
- standardized supra-regional matching portals
- solutions for barrier freedom (to be assured by 2022)
- adequate meeting point infrastructure (“new” park and ride/P+R)

major impediments in rural areas and the ensuing need to catch up to the leading countries become evident.

Economy - User Perspective

Besides the aforementioned willingness to pay for ad-hoc rides, a survey in the (below-average income) age group of 20-30 years (Matuszak et al., 2018) shows the limitations of ridehailing, set by viable modal alternati-ves, safety and security concerns, the fragmented mar-ket of matching portals, and partly data privacy issues.

Economy – Supplier Perspective

On a corporate level, there is a competition for scarce funding and ticket revenue, while the shortage of professional drivers for an additional small-capacity fleet precludes an extension of vehicle kilometers. The current scheme of subsidization and long-run concessions fixes the existing status quo and does not provide incentives to include DRT, since all deficits are ultimately balanced or remedies with a further rationing of fixed transport services. With exceptions for model projects, there is no regular co-financing of DRT fleet investments or just a small budgetary commitments to alternative modes for their organizational expenses and an adequate compensation for volunteers. (This makes citizen’s bus initiatives unsustainable.) Long depreciation periods of subsidized, but partly obsolete information systems were also prescribed as a barrier to innovation. The lack of supraregional standard solutions increases fixed costs for isolated applications. From the perspective of (volunteers considering becoming) small entrepreneurs, the incentive is limited with a regulatory kilometer rate cap that does not pay off revenues according to passengers’ willingness-to-pay and the better cost-effectiveness of pooled trip. The supply side is reluctant in uncertain expectations of long-term profitability. The financial resources of most rural municipalities do not permit the creation of new subsidy schemes and cover of start-up costs on its own.

Ecology & Sustainability

A counterproductive net effect on specific emissions, transport volumes, and traffic space requirements compared to fixed-route public transport called the sustainability into question (Schaller Consulting, 2017) Concerns of a likely displacement of public fixed route services, induced road traffic and empty vehicle kilometers beyond pooling of „anyhow“ car trips need to be allayed; the shifts in demand and induced traffic ought to be forecasted for rural areas more accurately. Questioning the assurance of social standards of all persons employed is another reason for a more reserved attitude towards the new operational concepts.

Stakeholder Influence

In addition to the critical questions already listed above,

stakeholders explicitly slow down a development in their areas of responsibility. Politics must be acquainted with the new concepts; otherwise the transformation processes are even more cumbersome. The decisive factor is the fear of political pressure, even with minor changes in supply, whereas projected cost savings may not be realized in the case of excess demand. Total budgeting bears the risk that unexpected additional deficits of DRTs will be incurred at the expense of the established fixed-line service.

In connection with too small economic success orientation at levels and institutions involved, traditional patterns of thought among decision-makers and little personal willingness to change paradigms on the incumbent’s side lead to a perpetuation of already thinned, poorly utilized fixed-route lines. A feared loss of the planning sovereignty of the municipalities affected and misallocation due to deadweight effects of new areas of subsidization were also found to be a relevant motivation. In combination, also modest IT knowledge and a general shortage of manpower limit the chances of realization.

Large-scale business plans appear to be thwarted due to concerns about a foreign market entry in the wake of a weak position of domestic matching platforms as well as the industrial policy implications for passenger car manufacturers, already exposed to a notable pressure.

8 SUMMARY

A brief examination of options and limitations of DRT with focus on rural Germany, in cross-country compa-rison to the U.S., was provided. For the overview of all arguments - both promoting factors and impediments / disincentives - at a glance, the contradiction of the influencing factors was summarized in Table 1. The relevance for the case studies was marked as well.

9 CONCLUSIONS AND OUTLOOK

Rural Germany in particular appears to be far detached from the dynamic international developments. There is still a counterproductive conceptual dichotomy bet-ween flexible supply inside & outside public transport.

Understandably - given a medium-to-low population density area with disperse trip pattern, the applicability of network-economic concepts of conurbations is under the impression of a complex set of determinants and not straightforward. Beyond the economic opportunities, the adoption of DRT concepts of proven success in the United States of America and beyond bears certain risks for Germany's which was so far shielded away from the interplay of market forces.

On the other hand, especially in rural areas, DRT can make a considerable contribution to ensuring mobility and strengthening public transport services. For example, DRT services have proved to be highly cost-effective while at the same time raising supply levels and daily hours of operation, as shown in the "Modell Wittenberg", Germany (Heinze & Kill, 2008). Given the economic viability and environmental relief of commissioning flexible integrated transport systems, as simulated by Mounce et al. (2018), one can cover a greater customer base, expand market reach and complement the traditional bus operations. Therefore, it could legitimately claim more public funds, released from savings of poorly utilized services.

Table 1: Summary – Promoting Factors versus Impediments, by Case Study (C/S)

	Promoting Factors				***Impediments***			
	Particular Relevance for C/S	1	2	3	Particular Relevance for C/S	1	2	3
Transport Geography	Apparent mobility needs without car av'ty	x	x	x	Thin traffic flows, disperse activity locations	x	x	x
	Truncated fixed-route networks	x	x	x	Parallel supply of fixed-route scheduled tpt.		x	x
	Issue of "last mile" connectivity	x	x	x	Metropolitan area deflects poolable traffic	x	x	
Legal Prerequisites	Obligation to assure a certain mobility level		x		Provision of fixed-route services with		x	x
	Option of functional supply specification			x	integrated school transport as a rule			
	Commute trip reduction legislation	x			"regulatory split" of the transport market		x	x
	High-occupancy vehicle lanes and toll	x			Present subsidization system against DRT		x	x
	exemption lanes, reverse tolling concepts				Road usage not differentiated by vehicle			
	Scarcity of parking space	x			occupancy			
Technology	Ultra-low transaction costs for ad-hoc rides	x			Missing Standards for Matching, Payment		x	x
	Appropriate (co-owned) vehicle fleets	x			Deficits in ubiquitous broadband mobile		x	x
	High standardization and integration levels	x			coverage to provide real-time data			
	Adequate meeting point infrastructure	x			No seamless, digitized multi-modal chains			x
Economics - User Preference	Apparent scale economies of trip pooling	x	x	x	Still-existing modal alternatives	x	x	x
	Deficient Supply with Fixed-Route Transit	x	x	x	Safety and security concerns of pooling	x		
	Willingness to pay for „direct /on demand"	x	x	x	Fragmented market of matching portals			x
	Transparent, rewarding tariff structures	x			Data privacy issues			
Economics – Supply Side	Strong financial incentive structures	x			Unfavorable economies of density	x	x	x
	Market entry opportunities for small	x			Shortage of professional driving personnel			x
	transport firms, by-product for taxis				IT fixed costs for isolated applications		x	x
	Lean, user-financed cost structures	x			Exclusion from subsidization schemes		x	x
	Joint brand development	x			Regulatory km rate cap for private drivers			x
Ecology & Sustainability	Overall goal conformity with the	x	x	x	Net effect on specific emissions, traffic	x		
	sustainability's system of objectives				volumes and traffic space requirements			
	Reduction of serious road accident rates				(transferability under discussion)			
	Role of DRT for resilience, disaster relief				Assurance of social standards of drivers	x		
Stakeholder Influence	Mediator role for the transport chains	x			Limited Stakeholder Commitment, Conflicts			x
	Differentiated, practice-oriented product	x			Deficits in the case of excessive demand?			x
	design – e.g. „guaranteed ride home"				Low econ. success orientation + IT affinity		x	x
	High, multi-channel marketing effort	x	x		Feared loss of the planning sovereignty		x	
	Exceptional Stakeholder Commitment	x			Role of the Incument Operating Companies			x
	Supra-regional networking incl. Universities	x			Concerns of weak competitive position		x	

Source:Heinitz, 2020

DRT is regarded as a bottom-up approach to the acquisition of once-lost public transport relevant demand, for example, by providing connection mobility from P+R lots.

Although still in an initial stage, the cooperation and competition between public and private providers could foster the integration of services in the interest of a better overall system performance. The local markets appear to be confined but still perceptible to state-of-the-art mobility options.

Clearly, here is a considerable need for further quantitative investigations, including the better integration of compartmentalized models for road planning and fixed-route public transport.

Beyond the supply-demand interaction, there is decisive dependency on the consideration of objective, unalterable framework conditions on the one hand, and the role and involvement of stakeholders on the other hand, which is even more difficult to grasp for modelling (cf. Eckhardt et al., 2018).

The possibilities for shaping transport policy ("support of potential-creating measures through appropriate framework conditions"), as well as the objectives, should be specified as soon as possible and regulated at the legal level or otherwise exempted from regulation. This includes the definition of goal-oriented forms of organization that maintain or create institutional trust. This entails questions of the extent of public contribution – particularly, whether to only integrate and mediate the offerings or to deliver and operate. A functional specification for low demand transport relations should become the rule rather than the exception.

Further to this, suggested measures include:

- Conversion of financing schemes of politically desired loss-making offers not with conventional production methods
- More funds, more decision-making leeway at decentralized level, combined with mandatory evaluation requirements of DRT vs. fixed-route efficiency
- A call for adequate, uniform rules on market access and operational requirements, which should be in place to create considerable incentives for DRT users and operators to link with other mobility services.
- Creation of technologically standardized, open and personalized level of mobility networking through a "Management of the information base" (Kutter, 2005)
- Consideration of DRT in medium-term transport plans and development of competences, assisted by the provision of a toolkit for decision support.

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INTERDISCIPLINARY APPROACH TO (VOYAGE) CHARTER PARTIES

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ABSTRACT

Commercial needs and patterns of trade relative to the carriage of goods have caused the shipping industry to develop two major types of commercial ocean carriage: liner shipping and tramp shipping. The liner service generally employs ships serving established trade routes whereas tramp shipping has no advertised sailings and involves vessels seeking employment in the carriage of goods at such times and between such ports as opportunity offers. The liner service is usually performed under the contract of carriage of goods evidenced by a special receipt of cargo and a document of title called the bill of lading. In tramp shipping, shipowners can generally employ their vessels by demise or bareboat charter, time charter, or voyage charter. Their choice will depend upon the charter market conditions or trade in which they wish to employ their vessels.

This paper is an interdisciplinary approach to *voyage charter parties* as they are presented during the legal, economic and language learning courses of maritime studies and transport. Legally, a voyage charter party may be defined as a contract of affreightment by which a shipowner (bareboat, demise, or time charter) places all or part of a fully-equipped and manned ship at the disposal of the voyage charterer for the carriage of cargo for one or more voyages. In particular, we will adopt an interdisciplinary approach to examine the standardized Universal Voyage Charter Party 1984 – NUVOY-84 (Revised Voyage Charter Party 1964). It will be shown that most of voyage charters (if not all) are embodied in standard form contracts, including NUVOY-84, with specific express and implied terms which are a perfect example of the maritime flavour and symbiosis of two major legal systems (Common Law and Civil Law). Then, the economic reasoning for selecting on-spot employment of the vessel instead of the time charter will be presented. Finally, the paper will adopt a terminological perspective and provide a contrastive English-Slovene analysis of typical terms used in voyage charters, aiming to identify discrepancies in the use of Slovene terminology across different authors and texts.

Keywords: voyage charter, NUVOY-84, electronic charter party, charter party clause for electronic bills of lading, economic aspect, terminological aspect, English-Slovene contrastive analysis

1 INTRODUCTION

There are two major types of commercial ocean carriage: liner shipping and tramp shipping. The liner service generally employs ships serving established trade routes whereas tramp shipping has no advertised sailings and involves vessels seeking employment in the carriage of goods at such times and between such ports as opportunity offers. The liner service is usually performed under the contract of carriage of goods evidenced by a special receipt of cargo and a document of title called *bill of lading*. In simple words, the cargo is looking for ships.

In tramp shipping, however, shipowners can generally employ their vessels by *demise* or *bareboat charter (party)*, *time charter (party)*, or *voyage charter (party)*. Their choice will depend upon the charter market conditions or trade in which they wish to employ their vessels. In these cases, the ships are looking for cargo.

This paper is an interdisciplinary approach to *voyage charter parties* as they are presented during the legal, economic and language learning courses of maritime studies and transport. Legally, a voyage charter party may be defined as a contract of affreightment by which a shipowner (*bareboat*, demise, or time charter) places all or part of a fully-equipped and manned ship at the disposal of the voyage charterer for the carriage of cargo for one or more voyages. In particular, we will adopt an interdisciplinary approach to examine the standardized Universal Voyage Charter Party 1984 – NUVOY-84 (Revised Voyage Charter Party 1964). It will be shown that most of voyage charters (if not all) are embodied in standard form contracts, including NUVOY-84, with specific express and implied terms which are a perfect example of the maritime flavor and symbiosis of two major legal systems (Common Law and Civil Law). Then, the economic reasoning for selecting on-spot employment of the vessel instead of the time charter will be presented. Finally, the paper will adopt a terminological perspective and will provide a contrastive English-Slovene analysis of typical terms used in voyage charters, aiming to identify discrepancies in the use of Slovene terminology across different authors and texts.

The research questions that this paper addresses are:

1. What is the legal definition and the legal usage of (voyage) charter parties?
2. What is the economic significance of (voyage) charter parties?
3. What are the discrepancies in the use of Slovene terminology concerning (voyage) charter parties?

2 METHODOLOGY

The paper follows a qualitative research design, and represents a descriptive, explanatory and interpretative analysis of charter parties from the legal, economic and linguistic points of view. Firstly, all charter parties are legally defined and explained, but the emphasis is given to voyage charter parties, the usage of which is presented in Civil and Common Law respectively. The economic approach to voyage charter parties is introduced by explaining *tramp shipping* in the field of economics, considering the fact that tramp shipping companies need to evaluate the most appropriate chartering option according to their needs and interests. In the final section, the case of *Universal Voyage Charter Party 1984* is presented from the terminological perspective. The analysis focuses on five terms ("charterer", "laydays", "laytime", "despatch", and "deviation") that have shown inconsistent terminological use across different Slovene authors. Finally, an initiative for standardising Slovene terms that are derived from the English maritime terminology is launched.

3 LEGAL, ECONOMIC AND TERMINOLOGICAL ASPECTS OF CHARTER PARTIES

3.1 Legal Definitions and General Aspects of Charter Parties

As mentioned above, in tramp shipping the shipowners can generally employ their vessels by demise or bareboat charter, time charter, or voyage charter. It is perhaps useful to define each of these because of their important legal differences.

A time charter party is a contract by which a shipowner places a fully equipped and manned ship at the disposal of a charterer for a fixed period of time. The shipowner retains the navigation and management of the ship but transfers its employment, the use to which the vessel is to be put, to the charterer.

A bareboat charter is a contract by which a shipowner places an unmanned vessel (i.e., without the crew) at the disposal of a charterer for a fixed period of time. In contrast to the time charter, here the shipowner transfers to the charterer the navigation, management, employment and agency of the ship. The same applies to a demise charter which entails a manned vessel (i.e., together with the crew). Thus, and for most purposes, the charterer is treated as the disponent owner or sometimes even the owner of the vessel. His position can be understood in case of salvage. In this case, an exclusively bareboat charterer or a demise charterer has the right to a reward which is in broad terms commensurate with the value of the property salved. In the case of a voyage or time charter, on the other hand, the reward is divided among the owner and charter(ers).

The present paper focuses on a voyage charter which may be defined as a contract of affreightment by which a shipowner places all or part of a fully-equipped and manned ship at the disposal of the voyage charterer for the carriage of cargo for one or more voyages. Arrangements can be made for a vessel to perform a series of consecutive voyages or a number of non-consecutive voyages within designated time frames.

The voyage charter or voyage charter party or voyage charterparty (the words may be used interchangeably) is distinct from other forms of charter parties in that it directly concerns the carriage of goods, and as such may be referred to as a contract of affreightment. The other forms of charters do not directly concern the carriage of goods, but rather the hire, the use and employment of the ship. On the other hand, the voyage charter party cannot be assimilated to a simple contract of carriage as the use and employment of the ship is also obtained by the charterer.

A voyage charter is subject to the usual (national) requirements of contract law, as well as to the customary rules, standardised contracts and other sources of maritime law. In Civil Law, it falls under the generic category of contracts of the hiring of labour, *locatio operis*, pursuant to which a merchant contracts (hires) the services of the carrier to transport the cargo. Under a strong influence of Roman Law, this notion has been historically described as locatio operis transvehendarum mercium where the charterer is provided with a service which necessarily includes the use of the ship. Such a contractual relationship ought to be distinguished from locatio navis et operarum magistri ad transvehendas merces which is a contract for the hiring of a thing (vessel), by which the shipowner lets the ship to a merchant for the purpose of conveying their goods. In this case, the charterer is provided with a ship which, however, necessarily includes its service.

In Common Law, a voyage charter is known as bailment for hire. It is a bilateral contract where the consideration for a promise (the payment of freight) is a counter promise (the undertaking to provide a ship in which to appropriately carry the cargo). In other words, it is a bargain or covenant between two parties, where one thing is given for another, a principle of *quid pro quo*. The shipowner must provide a seaworthy vessel to receive the cargo, generally has the obligation to carefully stow it in the ship (although stowage can be the charterer's contractual obligation), carry it within a reasonable time and without deviation, exercise all needful care of it during the voyage, and convey it to the port of discharge. The charterer, on the other hand, usually undertakes to load and discharge the cargo within a stipulated length of time (laytime), and they may be subject to a penalty of detention or demurrage if that length of time is exceeded, and they are always obligated to pay the freight, this being the fundamental consideration for which the vessel operator will agree to carry the cargo. It is to be noted that the compensation to be paid to the vessel operator by the voyage charterer is called freight, whereas in time charters it is described as hire. This necessary follows from the notion that voyage charters always directly involve the carriage of cargo (freight) whereas the other forms of charter involve the lease (and therefore hire) of the ship.

Voyage charter parties are invariably made in writing, although several national laws do not preclude the validity of an oral charter or are simply silent in this regard. This is not case in the Maritime Code of Slovenia from 2001. Article 441 explicitly demands that the charter party has to be made in writing. It is usually evidenced by one of the standard trade forms designed for a particular commodity, such as coal (NIPPONCOAL 1983), fertilisers (FERTIVOY – 88), grain (NORGRAIN – 89), livestock (LIVESTOCK CHARTER PARTY), meat (PLATE_MEAT A.), ore (MEDITERRANEAN C. (ORE) 7), salt (COASTSALT 1966), scrap (GENJAP-SCRAP), steel (STEEL CHARTER PARTY), sugar (SUGAR CHARTER PARTY), petroleum (ASBATANKVOY) and other liquids (VEGOILVOY 1950), and wood (SOVIETWOOD 1961), among others. In practice, the shipping company will not agree to enter into a charter party if is not made based on one of these standard trade forms. The charter party provisions have been a subject of many court cases and their content is predictable, which is an important feature of charter parties. Parties from different countries and legal backgrounds usually are entering these contracts that are not governed by any international treaty.

Some charter parties are available for general commercial purposes, for instance the Universal Voyage Charter Party 1984 – NUVOY-84 (Revised Voyage Charter Party 1964).

The express terms found in standardised voyage charter parties vary according to the type of trade concerned. A modern voyage charter party, for example, may contain provisions with respect to the identity of shipowners and charterers, loading ports, description of cargo, laydays and cancelling dates, demurrage, despatch, destination, bills of lading, freight, loading and discharging, stevedores, the paramount clause, exemptions, overtime, the both-to-blame collision clause, the general average and the New Jason clause, war risks and brokerage commission, arbitration and other clauses.

In addition, there are several implied terms or "gap-fillers" which are supplied by Common Law courts because the parties would have agreed upon a specific term if it had been brought to their attention or because this is a term which is in harmony with community standards of fairness and policy. Similarly, Civil Law recognises obligations implied by the nature of the contract, equity, usage and law. The most important implied undertakings of the shipowner under any voyage charter are to provide a seaworthy ship, to proceed with reasonable despatch, to exercise reasonable care, and to proceed without deviation. The charterer has the implied obligations to nominate a safe port and/or a safe berth, and to safely ship dangerous goods.

Nowadays, most charter parties are made by emailing clients through brokers. The changes to the charter party are then entered by one of the parties through tracking the text changes in the chosen charter party template, and vice versa. It should be noted that the charter party is different from the classic liner affreightment agreement, which is considered concluded already with the consent of the parties regarding the essential elements of the contract and not perhaps by issuing a bill of lading or waybill (these two documents are not contracts, although they are often wrongly considered as contracts between the shipper of the goods and the carrier). The charter party enters into force at the moment when both parties have signed it.

For several decades, e-commerce has been entering the shipping industry through the big door. Nonetheless, we certainly cannot claim that for bills of lading and charter parties. It is safe to say that blockchain technology has not brought about any significant innovations regarding charter parties, at least for now. However, the situation is different with the bills of lading. The concept of electronic bill of lading has been around for over thirty years. It seems that we are now waiting for the big bang because it is precisely the blockchain technology that has enabled the security for documents of title in electronic form, which the current technology has not been able to provide at an acceptable level. For this reason, BIMCO has drafted the charter party clause for electronic bills of lading. The clause addresses the issue of validity of an electronic bill of lading issued separately or in connection with a charter party in such a way that users of e-bills agree on a set of rights and obligations. This resolves the problems of, for instance, English Law regarding the transfer of rights of suit to third party lawful holders of a bill of lading (COGSA 1992) or, for example, Common Law which demands that documents of title have to be in paper form. The clause reads as follows: "At the charterers' option, bills of lading, waybills and delivery orders referred to in this charter party shall be issued, signed and transmitted in electronic form with the same effect as their paper equivalent." (Cf. UK P&I Club, May 2017). There is another (sub)clause that defines that the use and subsequently the fees or use or subscription of the electronic (paperless) trading system shall be on the charterer's account. There is another demand for the use of such electronic systems: that the system is approved by the international community of P&I clubs. Anyway, the development of e-commerce is so rapid that the content in this paper on e-commerce in the shipping industry will soon become obsolete.

Having described the above, it is fair to conclude that most of voyage charters (if not all) are embodied in standard form contracts, including NUVOY-84, with specific express and implied terms which are a perfect example of the maritime flavor and symbiosis of two major legal systems (Common Law and Civil Law) which have, according to the legendary Professor William Tetley, together evolved into the third legal system of international maritime law.

3.2 Economic Aspect of Voyage Charter Parties

Tramp shipping transports large quantities of low-value bulk and break-bulk cargoes over the globe without a fixed schedule or fixed route. Tramp ships follow the cargo and serve the regions, which offer favourable business opportunities.

The tramp shipping market is often denoted as an almost perfectly competitive market, where the prices, which is freight rates or hire rates, are based on the relation between demand and supply. The tramp market is thus very volatile and unpredictable, with extreme changes happening in short periods. Changes in freight rates of more than 25% can happen during one month (CRSL, 2015). Similarly, daily time charters for the same type of ship can be five or even more times higher during peak periods in comparison to troughs.For example, the daily hire for a Capesize ship in a 12-month time charter was 150,000 US$ in August 2008, and dropped to 18,000 in November 2008 (based on LSE data). For tramp shipping companies, it is thus of fundamental importance to select the proper chartering option at the right moment.

Like any other company, also tramp shipping companies divide their costs into two main categories, namely fixed and variable costs. Fixed costs arise every day of the year, regardless of the employment or movement of the ship, whereas the variable costs are related to each individual voyage. Fixed costs include capital and operating costs, while variable costs include voyage costs and cargo handling costs.

The voyage charter or the on-spot employment is the simplest form of charter, where the shipowner undertakes to transport specified cargo between chosen ports for a negotiated fixed rate per tonne. The freight rate typically includes all expenses occurred during the voyage but excludes the costs related to the cargo (e.g., inspection fees). We can say that the shipper "buys" the service of transport and is free from any concerns, as, in this kind of agreement, the shipowner assumes the risk of delays resulting from causes outside the control of the parties, such as congestion, strikes or adverse weather. Delays consequently affect the daily profit of shipowners.

Shipowners are often presented with several offers, so it is necessary to thoroughly evaluate each offered voyage before making the final selection and agreeing to the freight rate to maximise the profit per day. The voyage estimation consists of several steps, but firstly, it is necessary to determine if the ship fits the cargo and if it can enter and operate in the predetermined ports. Then the maximum quantity of cargo that a ship can accommodate is determined for which it is necessary to have information on the cargo and its stowage factor as well as the ship characteristics and planned passage (for example, where the bunkers will be taken, how much a tonne of consumed bunker changes the draught, and when the ship will change the sailing. These can be crucial for the financial result of the voyage, especially when the charter party has a "moloo" clause: e.g., 40,000/10% moloo; this is the quantity of cargo where the abbreviation "moloo" means "more or less in owners' option", which means that the charterer can accept a minimum of 36,000mt carried but can guarantee only up to 44,000mt. The next step is to determine possible dangers on the route and to estimate the duration of the voyage by calculating the optimal speed (consumption vs. fixed costs) and the time at sea, the time at ports, the time at bunkering ports/stations, and the deviation needed for reaching them. The costs of the voyage are estimated in the last step and are compared to the achievable revenues. Good and reliable information and knowledge are the foundations for planning a safe and economically efficient voyage. This means that information needs to be standardised and consistent, accurate, up-to-date, complete, and received on time.

The shipowner calculates the time charter equivalent (TCE) to make sure that it is worth taking a risk with the voyage charter. TCE helps in deciding whether to employ the ship in a voyage charter or in a trip time charter. In a trip time charter, the ship is hired for the approximate duration of the voyage (can change) at the agreed daily rate. During the period of the trip time charter, the ship is managed by the shipowner but directed by the shipper (the shipper has greater flexibility and is spared the problems of demurrage), who also bears the risk of delays, except those resulting from shipowner negligence.

$$TCE = \frac{voyage\ revenues - variable\ costs}{number\ of\ days} \tag{1}$$

However, in addition to considering the maximisation of gross profit per day, the shipowners must take a broader picture and analyse the port of discharge and future employment possibilities in the geographical area.

The voyage charter offers several advantages for the shipowner, such as the ability to benefit from increases in freight rates, the flexibility in selecting a voyage to strategically position the ship for a future fixture, and the avoidance of a long-term bond with a single charterer who may face financial issues over time. Moreover, the ship is free for selling in a short period of time. However, the on-spot market requires constant activities of the commercial management and a lot of decision making, without having a long-term income guaranteed. On the other hand, a voyage charter is convenient for inexperienced shippers or those shippers who only have occasional transport needs. Shippers are not exposed to risks (not even bunker cost risk) during the voyage but are exposed to upturns in the market as a whole and the necessity of dealing with a great number of owners who are not equally reliable.

Generally, a voyage charter is more profitable than the time charter. However, the shipowner that decides to operate on-spot bears not only the risk of the voyage execution but also the risk of not being able to employ the ship at all during periods of depression. The shipowner can then scrap the ship or lay it up; in the former case, the daily fixed costs keep running, and may vary from several thousand to tens of thousands of US$.

3.3 Case of Universal Voyage Charter Party: Terminological Perspective

In the linguistic section we will present an analysis of Slovene terminological equivalents for five English terms extracted from Part I of the Universal Voyage Charter Party 1984. The sources in the Slovene language that we consulted to extract the relevant terminology in the Slovene language and compare the choices made by their authors include two academic textbooks (Marko Pavliha et al.'s Prevozno pravo: Pogodbe o prevozu tovora, potnikov in prtljage, and Marina Zanne's Poslovanje ladjarja), one manual (Zlatan Čok's Pomorske prevozne listine in pogodbe o prevozu tovora, s poudarkom na ladjarskih pogodbah: Vrste, pojmi in kratice), two dictionaries (Lidija Šega's Veliki moderni poslovni slovar: angleško-slovenski, and Rok Sorta's Slovenska pomorska terminologija), one glossary (Dušan Fabe's English for Ship's Business and Law), and the Maritime Code of Slovenia.

In the first step of the analysis, 30 terms specific to voyage charter parties were extracted from Part I of the Universal Voyage Charter Party 1984. Next, the terms that are too specific to be found in most of the selected Slovene sources were eliminated, for example "lie always afloat", "more or less at Owner's option", and "SHINC/SHEX". The Slovene equivalents for the remaining 19 terms were then extracted from the selected Slovene sources and compared. Some terms were found to enjoy a (relatively) high level of standardisation, for example "Voyage Charter Party" (ladjarska pogodba za potovanje), "owner" (ladjar), "cancelling date" (odpovedni rok), "shipper" (vkrcevalec), "notice of readiness" (pismo o pripravljenosti), "demurrage" (podaljšani postanek), "freight" (voznina), and "brokerage" (brokeraža, provizija).

Therefore, the terminological analysis presented in this paper will focus on five terms that have shown inconsistent use across different Slovene authors. These terms are "charterer", "despatch", "deviation", "laydays", and "laytime".

In the following section, each presented term is first accompanied by the context in which it appears in the Voyage Charter Party, and then by the Slovene equivalent (if) found in each of the selected resources together with a sample context, if available.

1 Charterer (It is hereby agreed between the Owners and the Charterers that the Vessel shall be presented …)

- Šega (1997): TRANS, KOM zakupnik ladje, čarterski najemnik, kdor sklene pogodbo o najemu ladje/letala
- Fabe (2006): zakupnik
- Čok (2008): najemnik (Najemnik ladje (Charterer/Operater) upravlja z ladjo v gospodarskem smislu, saj odreja, kateri tovor bo prevažala, po kakšni voznini in na kateri relaciji.)
- Pomorski zakonik (2013): naročnik prevoza (V smislu določb tega zakona o pomorskih privilegijih se šteje za voznino oziroma prevoznino ladje tista voznina oziroma prevoznina, ki jo naročnik prevoza oziroma potnik dolguje ladjarju.)
- Pavliha et al. (2017): naročnik (Za ladjarja se praviloma šteje oseba, ki je vpisana v vpisnik ladij kot lastnik ladje (shipowner), razen če se dokaže nasprotno. Naročnik (charterer) je pogodbena stranka, ki pri ladjarju naroči prevoz tovora, lahko pa nastopa tudi v vlogi vrkcevalca (shipper).)
- Sorta (2017): najemnik /ladje/, zakupnik /ladje/
- Zanne (2018): naročnik, najemnik (… naročnik pa plačati voznino, tudi če tovora ne prepelje.).; najemnik (Ladjarska pogodba za potovanje mora vsebovati: … podatke o ladjarju in najemniku, in sicer za oboje popoln naziv in naslov;).

2 Despatch (Despatch money on working time (laytime) saved)

- Šega (1997): TRANS nagrada za nakladanje/razkladanje v krajšem roku od pogodbeno določenega
- Fabe (2006): skrajšan (prihranjen) čas nakladanja, nagrada za prihranjen čas nakladanja
- Čok (2008): prihranek (Prihranek pomeni dogovorjen znesek, ki ga ladjar plača, če se je vkrcevanje in izkrcavanje končalo pred iztekom postanka.) // nagrada (… podrobno določilo o podaljšanem postanku ali nagradi in način njunega obračunavanja ter plačilo).
- Pomorski zakonik (2013): /
- Pavliha et al. (2017): nagrada za hitrejše vkrcevanje tovora (V tipično ladjarsko pogodbo za potovanje so običajno vključena zlasti naslednja določila: … nagrada za hitrejše vkrcevanje tovora (dispatch) …).
- Sorta (2017): /

- Zanne (2018): prihranek (Prihranek (despatch) je dogovorjen znesek, ki ga ladjar plača najemniku, če se je vkrcaj ali izkrcaj tovora končal pred iztekom postanka.).

3 Deviation (The Vessel shall have the liberty to deviate for the purpose of saving life of property at sea …)

- Šega (1997): TRANS sprememba smeri plovbe, oddaljitev od vozne poti
- Fabe (2006): /
- Čok (2008): / (Klavzula v nakladnici ali ladjarski pogodbi, ki linijskemu ladjarju oziroma ladji dovoljuje, da skrene z dogovorjene poti oziroma normalne trgovske poti.)
- Pomorski zakonik (2013): skrenitev s poti (- skrenitve s poti v primerih iz prejšnje točke ali iz drugih utemeljenih razlogov;)
- Pavliha et al. (2017): skrenitev (… in ga opravi po dogovorjeni poti brez skrenitve (without deviation).).
- Sorta (2017): odstopanje od poti
- Zanne (2018): deviacija (… prav tako pa bo nastalo nekaj dodatnih stroškov zaradi deviacije s poti …).

4 Laydays (Laydays not to commence before)

- Šega (1997): (lay days) TRANS čakalni dnevi, čas ležanja blaga, dovoljen čas za razkladanje in nakladanje, stojnice
- Fabe (2006): stojnice, čas postanka/nakladanja
- Čok (2008): postanek – norme nakladanja/razkladanja (Glavni pogoji v ladjarski pogodbi so: … postanek – norme nakladanja/razkladanja (Lay Days).)
- Pomorski zakonik (2013): postanek (- postanek je normalen čas, ki je določen za vkrcanje oziroma izkrcanje tovora;)
- Pavliha et al. (2017): postanek (V tipično ladjarsko pogodbo za potovanje so običajno vključena zlasti naslednja določila: … postanki (laydays) in odpovedno roki (cancelling days), …).
- Sorta (2017): postanek
- Zanne (2018): odpovedni rok (Odpovedni rok (laydays) so predvideno obdobje prihoda ladje v pristanišče nakladanja. Po pretečenem obdobju stojnice se potovanje lahko prekliče, posledice takega ravnanja pa so definirane s pogodbo.).

5 Laytime (Laytime for loading/discharge shall commence to count: …)

- Šega (1997): (lay time) TRANS stojnice, čas ležanja blaga, dovoljeni čas za raztovarjanje in natovarjanje
- Fabe (2006): /
- Čok (2008): dovoljen čas za vkrcanje/izkrcanje (Laytime – postanek pomeni obdobje dogovorjenega časa med pogodbenima strankama, v katerem bo ladjar dal na razpolago ladjo za vkrcevanje ali izkrcavanje brez dodatnega plačila dodatka na voznino ali izrednega postanka.
- Pomorski zakonik (2013):
- Pavliha et al. (2017): postanek (Postanek (laytime) je čas, ki ga naročnik kupi za vkrcanje ali izkrcanje tovora.
- Sorta (2017): /
- Zanne (2018): postanek (Postanek (laytime) je obdobje, v katerem bo ladjar dal na razpolago ladjo za vkrcaj ali izkrcaj tovora brez dodatnega plačila dodatka na voznino ali izrednega postanka.).

The results of the analysis indicate a significant level of inconsistency in the use of Slovene equivalents for the selected terms. The term ‘charterer’ is most often referred to as ‘naročnik’ or ‘naročnik prevoza’ but several other terms are also used. The terms ‘despatch’ and ‘deviation’ display a very high variety of forms in Slovene, which indicates a lack of consistency and a low level of standardisation.

In addition, inconsistency in terminological use has been observed in the original English version of the Voyage Charter Party 1984. In fact, the term ‘laydays’ is only used once in Part I (“Laydays not to commence before …”) while in the charter party clauses in Part II the term ‘laytime’ is consistently used instead (for instance, “Laytime for loading/discharge shall commence to count …”). The same inconsistency can be noted in some among the leading glossaries of (maritime) law. Thus, Tetley (2002, p. 62) provides a definition for ‘laytime’ (“In a voyage charterparty, the period of time agreed between the parties during which the shipowner will make and keep the vessel available to the voyage charterer for loading or discharging without payment additional to the freight.”) but not for ‘laydays’. On the other hand, Black’s *Law Dictionary* (1979, p. 799): “In the law of shipping, days allowed to charter-parties for loading and unloading the cargo.” and The Dictionary of Canadian Law (1991, p. 568): “1. A day of work with pay to which an employee becomes entitled by working on board a ship for a number of days. 2. The time to load and unload ships.” only contain definitions of the term ‘laydays’ but not also ‘laytime’. Despite the synonymous nature of these two terms, their inconsistent use in English seems to have translated into an equally inconsistent use in Slovene. In fact, most authors have made attempts to provide terms that would distinguish ‘laydays’ from ‘laytime’.

It is terminologically preferred to follow the rule of using one term per one meaning. As a result, professionals should agree on the words or word combinations that should be consistently used and publish these on an open website with linguistic authority. In fact, the standardisation act (cf. Vintar 2008, 71) could be ensured by publishing the terminological preferences on the internet. This could offer solutions not only to the general public but would engage the professional and scientific communities to comment and find the best explanations and translation equivalents to often problematic terms.

4 DISCUSSION AND CONCLUSION

The interdisciplinary analysis presented in this paper explained and interpreted *(voyage) charter parties* from the legal, economic and linguistic perspectives. The initial legal section defined and clarified the legal usage of charter parties. This was then followed by the presentation of the economic significance of voyage charter parties since they are of great importance for tramp shipping companies. Thirdly, a selection of terms was linguistically analysed regarding their Slovene translation equivalents. The linguistic analysis identified some discrepancies in the usage of Slovene terminology across different resources. To adhere to linguistic guidelines for the standardisation of Slovene terms, collaboration with the Terminological Section of the Fran Ramovš Institute of the Slovenian Language at the Research Centre of the Slovenian Academy of Sciences and Arts in Ljubljana would be very convenient, especially because of their website *Terminologišče* (2004-2020). Finally, it is of utmost importance how terms are used in the current Slovene legislation which is the main referential resource not only for Slovene users, but also for English-Slovene and Slovene-English translators.

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STUDENT TRAINING ON A TRADITIONAL FISHING BOAT, PART OF THE REVITALISATION OF THE NORTHERN ADRIATIC MARITIME HERITAGE

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ABSTRACT

The Maritime Museum "Sergej Mašera" Piran, has recently completed a complex multi-year project, with the main objective being to build a reconstruction of a traditional fishing boat called the Istrian topo. This wooden boat was finished and launched in spring last year and has been leant to the Faculty of Maritime Studies in Portorož. In the future the fully functional boat will contribute to educational and research activities, as a model for the reverse engineering process, with additional theoretical hydrodynamic and stability calculations. But the primary advantage is practical training on a boat with only basic equipment. This offers the possibility of training courses for nautical students, providing them the opportunity to acquire knowledge and seamanship skills acquired on a traditional sailboat. We anticipate exhibitions, competitions, and dissemination in workshops in regard to traditional sailing, of course, but also including traditional methods of construction and maintenance of wooden boats, and the transitional practice of installing an inboard diesel motor.

Keywords: reverse engineering, reconstruction, maritime heritage, historical fishing boat, education, seamanship

1 INTRODUCTION

Shipbuilding is one of the oldest and most important traditional maritime trades, since, in all historical periods, the construction of wooden boats and ships has allowed and influenced the development of all other maritime economic activities. In the medium-size traditional shipyards of the Slovenian coastal cities of Piran, Izola and Koper, wooden boats and ships were built for fishing and transporting goods. For this reason, the thoughtful policy of collecting boats, other maritime objects, technical documentation and other historical materials related to traditional shipbuilding, is important to the preservation of the local heritage. The single typical examples of traditional boats are important for their testimonial value as artifacts of traditional shipbuilding; studying them can help to better understand the development of other marine activities. One of the most recognizable examples are the similar types of traditional wooden boats once common to the entire northern Adriatic area (Hribar et al., 2018a). A thoughtful policy of collection, a selective approach, and above all the great support of all those who have donated their collections to the museum, has led to a great and constantly growing museum collection (Hribar et al., 2018b). In addition to the preservation of the cultural and technical heritage, the educational and research aspect of the project is also very important. The boat will be used for both practical purposes and for various measurements at sea - i.e., stability, resistance, propulsion (Vidmar et al., 2018).

2 REVERSE ENGINEERING OF PRESERVED TRADITIONAL BOATS

Generally, a study process must be based on verified data, which is why an important part of this process is the classification of individual sources in view of their reliability. Historical sources are the basic source of data that we use to study all areas of development of human society (Hribar et al., 2018c).

To put it simply, an historical source can the preserved traces of past human activity, and, according to their form, in theory and practice are divided into:

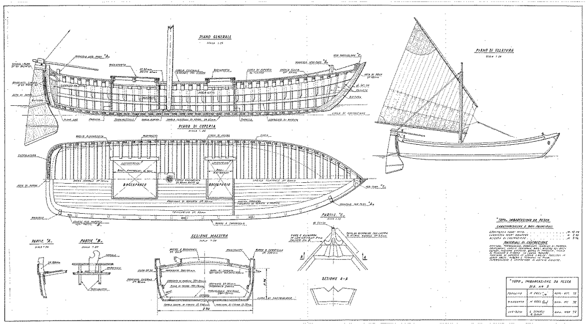
- Material sources,
- Written sources
- Oral sources.

Source: Authors

Figure 1: The original Istrian Topo boat kept by the Maritime Museum Piran

Older photographic, cinematographic and other audiovisual material are also used as sources of information. The most direct source of information on traditional vessels are the preserved original boats (Figure 1) and vessels, their parts and the equipment that remains preserved. The maritime museum cooperates and works closely with the maritime department of the Faculty of Maritime Studies and Transport in Portorož. A program of "reverse engineering" was prepared for students, a method which includes analogical measurements of the lines of old boats with subsequent computer graphic processing. For most boats, in fact, there are no original projects and therefore the only possibility is to implement them with the methodology described above and according to the procedure described.

The Istrian Topo historical plan was an additional important source of data to determine the deck form and its construction design, the course of the longitudinal curvature of the bottom form, and other details that have not been preserved in the original sample or that for various reasons are atypical. The fortuitous proximity to an expert of long experience has been of great help to us: shipbuilding engineer Narcisio Orel acquired his rich experience and knowledge of boat design and construction working in the shipyard of Piran until the middle of the last century (Figure 2).



Source: Personal archive Mr. Narcisio Orel

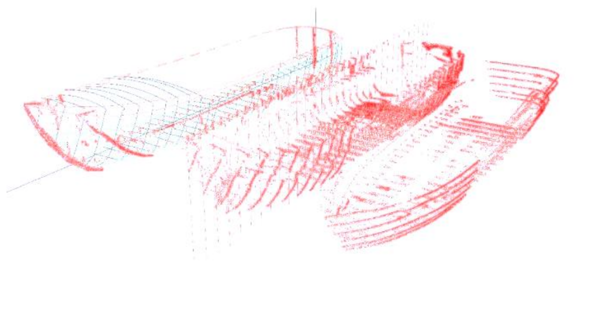
Figure 2: Historical plan of the Istrian topo boat typologies

3 DESCRIPTION OF THE ISTRIAN TOPO

In the northern Adriatic area, the Istrian topo was one of the most common and easy to build small fishing boats used to fish in bays and lagoons. The construction of the Istrian topo is relatively simple and largely similar to the smaller Batana. The bow and stern are more robust, while the central part of the hull is easier to build. Since the boat has a flat bottom and no classic external keel, the wooden frames, technically timbers, of the central part of the Istrian Topo are of simple shapes and are connected symmetrically by a longitudinal element, which in local jargon was called “paramezal” (Marzari, 1982). The Istrian Topo was eight to twelve meters long and, like all flat-bottomed boats, had a very small draught and a large rudder that went far below the flat bottom. The rudder ensured that the boat was properly steered even during coastal navigation and for this reason was equipped with a special iron reinforcement that allowed one to raise the rudder during navigation in shallow water. The large surface area of the rudder was mainly used to increase the lateral plane of the underwater part of the ship, which during upwind navigation reduced the relatively large drift of the flat hull and at the same time, together with the mast, helped to balance the boat. The balancing of both these elements improved the sailing properties, since lower directional corrections provided higher sailing speed (Penzo, 1996). The Istrian Topo boats were usually equipped with one mast. The main sail was trapezoidal, over 40 m², and a smaller bow sail was of the staple type.

4 RECONSTRUCTION PROCEDURE

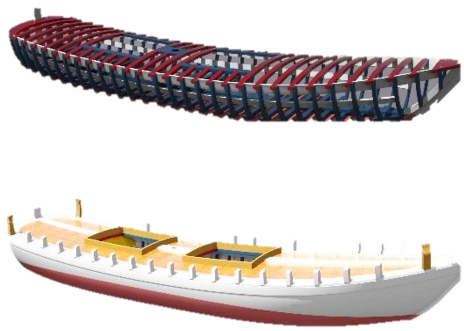
LiDAR measurements on the preserved structure provided a detailed picture of the original, which formed the basis for the further planning of the project and the preparation of the necessary technical documentation. Based on point cloud storage technology, the raw measurements are converted into 3D information representing spatial data as a collection of coordinates (Figure 3).



Source: Digital archive Maritime Museum Piran »Sergej Manšera

Figure 3: Point cloud data

The points are further rendered as pixels (surface reconstruction), resulting in a highly accurate 3D object model (Figure 4).



Source: Digital archive Maritime Museum Piran »Sergej Manšera

Figure 4: The computer generated 3-D construction plan of the Istrian Topo

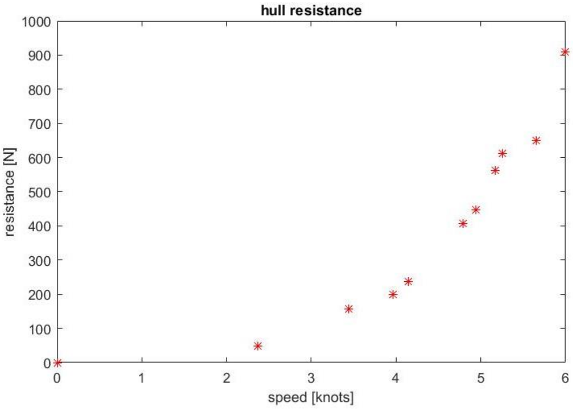
After the preparatory phase described above, the long-awaited construction of the replica of the Istrian Topo has begun. Since this type of flat-bottomed boat does not have the classic keel, it was first necessary to create the "bed" which in local dialect is called the "cantier", taking into account the expected longitudinal curvature of the hull. It is a wooden base that is not part of the boat but that allows you to build the boat in the expected longitudinal shape of the hull. The bow rod consists of two parts, one internal and one external, while the stern rod was made and glued in two parts and in the lower part further fastened with an internal knee. At the stern, in addition to the sternpost, four wooden frames were fixed on each side; so there were a total of nine elements, while at the bow this massive element in addition to the stem also connects two pairs of wooden frames of the side. Once built, the various pairs of side wooden frames are fixed in the joint of the corresponding bottom wooden frame, and we thus obtain the first clearly visible profile of the entire hull of the boat. The construction continued with two mirror pairs of longitudinal side joints, which had to be heat-molded to fit perfectly into the shape of both sides. The upper pair of these longitudinal side joints is at the height of the bridge and determined its position. The final shape of the hull appeared at the end of the long installation of the bridge wooden frames.

Source: Authors

Figure 5: Istrian Topo

5 EDUCATIONAL AND SCIENTIFIC CHALLENGES AND OPPORTUNITIES

To estimate the necessary engine power to install, a measurement was done by the students. The boat was towed by a motorboat, connected with a line of 80 meters of length. The towing position was far enough that the wake from the towing boat was negligible for the purpose of the experiment. During the towing experiment an Xsens MTI-g inertial measurement unit was installed on the towed boat to record of the speed and accelerations, while a dynamometer was connected between the towing line and the towed boat, recording the towing line tension, that was the only external propulsive force. The results of the experiment are given in the following diagram



Source: Authors

Figure 6: Boat resistance; experimental data

Given the results of the towing experiment on a real scaled boat, the towing force was 900N at 6 Nm/h (3.08m/s). The towing power P_P at 6 Nm/h is therefore 900N*3.08m/s==2778W.

Our target speed for the boat is around 7 Nm/h; however measuring the towing force at such a speed was not feasible, because of strong wake interaction that was seen during the experiment, therefore the propulsive force for 7 Nm/h would be extrapolated from measured data.

The power law $F(v) \propto v^2$can be used to extrapolate the resistance for higher speeds that are close to that measured. This way we can calculate resistance of 1225N at 7 Nm/h and 1600N at 8 Nm/h. This requires a propulsive power P_P of 4411W and 6584W.

Propeller efficiency η_p was expected to be 0.5, while mechanical efficiency η_m was expected to be 0.9. With these assumption we can readily estimate the required engine power P_E using the equation (Carlton, 2018)

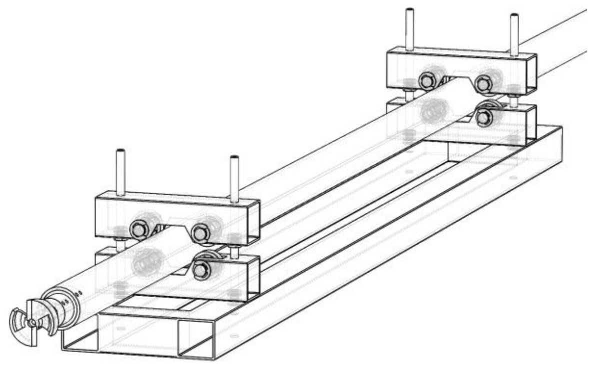
$$P_P = \eta_p \, \eta_m P_E \tag{1}$$

According to the assumption and extrapolated data, the required engine power would be 9.8kW at 7kt and 14.6kW at 8kt.

Given the commercial availability of inboard engine powers, we opted for a diesel marine engine of 11.2kW. The commercial propeller management program yielded a similar result, expecting a propeller efficiency of 53%, with a calculated target speed of 8kt. The two approaches gave similar results, which was welcomed by the students who had done the measurements.

Then we needed to drill the shaft hole through massive wood construction. For this purpose a drilling system was built to perform the 1010mm long hole with a drill bit of 45mm (Figure 7).

The drilling tool was equipped with 8 rolling bearings, that accommodated a long straight steel tube of 43mm diameter with an elastic section modulus of 3970 mm^3. The shaft hole was aligned to have 4° inclination with respect to the designed waterline and 8° inclination with respect to the counter-keel local tangent plane at the inner side of the shaft tunnel. Tunnel alignment and inclination was performed on site, comparing the real geometry with construction plans. No major discrepancies were found, which empsises the good craftsmanship. A propeller tunnel was installed in the hole and epoxy resin was injected between the wood and tunnel. The engine bed was adjusted to accommodate the 11.8kW diesel engine.



Source: Authors

Figure 7: Custom designed drilling guide

The engine alignment was done before fixing the supports. The resulting stern gear system is hinged on two points: on the engine gearbox and on the strut in the water. The strut was constructed by welding inox-steel plates of 5 mm thickness on the aligned shaft bearing that was suspended through the tunnel. On site only point welding was performed, which was finished in the workshop. At the end the shaft alignment was acceptable and the propeller distance from the hull complies with the advised relations given in (Gerr, 2009).

6 CONCLUSION

The main objective of this project for the Maritime Museum Piran was to preserve local maritime cultural heritage, above all traditional shipbuilding. Once finished, the new boat was also formally registered and given for permanent use to the maritime department of the Faculty of Maritime Studies and Transport in Portorož, where it will be used for the educational activities of practical training in the maintenance of wooden vessels, sailing and rowing with traditional northern Adriatic equipment.

The wooden sailing boat was dry-docked for the purpose of yearly maintenance. There was a crack between wooden plates, which was professionally treated using traditional materials and technique. The underwater part of the hull was painted with antifouling protection. During periodical maintenance of the boat, there was a decision for installation of a diesel engine, which will allow students to practice manoeuvring and allowed even more safe use of the boat for pedagogical use.

Occasionally they will use it to participate in various events, such as meetings involving old boats or fairs and tourist events at home and abroad. In this way we try to contribute to the preservation of the intangible heritage of old maritime skills and traditional maritime trades.

In future the students will have the opportunity to practically familiarize themselves with the »reverse engineering method«; measuring hull lines to get basic skills in computer graphic boat design.

Seaworthy reconstruction of a traditional wooden boat will also allow students to obtain dynamical stability simulation with the Micro Electro Mechanical System (MEMS), measuring the resistance of an underwater body to determine the exact navigable properties in variable weather and different loaded conditions. This will help in understanding why this kind of wooden sailing boat was for centuries used among local fishermen as a working boat and what kind of working-sailing capabilities were offered.

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THE STUDY OF THE DOMINANT INFLUENCES OF THE SEASIDE ENVIRONMENT ON THE DEGRADATION OF THE NI-TI SHAPE MEMORY ALLOY

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ABSTRACT

The prediction and assessment of the corrosive behaviour of potential construction materials in the coastal environment has an utmost importance for the protection of the environment and sustainable development. Related to this, the degradation of potential construction materials as a result of the influence of the environment on their resistance and durability is most significant. Therefore, it is important that we monitor these processes. One of the possibilities is to use tools such as various analytical techniques of materials by combining different skills and experiences. Within this research area, a very important place can be attributed to chemical analysis.

This research paper represents the possible corrosive influences of different types of the environment (the sea, air, ebb and flood tides) on NiTi alloy during six months of exposure. For this purpose, EDX analysis was used for identification of the elements that could be crucial in the degradation of materials. Due to an extensive and heterogeneous database, data interpretation relied on the methods of multivariate analysis - Cluster analysis and Principal component analysis. The methods applied detected data aberrations, and provided a more precise insight into the corrosive impact of different types of the environment.

The data obtained indicate clearly that the characteristics of a corrosive environment have a dominant influence on the damage degree of NiTi alloy, although the influence is not always notable. The most heterogeneous degradation of the NiTi alloy was observed in the sea, while the weakest and the most uniform corrosion was registered under the influence of the air.

Keywords: environment, NiTi alloy, degradation, multivariate analysis

1 INTRODUCTION

The dynamic development of different types of transportation industry in the last century is linked to the application of new construction materials. The new materials should be adapted to the environment, reduce production cost, improve functionality and ensure the sustainability of the vehicles. In that regard, shape memory materials have received special attention.

Various alloys based on nickel, copper and aluminium were developed after the discovery of the Shape Memory Effect in 1932 [1]. The main characteristic of Shape Memory Alloys (SMA) is their capacity to resume their original dimensional integrity (pre-deformed shape and size) after undergoing substantial deformation when heated to a certain temperature [2]. Additionally, binary and trinary alloys were developed at the same time. Alloys based on Ni-Ti, Cu-Al-Ni and Cu-Zn-Al and Fe are applied the most widely [3, 4].

The extensive research on different alloys and Shape Memory Effect (SME) identified other thermo-mechanical properties of Shape Memory Alloys, such as: Superelastic and pseudoelastic effects, high damping capacity and double Shape Memory Effect. These thermo-mechanical properties are the main reasons for the application of smart materials in different industries [5, 6, 7, 8].

SMAs have a wide application, but the earliest use was in Medicine and the Aircraft industry. The application of SMAs is significant in other branches of the Transportation industry, such as the Automotive industry, Rail Transportation and the Maritime industry, which is the focus of the latest research. The application of SMAs in the Aircraft industry is based on coupling, fastening, and actuation (morphing and damping) [9]. Coupling and fastening, actuators (thermal and electrical), as well as damping and security, are used in the Automotive industry [9]. When it comes to Rail Transportation, Shinkansen 700 – the Japanese bullet train - contains valves and SMA springs. A wider application of SME is noted in deep and shallow waters [9, 10].

The use of SME depends on the environment of construction materials. Therefore, environmental conditions should be researched in relation to the possibilities for the application of SME materials in different industries. The application of SME materials in the Aircraft industry is affected dominantly by the changeable conditions of the atmosphere (varied elevation, pressure and temperature), while the SME materials used for insulation in the deep seas are affected by the characteristics of seawater (temperature, salinity and conductivity). The complex influences of the sea and coastal atmosphere influence the behaviour and the exploitation of SME materials considerably in the Maritime industry [11]. The paper researches the behaviour of a NiTi alloy in different types of the coastal environment by means of multivariate analysis. The change in the chemical compositions of phases in SME materials and their degradation caused by corrosion, are the consequences of the environmental factors affecting the SME materials investigated. Therefore, a semi-quantitative analysis - Energy-Dispersive X-ray spectroscopy (EDX) - was applied, in order to detect the chemical composition of the phases, while Cluster Analysis and Principal Component Analyses were used to define the types of environment in coastal conditions.

Multivariate data, including the data on corrosive influences of the varied types of the coastal environment, are often too extensive, so it is almost impossible to observe the trends and relations between the data. However, there is a certain correlation between the variables in these systems. Due to the development of Information Technology, multivariate methods of analysis are now frequently applied for an easier and more precise interpretation of heterogeneous experimental data. Multivariate analysis can reduce data amount, classify data based on similarities and differences, and identify the dependences that are not initially visible.

2 MATERIALS AND METHODOLOGY

2.1 Materials

NiTi alloy produced through a standard casting process in the form of a disc with r = 50mm was used for the investigation (Figure 1). Three samples were inserted in a selected box for the experiment, which was conducted during a six-month exposure to different types of the environment - seawater, a littoral zone and the atmosphere.

Inductively Coupled Plasma (ICP) analysis was performed to identify and measure the ratio of chemical elements. X-Ray Fluorescence (XRF) composition analysis was applied as an excellent method for qualitative and quantitative analysis of the initial NiTi alloy composition. The results of the ICP and XRF analyses indicate the basic chemical composition: The percentage of nickel (Ni) was between 55.2% and 55.4%, while the percentage of titanium (Ti) was between 44.4% and 44.8%.

Figure 1: Disc-like NiTi alloy as cast

2.2 Methodology

The research is based on the analysis of the varied influences of the sea and atmosphere, as well as the changeable influences of the sea and atmosphere in a littoral zone during six months. Figure 2 shows the conceptual model of two phases of the research. The first phase systematised the data from the EDX analysis in order to obtain the distribution of the chemical compositions of the metals. The second phase was based on the data analysis through multivariate methods such as Cluster Analysis (CA) and Principal Component Analysis (PCA).
As already mentioned, the chemical composition of the NiTi alloy is determined by means of an electron microscope and a semi-quantitative analysis. The microscope contains an Energy Dispersive Spectrometer (EDS) - Oxford INCA 350 - for microchemical analysis. The EDX semi-quantitative analysis determined the chemical composition of the materials after corrosion; as well as the content of the elements on the surface of the examined samples. For the purposes of this research, the chemical compositions of the metal surfaces were examined for each sample of the NiTi alloy. Up to seven spectrums and the magnifications of 70 μm, 100 μm, 200 μm i 300 μm were used for each sample.

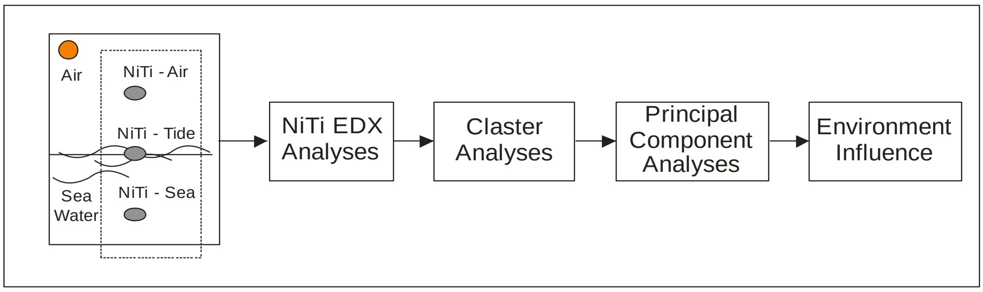

Figure 2: The scheme of the conceptual model of the research

The research applied CA and PCA to the matrix, in which corrosion parameters obtained experimentally from the EDX analyses represent variables (columns), while the different parts (spectrums) of the alloy sample observed represent rows. The labels used were: M - Sea, V - Air and P - Tide. The first figure behind the labels indicates a sample, while the second figure represents the spectrum number inside the samples. The matrix data were standardised before the calculation, in order to ensure the equal importance of all the analysed parameters.

3 RESULTS AND DISCUSSION

In accordance with the methodology presented in Chapter 2.2, the EDX analysis was conducted on the NiTi samples that were exposed to the air, tides and sea for six months. The corresponding measuring of the chemical composition of the NiTi alloy was performed depending on the location of the samples. The results of chemical composition and an appropriate EDX-spectrum were selected for each sample. Table 1 shows the number of samples, corresponding spectrums and magnifications.

Table 1: The number of samples and EDX-spectrums for the NiTi alloys in the sea and the littoral zone

	Air		Tide		Sea	
	Magn.	No. of Spec.	Magn.	No. of Spec.	Magn.	No. of Spec.
Sample 1	200	Spectrums 1-6	200	Spectrums 1-5	200	Spectrums 1-7
Sample 2	100	Spectrums 1-6	100	Spectrums 1-7	100	Spectrums 1-7
Sample 2	70	Spectrums 1-6	70	Spectrums 1-5	70	Spectrums 1-7
Sample 4					200	Spectrums 1-7

Figure 3 shows the location of the EDX-spectrums that were exposed to the littoral zone, while Table 2 exhibits the chemical compositions of all the analyzed samples. Magnification of 200 µm was used in Figure 3, while different magnifications of 70 µm, 100 µm and 200 µm were used for the remaining samples. All another samples, from 1 to 4 in different environment conditions (air, tide, sea), were analysed in the same way.

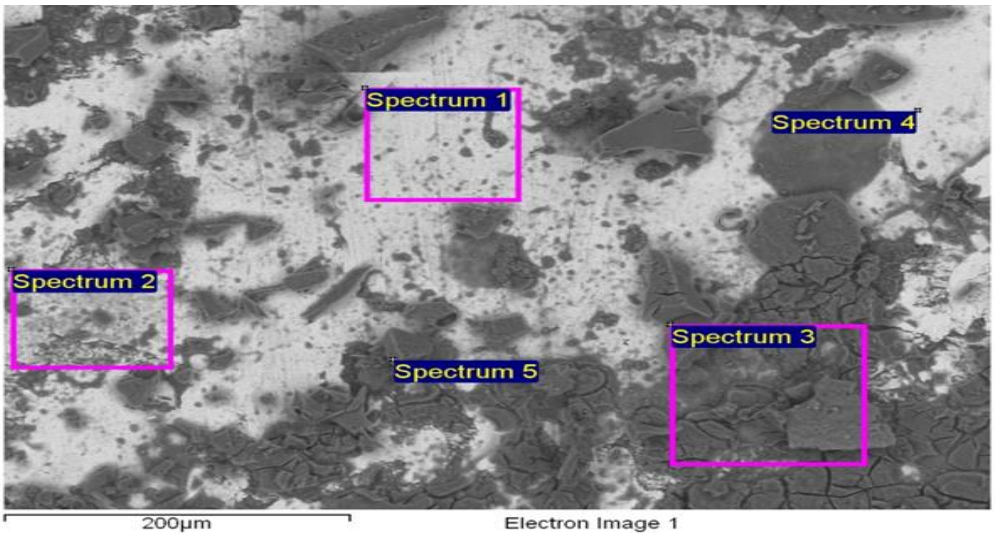

Figure 3: The view of Sample 1 of the as cast NiTi alloy located in the littoral zone; the locations of the five spectrums under the magnification of 200 µm

Table 2: The results of the EDX analysis of the NiTi alloy as cast, after six months of exposure to the littoral zone; the chemical composition of five spectrums from Figure 3

Spectrum	In stats.	O	Na	Si	Cl	Ca	Ti	Ni	Total
Spectrum entire image	Yes	29.18	0.00	1.06	0.00	0.00	32.91	36.85	100.00
Spectrum 2	Yes	45.33	0.00	0.00	0.00	0.00	27.76	26.91	100.00
Spectrum 3	Yes	77.11	2.71	0.00	1.38	0.00	9.71	9.09	100.00
Spectrum 4	Yes	9.14	0.00	0.70	0.00	0.00	41.73	48.43	100.00
Spectrum 5	Yes	78.57	2.93	7.36	0.00	1.21	6.07	3.86	100.00
Max.		78.57	2.93	7.36	1.38	1.21	41.73	48.43	
Min.		9.14	2.71	0.70	1.38	1.21	6.07	3.86	
Mean		**47.87**	**1.13**	**1.82**	**0.28**	**0.24**	**23.64**	**25.03**	**100.00**

As per the sample analysed, the Table above indicates the dispersion of the data, which is also relevant for other samples located in the atmosphere, littoral zone and the sea.

According to the results (Table 2), the surface of the alloy tested in each type of environment becomes quite heterogeneous after corrosion. The comparison of the images illustrating the surface of the NiTi alloy for all recorded Samples from Table 2, after six months` exposure to the influence of the air, flood tide and the sea, shows that the thickest layer of deposits is registered on the surface exposed to the sea. The results of the EDX analysis (Table 2) showed that, besides the emergence of nickel and titanium as corrosion products, additional inorganic salts are also formed on the surface of the alloy. The analysis of the chemical composition of the surface indicated that the inorganic salts include mostly the species based on sodium, calcium and magnesium, which are formed in chlorides, silicates and, less frequently, sulphates.

The presence of a flood tide causes the changes in the chemical composition of the surface, because salts, except for sodium and silicon, were not registered (Table 2). This means that flood and ebb tides flush the salts off the metal surface.

This proves that the environment affects the chemical composition of metal surfaces after corrosion considerably. Because of the large heterogeneity of the results obtained, multivariate analysis was used as a tool for a more accurate identification and easier interpretation of the influences of different types of the environment on the corrosion of the examined alloy. Figure 4 presents the dendrogram of the influences of the different types of the environment on the behaviour of the alloy tested by means of CA.

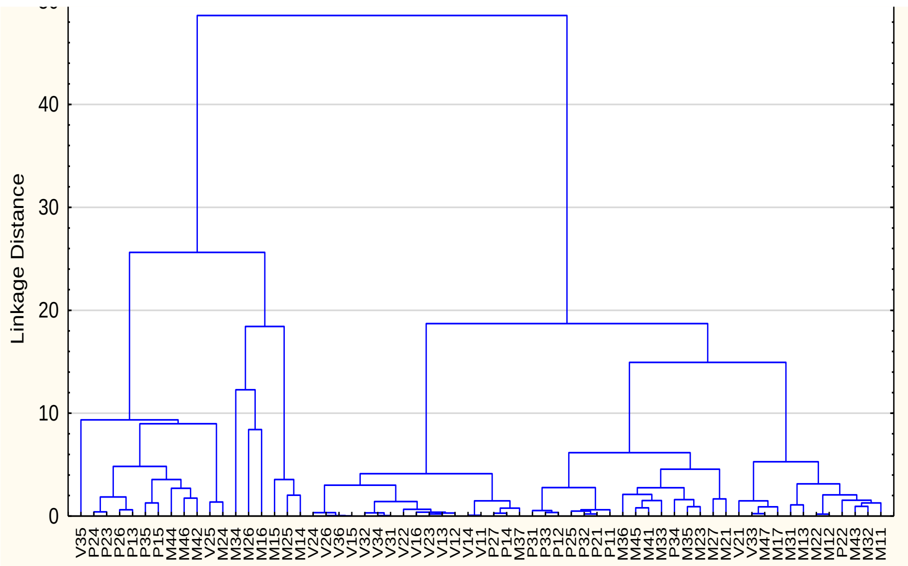

Figure 4: The dendrogram of the types of corrosive environment tested

As shown in Figure 4, Cluster Analysis groups the data in two clearly separated clusters. The clusters are mainly formed based on the characteristics of the corrosive environment including certain aberrations (V35, V25, M37, P27, P14, P34, P22, V21, V33). The results obtained by means of PCA (Figure 5) indicate a similar distribution.

In the case of both, PCA and CA, almost identical measured points (V35, V25, V21, V33, P27, P14) deviate from the characteristic trends of behaviour. On the other hand, M16 and M26 measured points are within the cluster, but still show a significant deviation from the characteristic behaviour trends. Based on these findings, the listed measured points should be excluded from further analysis, as they do not depict the typical behaviour of the alloy in the examined environment.

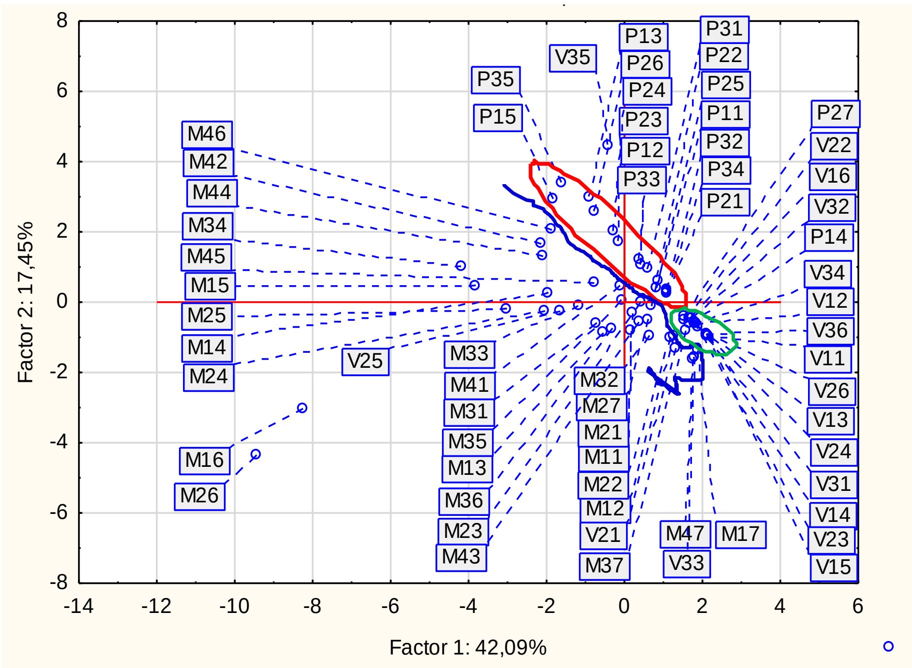

Figure 5: PC1 versus PC2 – the score plot

In addition to the identification of data deviations, both methods of multivariate analysis confirmed that the characteristics of the environment of the alloy, which are not always notable, still have a decisive influence on the corrosion degree of the NiTi alloy.

According to Figure 4, Cluster Analysis grouped all types of the examined environment in two separate clusters, whereby the right cluster is divided into two subclusters. Each subcluster, apart from the exceptions explained previously, typically gathers the types of corrosive environment based on their characteristics (the air, sea and littoral zone). The left cluster is also divided into subclusters, and contains the data relevant for the sea and ebb and flood tides. Ultimately, Cluster Analysis cannot separate the corrosive influences of the sea from the influences of the ebb and flood tides.

A clearer distinction is achieved by means of PCA, which identified and distinguished precisely the corrosive influences of the types of environment examined (Figure 5).The influences of the ebb and flood tides (red circle) and the air (green circle) are clearly separated from the corrosive influences of the sea (blue line). It should also be noted that the results relevant for the sea are the most heterogeneous (i.e. the most dispersed within the cluster), while the most uniform dissolution of the NiTi alloy is observed in the air. There is a considerable similarity between the influences of the air and ebb and flood tides as opposed to the influences of the sea.

4 CONCLUSION

Cluster Analysis and Principal Component Analysis are the multivariate methods of analysis that were applied, with the aim of a more precise data interpretation. This paper analysed the change of the NiTi alloy chemical composition after six months of exposure to different types of coastal environment (the sea, air and ebb and flood tides). The obtained results confirmed that, in all types of the environment, the surface becomes extremely heterogeneous, which impedes a proper identification and interpretation of the corrosive influences of the specific types of environment on the NiTi alloy. Both methods confirmed that the types of environment examined have a specific corrosive impact on the NiTi alloy, although the impact is not always notable. On the other hand, the multivariate methods of analysis were useful not only for the identification of the similarities among the analysed data, but for the detection of differences, as well. The identification of deviating data has a special importance, as it enhances the interpretation of the heterogeneous results that are typical for real samples.

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DISTANCE LEARNING DURING THE COVID 19 CRISIS

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ABSTRACT

The background of the study deals with distance learning during the COVID 19 crisis. This paper aims to provide an overview of key concepts in the distance learning process, to present the basics of development and its current achievements, information, and communication technologies, and the social and economic aspect of distance learning. Today's age of modern technologies and globalization brings rapid changes in all aspects of human life. There is a need for the fastest, most timely education, which will both be open and widely available. In the initial phase, it is very important to weigh its advantages and disadvantages before introducing an e-learning system to achieve maximum effect. By researching strategies on how learning is affected by communication, curriculum design, assessment and motivation contribute greatly to the quality of knowledge acquisition. Qualified distance learning systems such as Moodle, Merlin, Mod, Webinar, Zoom, Adobe Connect, E-Portfolio are also considered while considering the needs of future development. Analytical, descriptive, and survey method of scientific research work was used. Given the current situation (COVID 19), distance learning has been adopted at an enormous rate and the traditional form of teaching has become almost a part of the past. Support for this project must not be absent from the highest state of European and world institutions in the educational, economic, and social sectors.

Keywords: distance learning, e-learning, education, information and communication technologies

1 INTRODUCTION

Today's age of modern technologies and globalization brings rapid changes in all aspects of human life. New information is created every day, and general development continuously requires new knowledge and skills along with lifelong learning. There is a need for the fastest, most timely education, which will both be open and widely available. Maritime affairs are specific, the education of seafarers began at the moment when it was realized that not only one's own experience is enough for sailing, but also the acquired knowledge and experience of other seafarers. Education programs in maritime secondary schools and universities meet the minimum requirements of the Convention, but also meet higher standards, precisely because of the need for continuous training. The training of seafarers is, as a rule, carried out following the provisions of the International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers (STCW).

Designing and creating a quality and functional system for e-education usually requires considerable resources and a lot of time and effort for the whole subject or course to be put on the Internet platform. Investments in preparation for the online performance of one teaching unit are usually many times higher than in the case of the off-line live teaching. Considering previous arguments it is very important to weigh the advantages and disadvantages before the introduction of e-learning.

Education studies the way people learn and explores how learning is affected by communication, course and curriculum design, assessment, and motivation. Appropriate pedagogical methods that follow the way of presentation are necessary for the success of the distance learning process. To achieve the highest quality of distance education, it is necessary to have certain pedagogical measures with the synergy of the technological aspect.

In education as in many other areas of social life, globalization and information technology affect commercialization, reduce the feeling of isolation among countries in the world, allow the breaking down of artificial barriers for the flow of goods, services, capital, knowledge, and people across borders. The strength of such changes has influenced the creation of the need for new knowledge, occupations, and the demand for lifelong learning. The processes of training and acquiring the necessary qualifications can be adopted via the Internet, without a physical presence, anywhere, and at any time. In this way, the notion of education is no longer a structured knowledge transfer but acquires a broader context that takes place under the influence of globalization and information technology.

Platforms need to be upgraded and standardized according to e-learning needs, which require time, money, and expertise.

2 THE CONCEPT AND TYPES OF E-LEARNING

E-learning can be defined as support for learning through usage of network technology particulary web technology (Boer and Collis, 2002). The authors Ćukušić and Jadrić (2012) according to (Horton and Horton, 2003) give a very similar definition by presenting e-learning as the use of the Internet and web technologies in learning. A slightly more complex notion of e-learning is defined by Morrison (2003) as the continuous assimilation of knowledge and skills stimulated by synchronous and asynchronous learning activities created, delivered, supported, and managed by Internet technologies. [1]

In the professional literature, according to Aničić and Barlovac (2010), e-learning is defined in two groups: [2]

1. Technical definitions that emphasize technology. Such a definition would state that e-learning is any form of learning, teaching, or education that is supported by the use of computer technologies, and in particular computer networks based on Internet technologies.
2. Pedagogical definitions that have a focus on education, learning, and teaching, ergo e-learning is an interactive or two-way process between teachers and students, with the help of electronic media, in which an emphasis is on the learning process, while the media are only an aid that completes this process.

Education must adapt to economic and technological developments, which increasingly require an e-learning process, should also provide the necessary information, develop skills and competences with the greatest flexibility and the lowest cost. Learning is a continuous process that lasts a lifetime making learning and work-related activities no longer separated. This may resilt in technology affecting our brains and changing it. The various tools used today define and shape our thinking while technology supports the learning process. Since the professor and students are not in the same locations, the acquisition of knowledge, as well as their interaction with each other, is made with the help of computers. [1]

For e-education, we can say that it means any study program that uses information and communication technology to implement teaching/learning, while distance education is a narrower term because it is mostly limited to colleges and schools. Some point out that there is a difference between the terms distance learning and e-learning, which stems primarily from the fact that it first emerged long before the development of information and communication technologies, while e-learning uses only electronic media. [1]

Maritime affairs are specific, the education of seafarers began at the moment when it was realized that not only one's own experience is enough for sailing, but also the acquired knowledge and experience of other seafarers. Nowadays, most maritime high schools, colleges, and university departments implement education programs under the provisions of the International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers. The education of seafarers requires constant additional training due to the development of new technologies on ships. Education programs in maritime secondary schools and universities meet the minimum requirements of the Convention, but also meet higher standards, precisely because of the need for continuous training.

The training of seafarers is, as a rule, carried out by the provisions of the International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers (STCW). The convention was adopted at a conference of the International Maritime Organization held in 1978, in London. As the STCW Convention was not in line with the technological development of ships and their equipment, detailed amendments to the STCW Convention were introduced in 1995. The most important amendments relate to: [2]

1. The STCW Ordinance, which consists of Part A and Part B and forms an integral part of the STCW Convention,
2. formation of a "white list",
3. introduction of independent judgments of the quality system,
4. requirements regarding training programs, conducting examinations, use of simulators and introduction of quality systems at maritime universities,
5. requirements relating to the liability of shipping companies.

The next important amendment to the STCW Convention occurred at the Manila Conference in 2010 when new Manila amendments were adopted to address: [2]

1. issuance of certificates,
2. introduction of provisions on working hours and rest, prevention of work under the influence of drugs and alcohol, and provisions on the medical fitness of seafarers,
3. introduction of new professions,
4. introduction of new basic training programs and expansion of existing ones,
5. introduction of basic skills for work on oil, chemical and liquefied gas tankers, issuance of recommendations for navigation in polar waters and dynamic positioning,
6. amendment of the provisions on coastal navigation
7. introduction of the term "**distance learning**"

In addition to being executed under the provisions of the STCW Convention, it is necessary to highlight several basic features of seafarers' education: [2]

1. The education of seafarers implies a continuing need for further training to enable them to acquire knowledge of new technologies onboard ships;

2. Multidisciplinarity of programs and content;
3. Special attention is paid to the acquisition of knowledge in the field of safety and protection of the marine environment, and human resource management in a multicultural environment

3 ADVANTAGES AND DISADVANTAGES OF E-LEARNING

Designing and creating a quality and functional system for e-education usually requires considerable resources and a lot of time and effort for the whole subject or course to be put on the Internet platform. Investments in preparation for the online performance of one teaching unit are usually many times higher than in the case of off-line live teaching. Considering previous arguments it is immensely important to weigh the advantages and disadvantages before the introduction of e-learning. [3]

3.1 Benefits of e-learning

1. E-learning enables users to participate in quality teaching even when the question of distance, schedule, and similar circumstances make it practically impossible. Wide availability enables the simultaneous participation of a large number of users.
2. The fully modernized e-classroom is open 24 hours a day, which enables the most efficient use of time. Users themselves choose when and how to access e-learning as they have constant access to the materials and classes they attend.
3. E-learning via the Internet enables a particularly dynamic interaction between teachers and students, as well as students with each other. Each individual contributes to the teaching by initiating or participating in discussions related to the topic.
4. The system easily enables integration and access to other sources relevant to the material being taught.

3.2 Disadvantages of e-learning

1. E-learning requires users to have certain knowledge and skills to be able to use it. Without basic computer usage skills, material integrated within an electronic learning system becomes completely useless. In addition to this knowledge, it is important for the implementation of e-learning that each of the users has certain equipment for this.
2. Even the highest quality equipment on which e-teaching is performed is not 100% reliable. Even when possible technical problems do not lead to interruptions in the conduct of e-learning, it will certainly contribute to a decline in the concentration of users thus a decline in the quality of e-learning.
3. By enabling more independent determination of the way and time of learning, e-learning brings greater responsibility to its users. In certain forms of e-learning, self-motivation, individual assessment of learning needs is important, which can lead to questionable results and poor progress in the learning process due to the subjective approach.
4. An already developed e-learning system encounters copyright problems with certain content as well as the emergence of similar disloyal or higher quality content by other authors. The system requires some technical support, the constant development of which by current technologies requires additional financial investments.

4 SOCIAL ASPECT OF E-LEARNING

According to (Wolf, 2009), the authors Ćukušić and Jadrić (2012) point out that "education studies the way people learn and investigate how learning is influenced by communication, course and curriculum design, assessment and motivation." Appropriate pedagogical methods that follow the way of presentation are necessary for the success of the distance learning process. To achieve the highest quality distance education, it is necessary to have certain pedagogical measures with the synergy of the technological aspect. [2]

Table 1: Social dimensions of e-learning

PEDAGOGY homogeneous → diverse
LEARNING THEORIES Behaviorisam – cognitivism – constructivism – connectivism →
LEARNING CONTENT Standardized / formal – lifelong / real context →
TEACHER Instructor, support, mediator →
PARTICIPANTS Passive in learning – active and directing →
E – LEARNING Downloading information – in – community learning – a personalized environment →

Source: Mentis, 2008

The first level in Table 1 according to Mentis (2008) shows the development of educational theories and models that influence e-learning from traditional and more homogeneous approaches on the left side of the continuum to more open and diverse approaches on the right side. In terms of educational theories and models, development began from behaviorism through cognitivism and constructivism (Siemens, 2008). The transition from a homogeneous to a diverse pedagogical approach is thought to be linked to the separation of formal and non-formal learning. [2]

The most common theories related to distance learning are behaviorism, cognitivism, constructivism. Content can be offered by teachers or can be explored by students. The teacher in the role of instructor, support, and a mediator is harmonized with the role of students in the same educational process. The passive learner who has so far only downloaded the necessary data now becomes active and changes towards only the guiding learner using the various technologies of the modern age. In the e-learning process, information is taken over by the lecturer, while learning within the community is student-centered, and personalized learning environments achieved using social networking tools. For the entire educational process to be successful, it is necessary for the student to be extremely motivated and actively involved in learning. [2]

5 ECONOMIC ASPECTS OF E-LEARNING

In education, as in many areas of social life, globalization and information technology affect commercialization, reduce the feeling of isolation among countries in the world, allow the breaking down of artificial barriers to the flow of goods, services, capital, knowledge, and people across borders. The strength of such changes has influenced the creation of the need for new knowledge, occupations, and the demand for lifelong learning. The processes of training and acquiring the necessary qualifications can be adopted via the Internet, without a physical presence, anywhere, and at any time. In this way, the notion of education is no longer a structured knowledge transfer but acquires a broader context that takes place under the influence of globalization and information technology. [4]

Business organizations have long taken advantage of e-learning as their employees are spread over a wider geographical area, so they see the main benefit of investing in e-learning systems in overcoming the spatial and temporal framework of the classic classroom and eliminating the need to gather all employees in the same place at the same time. Furthermore, the implementation of e-learning activities within the LMS means the centralization of all necessary data for learning in one location and the elimination of the need to search several different sources for data collection and harmonization. [1]

Business organizations, naturally, see the greatest importance in realizing the economic benefits of investing in e-learning systems. Significant savings resulting from this type of investment are most commonly seen concerning traditional employee training methods. [6]

Savings achieved compared to traditional training include reduction of travel costs, reduction of training fees, reduction of materials costs - this item refers to the costs of creation and distribution, storage and management of teaching materials, (printing, books, brochures (), that is, the costs that are repeated with each content update. With e-learning content, these costs are virtually non-existent. [6]
The group of organizational benefits is particularly difficult to highlight and measure and can be defined as all that the organizational structure derives from the replacement of classical training methods with those supported by the IT system. This factor makes it possible to achieve synergies that traditional training methods cannot. [4]

Knowledge resource management and the potential to create virtual learning communities are potential benefits that only e-learning provides. Even if these benefits are not explicitly economic, their indirect economic consequences are extremely important.

The benefits that a business organization achieves by investing in e-learning systems can be considered by dividing them into three levels, according to their characteristics. The benefits of the first level would be the reduction of training costs, the benefits of the second level the improvement of performance through learning, and the benefits of the third level of organizational transformation through learning. [4]

Moving, therefore, from the first to the last level of benefits, their significance for the organization shifts from operational to strategic. The benefits of the first level thus include lower costs of delivering learning content, lowering travel and subsistence costs, lowering the cost of printing and distributing materials, and enabling easier, cheaper, and faster updating of learning materials. [4]

The benefits of the second level relate to improving the performance and learning outcomes and indicate that e-learning is more cost-effective and more efficient in terms of knowledge retention, learning availability, and control of the learning process.

Third, the strategic level of benefits an organization derives from e-learning relates to the transformation of the organization through e-learning processes. This level also includes benefits such as improving student-teacher relationships through learning initiatives with a focus on external factors. [2]

Thus many organizations today provide free courses to their clients and enable two-way communication about ideas on how they can improve their products or services. Attracting customers to your website in this way helps create brand loyalty and increase revenue. [2]

E-learning brings economic benefits to a company because it helps to improve relationships with customers, strategic partners, suppliers, investors and raises the image of the company. Employees also benefit from e-learning because it increases their abilities, knowledge, and skills gives them a new experience, and increase the ability to solve problems they may encounter in everyday business. [1]

The introduction of e-learning systems improves information and communication technologies, working methods as well as management systems. Ultimately, e-learning as a potential source of knowledge, skills, and techniques for human capital should provide business organizations with better and safer growth and development, as well as better competitiveness and profitability. [1]

Calculation of return on investment (ROI) when considering e-learning: [2]

1. E-learning saves time. Research has shown that the adoption of materials using information and communication technologies takes 35-45% less time than it takes classical learning.
2. Minimizes travel costs, over 50% (and according to some opinions up to over 80%) because the organization of classic courses for employee training includes the cost of transportation, accommodation, and meals for employees.
3. Minimizes absence from work due to employee being prevented from performing his duties at work while at professional training. The goal of any organization should be to increase staff productivity while providing top-notch training.
4. Increases effectiveness. It has already been said that the implementation of the e-learning system requires certain resources, but already in the first year of application the savings for employee education are on average about 20%, and in the second and third year the savings grow to almost 50%. Therefore, the entire investment can have a return after only 2-3 years, depending on how much employees are educated.
5. Meets the needs of geographically dispersed employees because e-learning is flexible. Employees can learn at their own pace, anytime, and from anywhere.
6. Individualizes teaching. Unlike a traditional classroom, if they have adopted the content, course participants move on to new resource on their own, and those who have not adopted the content stay on the same resources or return to the previous ones without affecting others.
7. Achieves better results compared to traditional training. According to research, employees trained in e-learning are more productive compared to those employees trained in traditional learning (observed through reduced production cycles, increased sales, reduced absenteeism, increased quality of products and services, and reduced accidents and injuries at work).
8. Administrative tasks are reduced through the use of e-learning interfaces. When monitoring the development of training and creating various reports, the number of required hours is cut to 50%.

The above text lists all the advantages observed by business entities, guided by competitiveness and profitability. Consequently, these advantages of e-learning can be recognized in the business of the university.

6 DISTANCE LEARNING SYSTEMS AT UNIVERSITIES

MERLIN - e-learning system in higher education. Following the e-Learning Strategy of the University of Zagreb, the Center for E-learning has established and maintains a university system for e-learning. The Merlin e-learning system is based on the Moodle software solution, which has been developed and adapted to the needs of users. The system is maintained by the staff of the Center for E-learning and provides institutions, teachers, and students with a reliable platform for e-learning free of charge. The system is constantly evolving and adapting to the needs of its users. Most of the application is in Croatian, and the translation of the rest of the application is still being worked on. Merlin is available to teachers, students, and institutions in the higher education system for teaching in a virtual environment that is performed according to the official teaching schedule of the institution in the current academic year.

MoD - The e-Learning Center has established the MoD (Moodle Community) e-learning system for community e-learning projects. The MoD system hosts courses related to e-learning projects in the community that has been created or launched within the academic community.

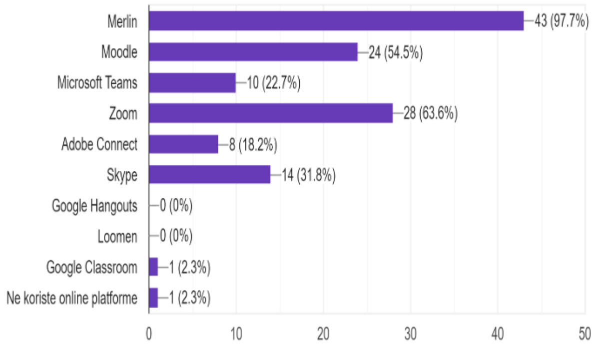
WEBINAR - is performed via the Merlin platform. It is used to record students and their presence in online classes.

ZOOM - Zoom is a leader in modern video communications that contains a simple and reliable cloud platform for video and audio meetings, conferences, negotiations, training, and webinars. It can be used with the help of various electronic devices (mobile phone, computer, laptop, tablet, etc.). It allows the use of basic tools used in communication with multiple people. These include sharing documents, photos, and videos, sharing screens with participants in communication, using an online writing and presentation board, recording communication with MP4 or M4A. We use zoom to teach, to form virtual classrooms in which lectures are held. During the classroom lecture, you have the option to turn on your microphone and say that everyone present can hear you, turn on the camera so that others can see you, send a public chat message to others, and leave the classroom after the lecture.

ADOBE CONNECT - independent of Zoom and other platforms. Used to broadcast real-time video lectures.

E-PORTFOLIO - a system used to record and present acquired qualifications and experiences. It consists of a set of papers in digital form that document ideas, activities, and achievements. The use of digital technology enables the collection and organization of content in the portfolio in several different media forms (audio, video, graphics, text).

A single platform should be selected and standardized, preferably one used by more technically or informatically developed faculties, and licenses should be provided to students and professors. At the same time, it will be able to be used by both students and professors and to consolidate the entire content, from the student's application to classes, teaching materials, and video materials that should be of good quality. Figure 1 shows all the platforms used at the Faculty of Maritime Studies in Split during the COVID 19 crisis:



Source: Authors

Figure 1: Platforms used at pfst during the COVID 19 crisis

To achieve efficiency in the distance learning process, the involvement of human and material resources and their mutual interaction is required. This efficiency is best achieved by using platforms that greatly facilitate the distance learning process. Nowadays, depending on the area, there are many learning activities, and a large number of commercial or free platforms are available that are used in distance learning. The platform that best meets the needs of the student can be determined independently, and is divided into the following groups: [1]

Table 2: Groups when selecting a platform

Student working environment - access to materials, user interface, help, private space and settings, asynchronous communication: forums, e-mail, calendar, synchronous communication: chat, videoconferencing chat, pedagogical tool
Material working environment - creating materials, choosing the layout of the interface, creating a course, checking and self-checking knowledge, calendar
Administration - in general, logging in to the system
Requirements for the Croatian market - diacritical marks, support
Technical prerequisites - client platform, server platform
General properties - general, support

Source: http://www.carnet.hr/referalni/obrazovni/oca/metoda.html

Our education system lags far behind other European countries, on the one hand, due to deficient technological equipment and financial resources, and on the other hand, due to teachers who perceive the application of information and communication technology in teaching as an additional effort. The reason is also the administrative barrier of the Ministry of Science, which restricts the permission of public higher education institutions for this type of education.

For the Croatian education system to be characterized by development and not stagnation, it is necessary to invest in the development of computer networks and technologies essential for the successful functioning of the entire distance learning process. Furthermore, training teachers to apply new technologies, them adapting the curriculum to modern needs and ministries supporting such programs will contribute to this cause.

7 THE FUTURE OF DISTANCE LEARNING DEVELOPMENT

Considering the future of e-learning, the biggest changes should be reflected in the abandonment of monolithic learning management systems and the transition to personalized learning environments. This means that in the future, distance learning programs will enable greater cooperation and easier adoption of information by all participants in the educational process. Everyone is offered the opportunity to participate. Due to the remarkable progress of social and scientific movements, and thus the development of technology, great challenges are foreseen in the field of the educational process. [2]

Education is becoming a key factor for every individual on a personal and professional level, both students and teachers. Every day we encounter the promotion of various educational institutions that provide the possibility of an increasing choice of distance learning programs. [2]

Traditional forms of teaching in which the teacher gives a lecture and the student as a passive participant just listens and writes is a part of the past. There is a growing level of awareness of the new approach to education where students are maximally involved in the teaching process, critically review the material, and respect their opinion, teaching is individualized. They have a sense of motivation, confidence, and respect. [2]

New social, professional, and economic needs of the individual and the community have modernized education as a multidirectional, dynamic and active process of exchanging knowledge, opinions, and needs of all involved in its process: from the individual enrolling in college to the highest state, European and world institutions in education, economic and social sectors. Consequently modern society as a whole positions education and nurtures knowledge as its fundamental value, and actively builds and develops the global knowledge society as its most successful brand. [2]

In Croatia, the model of distance learning is still being compared with the traditional way of education, and its application has not been fully implemented. Although educational institutions provide a wide range of different distance learning programs, and we have an enviable number of experts who present this form of learning in world markets, we are still afraid of obtaining a degree in this way. To improve the state of distance learning in a small but full of the potential country such as Croatia, it is necessary to invest in the entire distance learning process, raise the quality of educational standards to an enviable level and to follow and try to get closer to world trends. [2]

Ćukušić and Jadrić (2012) according to (Vovides et al., 2007), state that "future e-learning systems should be designed to take into account the differences of learners regarding learning styles, their prior knowledge, culture and self-organization, and the direction of the development of e-learning today is mainly focused on openness, internationalization, content enrichment, and pushing the boundaries of the learning context (Delrio and Ficsher, 2007). [2]

The modernization of the teaching and educational process, and increasingly high-quality multimedia content contribute to the high efficiency of the distance learning environment. It can be concluded that by further development of technology and innovation, and the flexibility which allows the abolition of time and space constraints significantly increases the form of education through distance learning. [2]

8 CONCLUSION

For the successful functioning of modern society and the monitoring of market trends, traditional methods of education are no longer sufficient, but there is a need for newer forms of knowledge acquisition. Security challenges impose a new approach to higher education. New communication and information technologies enable a wide range of applications. It is necessary to update new platforms, following the requirements of the individual, but also society.

It is necessary to approach by respecting man as a social being and to adapt the content towards more efficient acceptance of knowledge. It is proven that there are significant advantages in e-learning, while the observed shortcomings need to be constantly corrected and upgraded.

It is necessary to upgrade and standardize a single platform following the needs for e-learning, which requires time, money, and expertise.

From an economic point of view, the savings are evident with wide availability.

Looking into the future of e-learning development, Croatia still lags behind the leading countries. Traditional learning is becoming a part of the past, thus focus should be on improving e-learning, including the development of appropriate platforms and constant investment in knowledge and skills.

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SWOT ANALYSIS OF SELECTED INFORMATION MANAGEMENT TECHNOLOGIES IN ELECTRONIC TRANSPORTATION MANAGEMENT SYSTEMS

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ABSTRACT

This paper presents an analysis of selected information management technologies (Big Data/data management, data standardization and Port/vessel traffic management) in electronic Transportation Management Systems, with an emphasis on maritime transport. The theoretical frameworks and economic aspects of transportation and Transportation Management Systems are provided. SWOT Analysis of the Big Data/data management, data standardization and Port/vessel traffic management (from an internal and external perspective) is conducted. The research has shown that information management technologies may be beneficial in improving e-TMS performance.

Keywords: Information management technologies, electronic Transportation Management Systems, maritime transport, SWOT analysis

1 INTRODUCTION

Transportation represents "a multimodal, multi-problem and multi-spectral system", as it involves various categories and activities, such as "policy-making, planning, designing, infrastructure construction and development" (Almasi, Sadollah, Kang, Karim, 2016). Trade and cargo volumes continue to grow internationally, and consequently, companies in the transport sector implement new technologies which may enable improved decision making and cost savings (GreenPort, 2016). Furthermore, transportation involves stakeholders who have to closely cooperate in order to execute transport services (Tijan, Jović, Jardas, Gulić, 2019), (Tijan, Jović, Karanikić, 2019). The usage of information technology may ensure the efficient connection of different segments of business processes that take place among the various stakeholders of transport operations (Tijan, 2012).

Due to different priorities of key stakeholders (carriers, shipping companies, agencies) involved in transport management, various IT solutions are needed for a specific business area. For example, both Port Community System (PCS) and National Single Window enable improved data exchange between stakeholders involved in the transport (Tijan, Jović, Karanikić, 2019), but involve different business process groups and stakeholders. Commercial processes and stakeholders fall under the PCS scope (which enables simplified and secure exchange of information and optimizes processes through a single data submission). On the other hand, in order to simplify the administrative procedures and involve administrative stakeholders, the concept of a National Single Window was introduced.

Transportation costs are a significant portion of total logistics costs for many organizations. To help reduce these costs, transportation management system (TMS) implementation allows companies "to select the best mix of transportation services and pricing to determine the best of use of containers, rank transportation options, clear customs, track fuel usage and product movements, and truck carrier performance" (Wisner, Tan, Leong, 2018).

As mentioned above, various information management technologies exist in the transport sector, for example automation management systems (Maritime transport Chain solutions, Deliveries Planning solutions etc.), informatization management systems (Document digitalization, PCS, etc.) and Big Data/data management systems. Based on the experience in several projects related to information management in transport, authors have selected the following information management technologies to be analysed in this paper: Big Data/data management, Data standardization and Port/vessel traffic management. These technologies that can be applied to electronic Transportation Management Systems. The goal of the research is to analyze strengths, weaknesses, opportunities and threats of the three selected information management technologies through the SWOT analysis. The SWOT analysis is a technique that involves systematic thinking and comprehensive analysis of factors (both internal and external), which may affect an organization or a project (Amin, Yan, Morris, 2018).

2 ECONOMIC ASPECT OF TRANSPORTATION AND ELECTRONIC TRANSPORTATION MANAGEMENT SYSTEMS

Transportation is one of the most important economic activity in logistics as transport costs represent the largest share in the structure of the logistics costs of a company (Tseng, Yue, Taylor, 2005), (Muha, 2019). Efficient transportation systems enable numerous benefits and economic opportunities such as: reduced costs, improved accessibility to markets, employment and additional investments (Mosaberpanah and Khales, 2012). The implementation of new technologies and digitalization can positively affect the transport sector's business (reducing costs and enabling competitive advantage) (Jović, Filipović, Tijan, Jardas, 2019). On the other hand, numerous technological, economic, institutional and political barriers exist to the successful implementation of innovations and new technologies (Geerlings, Kuipers, Zuidwijk, 2018),.

Electronic Transportation Management System (e-TMS) is a platform that streamlines business processes, improves the execution of transport activities, enables improved monitoring of any physical or administrative operation etc. (Tijan, Jović, Karanikić, 2019). e-TMS may improve managing certain aspects of the transportation process such as planning and decision making and transportation execution (AQT Solutions, 2019). Furthermore, the development of e-TMS enables the optimization of the transport chain management, as the key stakeholders such as seaport administrative bodies, freight forwarders and carriers become interconnected (Jović, Tijan, Aksentijević, Sotošek, 2019).

Sustainable development should be considered when planning and executing transport operations. Sustainability is based on the consideration of present needs, without compromising the needs of future generations (Tijan, Agatić, Jović, Aksentijević, 2019). It consists of three components i.e. the "triple bottom line": economic, environmental, and social (Zeng, Fu, Ouyang, 2018). Economic sustainability is created by producing various goods and services in a responsible manner. The dimension of economic sustainability is comprised of the elements, that include technology and innovation (Masocha and Fatoki, 2018). The goal of sustainable transport which is based on three core values, should ensure mobility that preserves regional economic development while at the same time, ensuring a long-lasting future for natural resources (Bamwesigye and Hlavackova, 2019).

3 SWOT ANALYSIS OF SELECTED TECHNOLOGIES

Authors have analyzed the following information management technologies: Big Data/data management, Data standardization and Port/vessel traffic management. Big Data/data management and Data standardization may represent a prerequisite for the efficient application of Big data analytics (BDA). BDA is applied to many industries (among which is the transport industry) in order to improve decision-making processes. The Port/vessel traffic management, another information management technology, within a secure network of sensors and collaborative control rooms may provide real-time information to various stakeholders responsible for the port security.

The goal of the SWOT analysis is to identify strengths, weaknesses, opportunities and threats that may affect the transport industry. The identified opportunities and threats may suggest mitigation strategies and methods that could be applicable under certain conditions.

3.1 Big Data/data management

As mentioned above, Transportation Management System may enable numerous benefits such as improved planning and decision making and stakeholder collaboration. Big Data/data management may play an important role in e-TMS. The authors have performed the SWOT analysis of Big Data/data management as follows:

Strengths: Big Data enables increased security and resource utilization (Heilig, Schwarze, Voss, 2017), sustainable business, decreased costs (while at the same time provide improved output) (safety4sea, 2019), (Trelleborg Marine Systems, 2018). Big Data ensures improved safety at sea by preventing collisions and machinery failures (Mirović, Miličević, Obradović, 2018). Collisions can be avoided by collecting data about the standard routes of vessels on long-term basis. These data reveal if a vessel deviates from the declared path. Another strength are multiple basic functions which enable accelerated storage, conversion, transfer and analysis of massive amounts of data (Kumar and Sharma, 2017). Ability to handle velocity of data is another strength (Özköse, Ari, Gencer, 2015). Tactically and operationally, this strength enables a business to start offering its services through Internet of Things and related machine sensor devices. Other strengths are: ability to handle unstructured data, heterogenous data sources (various data sources provide various information that may be useful to industries and organizations) (Kumar and Sharma, 2017), emphasized collaboration between stakeholders, data transparency and optimization of business processes.

Weaknesses: one of the weaknesses is low data quality (value of the data is low in relation to its acquired volume) (Ahmadi, Dileepan, Wheatley, 2016). Existence of independent data sources is another weakness: a large amount of data is generated from different independent sources along the path of the transportation and supply chain of goods (CLECAT, 2017). Furthermore, processing of incoming data, which should provide proper real-time information (in order to support ongoing transportation operations), is impossible due to the lack of suitable processing and storage devices. The traditional toolsets are no longer sufficient. Big Data Management in general refers to the collection of large and complex datasets which are difficult to process and analyse using traditional database management tools. One of the weaknesses are increased costs related to Big Data storage and manipulation: when handling Big Data, advanced data-processing techniques and tools are required in order to effectively analyse and utilize the data. Specific technologies or methods, such as algorithms to handle Big Data are needed (Taylor-Sakyi, 2016). Data ownership may also represent a weakness: the ownership is often unclear, and some data are of the utmost interest of the company (confidential information).

Opportunities: A long-term analysis of waiting times for a berth can enable cost savings through reducing average speed or changing the route of the ship in order to avoid waiting times. Furthermore, Big Data can bring advantages to the transport sector regarding efficient routing, operation optimization and safety improvements. For example, collecting ship engine data or machinery data can provide increased safety, lowering the operational risk. Errors can be detected and even dealt with immediately. Damage can be avoided, and fixed maintenance schedules will become less frequent or even unnecessary. In a long run, this can reduce high docking cost for larger damages caused by the ongoing use of defective equipment and needless service, because maintenance can now be scheduled when needed. Besides, a rising number of companies are offering high-technology solutions to optimize ship operations. This number is expected to rise continuously in the future (Jović, Tijan, Marx, Gebhard, 2020). Moreover, internal platforms are getting developed to provide more efficient use of collected data. Future prospect anticipated through the more efficient use of collected data is a higher level of cooperation between the actors in a transport operation or supply-chain, which provides real-time information, enabling cost savings (Jović et al., 2020).

Threats: One of the threats is a lack of government or top management support (Tijan, Agatić, Hlača, 2012). Furthermore, regarding the competitive conditions, by storing many datasets in the same infrastructure, it is difficult to overview the different owners and to avoid the monopolization of property rights because a strong demand for only one data provider leads to monopolistic deals (Koga, 2015). Mutually accepted agreements and legal framework with clear instructions and rights needs to be implemented by international and local policies to ensure competitive conditions. For instance, a ship owner may use Big Data to consider which cargo to transport, when and how, and with what fuel consumption to keep costs down etc. (safety4sea, 2019). Although the ship owner (on whose ship the data is collected) is considered as the data owner, the issue arises when third-party services are included in order to analyse the data. Other threats are lack of skilled workforce or inability to adapt to rapid changes in the technologies (Unhelkar, 2018).

3.2 Data standardization

Electronic Transportation Management Systems may lack a uniform data transferring capability that prevents simplified data exchange (Xu, Zhen, Li, Yue, 2017). Data standardization is the critical process of bringing data into a common format, enabling collaborative research, large-scale analytics, and sharing of sophisticated tools and methodologies (OHDSI, 2020). SWOT analysis of data standardization has been performed as follows:

Strengths: Improved communication and information exchange between stakeholders: a paperless and standardized communication is a prerequisite not only for effective transport operations involving many stakeholders but also for improving the integration, coordination, and performance of the supply chain. Therefore, the advantages of the standard messages are accelerating electronic data exchange process and reduction of administrative errors and costs, which eventually positively affect the execution of business and administrative activities. One of the strengths is a data re-use: stakeholders have to input the necessary data only once, and to reuse the data as well as decreased processing time. Furthermore, data standardization optimizes both communication and efficiencies within a large and complex network (for example, transport industry) (UNECE, 2017). Other strengths are: facilitates message exchange externally, as well as within the company (UNECE, 2017); decreased errors and costs, which ultimately affects the performance of commercial and administrative operations; the need for a standardized communication platform is important as it improves the systems in terms of punctuality, reliability or costs (IPCSA, 2014).

Weaknesses: Individual companies may be cautious about adopting new technologies since there are no common data standards in the market. Besides, most of the stakeholders in the supply chain already operate their own supply chain management solution. One of the weaknesses is short-term costs: standardizing data is not free. The costs of developing standards, testing them, retooling firm and regulatory systems to use them, and working out the kinds in implementation are considerable, and the costs of these investments are incurred early on (Berner and Judge, 2019). Furthermore, data standardization may be a complex process as it should be harmonized between all involved stakeholders. Data standardization does not bring complete process automation. Employees have to monitor the data quality.

Opportunities: Data standardization can significantly optimize both communication and efficiencies within a large and complex network such as the maritime industry. Well-designed standards can reduce reporting burdens and enable firms to better track and manage risks (Judge and Berner, 2019). One of the opportunities is a strong industry support: several world's largest carriers (e.g. Maersk and MSC) have established the Digital Container Shipping Association (DCSA) in order to create common information technology standards. Evergreen Line, Hyundai Merchant Marine, Yang Ming and ZIM join DCSA with the purpose of enabling digital standardization in the container shipping industry ("Hellenic Shipping News," 2019). Data standardization can contribute to better resource utilization (based on better planning) in maritime and supply chain industry and employees can focus on service quality.

Threats: One of the threats are coordination issues: core challenge is that data standardization requires coordination from diverse parties, not only government and market actors, but various groups within those broad categories. Effectively implementing data standardization requires groups who think about issues in slightly different ways – business leaders, risk managers, legal officers, data scientists and financial economists – to understand different perspectives. They have to figure out collectively how to devise standards than can serve related, but not identical aims (Berner and Judge, 2019). Inadequate IT and data infrastructure at enterprises is another threat: in theory, private enterprises stand to enjoy an array of gains from well-designed data standards. To fully enjoy these gains, however, enterprises need the technology and enterprise-wide data management and governance practices that will allow them to use the data to better identify and manage their risks (Berner and Judge, 2019). Furthermore, data standardization will in most cases require changes in data management and operation processes.

3.3 Port/vessel traffic management

According to (Xu et al., 2017), one of the shortcomings of Transportation Management Systems is the following: the monitoring information relies on "the positioning and geographical information of the goods or vehicles without the physical status sensing during the transport procedure". Although Port/vessel traffic management is designed to manage ship traffic in ports, rivers and coastal areas, it can enable monitoring of all vessel movements and thus, improve e-TMS performance. SWOT analysis of Port/vessel traffic management has been performed as follows:

Strengths: Several strengths exist such as efficient management of port calls (Port of Rotterdam, 2019), minimized delays, keeping track of all vessel movements, eliminating unnecessary waste of materials and resources (Mei and Afli, 2017), improved visibility (Peercore, 2019), a lower occurrence of errors, increased port performance at all levels, a real-time information to responsible stakeholders. Furthermore, the technology facilitates proper planning and handling of freight; enables monitoring all inventory that comes in and leaves the port; allocates specific zones and manages all inventory within the yard and facilitates administration, monitoring and report (regarding cargo in ports) etc.

Weaknesses: Costs and complexity: the technology requires the implementation of various sensors (e.g. Internet of Things) or other sources such as Voyage Data Recorder (VDR) and Automatic Identification System (AIS). Furthermore, data that needs to be inserted manually into report forms, computer systems or AIS transceivers, present an important source of errors, as there is no way to validate it. Besides, unauthorized individuals can willfully insert, delete or update information in order to reach economic advantages or to disguise illegal activities. "Ships are increasingly transmitting false or stolen identifying marks, taking advantage of the AIS 'honours system', as ships are required to transmit their information […]" (Windward, 2014). Some of the challenges of the Satellite AIS technology (a vessel identification system that tracks the location of vessels in the most remote areas of the world (Jović et al., 2020)), include satellite revisit times, message collision, and ship detection probability. The data processing latency and lacking the continuous real-time coverage have made it less reliable for end users in certain aspects of monitoring and data analysis (Šakan, Rudan, Žuškin, Brčić, 2018).

Opportunities: Implementation of port traffic management can improve organization of maritime transport. It can be based on Big Data and Artificial Intelligence technology, providing much more accurate information (such as ETA/ETD) than currently available. It can efficiently manage port calls and minimise delays, keep track of all vessel movements. Big Data Innovations in the field of Monitoring/Tracking: to avoid collisions of ships in seaport areas, forecasts of vessel arrival times with real-time information about their current speed are made to illustrate the estimated traffic. Through this technology, collision issues are identified and vessels are notified before accidents could happen (Jović, Tijan, Marx, Gebhard, 2020). The encounter of two vessels in narrow areas can be avoided. For example, the Vessel Traffic Service is designed to improve maritime safety, to support security activities in the maritime sector, to promote smooth and efficient maritime traffic, and to prevent accidents and the potential environmental harm they may cause. The system displays a graphical environment with movements of vessels in the approach areas, putting each of these overlapping vessels to a digital nautical chart, in its real geodesic position and informs the identification of each vessel (Shelter, 2019).

Threats: Shortage of skills and a qualified labor force: developing new devices for data processing and validating the collected data is labor intensive and requires a high degree of technological knowledge in analytics, statistics and software modelling, as well as experts such as computer scientists, mathematicians and data scientists (Heilig, Schwarze, Voss, 2017). Enough quantity and quality of human resources needs to be ensured through cooperation between universities and the private sector for further development and implementation of Big Data solutions in maritime transport (Jović, Tijan, Marx, Gebhard, 2020). Furthermore, the failure of one or more sensors in the network, on which the entire solution depends, represents another threat. In case of errors or non-functioning, a backup solution should exist. Other threats are: absence of adequate infrastructure, employee’s resistance, poor access to funding and stakeholders who do not want to cooperate.

4 CONCLUSION

Transportation represents the largest share of total logistics costs, and involves numerous stakeholders. If the transportation systems are efficient, they provide benefits in terms of reduced costs and competitive advantages. Furthermore, digitalization and new technologies can reduce transport costs as well. The e-TMS improves decision making and stakeholder collaboration, and the analysed technologies may further improve e-TMS performance as follows:

Big Data and its analyses provide deep understanding of causalities and correlations in maritime transport, improving decision making. However, Big Data usage in the maritime transport has yet to overcome challenges to fully exploit these advantages due to competitive conditions, lack of suitable processing and storage devices and shortcomings in human resources. Issues such as the lack of regulations for the market environment, cyber-crime and lack of skilled experts have slowed down the Big Data development in the maritime transport sector.

Data standardization enables improved communication and information exchange between stakeholders, data re-use, decreased processing time etc. On the other hand, individual companies are uncertain about adopting new technologies as no common data standards in the market exists. Data standardization will probably require changes in data management and operation processes.

Port traffic management enables minimized delays, facilitates administration, monitoring and reporting (regarding the movement of vessels and cargo in ports). On the other hand, this solution requires the application of a range of sensors, which ultimately leads to additional costs.

Although the selected information management technologies provide numerous advantages and opportunities in transportation, companies have to prepare for challenges which can affect their business performance. Despite possible negative consequences, companies should be encouraged to use information management technologies in electronic Transportation Management Systems, as those technologies will be upgraded over time, enabling variety of benefits such as better stakeholder connectivity and improved collaboration, finally enabling cost reduction.

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WIRELESS COMMUNICATIONS AS A TOOL FOR ESTABLISHING BUOY MONITORING SYSTEMS ON MARITIME WATERWAYS IN THE ADRIATIC

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ABSTRACT

The Adriatic Sea is covered with a large number of maritime signalling facilities, including light and signal buoys, which mark the waterways at precisely determined positions. In order for the buoys to perform their function correctly, their correct positioning is crucial. Therefore, to control the buoys position it is necessary to implement a system of constant monitoring of their position, which is not established in the Croatian part of the Adriatic yet. This paper discusses the available options for establishing such system, and it brings the results of an experimental test-device implementation on a real buoy in the Split sea area. The conclusion is made based on the experimental results, as well as the recommendation about requirements and limitation of the system.

Keywords: maritime waterways, buoy, wireless communications, monitoring, Adriatic

1 INTRODUCTION

There are over 1200 maritime signaling facilities throughout the Adriatic Sea, which are used for safe navigation of ships and boats of various types and purposes. Out of those, almost 150 objects are buoys or elastic-articulated markers, whose function is to mark the boundaries of obstacles and waterways at the set positions. Due to the action of the sea currents and waves, a smaller but significant change in the position, along with the tearing of the buoy itself, is frequent. By changing the position of the buoy, it loses its function and gives navigators misleading information about the waterway, which can result in a shipwreck, or negative consequences for human lives, property and the ecology of the sea. In order for all the above markings to be at prescribed positions and in a nautically correct condition, it is necessary to introduce continuous communication and monitoring of the positions of each of them [1], which has not been realized yet in the Croatian part of the Adriatic. To effectively deal with this issue, this paper explores the possibilities of wireless monitoring of this type of facilities, taking into account the availability of electricity and the availability of wireless signal.

2 AIDS TO NAVIGATION

Regulations about the way of waterways marking and aids to navigation prescribe types and characteristics of aids to navigation in the internal sea waters and territorial sea of the Republic of Croatia which is in line with the recommendations of IALA (International Association of Marine Aids to Navigation and Lighthouse Authorities). The types of maritime signaling facilities are: maritime lighthouses, coastal lights, port lights, signal stations, light and signal signs, light and signal buoys and cover direction signs. They are located along the entire Adriatic, which is divided into the navigable areas of Pula, Rijeka, Zadar, Šibenik, Split, Korčula and Dubrovnik, as shown in Figure 1.

Figure 1: Maritime regions of the Adriatic

The categorization of maritime signaling facilities, in terms of legal regulations for the elimination of faults on the facility itself, which includes the light extinguishing, tearing off the buoy and buoy position losing is regulated as follows:

- Category I. - troubleshooting within 24 h;
- Category II. - troubleshooting within 48 h;
- Category III. - troubleshooting within 72 h.

In addition to categorization according to legal regulations, equipment at maritime signaling facilities is divided into six fixed categories according to the installed equipment (type of light, type of power supply, installed additional primary equipment).

From the mentioned above, it is clear that monitoring of the position of the light and signal buoys, presented in Figure 2, is important and can contribute to the level of safety of navigation at sea. The possibilities of introducing monitoring of the positions of buoys are discussed in the following chapters of this paper.

Figure 2: Light and signal buoys

3 AVAILABLE WIRELESS COMUNICATIONS

Before starting the analysis and finding a solution for monitoring buoys across the Adriatic coast, it is crucial to set basic criteria and technical requirements. In this case, there are inevitable limitations, namely electricity consumption and the required distance for data transmission. It is necessary to take into account the dislocation of the objects in question and the unavailability of electricity or network infrastructure. By reviewing available professional and scientific papers, one can find a large number of papers dealing with available wireless data transmission methods, such as Wi-Fi [12], Bluetooth, LoRa (Long Range) WAN or ZigBee [1], but each with some limitations covered below.

3.1 Wi-Fi

The IEEE (Institute of Electrical and Electronics Engineers) community has defined the 802.11 standard as Wi-Fi, which is a wireless network of exceptional similarity to a wired one, with the difference that data transmission cables are not required in this way [6]. To create a network, it is necessary to have a Wi-Fi client and an access point, which is the central device to which clients connect. Clients are devices that detect the transmitted signal and connect to it. The key features of Wi-Fi technology are range and frequency band. The range, i.e. the radius of Wi-Fi signal transmission is about 50 m and depends on the environmental conditions and Wi-Fi standard, while the frequency bands are 2.4 GHz and 5GHz, which in turn results in the range and speed of data flow. Technically, the most advanced is Wi-Fi 802.11ac standard (also called 5G Wi-Fi); it operates at a frequency of 5.8 GHz and achieves transfer speeds of up to 7 Gbps.

3.2 WiMAX

WiMAX wireless technology is based on IEEE 802.16 standard and works on GSM network. According to the principle of functionality, the network uses similar principles as Wi-Fi, with the difference that the range of this network is up to several tens of kilometers. This standard enables stable data transfer speeds of up to 40 Mbps, and in the experimental phase the speed is up to 1 Gbps [3]. To connect via WiMAX network, it is necessary to install antenna poles, base stations and peripheral electronic devices that emit a WiMAX signal. This technology is mostly used in the so-called Smart cities where infrastructure is available, along with appropriate power supply.

3.3 LTE

The LTE (Long-Term Evolution) network emerged only a few years ago as the successor to 3G UTMS and HSPA technologies, providing much higher data rates. The technology is based on the IP protocol supporting the IPv4 and IPv6 standard [4]. However, for the stable operation of this technology it was necessary to develop the architecture of the system SAE (System Architecture Evolution), which was the basis for the establishment of LTE-A (LTE-Advanced) technologies. LTE-A technology offered much better performance than its predecessor at significantly reduced costs. All of the above has led to the implementation of 4G mobile systems, which are based on LTE and LTE-A technologies, globally. The data transfer speed with this technology can be higher than 1 Gbps, with a long range, but also with a significant consumption of electric power, what makes them inappropriate for the buoy monitoring.

3.4 Bluetooth

Bluetooth is a low-power wireless technology, suitable for transferring data between two or more devices. There are two types of Bluetooth technologies, BR/EDR (Basic Rate/ Enhanced) and BluetoothLE (Low Energy), which is Bluetooth 4.0 standard [10]. Bluetooth BR/EDR is suitable for large amounts of data, but limited in terms of short range, while BluetoothLE is more suitable for use in systems that require less data and low power. BluetoothLE is also known as Bluetooth Smart because it uses multiple network topologies such as Broadcast and Mesh. Broadcast topology establishes a connection from one to multiple devices, while Mesh topology creates large networks with multiple devices, which may be convenient for establishing a buoy monitoring system, combined with another of the available technologies. The biggest disadvantage of Bluetooth technology is the range, with maximum of

100 m, which is insufficient to establish the system for the case study.

3.5 ZigBee

ZigBee technology was initially designed for remote control and the use of sensor devices based on the IEEE 802.14.4 standard [11]. The main features of the ZigBee standard are the on/off function of the radio receiver, which results in extremely low power consumption. In Europe, the system operates at 868 MHz, but is also available for use worldwide, at various available frequencies. Data is sent using a packet of max. 1024 bits, which is a small amount of data compared to other available systems. But when the network is established, more than 65.000 devices can be connected to the network. ZigBee network topology is supported through star, P2P and cluster network. Each of the above has advantages, depending on the circumstances in which it will be used. For the establishment of a buoy monitoring system, it would be appropriate to use P2P (Peer to peer) network (Figure 3), which consists of a number of nodes, which are set up according to the needs. The benefit is the ability to communicate with nodes and thus form a network with a large number of devices, ultimately several hundred miles away as needed.

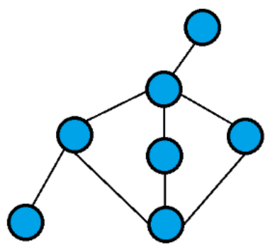

Figure 3: P2P network

The technology is low power, which results in battery life measured in years, and the range of the technology is, using available antenna systems and amplifiers, up to 20 km. Given all the above, the use of ZigBee technology, in combination with some of the other available technologies can be a good basis for establishing the system.

3.6 Z-Wave

Z-Wave technology uses RF to ensure optimal encoding and decoding of data with low power consumption, which allows signal modulation in two ways: PSK modulation (speeds of 9.6 and 40 kbps) and GFSK modulation (speeds up to 100 kbps). Much like ZigBee technology, Z-Wave technology uses CSMA/CA technology to avoid interference with other devices, but with support for only 232 devices on the network. The frequency spectrum of 868.4 MHz for the European area allows a network range of a maximum of 100 m in the outdoor, which is insufficient to design a buoy monitoring system.

3.7 LoRaWAN

The name LoRaWAN encompasses two network technologies, LoRa and WAN. LoRa (Long Range) is applied in P2P communication and contains only the data layer, while LoRaWAN, in addition to being physically identical, also contains the network layer. LoRaWAN is a wireless technology developed to send data at low speeds and low power, but over long distances. It uses unlicensed ISM frequency bands and makes it available worldwide (Europe - 868 MHz). The specified frequency in combination with the LoRa type of modulation allows a very large signal range, which is 20 dB below the noise level when said demodulation is combined with FEC (Forward error correction). The 7.8 kHz frequency bands can be expanded up to 500 kHz as needed [9], which is not often the case, precisely because of the need to transmit small amounts of data. The result of all these parameters is a data transfer rate of up to 50 kbps and a connection range of more than 15 km with extremely low power consumption. Figure 4 shows the main components of the LoRaWAN network, which consists of the host computer (Application server) that manages the endpoints and collects data from it, and the network server (Network server) that manages the network by regulating the baud rate by removing the duplicates.

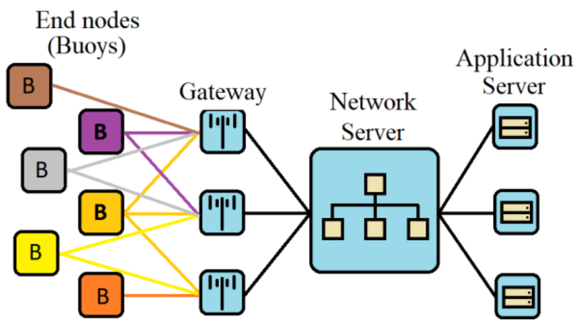

Figure 4: LoRaWAN network architecture

Network servers with the host computer and base stations are connected using IP addressing. Base stations receive data from endpoints and forward it to a network server, using known and available technologies. End nodes (buoys) can be of different types, because LoRaWAN supports A, B and C classes of end devices, and they support two-way communication. Class A includes devices with the lowest power consumption, for the reason that they require only incoming communication from the server, immediately after the transmission of the specified information. If in the period between two configured messages, new information from the base station that must be delivered to the device appears, then it is necessary to wait for the next date of the device response. Class B includes devices of the same type as Class A, with slightly improved communication with the base station, resulting in increased power consumption. Class C includes devices that continuously communicate with the base station, but the result is extremely high-energy consumption and they definitely do not belong to the devices that are applicable in the conditions in which the sea buoys are located.

However, it is not possible to apply only one technology for a quality solution to the problem that this paper deals with, so the proposed solution is given below.

3.8 Comparative presentation of processed technologies

Table 1. shows a comparative overview of the processed technologies with the given technical data crucial for the use in the system for monitoring the position of buoys in the Adriatic Sea. According to the presented data, but also the technical details presented in the previous chapters, it is evident that none of the available technologies is able to fully meet the given requirements. This is due to short range, insufficient number of base stations, low data transfer speed or high power consumption.

Based on this, Chapters 4 and 5 provide a solution that encompasses two technologies, which synergistically provide the possibility of networking and monitoring of all buoys throughout the Croatian part of the Adriatic.

Table 1: Comparative presentation of technology

Technology	Frequency	Range (max.)	Speed
Wi-Fi	2.4 GHz, 3.6 GHz, 4.9 GHz, 5 GHz, 5.9 GHz	100 m	1-54 Mb/s
WiMAX	3.5 GHz	50 km	75 Mb/s
LTE/LTE-A	2.5 GHz, 5 GHz, 10 GHz, 15 GHz, 20 GHz	30 km	300 Mb/s (DL) 75 Mb/s (UL)/ 1 Gb/s (DL) 500 Mb/s (UL)
Bluetooth	2.4 GHz	100 m	1 Mb/s
ZigBee	2.4 GHz	20 km	250 kb/s
Z-Wave	900 MHz	100 m	9.6–100 kb/s
LoRaWAN	868 MHz (Europa)	15 km	290 b/s – 50 kb/s

4 NETWORKING AND BUOY MONITORING

In order to perform the analysis of the given problem and approach the selection of the right solution for the control of buoys, as done in Chapter 4.2, Chapter 4.1 provides a brief overview of the micro-locations and technical conditions in which the buoys are positioned.

4.1 Buoys micro locations

Light and signal buoys are floating objects that mark the position and boundaries of navigation obstacles and waterways in the sea. In the Croatian part of the Adriatic, there are 127 light buoys and 12 signal buoys, placed in key positions on waterways, the number of which is constantly and rapidly increasing. They are located from Savudrija Bay in the far north to Prevlaka in the extreme south of the Adriatic coast, within the boundaries of the navigable areas shown in Figure 1. As an example of the system, Figure 5 shows the position of two signal buoys, called Signal Buoy Kuversada and Signal Buoy Lim, which are placed on the site of submarine obstacles at the very entrance to the Lim Channel. The Lim Channel is located on the west coast of Istria, between the towns of Rovinj and Vrsar.

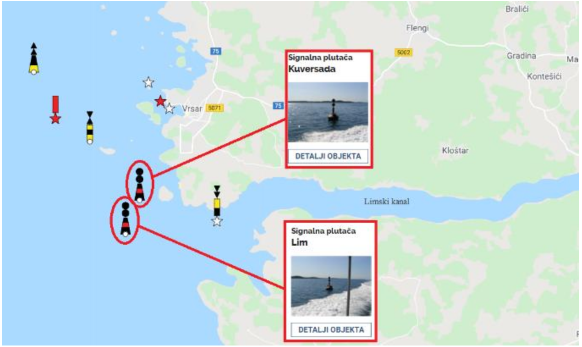

Figure 5: Buoys Kuversada and Lim - Lim Canal

Proper operation of the system has high impact on the safety of navigation at sea. Potential rupture of one of the buoys shown in the example displayed in Figure 5 could be stranding, human casualties, oil spill or environmental pollution. Along the Adriatic coast, there is a large number of similar micro locations, which are marked by some of the available maritime signaling facilities, including buoys, as shown in Figure 6, which shows all the facilities on the Croatian side of the Adriatic.

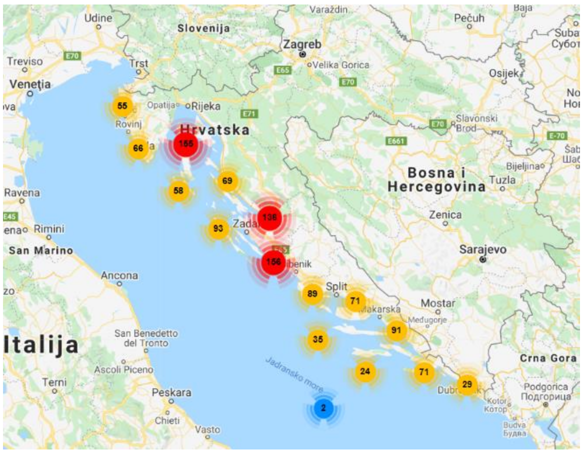

Figure 6: Aids to navigation in the Adriatic

Although the paper deals with marking and monitoring of the buoys, it is necessary to monitor other technical parameters of maritime signaling facilities, such as light monitoring, battery charge levels and burglary. In further research, it should be possible to apply the selected communication technology for buoy monitoring to all other maritime signaling facilities, of which only 103 of over 1200 of them are involved in some form of remote monitoring at the moment.

4.2 Communication solution for buoy monitoring

Analyzing the available communication solutions, the summary of which is shown in Table 1, and taking into account the most important technical requirements for the possible connection of buoys in the Adriatic, which is primarily the range, the optimal solution for this purpose is LoRaWAN. The range of LoRaWAN is up to 15 km, and the electric power consumption is extremely low, e.g. a device with basic functions and a built-in battery can have an autonomy of 5 years, operating at sufficient data exchange frequency on a daily basis. LoRaWAN is also a quality choice due to the large number of base stations in the Republic of Croatia, spread along the Adriatic coast on the highest peaks and in all major cities. Taking into account the available infrastructure, base stations for LoRaWAN are available at a total of 308 locations throughout the Adriatic. For example, base station installed on the mountain Labinštica, which is located in the hinterland of Trogir and is located at 715 m above sea level is operating on that principle. It meets the requirements for monitoring buoys located in the Kaštela Bay, i.e. the northern part of Split, entrance to the Split transport port. The geographical area it covers is selected as the area where the operation of the LoRaWAN network and GPS (Global Positioning System) position monitoring devices will be tested. Despite all the presented technical details, there is a real possibility of mismatch between the micro location of the buoy and the transmitting point, in which monitoring will not be possible using the LoRaWAN network. In this case, it is possible to connect the inaccessible buoy with the first available buoy located in the LoRaWAN network using the PSP network, ZigBee technology, shown in Figure 3, and thus introduce it into the monitoring system.

5 ANALYSIS, MEASUREMENTS AND INSTALLATION OF THE TEST DEVICE

As mentioned in previous Chapter, Kaštela Bay light buoy Hrid Galija - PS no. 547, was selected as a micro location for installation, research and development of a system based on LoRaWAN communication, including the associated GPS module, as shown in Figure 7.

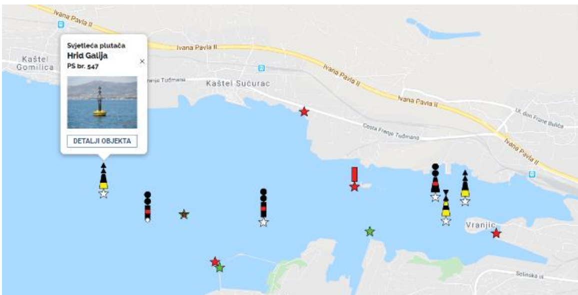

Figure 7: Light buoy Hrid Galija

Light buoy transmits data to LoRaWAN receiving base station located on mountain Labinštica (D08-Labinštica-OiV), which is 15890 m (d) away from the location of the buoy, and taking into account the altitude of the transceiver antenna on Labinštica, which is 715 m (h). The air distance between the two points is calculated according to the equation (1) and it is 15906 m (l).

$$l = \sqrt{d^2 + h^2} \tag{1}$$

Where:

l = total distance [m];
d = distance between antennas [m];
h = altitude of antenna [m].

Maximum TX power of installed base station on the Labinštica site is 25 dBm. It is possible to access dBm to watt conversion according equation (2), with result $P_{(W)} = 0.316\,W$.

$$P_{(W)} = 1W \times 10^{\left(\frac{P_{dBm}}{10}\right)} / 1000 \tag{2}$$

Figure 8 shows the location of the test buoy, the location of the transceiver antenna and the distance between the two points.

Figure 8: Distance between Labinštica and test buoy

Measured signal power level at the buoy location is about -120 dBm, depending on the signal propagation. Power was measured with the Adenuis field test device for LoRAWAN ™ and MARCONI 2965A on site, and it is possible to make calculation according to the equation (3).

$$P_{(dBm)} = 10\log_{10}\frac{P_{(mW)}}{1mW} \tag{3}$$

Otherwise, signal power level at buoy location can be calculated using Friss Transmission Formula (4), as presented in [8], with result for the case study of $P_{RX} = -84.49$ dBm.

$$P_{RX} = P_{TX}G_{TX}G_{RX}\left(\frac{c}{4\pi Df}\right)^2 \tag{4}$$

Where:

P_{RX} = power arriving at the receiver [W]
P_{TX} = power at the transmitter [W]
G_{TX} = gain at the transmitter (absolute)
G_{RX} = gain at the receiver (absolute)
c = speed of light ($3\cdot10^8$ m/s)
D = distance between trans. and receiver [m]
f = signal frequency [Hz]

There is difference between measured and calculated signal power level. Measured signal power level is about 30% less than calculated. It can be assumed that difference occurs because of the large number of base stations, antennas and other equipment on the Labinštica site.

Detailed analysis of this problem is possible, but it is not the focus of this paper. Signal strength limit for the operation of the installed device is about -140 dBm.

Additional measurements were performed at several different points, in order to obtain a complete picture of the coverage at the specified location and the results are presented in Table 2. The same results are presented graphically in Figure 9 for better understanding.

Table 2: RSSI at several distances

Distance (km)	RSSI (dBm)
0.5	-55
1	-85
2	-90
4	-94
6	-100
8	-107
10	-110
12	-115
14	-117
16	-120
18	-125

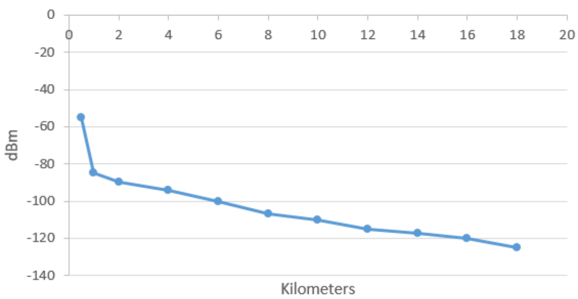

Figure 9: RSSI and distance measurement

The positioning device is the Telemetrics MK0920, presented in Figure 10, which has a built-in GPS module and the ability to connect to a LoRaWAN network.

Figure 10: Telemetrics MK0920

By installing and commissioning the device, it is possible to obtain a graphical representation of power in time as shown in Figure 11, which shows that the average power on a longer time sample is stable, which meets the specifications of the positioning device. This confirmed stable operation is at a distance of 15 km, as stated in Table 1.

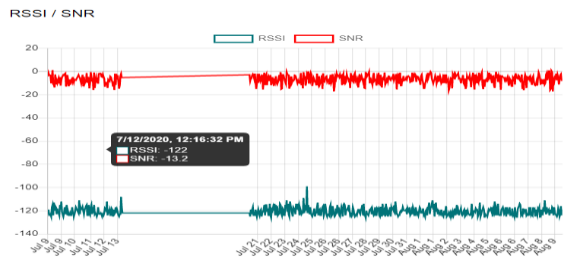

Figure 11: Graph of measured power

Apart from the location of the monitored buoy, which is shown in Figure 12, the device provides additional telemetry data.

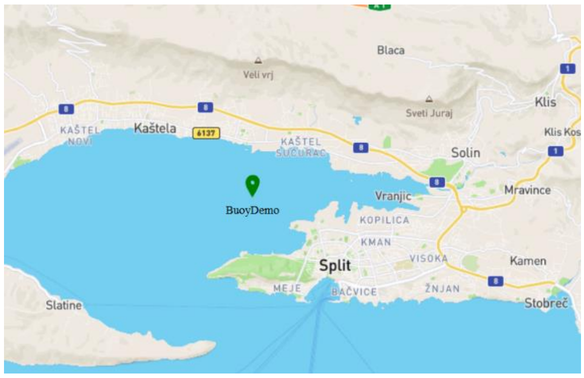

Figure 12: GPS position of demo buoy

Available telemetry data are temperature, battery voltage, RSSI, SNR, latitude and longitude. Nominal voltage of the battery that powers the device is 3.7 *V* and capacity of battery is 6000 *mAh*, while the current in the so-called sleep mode is around 14.5μA. At the time of broadcast, the current is 174 *mA*, and the duration of the broadcast to send a complete message is 1 *s*. According to the budget, taking as an example one data exchange in a period of 24 hours, the capacity of the battery is sufficient for autonomous operation for a period of almost 9 years. It is possible to access the calculation according equation (5).

$$Q_t = (I_b \times t) + (I_s \times t) \tag{5}$$

Where:
Q_t = *battery capacity [Ah];*
I_b = *current during broadcast [A];*
Is = current during sleep mode [A];
t = time [s].

By changing the daily number of data exchanges, the total battery life decreases or increases, which can be compensated by installing a 5V photovoltaic panel. If we hypothetically set, in the test phase, that the range will not be sufficient to retrieve data from the Vranjic light buoy (Figure 13), in the next development phase it is planned to connect the buoys with ZigBee technology.

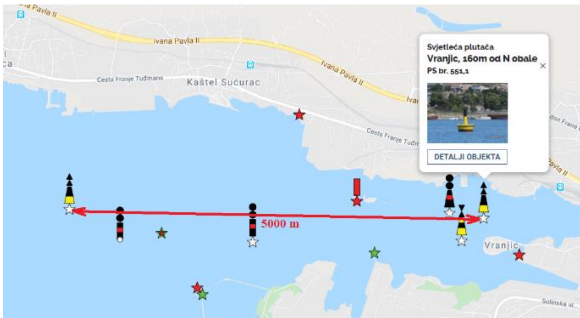

Figure 13: Light buoy Vranjic

In this way, the two monitored buoys are interconnected by ZigBee technology (Figure 14), forming a P2P network, and the buoy within range of the LoRaWAN network transmits all collected data to the network / application server.

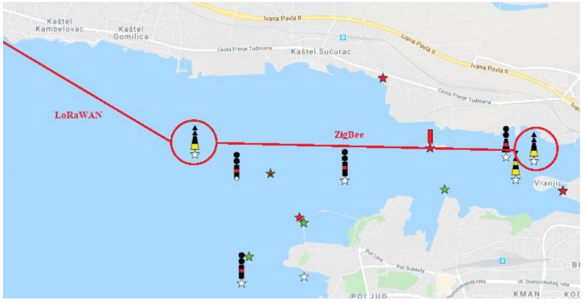

Figure 14: ZigBee technology

If the processed conceptual design turns out to be of good quality after the testing, it would be possible to establish control over all buoys in the Croatian part of the Adriatic, with low electricity consumption, negligible maintenance and ultimately with minimal financial costs.

Figure 15 shows the actually installed device on the light buoy Hrid Galija, which has been in operation for several months without any recorded defects.

Figure 15: Installed device

6 CONCLUSION

The Adriatic is covered with a large number of maritime signaling facilities, many of which are fixed objects such as buoys already equipped with maritime equipment. Correct positioning of buoys is crucial for the proper operation of the waterways marking system. It is possible to form a system for constant position monitoring of the signaling devices, i.e. buoys. This paper analyses the available communication facilities for establishing monitoring system. A test device was installed on a buoy near the north port of Split. Prior to installing this device, the measurements and calculations of wireless signal strength of the LoRaWAN were performed. This technology is chosen as the best wireless communication option for the case study. The measured signal strength at a given distance is sufficient to establish a network for this system, using additional communication means for buoys positioned at greater distances. The measured signal had 30% less power intensity predicted by calculations. In conclusion, this research is applicable to all locations on the Adriatic, due to similar conditions at all buoy micro locations and is the basis for additional research in the future.

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SHIP REAL TIME SIMULATIONS IN PORT APPROACH DESIGN

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ABSTRACT

Port design and approaches are usually carried out using real-time computer simulation methods for vessel traffic. Vessel traffic simulation methods are not cheap, especially in terms of survey time. A number of real-time simulation scenarios carried out by masters and pilots are usually performed, with several simulation attempts in each scenario. Each such attempt can last up to one hour, which, with a large number of scenarios, prolongs the research and increases its cost. Particularly time-consuming is the repetition of many scenarios with alternative solutions for infrastructure development and in various hydrometeorological conditions. In order to reduce the time consuming of the tests, a new two-stage method was used to design the target approach to the modernized Port of Ustka, where in the first stage the simulations were carried out with significantly reduced floating navigation marking, and in the second stage with the target marking.

Keywords: simulation of ship maneuvering process; design of port approaches

1 INTRODUCTION

The major aim of the study [1] was to design the new approach and breakwater solution for general cargo ship of following parameters: L=133m, B=20m, T=7,9m by means of real time ship maneuvering simulation methods for the modernized Ustka Port located in middle of Polish coast. Additionally the conditions of safe operation of port for maximal vessel will be established. The main aim of researches was concerned with:

1. Determination of:
   - safety waterways parameters needed for safe operation of maximal ships,
   - turning place diameter with respect to its shape.
2. Determination of safety conditions of port operation in respect to:
   - admissible meteorological conditions for given kind of ships and maneuvers,
   - other navigational conditions and limitations like presence of other ships on berths, use of position fixing systems on approach, navigational markings, vessel traffic service.
3. Determination of maneuvering procedures during entrance, berthing, un-berthing, exit the port, and turning for different kind of ships and propulsion systems.
4. Determining the conditions of ship mooring inside port.

The major problem with designing the simulation experiment is the number of simulation trials (one trial is defined one simulation run in given conditions), which have to be done within experiments. Each simulation trial is realised in real time and it last sometimes half an hour in presented case study.

The simulation trials are performed in groups (series) in the same controllable environmental condition but with different captains/navigators performing the simulation to achieve statistical variability of human (navigator) influence. The whole study must cover all possible wind and current conditions. In single simulation series usually 15 simulation trials are performed which causes the design process is highly time consuming.

The preliminary design of the breakwater layout is presented in Figure 1 (presented in yellow). After the extensive wave development inside port analysis, it was found that the wave was too high inside the port with NE winds and it was decided to investigate also the long version of breakwater (Figure 2 presented in red), which reduce wave development inside the port.

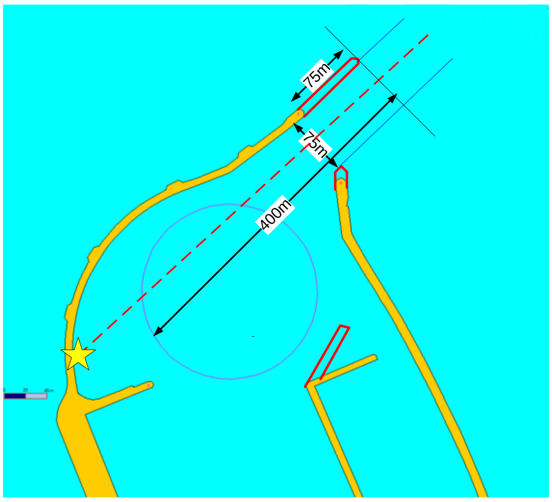

Figure 1: Ustka Port – the preliminary design (yellow) and proposed changes in the breakwater after wave conditions modelling inside the port (red).

2 REAL TIME MANEUVERING SIMULATION METHOD – LIMITED TASK SIMULATOR

The real time simulation interactive method with Captains and Pilots engaged in ships maneuvering trials was applied. This method is assumed as most reliable and suitable in this kind of research studies [3]. The so-called limited task simulator with 2D display was utilized in the researches. The simulator is made and owned by Maritime University of Szczecin [3,4]. The hydrodynamic models used in this simulator is based on detailed and exact characteristics parameters of hulls, propellers and steering devices are known. Additionally real maneuvering characteristics are used for validation of models. The model of so called m/f Ustkamax used in researches is based on modular methodology where all influences like hull hydrodynamic forces, propeller drag and steering equipment forces and given external influences are modelled as separate forces and at the end summed as perpendicular, parallel and rotational ones [5].

3 STATISTICAL METHODS OF DATA PROCESSING

Ship real time simulators are very widely used today especially for training purposes. The hydrodynamic models are becoming more and more reliable. Without efficient statistical data processing, it is not possible to draw proper conclusions from the conducted experiments. Usually different kind of data processing analysis is applied in case when horizontal and vertical ships movement is considered.

3.1 The method of simulation result data processing

The most important safety factor is horizontal area needed for navigators for perform the maneuvers [16,20]. In the single series of simulations several trials (single ship runs) are executed. Statistical processing of the simulation results allows determining the statistical parameters necessary to determine the safe maneuvering area (SMA).

The characteristic values for the examined waterway are areas occupied by ships determined at the level of (Figure 2):

1. maximum (extreme ships positions in all trials),
2. average - mean (defined as mean SMA),
3. on given confidence level (defined as SMA).

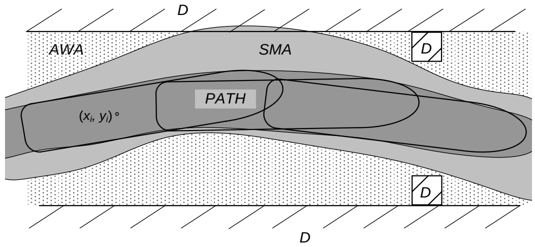

Figure 2: Definition of the ideas connected with horizontal areas taken by ships (PATH – lane of single ship, AWA – available water area, SMA – safe maneuver area on the required confidence level, D – navigational danger)

4 RESULTS OF SIMULATION RESEARCHES

All the simulation trials have been conducted by skilled captains and pilots having experience in this kind of ships and maneuvers. The simulation data have been recorded and analyzed. Analysis of simulation results was performed in basis of the criterion of horizontal safe maneuvering area on 95% (SMA) level of confidence as typically used in maritime operations [6, 2] according to the previously presented method.

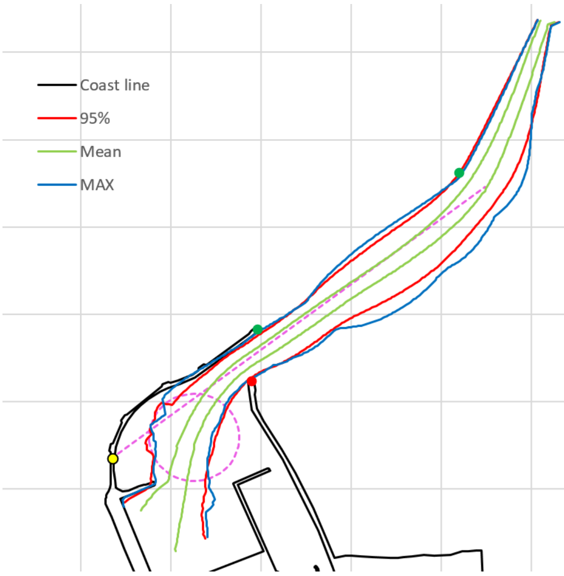

Figure 3: Maneuvering areas of general cargo ship of L=133m on approach to modernized Ustka Port by "Soft-Bank" with limited (preliminary) navigational marking

As it is presented on Figure 3. the navigational marking in "Soft Bank" method is reduced to minimum – there is only one green buoy on approach to show the Captains the turning point but only in very approximately manner. The Figure 10 present results of standard method (without "Soft-Bank") with final navigational markings and with modelled embankments and canal effects. The explanation for Fig 3:

- 95% is the Safe Maneuvering Area (SMA) at 95% level of confidence.
- Mean is average waterway area.
- MAX is maximal over bound area of ships.

4.1 Comparison of methods

The basic statistical parameters of maneuvering area namely: mean and standard deviation are presented in Figure 4 for designed approach waterway. The number of sections is 250 and the section width is 5m. It can be observed that the mean and standard deviation is significantly lower for standard method in compare to "Soft-Bank" method. It is because the designed, after the first step, navigational marking limits the waterway. Moreover, some changes in waterway layout have been made so the movement of the ship on the approach is more optimized. The green buoy on the approach in "Soft –Bank" method (Figure 9) have been removed and final layout of navigational marking is proposed (Figure 10) that consists of the gate of red-green buoys and two green buoys marking starboard side of approach waterway. Such design of waterways together with the navigational marking need an experienced marine traffic engineers engaged in the process.

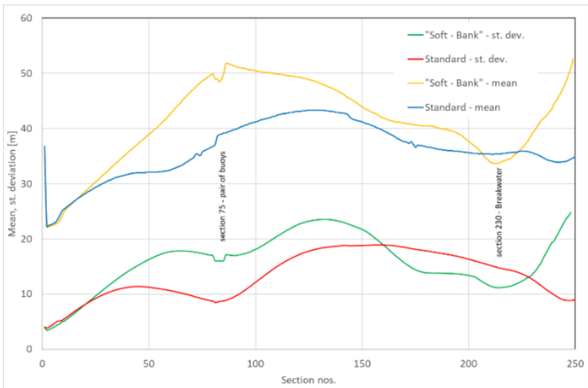

Figure 4: Comparison of two parameters of maneuvering areas of investigated ship on approach to modernized Ustka Port using "Soft-Bank" method for preliminary design and standard method for final design

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INFLUENCE OF HURRICANES ON NAVIGATION IN THE NORTH ATLANTIC

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ABSTRACT

Tropical cyclones are intense vortical storms that develop over the tropical ocean in regions of very warm surface waters. The strength of a tropical cyclone, during its development, may be determined by the value of the central pressure at sea level and/or by the maximum wind speed as: tropical disturbance, tropical depression, tropical storm and tropical cyclone. Typical tropical cyclones/hurricanes space scales are between 100 and 2000 km in diameter. The Saffir-Simpson Hurricane Wind Scale is a tool that meteorologists use to measure the intensity of hurricanes. Considering the amount of energy, loss of life, and material damage they cause, hurricanes are the most powerful atmospheric systems. Hurricanes are characterized by their four most destructive forces: strong winds including tornadoes, high storm surge and washover, large waves, and associated rain. Of all human activities, hurricanes, with their devastating power, do the most damage to maritime affairs.

The aim of this paper is to present the impact of hurricanes on the waterways in the North Atlantic, linking Europe and North America. General hurricane characteristics like space scale, intensity and structure, formation and development, weakening and decay were presented. The possibilities of their forecasting and warnings of the population, especially of seafarers were evaluated. It was concluded that special attention should be paid to the procedure that seafarers must follow to avoid a hurricane, both on the high seas and in port.

Keywords: hurricane, North Atlantic, Saffir-Simpson Hurricane Wind Scale, seafarers

1 INTRODUCTION

Hurricanes are the most violent storms on Earth. They form near the equator over warm ocean waters. Actually, the term hurricane is used only for the large storms that form over the Atlantic Ocean or eastern Pacific Ocean.

The generic, scientific term for these storms, wherever they occur, is tropical cyclone. Other names they are given, depending on where in the world they are born, are typhoons, cyclones, severe tropical cyclones, or severe cyclonic storms. Whatever they are called, the same forces and conditions are at work in forming these giant storms, any of which can cause damage or devastation when they hit land where people live [1].

Tropical cyclones form only in tropical regions where the ocean is at least 26 °C. The second ingredient for a tropical cyclone is wind. In the case of hurricanes that form in the Atlantic Ocean, the wind blowing westward across the Atlantic from Africa provides the necessary ingredient. As the wind passes over the ocean's surface, water evaporates (turns into water vapor) and rises. As it rises, the water vapor cools, and condenses back into large water droplets, forming large cumulonimbus clouds. These clouds are just the beginning [URL 1].

Hurricanes usually weaken when they hit land, because they are no longer being fed by the energy from the warm ocean waters. However, they often move far inland, dumping many millimeters of rain and causing lots of wind damage before they die out completely.

The main goal of this paper is to show the devastating impact of tropical cyclones on navigation in the North Atlantic and especially to give seafarers a brief historical overview of the intensity and frequency of the strongest hurricanes and the catastrophic damage they caused to ships, both on the high seas and in ports. All elements related to hurricanes, their formation, movement, physical structure in the North Atlantic will be presented. Particular attention will be given to the procedure that seafarers must follow in order to avoid a hurricane, thus determining the dangerous semicircle and the dangerous quadrant of a hurricane during navigation.

2 GENERAL HURRICANE CHARACTERISTICS

2.1 Genesis area, climatological tracks and frequency

Tropical cyclones/storms frequently form in the warm waters of the Gulf of Mexico, the Caribbean Sea, and the tropical Atlantic Ocean as far east as the Cape Verde Islands (Fig. 1), the origin of strong and long-lasting Cape Verde-type hurricanes [URL 2].

The official hurricane season for the Atlantic Basin (the Atlantic Ocean, the Caribbean Sea, and the Gulf of Mexico) is from 1 June to 30 November. As seen in Fig.

2, the peak of the season is from mid-August to late October. However, deadly hurricanes can occur anytime in the hurricane season [URL 3].

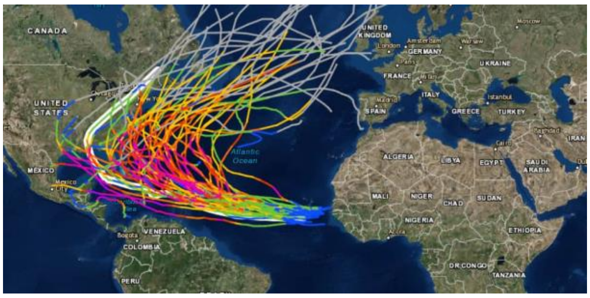

Figure 1: Category 4 and 5 hurricane tracks from 1851-2016 in the East Atlantic ocean basin [URL 4].

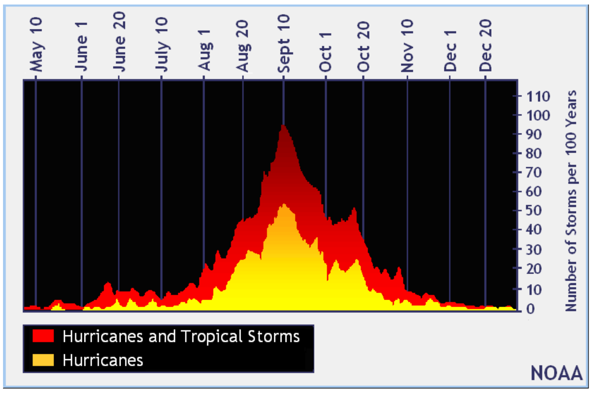

Figure 2: Number of tropical cyclones per 100 years in the Atlantic basin [URL 5].

2.2 Space scale, intensity and structure

Typical tropical cyclones/hurricanes space scales are between 100 and 2000 km in diameter. They are largest on average in the Northwest Pacific, while in the North Atlantic basin they are on average slightly smaller in size.

Meteorologist measure hurricane's strength based on the intensity of their sustained wind speeds and rate them using Saffir–Simpson hurricane wind scale.

The Saffir–Simpson hurricane wind scale (SSHWS), formerly the Saffir–Simpson hurricane scale (SSHS), classifies hurricanes – Western Hemisphere tropical cyclones – that exceed the intensities of tropical depressions and tropical storms – into five categories distinguished by the intensities of their sustained winds (Table 1).

To be classified as a hurricane, a tropical cyclone must have one-minute maximum sustained winds of at least 74 mph (33 m/s; 64 kn; 119 km/h) (Category 1). The highest classification in the scale, Category 5, consists of storms with sustained winds over 156 mph (70 m/s; 136 kn; 251 km/h) [URL 6].

The 2018 Atlantic hurricane season was the third in a consecutive series of above-average and damaging Atlantic hurricane seasons, featuring 15 named storms, 8 hurricanes, and 2 major hurricanes (Cat. 3+).

The 2019 Atlantic hurricane season was the fourth consecutive year of above-average and damaging seasons dating back to 2016, with 18 named storms and 20 tropical cyclones in total (6 hurricanes of which 3 Cat. 3+) [URL 7].

A list of the strongest hurricanes recorded in the Atlantic Ocean is shown in Table 2.

Table 1: The Saffir–Simpson hurricane wind scale (SSHWS) [URL 6].

Cateory	Wind speeds (for 1-minute maximum sustained winds)			
	m/s	knots (kn)	mph	km/h
5	≥ 70	≥ 137	≥ 157	≥ 252
4	58–70	113–136	130–156	209–251
3	50–58	96–112	111–129	178–208
2	43–49	83–95	96–110	154–177
1	33–42 s	64–82	74–95	119–153

Table 2: Strongest Atlantic hurricanes by peak sustained wind speeds [URL 8].

Strongest Atlantic hurricanes			
Hurricane	Season	By peak sustained wind speed	
		mph	km/h
Allen	1980	190	305
"Labor Day"	1935	185	295
Gilbert	1988	185	295
Dorian	2019	185	295
Wilma	2005	185	295
Mitch	1998	180	285
Rita	2005	180	285
Irma	2017	180	285

2.2.1 The formation and development of a tropical cyclone

Tropical cyclones are like engines that require warm, moist air as fuel. So the first ingredient needed for a tropical cyclone is warm ocean water. That is why tropical cyclones form only in tropical regions where the ocean is at least 26 °C for at least the top 50 meters below the surface.

Meteorologists have divided the development of a tropical cyclone into four stages: tropical disturbance, tropical depression, tropical storm, and tropical cyclone. Tropical cyclones begin with a meteorological phenomenon called tropical wave which is a low pressure trough or front that moves from east to west, with wind speeds of around 45 km/h. As tropical wave develops, with the wind circulating around a center, the moving column of air encounters more clouds, it becomes a persistent group of thunderstorms with heavy rains and strong wind gusts, called a tropical disturbance.

As the thunderstorms grow higher and larger tropical disturbance moves into the tropical depression phase, characterized by maximum wind speeds of 62 km/h. The low-pressure depression's center draws warm air and water from the ocean's surface, feeding and intensifying the storms.

When the wind speeds reach 63 km/h, the tropical depression becomes a tropical storm. This is also when the storm gets a name. The winds blow faster and begin twisting and turning around the eye, or calm center, of the storm. Wind direction is counterclockwise (west to east) in the northern hemisphere and clockwise (east to west) in the southern hemisphere. This phenomenon is known as the Coriolis effect [2].

When the wind speeds reach 119 km/h, the storm is officially a hurricane (Table 1; Fig. 4). The storm is at least 15,5 km high and around 230 km across. The eye is around 10 to 50 km wide. The trade winds (which blow from east to west) push the hurricane toward the west—in the North Atlantic toward the Caribbean, the Gulf of Mexico, or the southeastern coast of the U.S. (Fig. 3). The winds and the low air pressure also cause a huge mound of ocean water to pile up near the eye of the hurricane, which can cause monster storm surges when all this water reaches land [URL 1].

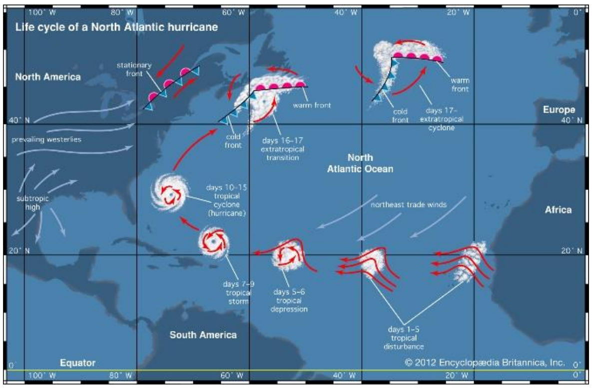

Figure 3: Life of a tropical cyclone [URL 9].

2.2.2 Weakening and decay of a tropical cyclone

If a tropical cyclone/hurricane remains over the ocean, once the storm moves northward (in the Northern Hemisphere) out of the tropical ocean and into the mid-latitudes, it begins to move over colder water, again losing the warm water source necessary to drive the hurricane.

Landfall usually causes a hurricane to quickly decay. Hurricanes require evaporation from the warm ocean surface to survive. Once a hurricane makes landfall, it is separated from its ocean energy source, and hence, can no longer extract heat from the ocean [URL 10].

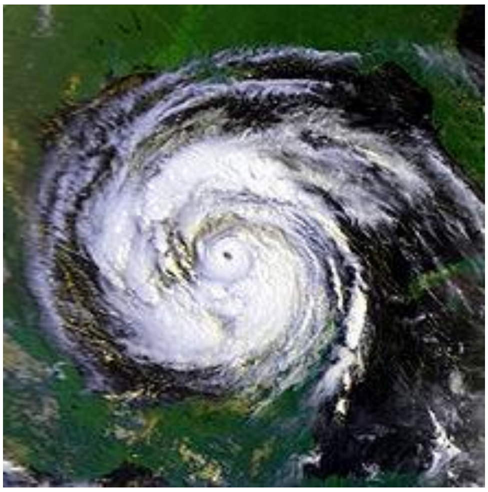

Figure 4: Hurricane Alen in the Gulf of Mexico on August 8, 1980, Category 5 [URL 11].

2.2.3 Physical structure

The wind field of a tropical cyclone may be divided into three regions (Fig. 5). First is a ring-shaped outer region, typically having an outer radius of about 160 km and an inner radius of about 30 to 50 km. In this region the winds increase uniformly in speed toward the centre. Wind speeds attain their maximum value at the second region, the eyewall, which is typically 15 to 30 km from the centre of the storm. The eyewall in turn surrounds the interior region, called the eye, where wind speeds decrease rapidly and the air is often calm.

A characteristic feature of tropical cyclones is the eye, a central region of clear skies, warm temperatures, and low atmospheric pressure. Typically, atmospheric pressure at the surface of Earth is about 1,000 millibars. At the centre of a tropical cyclone, however, it is typically around 960 millibars, and in a very intense "super storm" it may be as low as 880 millibars. In addition to low pressure at the centre, there is also a rapid variation of pressure across the storm, with most of the variation occurring near the centre. This rapid variation results in a large pressure gradient force, which is responsible for the strong winds present in the eyewall.

The most dangerous and destructive part of a tropical cyclone is the eyewall. Here winds are strongest, rainfall is heaviest, and deep convective clouds rise from close to Earth's surface to a height of 15,000 metres. As noted above, the high winds are driven by rapid changes in atmospheric pressure near the eye, which creates a large pressure gradient force.

In addition to deep convective cells (compact regions of vertical air movement) surrounding the eye, there are often secondary cells arranged in bands around the centre. These bands, commonly called rainbands, spiral into the centre of the storm. In some cases the rainbands are stationary relative to the centre of the moving storm, and in other cases they seem to rotate around the centre [URL 11].

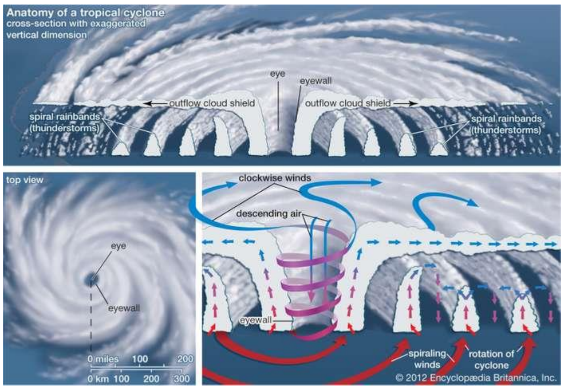

Figure 5: Physical structure of the hurricane [URL 12].

3 OCEAN PHENOMENA CAUSED BY A HURRICANE

Hurricanes are one of nature's most powerful storms. Once generated and developed above the ocean surface, they produce strong winds, huge waves, storm surge which causes flooding in the coastal area, heavy rainfall, tornadoes, and rip currents [1,2].

To gain insight into the intensity of meteorological and oceanographic parameters that a hurricane can develop, the values recorded during Hurricane Dorian, one of the strongest hurricanes to occur in the North Atlantic, will be presented. Dorian developed from a tropical wave on 24 August 2019 over the Central Atlantic and reach its peak as a Category 5 hurricane with a minimum central pressure of 910 millibars by 1 September.

Hurricane Dorian (Fig. 6) is expected to bring potentially fatal storm surges of 5 to 7 metres. The winds are estimated to be between 260 km/h to 295 km/h, with peaks up to 360 km/h. Only hurricane Allen in 1980 was more powerful with maximum average winds of 305 km/h. Copernicus Marine Service product predicted up to 11.2 m significant wave heights. Hence observed maxima waves could be 20 m. Hurricane Dorian brought a 7 m high wall of water (storm surge) to parts of the Bahamas [URL 13]. Similar values for winds and waves were obtained in scientific research [3].

4 HURRICANE FORECAST REGIONS AND CENTERS

The marine weather broadcast and radiofacsimile weather maps are the most important tools for avoiding tropical cyclones.

Tropical storms developing in the world's ocean basins are tracked by various national weather services that have been designated Regional Specialized Meteorological Centres (RSMCs) by the World Meteorological Organization (WMO).

Forecasting hurricane landfall and providing warnings for storms that will effect the United States in the North Atlantic is done by the National Hurricane Center in Miami. Forecasters use a variety of observational information from satellites and aircraft to determine the current location and intensity of the storm (Fig. 7). This information is used along with computer forecast models to predict the future path and intensity of the storm (Fig. 8).

5 NAVIGATION AND STAY IN PORT

During navigation in the North Atlantic when approaching tropical cyclone mariners firstly observe a long swell. Swell generated by a hurricane is about twice as long than in it´s absence. As tropical cyclone comes nearer, a cloud sequence begins which resembles that associated with the approach of the warm front in middle latitudes: firstly white cirrus, than altostratus and stratocumulus. These clouds gradually become more dense, so the weather becomes unsettled with rain showers.

At these moments the air pressure falls rapidly, wind increases in gustiness (20 to 40 knots) and on the horizon appear a dark wall of a heavy cumulonimbus, called the bar of the storm. These heavy clouds are accompanied by rain squalls and wind of increasing speed. The seas which have been gradually mounting, becomes tempestuous (Fig. 9). Even the largest and most seaworthy vessels become virtually unmanageable, and may sustain heavy damage [URL 17].

From the previous description of meteorological parameters within a tropical cyclone, it can be concluded that a tropical cyclone is best to be avoided.

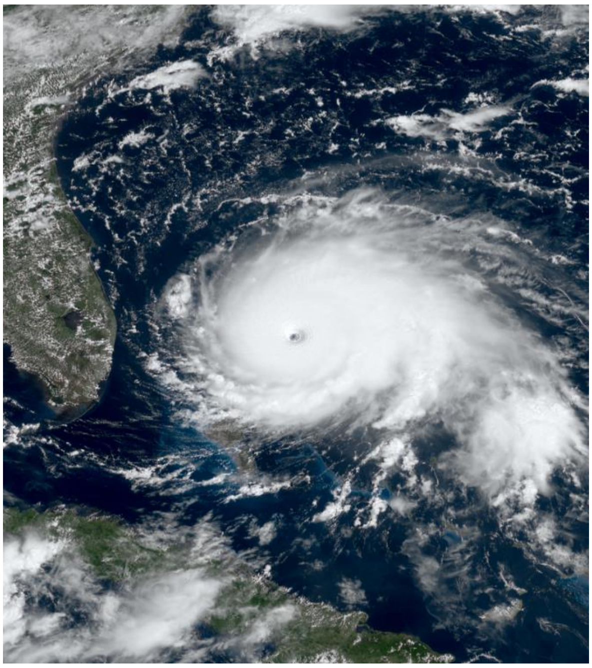

Figure 6: Hurricane Dorian at peak intensity over the Abaco Islands on September 1 [URL 14].

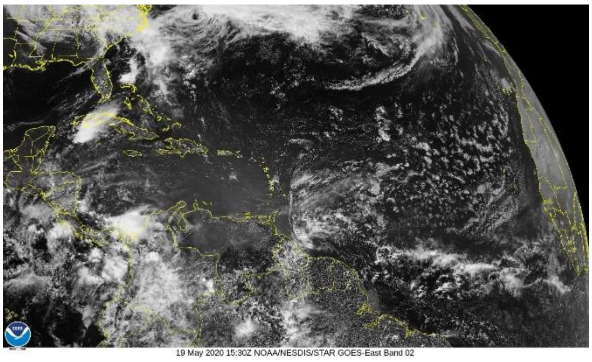

Figure 7: Satellite image of the North Atlantic on 19 May 2020, from the data available on the website of the National Hurricane Center in Miami [URL 15].

Because the tropical cyclone spins and travels at the same time, it creates different wind conditions north and south of the storm's track. However, if the vessel is within a tropical cyclone, it is necessary to know its structure from the point of view of navigation safety (Fig. 10). In order for that to be possible, it is necessary to first explain some official terms. Track is the route over which tropical cyclone is already passed, while path is its predicted route. If tropical cyclone is divided along the route at which it is passing, then we get 2 parts (semicircles) in the Northern Hemisphere:

1. Right-hand semicircle (RHSC), which lies to the right of the observer, who faces along the route of the storm. It is dangerous semicircle, where the storm has the strongest winds and heavy seas. The most destructive section of the storm is in this semicircle, usually in the eyewall area to the right of the eye, known as the right-hand quadrant, northwest quadrant or danger quadrant (Fig. 10);
2. Left-hand semicircle (LHSC), which lies to the left of the observer, who faces along the route of the storm. It is navigable semicircle, where wind are weaker (Fig. 10) [URL 19].

There is a special procedure for a ship that is near the port or in the port itself [4]. Then it is advisable, if possible, try to go to the sea at a safe distance and sufficient depth of water, or double the moorings.

The fatality of staying in the port was recognized long ago, when the structure of the hurricane was not yet known (Fig. 11).

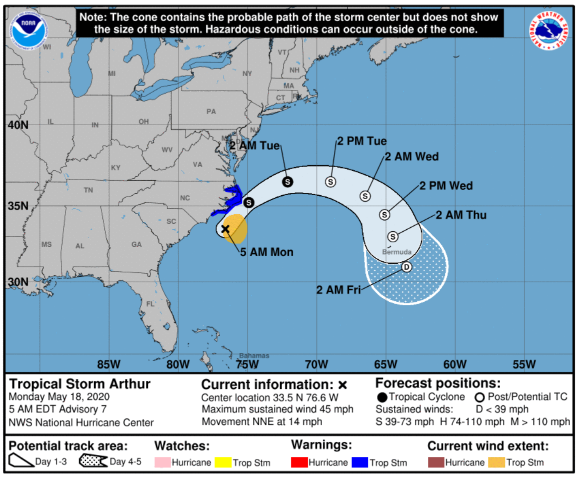

Figure 8: Forecast of the path and intensity of the tropical storm Arthur on 18 May 2020 [URL 16].

Figure 9: Huge hurricane waves [URL 18].

6 CONCLUSION

Tropical cyclones are intense storms that develop over the tropical ocean in regions of very warm surface waters, where the ocean is at least 26 °C for at least the top 50 meters below the surface. Meteorologists have divided the development of a tropical cyclone into four stages: tropical disturbance, tropical depression, tropical storm, and tropical cyclone. Very large storms that form over the Atlantic Ocean or eastern Pacific Ocean is called hurricane. Hurricanes are the most violent storms on Earth. Meteorologist measure hurricane's strength based on the intensity of their sustained wind speeds and rate them using Saffir–Simpson hurricane wind scale.

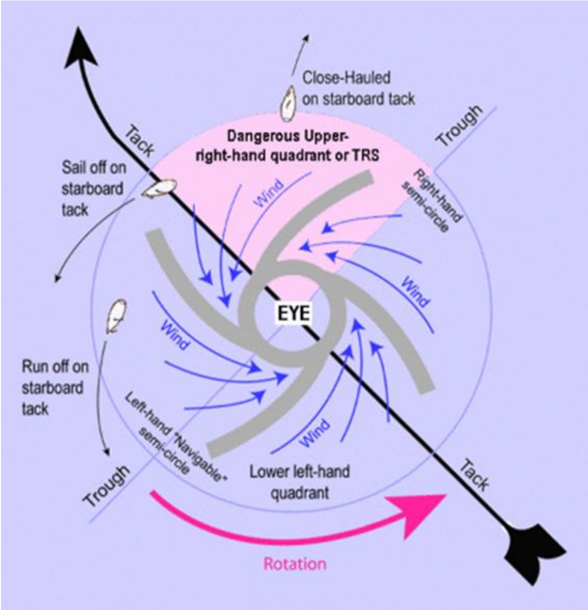

Figure 10: Navigation in tropical cyclone [URL 20].

Figure 11: The Great September Gale of 1815 in New England occurred well before the ability to distinguish hurricanes [URL 21].

To be classified as a hurricane, a tropical cyclone must have one-minute maximum sustained winds of at least 119 km/h (Category 1). Typical tropical cyclones/hurricanes space scales are between 100 and 2000 km in diameter. Physical structure of the hurricane can be divided in three main parts: eye, eyewall and outflow cloud shield.

The official hurricane season for the Atlantic Basin (the Atlantic Ocean, the Caribbean Sea, and the Gulf of Mexico) is from 1 June to 30 November. The peak of the season is from mid-August to late October. However, deadly hurricanes can occur anytime in the hurricane season. The 2019 Atlantic hurricane season was the fourth consecutive year of above-average and damaging seasons dating back to 2016, with 18 named storms and 20 tropical cyclones in total (6 hurricanes of which 3 Cat. 3+). This indicates an increase in the number and intensity of hurricanes occurring in the North Atlantic area, most likely due to climate change. Hurricanes of Category 5 produce strong winds (up to 360 km/h), huge waves (more than 20 m), storm surge (more than 7 m) which causes flooding in the coastal area. Navigation in such meteorological and oceanographic conditions requires knowledge and top skills from the seafarer. To avoid tropical cyclones/hurricanes, seafarers must first follow the marine forecast by various national weather services that have been designated Regional Specialized Meteorological Centres (RSMCs). For the North Atlantic basin it is National Hurricane Center in Miami. For navigation within a tropical cyclone / hurricane as well as for staying in port, seafarers must follow the procedures specified in the maritime manuals.

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BUILDING A FRAMEWORK TO IMPROVE TRAFFIC SAFETY CULTURE - A CASE STUDY, PROFESSIONAL DEVELOPMENT OF EDUCATORS AND TEACHERS IN THE FIELD OF TRAFFIC SAFETY IN BELGRADE

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ABSTRACT

Building a framework to improve traffic safety culture in the EU is one of the key needs in Road Safety Research Roadmap for EU. Educating children about traffic is the most important long-term basis for enhancing the culture of participation in traffic. In this process, the role of educators and teachers is very important as professionals who should systematically contribute to this process.

A project was designed and implemented in Belgrade aimed at improving traffic education in preschools and in the first grades of primary schools. The project was aimed at strengthening the capacity and integrity of the most important subjects – educators and teachers in the field of traffic safety and traffic culture in general. This project involved over 500 educators and 500 teachers. They, in small groups, covered the most important thematic units in the field of safe behavior in traffic and modern methods of working with children. On the example of traffic related topics, the trainees practiced monitoring and evaluating teaching and learning.

Accredited seminars are a combination of theoretical and practical training. The seminar participants were taught how to adjust the contents and teaching methods to the age of the child. This involves a didactic and interactive approach, simulation and demonstration. Among others, this paper presents the concept of educating educators and teachers, as one of the most important bearers of traffic education.

The aim of this paper is to present the concept of six-hour professional development of educators and teachers on the safety of children in traffic, which was applied in the territory of the city of Belgrade, in all 17 municipalities.

Keywords: traffic safety culture, education concept, educators, teachers, children road safety

1 INTRODUCTION

The number of road traffic deaths on the world's roads remains unacceptably high with 1,35 million people dying each year. Road traffic injury is the 8th leading cause of death for all age groups (WHO, 2018) and leading cause of death for children and young adults aged 5-29 years, signaling a need for a shift in the current child health agenda, which has largely neglected the road safety (WHO, 2018). More people now die as a result of road traffic injuries than from HIV/AIDS, tuberculosis and diarrheal diseases (WHO, 2018).

Achieving global and national road safety goals and targets requires appropriate management capacity. Institutional management provides the foundation for improving road safety (Peden et al., 2004). The establishment of an appropriately resourced lead agency and coordination arrangements to guide the national road safety effort; the assessment of the state of play and capacity; the setting of goals and targets in road safety strategies; plans and project; the provision of financial and human resources to address the problem and the monitoring and evaluation of activity are all essential to implementing effective, system-wide interventions (WHO, 2018; Bachani et al., 2017).

In order to improve the traffic education system, numerous documents have been adopted and being implemented, both globally, nationally and locally. The responsibility and participation of children in traffic are regulated by: the Constitution of the Republic of Serbia, the UN Convention on the Rights of the Child (ratified by RS), the Law on Road Traffic Safety, the Law on the Basics of the Education and Upbringing System, the Family Law, the Criminal Code, the Law on Offenses, Road Safety Strategy of the Republic of Serbia 2015-2020, Road Safety Strategy of the City of Belgrade 2017-2020. years etc.

Educating children about traffic is the most important long-term basis for enhancing the culture of traffic participation. In this process, the role of educators and professionals is very important as professionals who should systematically contribute to this process.

Bearing in mind the problem of suffering of children in traffic in Belgrade, numerous measures have been taken to improve the safety of children in traffic.

The project of professional development of educators and teachers aims to permanently improve traffic education and upbringing in preschools and in the first grades of primary schools. However, this is one of the most important prerequisites for the long-term improvement of the capacity and integrity of all road safety entities. The project involved over 500 educators and 500 teachers. In small groups, they covered the most important thematic units in the field of safe behavior in traffic.

Accredited seminars are a combination of theoretical and practical training. The seminar participants were taught how to adjust the contents and teaching methods to the age of the child. This involves a didactic and interactive approach, simulation and demonstration.

The participants had the opportunity to improve their knowledge and attitudes in the field of traffic safety, to better understand the psycho-physical organization of children and how this affects learning opportunities and the risks of traffic participation. However, participants are able to improve their teaching skills by applying new methods of interactive teaching.

Bearing in mind the above the aim of this paper is to present the concept of six-hour professional development of educators and teachers on the safety of children in traffic, which was applied in the territory of the city of Belgrade, in all 17 municipalities.

2 METHODOLOGY

Methodology of this paper is shown in the figure 1. The first step is review of major regulations and strategic documents which is a basis for improving traffic safety culture.

Next, multidisciplinary group of experts defined the training programs which were then accredited as programs of public interest.

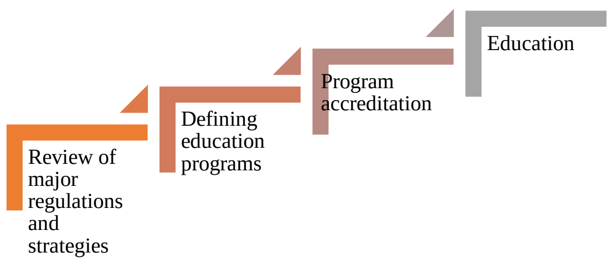

Figure 1: Methodology

In this paper we presented Traffic education program for educators and teachers about children road safety which was implemented in Belgrade.

3 MAJOR REGULATIONS AND STRATEGIC DOCUMENTS AS A BASIS FOR IMPROVING TRAFFIC SAFETY CULTURE

At the global, national and local levels, there are significant documents that highlight traffic education and upbringing, that is, protecting children in traffic, as a community priority. Among these documents are particularly significant:

- Constitution of the Republic of Serbia[1]
- UN Convention on the Rights of the Child (ratified by RS)[2]
- Road Traffic Safety Act[3]
- The Law on the Basics of the Education and Upbringing System[4]
- The Family Law[5]
- The Criminal Code[6]
- The Law on Offenses[7]
- Road Safety Strategy of the Republic of Serbia 2015-2020 years[8]
- Road Safety Strategy of the City of Belgrade 2017-2020. years[9]

The Constitution of the Republic of Serbia, as the highest general legal act in "Children's rights', provides that children enjoy human rights suitable to their age and maturity. The UN Convention on the Rights of the Child states that, in all activities concerning children, the interests of the child are of primary importance. In addition, Member States are required to take appropriate measures to reduce child mortality.

The Road Traffic Safety Act prescribes the responsibility of different entities for the implementation of traffic education and other issues related to the participation of children in traffic. Preschools and primary schools are one of the 14 responsible entities for the implementation of traffic education. Their curricula must address topics related to the safety of children and students in traffic.

The Law on the Basics of the Education and Upbringing System regulates the basics of the system of preschool, primary and secondary education and adult education, namely: principles, goals, outcomes, standards of education and upbringing, knowledge, skills and attitudes, manner and conditions for performing the activity of preschool education and education, primary

[1] Constitution of the Republic of Serbia, Official Gazette of the Republic of Serbia, No 98/06.
[2] UN Convention on the Rights of the Child (ratified by RS), Official Gazette of Yugoslavia, International agreements 4/96 and 2/97.
[3] Road Traffic Safety Act, Official Gazette of the Republic of Serbia, 41/09, 53/10 and 101/11, 32/2013, 55/2014, 96/2015, 9/2016, 24/2018 and 23/2019.
[4] The Law on the Basics of the Education and Upbringing System, Official Gazette of the Republic of Serbia, No 88/17.
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and secondary education, the type of education and training programs, the establishment, organization, financing and supervision of the work of educational institutions, as well as other issues of relevance to education. This Law stipulates that the goals of education and upbringing are: the development and practice of healthy lifestyles, awareness of the importance of one's own health and safety, the need to nurture and develop physical abilities, etc. It should be emphasized that one of the important goals of traffic education of children and students is to develop an awareness of the importance of their own safety. A child who understands that his or her safety is the most important will better understand and become more involved in the process of traffic education.

Family law provides that everyone is required to be guided by the best interests of the child in all activities concerning the child. On the other hand, the Criminal Code recognizes a child as a person under the age of 14 and accordingly defines the limits for determining crimes, but also prescribes special protection for children. Among other things, this code also regulates criminal offenses against the safety of public transport.

The Law on Offenses defines the concept of offenses, conditions for offenses liability, conditions for prescribing and applying offenses sanctions, system of sanctions, offenses procedure, issuing offenses order, procedure for enforcement of decision, register of sanctions and register of unpaid fines, etc. The most common violations in Serbia are traffic violations, ie violations against road safety. Children as road users are especially protected, as evidenced by the penal provisions in the Road Traffic Safety Act.

The Road Safety Strategy of the Republic of Serbia for the period 2015 to 2020 emphasizes the importance of improving the safety of children in traffic and the principle relating to the protection of children: “Children enjoy special protection in traffic. When operating in a traffic safety system, child safety is a top priority. "

This Strategy defines key areas of work to improve the safety of children in traffic:

- continuous presence of traffic safety topics throughout schooling;
- educating educators, teachers and teachers about the importance of traffic safety,
- exchange of best foreign and domestic experiences related to a safe school environment and
- campaigns, stands and performances on the topic of child safety in traffic.

Acording to Road Safety Strategy of the City of Belgrade 2017-2020. the role of educators and teachers in the process of traffic education in the City of Belgrade was recognized. Kindergarten teachers, teachers and parents should be pointed out that it is not enough just to tell children how to behave in traffic, but it is more important to teach them by example ("Be a good role model to them!"). The process of traffic education should be realized in the family, in the classroom, on school yard and on the street - realistic traffic conditions. In preschools and elementary schools, different parts of traffic education are systematically processed. However, the most significant part of traffic education is taking place in the family, in daily traffic activities. The two processes must be well coordinated. Therefore, in order to improve the safety of children in traffic, it is necessary to implement quality education of educators, teachers, or parents.

4 THE CONCEPT OF EDUCATING EDUCATORS AND TEACHERS ABOUT CHILDREN ROAD SAFETY

Given their importance, these seminars are accredited as programs of public interest. Six-hour training program were carried out with groups of up to 30 educators, in which three areas were represented: road traffic safety, psychophysical characteristics of children important for safe traffic participation, and implementation of traffic education in the context of the new foundations of pre-school education (for the educators), that is, the modern concept of traffic education in the context of new teaching and learning programs focused on the outcomes and learning process in the first grade (for teachers). The seminars were realized during the period when the process of implementation of new basics of preschool education programs was established in preschool institutions, and the introduction of new teaching and learning programs focused on outcomes and learning process in primary schools.

Educating children about traffic is a very complex process. Establishing a structured traffic education system involves the development of guidelines by professionals and creators of traffic safety systems. It is essential that children acquire certain knowledge and skills in traffic before they start their own participation in traffic.

Keeping that in mind is important to properly present to the children the most important thematic units in the field of safe behavior in traffic, in accordance with their age and needs.

Traffic education program should be based on the principles of road traffic safety and to take place in a room (house and classrooms), the polygon (yard) and on the street in real traffic conditions, in a real environment. The training of children should be regular and should be a combination of theoretical and practical training. It is important that teaching methods are child-friendly and multimodal conceptualized, which includes a didactic and interactive approach, simulation and demonstration. The whole process should be designed to encourage as many parents (guardians) as possible to monitor and support this process, and in particular to communicate consistent messages to the children and to use every opportunity to exercise in real traffic.

Accordingly, the Traffic Safety Educator / Teacher Training Program cover the following areas:

- The problem of suffering children in traffic;

- Regulations governing the responsibilities and participation of children in traffic;
- The most important contents of traffic education for preschool and first grade children;
- The specific characteristics of preschool children that are important for their safe participation in traffic;
- Contemporary concept of traffic education in the context of new foundations of preschool education programs;
- Characteristics of young elementary school children that are important for safe traffic;
- The modern concept of traffic education in the context of new teaching and learning programs focused on the outcomes and learning process in the first grade.

Topic: *"The problem of suffering children in traffic"* aims to inform the trainees about the problem of suffering children in traffic, ie to get statistics about the extent and circumstances of the suffering of children in traffic. In the last 8 years in Serbia, nearly 4 child wards have been killed in traffic accidents. Special attention was paid to the categories of injured children (gender, age) as well as the periods of occurrence of traffic accidents involving children (period of the year, day of the week, time of day). The main objective of this lecture is to show trainees the typical situation of traffic accidents involving children, with special emphasis on the vulnerabilities of children who have contributed to the accident.

The most important questions in this lesson that the participants in the training process received were:

- What is the trend of traffic accidents involving children in Serbia and Belgrade?
- In which category of traffic participation are children most at risk?
- Who suffers more traffic injuries, boys or girls?
- Which age categories of children are most affected by traffic in Belgrade?
- In what type of traffic accidents do children suffer the most?
- What are the most common failures that contribute to the occurrence of an accident or severity of accidents?

The next topic: "Regulations governing the responsibilities and participation of children in traffic" aims to familiarize trainees with the most important documents governing children's rights and safety. The trainees get acquainted with the most important provisions of the Road Traffic Safety Act concerning the participation of children in traffic. Finally, explain the objectives of reducing the suffering of children in traffic as defined by national and local road safety strategy that is needed to reach by 2020.

Throughout this lesson, trainees receive answers to the following questions:

- What documents regulate children's rights and safety?
- What are the goals of UN conventions related to child safety?
- Who is responsible for traffic education and upbringing of children?
- How and where does a child sit in a passenger car, depending on his or her height and age?
- At what age is a child allowed to operate a bicycle on the streets in an area of calm traffic, in other zones, on a cycle path or on another public road?
- How can pedestrians moving through the streets of the settlement and roads outside the settlement?
- What are the most important objectives of the national and the local Road Safety Strategy relating to reducing the suffering of children?

The aim of the lecture *"The most important contents of traffic education"* is to show the trainees the correct and irregular behaviors of children and adults in traffic, all in order to enable them to convey the right behaviors and attitudes to children. A child participates in traffic as a pedestrian, a passenger in a passenger car, a passenger in a bus, a bicycle driver, etc. Depending on how the child is involved in traffic, the risks and rules of traffic participation is different. These lessons are based on a detailed analysis of the traffic accidents in which children suffered in Belgrade and Serbia. Specifically, the Commission expert at the Institute of Traffic Engineering in Belgrade allowed filtering the large number of accidents in which the damaged (injured or died) children. Each incident identified the accident participants who contributed to the occurrence of the accident, which are related to the possibility of avoiding the accident or related to the severity of the consequences of the accident. Understanding these gaps is at the heart of defining the most important content of traffic education and upbringing of children and students. The following are some of the most important 'lessons' that should help educators, teachers and parents better understand the link between personality traits, traffic participation rules, traffic mistakes and traffic participation risks. These "lessons "are systematized according to the mode of participation of children in traffic, namely lessons relating to the participating child as:

- passenger in a passenger vehicle,
- passenger on the bus,
- pedestrian,
- cyclist.

A systematic overview of topics, or 'lessons', is presented in Table 1.

The second part of professional development is different for educators and teachers, as it relates to practical work with children and students. This part of the seminar is harmonized with the age and maturity of the child, that is, with the specifics of working with children in preschool or the specifics of working with students in primary school.

With regard to educators, the topic *"Psychophysical characteristics of preschool children that are important* *for their safe participation in traffic"* aims to introduce educators to the most important psychophysical characteristics of preschool children that are important for their safe participation in traffic.

During this part of the seminar the following questions can be answered:

- Do children of this age use hearing aids to assess traffic situations?
- Do children, at this age, also understand how they respect the signals received from adults?
- Do children of this age have an awareness of their own danger?
- Do children recognize different sounds at this age?
- etc.

The last part of professional training, for educators, aims to familiarize teachers with the modern concept of traffic education in preschool institutions and to realize the possibilities and importance of the concept developed for the proper and quality education of children for independent participation in traffic.

The middle part of the seminar for teachers refers to the topic "Psychophysical characteristics of elementary school children from 7 to 11 years of age that are important for their safe participation in traffic".

The aim of the lesson is to get teachers familiar with the most important psychophysical characteristics of early elementary school children, which are important for their safe participation in traffic, that is, to answer questions that are the most important physical, intellectual and sensory characteristics of children; why it is important for a child to stop rather than run out onto the roadway; whether children can accurately evaluate time intervals; with how old the children begin to use the hearing aid to assess traffic situations.

Table 1: Systematized overview of lessons about the children road safety

Child as…	
…passenger in a passenger vehicle	**…passenger on the bus**
Which car door are the safest for kid to come in/out?	How are the kids waiting for the bus?
Where is the safest position for kid to sit in car?	How do kids get on the bus?
How is appropriate for kid to sit in the car?	Which door does the child get on the bus for?
How does kid sit in the child seat?	How's the kid doing on the bus?
Where is the little brother/ sister sitting in car?	How's the kid sitting on the bus?
Where's the little kid sitting in car?	How to prepare your child in and out of the bus?
Where does the child sit when he or she grows up to the roof of a smaller car?	What does a kid do when he gets off the bus?
How kid travels on long trips?	
How does a child sleep in a car?	
How to ride a child when they are 12?	
… pedestrian	…cyclist
Where are the kids playing?	How to be noticed in traffic?
What is whose? Who moves on what surfaces?	Does a cyclist have to use a safety helmet? How to use a safety helmet?
How should a child navigate the sidewalk?	How to hold your arms and legs properly on a bike?
How to get around a sidewalk obstacle?	Where does the cyclist go?
How do we move when there are no sidewalks?	How to ride a bike properly?
How do you cross the pavement when there is an aboveground / underground passage?	How do cyclists tour and overtake the pavement?
How do you cross the street at a pedestrian crossing with a traffic light?	How to cross the road?
How do you cross a pedestrian crossing when there are no traffic lights?	Where do we go through the intersection?
How do we navigate the sidewalk / cross the street with your pet?	How do cyclists treat pedestrians?
What does a kid do when it's not safe to just cross the street?	How do cyclists treat vehicles?

The last two classes of teacher training are aimed at getting teachers acquainted with new teaching and learning programs, teaching and learning planning methods, as well as the so-called project teaching. Through practical examples, students in groups discover how traffic safety content can be handled in different subjects: the world around us, fine arts, music, physical education, foreign language, mathematics, etc. For example, a math assignment might read:

"A group of 15 students were biking. When crossing the street, 3 students crossed the pavement at the pedestrian crossing while cycling, and 2 students outside the pedestrian crossing pushing the bike beside them. The other students crossed the pedestrian crossing, pushing the bike beside them. How many students have crossed correctly (at a pedestrian crossing, pushing a bicycle by their side) to the other side of the street?"

In this way, a math class can open a conversation about the safety of children of cyclists in traffic and establish knowledge about the proper crossing of the street.

In accordance with the new concept, the participants were presented with an example of a thematic week dedicated to traffic safety. Then the students, in groups, prepared a thematic week plan and daily work plans for the themed week, that is, worked out plans for individual classes.

5 DISCUSSION AND CONCLUDING CONSIDERATIONS

Traffic culture has evolved since the birth of a child and has improved throughout life. Accordingly, the process of education on safe participation in traffic from an early age, that is, from the family through preschools, primary schools, auto schools until the later, continuous professional development is very important.

The activities carried out so far have focused mainly on building-regulatory measures for adapting the traffic environment to children and occasional non-systematic educational activities dedicated to children. With this in mind, the concept of traffic education must be based on a systematic, inclusive and continuous approach. In other words, the concept of traffic education and upbringing must be based on short lessons with clearly defined content and objectives, enabling coverage of all essential topics important for the "survival" of the child in early childhood, but also setting the starting basis for the establishment of road users to intelligently way it accepts the dangers that traffic participation brings with it (Faculty of Transport and Traffic Engineering and Savski Venac, 2015).

This paper presents the concept of six-hour professional development of educators and teachers on the safety of children in traffic, which was applied in the territory of the city of Belgrade, in all 17 municipalities. About one thousand educators and teachers have passed the professional development program. It was accepted by the students, and rated highest (over 4.8 out of 5).

The most important conclusions in the process of preparation and realization of professional development of pedagogues and teachers on the safety of children in traffic are that there is a good legal basis for the implementation of traffic education in preschools and primary schools. Also, the modern concept of the traffic education in the context of the new program of teaching and learning-oriented outcomes and learning process leaves enough space for the introduction of this topic, and integrated across all subjects. For example, within the Serbian language (native language), it may be a dictation where the teacher dictates the story of crossing the street safely on the way from home to school. In maths, I can get text assignments where they will sum up some proper actions (for example, if five children crossed the street while there was a green pedestrian light, four were in the middle of a pedestrian crossing when a light change occurred, two of them continued crossing, and two returned. How many children crossed the road safely?). In art, they can draw a road from home to school, marking the place where the street is crossed / exited, etc. In physical and health education, they can prepare the polygon and carry out activities, such as "Safe way from home to school", etc.

In addition, a significant prerequisite for the successful realization of this concept of professional development is that there is a willingness of educators and teachers to apply them. The example of the City of Belgrade showed that educators and teachers are ready to put their refreshed knowledge from this seminar into practice, which they have confirmed with the realized activities in their institutions.

Having in mind the experience of previous projects (Road Safety Agency, Faculty of Transport and Traffic Engineering, 2015) traffic education should be realized in the classroom, polygon and in real traffic situations. Accordingly, traffic education and upbringing in basic schools and preschools will be more successful if parents/caregivers become involved in the process and in real-life traffic situations apply the lessons taught by children in preschools or primary schools in classrooms and in the polygon. Responsible for the proper, comprehensive and systematic learning of lessons in the right order. In the family, it is important that the lesson is repeated and in real life situations (when walking, going to the store or in the park) exercise (situational learning). Just a common, well-coordinated and harmonized like to give visible results.

The training program is of great importance for the future. Specifically, educators and teachers will impart knowledge of traffic safety to children who will be drivers, police officers, teachers, educators, decision makers at local or national level and with properly constructed attitudes will influence the improvement of traffic safety in their field of activity.

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PROBLEMS AND CHALLENGES FOR MEASURING AND REDUCING EMISSIONS OF INTERMODAL TRANSPORTATION CHAINS

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ABSTRACT

The freight transportation sector is the only economic sector where emissions are likely to rise in the next years, despite the fact that some efforts have been made to reduce emissions. In politics as well as in research, one of the main strategies to reduce emissions in transportation is the modal shift. This strategy leads to a rise in intermodal/multimodal transportation and therefore to more complex transport chains. The literature review in this article is oriented around the specific characteristics and requirements of intermodal transport chains and will give an overview about the planning problems that are connected with the measurement of emissions for the entire transport chain. An analysis of these specific characteristics and the identified problems is made in order to deduce challenges for the emission oriented planning of transport chains, and for the connected measurement of emissions. A possible solution to cope with these challenges is proposed.

Keywords: Emission optimization, transportation chain, intermodal transport, transportation modelling, transportation planning

1 INTRODUCTION

The efforts to reduce the overall greenhouse gas (GHG) emissions will not be enough to reach the emission goals Germany has derived from the climate agreement in Paris in 2015 (UBA, 2019). The same goes for many other countries (CAT, 2019). While emission reductions have already been achieved by many economies and private sector industries, the emissions caused by freight transportation are barely changing (UBA, 2019). On the basis of an estimated rise in freight transportation of 60% by 2050 (EC, 2019) the GHG emissions are even likely to rise, if no better working strategies, policies and tools are used.

Strategies for emission reduction in the freight transportation sector have been developed and addressed in politics, economics and scientific research. Three main strategies have been identified. The first of these is the avoidance of transport, including logistical improvements for a better efficiency in transport and the achievement of a higher social awareness. Another strategy is the use of low emission technologies like alternative engines for cars or new onboard technology. The final strategy is one of modal shift (Walnum & Aall, 2016). The aim of the modal shift strategy is to transport goods on water or railways instead of roads, since truck transportation causes higher emissions (EC, 2019). The implementation of this strategy will lead to an increase in multi-mode transportation chains.

Multi-mode transportation chains can be organised as multimodal, intermodal, co-modal or synchromodal transports. In multimodal transportation the loading unit and the vehicle is changed at least once (ECE, 2001). Intermodal transport is a special type of multimodality, the goods are moved in the same road vehicle or loading unit only the transportation mode is changed (ECE, 2001). By using more sustainable modes and simple loading actions, intermodality also focusses on the reduction of the environmental impact (Giusti, Manerba, Bruno, & Tadei, 2019). In addition, co-modality aims to reach the best sustainable utilisation of different (parallel) transport modes, either individual or combined (Giusti et al., 2019; Resat & Turkay, 2019). Synchromodal transportation is a further evolution of intermodal and co-modal transportation including the integration and cooperation between modes and transport services. By utilising multiple services of multiple modes, the shipper can be provided with optimised sustainable transport alternatives. (Giusti et al., 2019; Resat & Turkay, 2019; Zhang & Pel, 2016).

Planning problems for multi-mode transportations are a well-researched area in logistics. The following overview of literature reviews and taxonomies still shows a gap which this article aims to fill. So far, no review or taxonomy has focussed on a review of literature which is concerned with planning and decision problems in multi-mode transportation, in a way that makes it possible to use calculated emission figures as a basis or orientation for transport decisions in the micro domain. The actions taken to reach environmental optimisation can be divided into two main domains. The macro domain includes actions taken by governments, municipalities and legislative authorities, while the micro domain is concerned with the actions taken by companies (Aronsson & Brodin, 2006).

The following reviews on multi-mode transportation problems do not include emission considerations. Bontekoning et al. (2004) provide a literature review on intermodal rail–truck freight transport planning. SteadieSeifi et al. (2014) look into multimodal transport planning problems, structured into static, tactical and operational planning horizons. Caris et al. (2008) and Macharis and Bontekoning (2004) not only consider the time horizon, but also the decision makers, in their reviews on intermodal transport planning problems. Jaržemskiene (2007) conducts a vast literature review on intermodal research, describing the methods, algorithms and models used. A review for the specific area of port hinterlands and their link to sea and rail transportation was conducted by Roso et al. (2009). For public authorities as decision makers de Jong et al. (2013) give an overview about freight transport planning models.

Only a few reviews mention emission as an important topic. Crainic and Kim (2007) and Sun et al. (2015) mention emission reduction as a possible objective for mathematical problems. Crainic and Kim (2007) show the operation and planning issues for long-haul carriers and terminals for container based intermodal transportation. Sun et al. (2015) provide a state-of-the-art review about multimodal optimisation models and solution algorithms for freight routing planning. Crainic et al. (2009) and Gattuso and Pellicanò (2014) focus on articles concerned with intelligent freight-transportation systems (ITS). Tavasszy et al. (2012) conducts a state-of-the-art review on multimodal micro-level transport demand models. Mathisen and Hanssen (2014) examine the development of and identify the seminal works on intermodal freight transport. Kuzmicz and Pesch (2019) studied the approaches used for empty container repositioning problems in the context of intermodal transportation on the new Silk Road.

Of course, there are reviews including literature on emission reduction or environmental concerns. Caris et al. (2013) address the decision support models in intermodal transport and mention seven articles which include environmental costs. In their taxonomy Caris et al. (2014) identify opportunities for the integration of inland waterway transport (IWT) into an intermodal supply chain. One of their research areas is concerned with the calculation of external costs for IWT and provides a list of articles relevant for this specific area. Demir et al. (2014) provide a review of research articles focussing on macroscopic and microscopic models for the calculation of fuel consumption in road transportation. Crainic et al. (2018) include in their taxonomy an extensive amount of literature concerned with simulation of intermodal freight transportation, mainly in urban transportation. For the planning of synchromodal transportation chains Giusti et al. (2019), Pfoser et al. (2016) and Resat and Turkay (2019) provide a broad overview. Except the study of Giusti et al. (2019), which lists four synchromodal planning problems including models or simulation tools that show the environmental impact of decisions, none of the studies show articles supporting the possibility of making decisions based on emission figures.

Thus, the aim of this paper is to give an overview of planning problems for multi-modal freight transport (excluding urban transportation), which includes emission calculation/measurement, or at least some kind of emission figures, in order to show the impact of the decisions. Furthermore, the challenges connected with measuring and reducing emissions are identified, and a possible research direction is given. In section 2, a literature review on multi-mode emission freight transport planning problems is conducted. In section 3, the challenges of planning low emission intermodal transport chains are derived from an analysis of planning problems. A possible research direction is discussed in the last section.

2 LITERATURE REVIEW

2.1 Approach

The main focus of the review will be on intermodal planning problems. Not much research on co-modality was found. Only a view fitting researches about multimodality were found and included in this research. In contrast to intermodality, multimodality does not aim to reduce an environmental impact (Wang, Chen, Tseng, Luan, & Ali, 2019). For literature on synchromodality, the aforementioned reviews (Giusti et al., 2019; Pfoser et al., 2016; Resat & Turkay, 2019) and for urban transportation, the review of Crainic et al. (2018) are recommended. Additionally this research is focussed on the micro domain.

Research databases 'ScienceDirect' and 'Scopus' were used, connecting planning and decision problems with emission and intermodal or multimodal freight transport. Afterwards snowball research was conducted. Overall, 113 research articles were examined. After excluding the articles which were concerned with public transport, focussed on a single mode or did not include the term inter- or multimodal(ity), along with the other restrictions previously outlined, 17 articles were analysed.

All of these articles follow the modal split strategy. In Table 1, these research studies are shown segmented after the time horizons of their planning problem. The articles included were written between 2009 and 2019. The highest peak in the absolute numbers of articles was in 2016 with five studies.

Table 1: Overview of the articles dealt with IM/MM planning problems with emission reduction methods

Strategic					
Article	**Multi-modality**	**Planning problem**	**Solution method**	**Emission reduction method**	**Emission unit**
Berling and Eng-Larsson (2016)	IM RO, RA	Pricing and timing	Highly stylised modelling	Consolidation	Environ-mental costs
Kayikci (2010)	IM	Location planning (LP)	Fuzzy AHP and ANN methods	Consolidation, centralisation	Environ-mental effect
Iannone (2012)	MM RO, RA	LP	Linear mathematical programming	Consolidation	Railway share in %
Vidović et al. (2011)	IM RO, RA, IWW	p-hub LP	Mixed integer mathematical programming (MILP) and simulation	Consolidation, performance indicator	g/CO_2 per ITU
Tactical					
Baykasoğlu and Subulan (2016)	IM RO, RA, M	Network flow planning NFP	Multi-objective MILP and analysis	Min. emission objective	kg CO_2 km per TU per mode
Fan et al. (2019)	IM RO, RA, IWW	NFP	Multi-objective MP and simulation	Min. emission objective	kg CO_2 per tkm
Inghels et al. (2016)	MM RO, RA, IWW	Service network design (SND)	Mathematical programming (MP)	Internalised in objective as external costs	External costs €/tkm
Lam and Gu (2016)	IM RO, RA, IWW, M	SND	Bi-objective MILP	Max. emission constraint	kg CO_2 per TEU
Macharis et al. (2012)	IM RO, RA, IWW	ND + NFP	Web-based tool	Comparison	kg CO_2e per TEU
Operational					
Hrušovský et al. (2018)	IM RO, RA, IWW	Transport planning	Novel solution framework: MP and simulation	Internalised in objective as external costs	External costs for kg CO_2e
Liao et al. (2009)	IM RO, M	Emission calculation	Activity based calculation	Comparison	g/CO_2 per tkm

Multi-horizons						
Article	**Time ho-rizon**	**Multi-modality**	**Planning Problem**	**Solution Method**	**Emission reduction method**	**Emission figure**
Bauer et al. (2010)	t,o	IM RO, RA	SND + fleet planning (FP)	Integer linear programming	Main objective external	kg CO_2 per kWh
Baykasoğlu and Subulan (2019)	s,t,o	IM RO, RA, M	FP	Multi-objective mixed Integer programming	Min. emission objective	kg CO_2(km)
Demir et al. (2016)	t,o	IM RO, RA, IWW	SND + vehicle routing	MILP and SAA	Internalised in objective as external costs	External costs for kg CO_2e
Le Li et al. (2015)	t,o	IM RO, RA, IWW	NP + NFP + container flow planning	LP + RIFC	Comparison	modal split in %
Liotta et al. (2015)	s,t	MM RO, RA, M	SND + NFP	Multi-objective, capacitated MILP,	Internalised in objective as external costs	External costs € per CO_2/tkm
Wang et al. (2019)	t,o	MM RO, RA, IWW, M	SND + transport routing	MTEE + G1 method + E-FAHP	Min. emission objective + green index	kg CO_2/tkm + CO_2/TEU

2.2 Categories

2.2.1 Time horizon and planning problems

The articles are segmented by their time horizon into a strategic, tactical and operational level. Strategic planning problems relate to long-term investment decisions on the present infrastructure network. Tactical planning is concerned with medium term decisions on utilisation and efficient allocation of the existing resources. The short-term operational planning is focussed on real-time and adjustment decisions (SteadieSeifi et al., 2014).

2.2.2 Multi-modality

The multi-modality column shows the type of modality as well as the modes of transportation used in the article. Of the analysed studies, 76.47% deal with intermodal (IM) and 25.53% with multimodal (MM) planning problems. The modes used are a combination of road (RO), rail (RA), inland waterway (IWW) and maritime transportations. Air transportation was not considered in any of these studies. Kayikci (2010) does not mention the modes and is therefore not part of the following evaluation. All articles regard road as a transportation mode; all but one consider rail transportation, 50% consider inland waterway and 37.5% consider maritime transportation. The combination of RO, RA and IWW is the most commonly used (43.75%), and only two articles take the combination of all four modes into account.

2.2.3 Emission reduction method and emission unit

The emission reduction method refers to the approach that is used for minimising the emission in the solution procedure for the planning problem. Depending on the method, different emission units are used for the measurement or presentation of emission or emission reduction figures.

2.3 Literature analysis

Four articles are concerned with strategic planning problems using consolidation as a main emission reduction method. Berling and Eng-Larsson (2016) develop a highly stylised model for a timing and pricing problem with environmental considerations, calculating emissions as external costs. The other three research studies by Kayikci (2010), Iannone (2012) and Vidović et al. (2011) are focussed on location planning (LP) problems. The first solves the problem using the analytical hierarchy process (AHP) in combination with artificial neural networks (ANN) methods considering the environmental effect. The other two use mathematical programming as a solution. KayikciKayikci (2010)(2010) presents the changes as modal share and Vidović et al.Vidović et al. (2011)(2011) uses the CO_2 emission in g/ITU (intermodal transport unit) for the calculation of a performance indicator.

The five tactical planning problems tackle (service) network design problems (Inghels et al., 2016; Lam & Gu, 2016) and network flow planning problems (Baykasoğlu & Subulan, 2016; Fan et al., 2019), while Macharis et al. (2012) are looking into both. All of them use a form of mathematical programming. For the NFP problems, emission reduction is one of the objectives of the models and the emission is measured in kg CO_2 per km or per TU (transport unit). For the SND problems, the emission reduction is achieved in Inghels et al. (2016) by including the emission as external costs (€ per tkm) into the objective function and in Fan et al. (2019) by formulating an emission constraint for the maximum kg CO_2 per TEU emission. In Macharis et al.Macharis et al. (2012)(2012), the emission is calculated in kg CO_2e per TEU to compare different possible scenarios.[1]

Only two articles look into operational planning problems. Hrušovský et al. (2018) also integrate emission as external costs (€ per kg CO_2e) into the objective function of their mathematical programming approach which is combined with a simulation to propose a novel solution framework for a transportation planning problem. Liao et al. (2009) focus on the emission calculation problem to compare different existing transportation possibilities using an activity based calculation based on g/CO_2 per tkm.

While Caris et al. (2008) and Macharis and Bontekoning (2004) state that there is only a limited number of studies looking into various time horizons, there are six studies in this research which fit into this category. Only the work of Baykasoğlu and Subulan (2019) covers all three levels: the strategic (s), tactical (t) and operational (o) planning. They include emission reduction as an objective in the mixed integer programming approach in order to solve a fleet planning problem, calculating the emission by using kg CO_2 per km as an emission unit. A combination of a service network design and a network flow planning problem on a strategic and tactical level is explored by Liotta et al. (2015). The problems are solved using MILP, while internalising the emission as external costs (€ per CO_2/tkm) into the objective function. The following four articles consider planning problems on the tactical-operational level. Demir et al. (2016) also include emissions as external costs in € per kg CO_2e into the objective function for an SND problem in combination with a sample average approximation (SAA) method for a vehicle routing problem. Li et al. (2015) solve a container flow control problem consisting of a tactical flow planning problem and an operational container flow planning problem, with a linear programming and a receding horizon control approach (RIFC) to cope with the dynamic transport demands and traffic conditions. The emission reduction is not

[1] CO_2e is the carbon emission equivalent including all greenhouse gases translated into CO_2 emissions, using the global warming potential (DSLV.

calculated but the changes in the modal split are compared. Bauer et al. (2010) make emission reduction the main objective of their model to tackle an SND and an FP problem. The emission is calculated on the basis of kg CO_2 per kWh. In the study of Wang et al. (2019), a multimodal transport road network (MTRN) with witness simulation is modelled for an SND problem with emission reduction as one of the objectives. For the transport routing problem, the route performance is assessed combining a multimodal transport efficiency evaluation framework (MTEE) with an order relation analysis method (G1) and an entropy-weight fuzzy analytical hierarchy process method (E-FAHP). The distribution range of the emission is given in kg CO_2 per tkm. Finally, the building of a green transport index for transportation is established in order to focus on energy saving and emission reduction instead of cost and time.

3 CHALLENGES OF EMISSION ORIENTATION IN TRANSPORTATION CHAINS

3.1 Making emission reduction a priority

The importance of emission reduction in research and economics is still relatively low. In the planning problems described, emission reduction was only the main objective of the model once (Bauer et al., 2010). In addition, Wang et al. (2019) developed a green index to make emission the top priority in the final chapter of their study. In Figure 1 and Figure 2 these two articles are rated with a 4 for high importance. A 3 represents the possibility to decide the priority, 2 stands for medium priority and 1 for low priority. In most of the research studies (76.47%), the importance of emission reduction is low to medium as can be seen in Figure 2. This is problematic; in order to prevent further global warming the emission reduction needs to be the top priority, or at least it needs to be possible in these planning problems to make it a top priority.

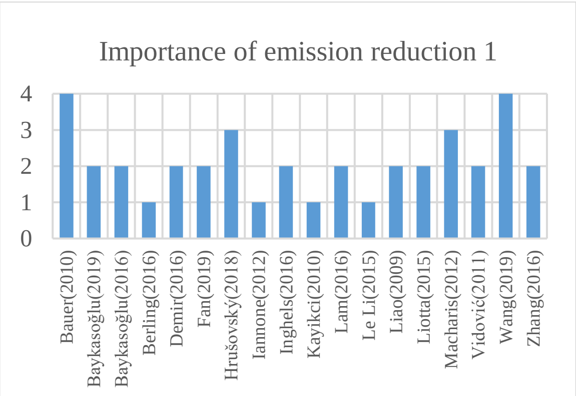

Figure 1: Importance of emission reduction 1

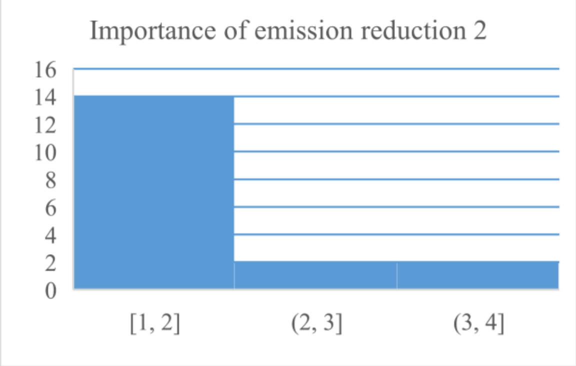

Figure 2: Importance of emission reduction 2

3.2 Coping with political uncertainties

Making emission reduction a top priority would mean that the economy was prepared for possible political changes. The current state of political decisions and developments are highly uncertain, especially if companies operate on an international level. Different countries have different regulations for emissions. At the European level, for example, the DIN EN 16258 exists, which covers various regulations for the calculation of emission in transportation (DSLV). But even this standard leaves plenty of room for individual adaptions (Auvinen et al., 2014; Davydenko, Ehrler, Ree, Lewis, & Tavasszy, 2014). This leads to diverse calculation formulas and models for emissions, and supports the low to medium importance of the reduction approaches.

3.3 Taking on a systemwide view

Various actors are part of a transportation chain like the shipper, carrier or logistics service provider (Bauer et al., 2010), all of which can take on different transportation tasks. Furthermore, different decision makers in transportation are identified. Caris et al. (2008) differentiates between drayage operators, terminal operators, network operators and intermodal operators who have different scales of planning responsibilities. In their taxonomy, Crainic et al. (2018) find that a systemwide vision from the microscopic viewpoint, including all decision makers and actors involved, is still missing in simulation studies on intermodal transportation. The same can be said about the literature viewed in this study.

Most research only focusses on parts or legs of the intermodal transportation. In the current literature analysis, 41.17% of the articles are exclusively looking into port hinterland transportation problems. This also means they are only looking into pre-/post-haulage and only one of these studies (Fan et al., 2019) on port hinterlands looks into the influence of transshipment on emission. The same percentage of articles deal with planning problems on a continental (more specifically European) level. Two of these articles (Demir et al., 2016; Hrušovský et al., 2018) include transshipment considerations in the calculation, in addition to the pre-, main and post-haulage phases. Only two studies look into an international planning problem and again only one of them (Wang et al., 2019) considers transshipment. In order to plan a low emission transportation chain, it is essential to plan the whole chain from an emissions perspective, including all haulage processes as well as all transshipment processes.

3.4 High number of participants

A systemwide view would mean the involvement of a high number of participants (namely decision makers and actors) in the transportation chain. This also leads to complex planning problems and includes further challenges in the planning process. But it would also offer new possibilities and a new potential of overall emission reduction, comparable with an overall cost reduction in the supply chain.

3.4.1 Reaching collaborative emission-oriented planning

The first requirement for a systemwide planning of the transportation chain would be a collaborative planning process with all participants. In order to reach low emission aims, the aforementioned challenge of making emission reduction a priority would be necessary not only in research but in reality for all of the actors and decision makers—which might be the most challenging task of all. In addition, the research on collaborative emission oriented intermodal planning problems is still limited. Of all 17 articles, only Le Li et al. (2015) address a collaborative planning approach by looking at the planning problem from the point of view of a horizontally fully integrated intermodal freight transport operator.

3.4.2 Reaching data availability

Liotta et al. (2015) names data availability as an important enabler for the adoption of CO_2 emission key performance indicators. Often the data needed to calculate and reduce emissions, or the data about the infrastructure, is not available for the decision making party (Baykasoğlu & Subulan, 2019; Demir et al., 2016; Hrušovský et al., 2018). It would be necessary to make data available for all parties involved in transportation planning.

3.4.3 Tackling the Difficulties with emission allocation and responsibility

The questions of who is responsible for which emission in the transportation chain, and how should emissions be allocated, also need to be considered. This was not addressed by any of the reviewed articles.

3.5 Reaching comparability

As shown in table 1 the units in which the emission is calculated vary, to compare the emission figures they would need to be converted into the same unit. But even after the conversion the emission figures are still not comparable. Not only the units vary but also the methods to calculate the emission figures (table 1). For example, there are four researches in this review which calculate external costs, all of them are using different methods and also different influencing factors. Demir et al. (2016) and Hrušovský et al. (2018) calculate the external costs per container serviced and per transhipment. Liotta et al. (2015) calculate the external costs by calculating the emission for every transportation using the emission figures from the French Ministry. Inghels et al. (2016) also includes factors like costs for accidents, noise, congestions and so on. Even if they would all calculate the external costs of the same transportation link the different influences and focus areas would lead to different outcomes. The researches and calculation methods included in this article are an excerpt of all calculation methods that are used for emission calculation and reduction. Further standards and methods of emission measurement that are used for different calculation approaches are listed by Cichosz and Pluta-Zaremba (2019) like the GHG Protocol initiative, ISO standards, the aforementioned EN standards, and also studies on calculation and reporting. The usage of different calculation methods and emission units leads to non-transparency and makes it nearly impossible to compare emissions of different or even the same transportation chains.

4 CONCLUSION

The analysis of the literature on multi-mode transportation planning problems, including emission reduction considerations and the presentation of emission figures, has shown some challenges that still need to be contemplated in future research. It seems that so far there is no planning approach or tool which allows for the design and planning of a low emission multi-modal transportation chain from a private economic, collaborative and systemwide point of view.

In order to tackle the named challenges, future research could be directed to the development of a new decision tool or an extension of existing tools. This would need to be a standardised decision tool in which emission reduction is the top priority; or at least one of the top priorities. It should also allow for the integration of new political restrictions, making it possible to cooperatively plan the overall transportation chain. To reach transparency, the same emission units, indicators and methods for the calculation of emission are to be used by all actors and decision makers, and at the same time the availability of data and information for every involved actor needs to be ensured. As a final configuration, certain rules need to be included for the allocation of the emissions caused.

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MEASURING AND EVALUATING THE PERFORMANCE OF CRUISE PORTS WITH A MULTICRITERIA APPROACH

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ABSTRACT

The global cruise sector has experienced a noticeable passenger growth every year in the last decades, consequently have ports invested in infrastructure, capacity and services to gain advantages and to attract more cruise services than competitors. In particular, the Mediterranean cruise market is facing a rapid growth due to general increase in the regional market, varied tourist attractions with natural and historical diversity, port connectivity and accessibility and geopolitical and economic situations of Mediterranean region. Therefore, performance of cruise ports is related to multiple aspects involving technical, social, environmental and economic attributes usually evaluated with different methods and involving several decision-makers and planning actors. In this paper we present a new approach for evaluating cruise ports performance, which bases on the best practice analysis and multicriteria evaluation. This approach is applied to two case studies, the Port of Koper and the port of Catania, two Mediterranean ports which recently entered cruise sector with similar characteristics, cruise attraction potential and territorial framework. With this approach can decision-makers evaluate performance of cruise ports from multidisciplinary perspectives.

Keywords: maritime passenger transport, transport decision-making, MCDA, TOPSIS

1 INTRODUCTION

The Mediterranean is one of the fastest-growing regions in the world and it is ranked as the second biggest area for cruising. In 2018, the Mediterranean region gained 16.7% of the world cruise market, and the Caribbean, as the most popular region, 35% of the world cruise market. Recently, in 2018, the number of the Mediterranean cruise passenger movements reached 28.04 million, representing +8.2% variation on the cruise passenger movements that took place in 2017 at the same ports (MedCruise, 2019). This indicates that the popularity of the Mediterranean region is increasing.

The growth of the Mediterranean cruise market and the attractiveness of the region is forming competitive relationships between cruise ports in the region. Here are more efficient and effective cruise ports in the region in greater advantage to become a chosen port for cruise ship itinerary. Cruise ship itineraries are especially focused on the most popular destinations such as Venice in Italy, Barcelona and Balearic Islands in Spain, and Italian Civitavecchia as the gateway to Rome (Lorenčič, Twrdy, & Batista, 2020). Due to this, cruise ports can be divided into two categories: destination cruise ports and gateway ports. Where destination cruise ports are presenting itself as the main attraction for the cruise passengers. And gateway ports, which are start point and a path to the significant cultural and historical wanted tourism attractions located in the hinterland of cruise port.

This all affects the decision making of cruise lines to add a port to the cruise itinerary, consequently, to attract potential passengers to cruise. The competitive advantage of port usually correlates to infrastructure characteristics, characteristics of tourist destination and characteristics of passenger terminal services.

Moreover, cruise ports are giving great attention to the operations and management at the terminal level, as it influences on the level of efficiency and consequently on cruise port performance of the terminal cruise operations.

The aim of this paper is to evaluate the performance of cruise port starting from best practice analysis and using multicriteria evaluation. The presented approach in this paper is applied to measure and evaluate the performance of the cruise port on the case of the Port of Koper and Port of Catania, two Mediterranean ports with similar characteristics in the cruise attraction potential and territorial framework. This approach could help guide decision-making, from multidisciplinary perspectives: transport, environmental, social and economic policy perspective. This paper is also generating ranking of cruise ports through the port performance.

The reminder of the paper is organized as follows: in the following section, state of literature on cruise ports evaluation is investigated to define criteria's and attributes for TOPSIS analysis. Third section is presenting the data, methodology and criteria for port evaluation. Section four presents case study application on Port of Koper and Port of Catania. In section five and six the results and conclusions of the paper are presented.

2 LITERATURE REVIEW

The literature dedicated to the cruise industry and cruise ports focus mainly on the demand, itineraries planning and port infrastructure, but also on the operation and management at the terminal level. However, in the last decades, noticeable progress has been made in analyzing the efficiency (Monpanthong, 2018; Vaio, Medda, & Trujillo, 2011) and performance of ports (Kofjač, Škurić, Dragović, & Škraba, 2013; Vaggelas, 2019).

The performance of port management should be evaluated from several points of view: the transport impact is certainly the fundamental, but the three pillars of the paradigm of sustainable mobility (social, environmental and economic) must certainly be taken into consideration. Each of these four impacts can be assessed according to different criteria, often not homogeneous: hence the need for a multi-criteria approach.

Multi-Criteria Decision Making (MCDM) methods are widely used in transport planning for the assessment of alternative projects with different evaluation criteria (Figueira, Greco, & Ehrogott, 2005): complex transport decisions requiring the evaluation of multiple and heterogeneous aspects (e.g. environmental, social, economic), indeed, need to be tackled with a multicriteria approach (Ignaccolo et al., 2017). Several scholars have dealt with MCDA in the transport sector, both in the planning of the service and in the infrastructure design (Kang & Lee, 2006; Sadeghi-Niaraki & Kim, 2009; Sharifi, Boerboom, B, & Veeramuthu, 2006). MCDA has also been used to compare different road or rail projects (Gercek, Karpak, & Kılınçaslan, 2004; Piantanakulchai & Saengkhao, 2003); in particular Technique of Order Preference Similarity to the Ideal Solution (TOPSIS) method, has been used in comparison between Light Rail Transit and Bus Rapid Transit (López-Lambas, Giuffrida, Ignaccolo, & Inturri, 2017) to test their performance in similar European cities. In the port industry, two main approaches have been developed to measure port efficiency: the economic approach and linear programming techniques represented by the Data Envelopment Analysis (González & Trujillo, 2009). In this context we used TOPSIS analysis to rank the prominent criteria's for evaluating port performance and to compare cruise ports.

With regard to the criteria for evaluating port performance, in general, spatial criteria are of fundal importance in the assessment of transport systems (Giuffrida, Le Pira, Inturri, & Ignaccolo, 2019); in particular, indicators such as accessibility may prove useful to provide a qualitative as well as a quantitative score for the assessment of the transport impact (Ignaccolo, Inturri, Cocuzza, Giuffrida, & Torrisi, 2019; Perea-Medina, Rosa-Jimenez, & Andrade, 2019). The economic rankings of the ports are generally carried out on the basis of the movement of goods and passengers; consequently, also in the cruise sector, this should be one of the indicators to be taken into consideration (MedCruise, 2019). The social impact of the presence of the port and in particular of the landing of cruises should be assessed on the one hand by what the city can offer in terms of attractiveness to incoming cruise passengers (Seabra, Beck, Manfredini, & Muller, 2020); on the other, the externalities produced near the port by its traffic and by the often present movement of goods. Finally, the environmental impact can be assessed both by evaluating the emissions present in the port areas and near the port (Paiano, Crovella, & Lagioia, 2020), and on the basis of the green areas that are present in the same zones.

Based on this premise, in this paper we present the application of TOPSIS methodology to evaluate the performance of two ports (Port of Koper in Slovenia and Port of Catania in Italy) in comparison with best practices from successful European Cruise ports, in terms of all the previously described impacts.

3 THE DATA AND METHODOLOGY

The data for evaluation is constructed by combining data from official cruise port reports, MedCruise webpage and other open sourced databases. As discussed earlier, we defined criteria's for evaluating efficiency of cruise port management.

3.1 The TOPSIS method

TOPSIS is one of the multi-criteria decision analysis, which was firstly proposed by (Hwang & Yoon, 1981) and widely applied by other researchers. The TOPSIS bases on the concept that the best alternative would be the one that has the shortest geometric distance from the positive ideal solution and the longest geometric distance from the negative ideal (or anti-ideal) solution. It compares alternatives by identifying weights for each criteria by calculating geometric distance between alternatives and the ideal alternative, which is the best score in each criterion. TOPSIS is performed through six computation steps:

1. Information collection of the attribute values of each alternative on the different criteria.
2. Normalization of attribute values in order to allow the comparison on different unit: the used normalization technique will be the ideal normalization, which requires dividing each attribute by the highest value.
3. A weighted normalized decision matrix is constructed by multiplying the normalized scores by their corresponding weights;
4. Calculation, for each attribute value V_{Ai}, of the distances to an ideal (V_i^+) and anti-ideal (V_i^-) point. In this study an absolute ideal point, defined considering best practice in European port cruise management, has been assumed $A^+ = (1, ..., 1)$; *A* value of 0 has been given to every attribute for absolute anti-ideal point $A^- = (0, ..., 0)$. The distance for each action to the ideal action is calculated through the following equation:

$$d_A^+ = \sqrt{\Sigma_i (v_i^+ - v_{Ai})^2} \quad (i=1, ... \, m) \qquad (1)$$

The distance for each action to the anti - ideal action is calculated through the following equation:

$$d_A^- = \sqrt{\Sigma_i (v_i^- - v_{Ai})^2} \quad (i=1, ... \, m) \qquad (2)$$

5. Finally, the closeness, whose value is always between 0 and 1, is given by the ratio of the calculated distances:

$$C_A = d_A^- / \left(\left(d_A^+ \right) - \left(d_A^- \right) \right) \quad (i=1, ... \, m) \qquad (3)$$

6. Rank the alternatives according to C_A *(i=1, ... m).*

The analysis gives the possibility to create an efficiency ranking of cruise ports.

3.2 Framework of criteria for port evaluation from literature

In literature is often mentioned that the largest port must have the highest level of efficiency due to their higher number of cruise activities. But some large ports can be developed just to their physical limit, this makes it difficult for them to increase their efficiency. On the other hand, smaller ports may find it easier to grow and reach faster more efficient port management. Based on this it is difficult to understand that port size is the only relevant indicator that affects the cruise port efficiency. Because of this it is necessary to compare various criteria's and their indicators in order to evaluate performance of cruise ports, which can be assessed on the basis of efficiency and effectiveness dimensions of cruise port. Efficiency is defined as the performance in the perspective of the port authority, while effectiveness involves the prospect of customers and all actors involved in the port environment.

From the literature review in section 2 and other publications, we defined different criteria and sub criteria to evaluate the performance of cruise ports: each of the sub criteria has a related attribute and indicator in order to carry on the analysis (Table 1).

Table 1: Criteria, sub criteria and attributes for MCDA

	Sub criteria	Attribute	Indicator
1. Transport	1.1 Number of cruise passengers	Embarkation/ disembarkation and transit passengers	Total number of cruise passengers
	1.2 Accessibility by Public Transport	Presence of Public Transport stops	Number of transit stops/stations in 1,5 km threshold
	1.3 Accessibility by bike	Presence of cycling Points of Interest	Number of cycling Points of Interest in 1,5 km threshold
	1.4 Accessibility by walking	Pedestrian facilities	Length of pedestrian paths in 1,5 km threshold
	1.5 Connectivity	Presence of stations, airports, arterial roads	1 if present, else 0
2. Environmental	2.1 Pollution	Pollution index	Survey results
	2.2 Healthiness	Presence of green areas	Number of green areas in 1,5 km threshold
3. Social	3.1 Tourism amenities	Presences of tourism Points of Interest	Number of tourism Points of Interest in 1,5 km threshold
	3.2 Tourism attraction	Presence of tourists in the city	Net occupancy rate of bed-places in hotels and similar accommodation
	3.3 Safety and Security	Crime index	Survey result
4. Economic	4.1 Employment	Jobs in region	Employment rate of the age group 20-64
	4.2 Economic impact	Direct expenditures of cruise passengers	Average expenditure of cruise passenger

3.2.1 Transport criteria

Transport sub-criteria analysis evaluates accessibility and connectivity of the ports by different indicators affecting on the cruise terminal operation and management. Efficiency of cruise port is mostly present as the ability of terminal to maximize its output (embarkation/disembarkation and transit). In order to carry out the efficiency analysis is necessary to conduct the number of embarkation/disembarkation and transit passenger movements - traffic flow (Vaio et al., 2011). Data for the analysis has been collected from official port reports and MedCruise association reports (MedCruise, 2019).

Accessibility of the public transport is strongly affected by the design of the public transport routes, stops, timetables, and by the design of the road network. Accessibility by walking is related to the physical characteristics of the cruise terminal and passenger building presented as infrastructure categories in cruise operations. This are: number of check-in desks, number of elevators, number of escalators, number of gangways, number of stairways total area of passenger building, and number of floors in the passenger building, length of pedestrian paths, etc. (Vaio et al., 2011). In this paper, we expressed public transport, walking and cycling accessibility by using a threshold measure (Handy, 1992) evaluating the number of related facilities located in a threshold of 1,5 km from the port, considered as the maximum walking distance for a passenger (Ignaccolo et al., 2019).

3.2.2 Environmental criteria

The environmental criteria consider both the externalities produced by port activities and the health benefits that could be achieved through a good planning of port-city interface areas. SOx emissions are forming sulfate aerosols and fine particles that are harmful for human health and cause acid rain and acidification of the seas. In any case, the values of sulfur emissions for the case of Catania are inevitably conditioned by the presence of the Etna volcano, which has frequent activity. It was therefore decided to consider more subjective indicators of environmental quality: the Pollution Index (2.1) of the Numbeo database ("Numbeo," 2020) and the presence of green areas in a threshold of 1.5 km from the port (2.2).

3.2.3 Social criteria

Recent developments related to the maritime transport of goods, with the consequent need for larger spaces for the storage of goods, made that the port-city interface areas became a great opportunity for redevelopment of marginal areas located close to the city center (Ignaccolo et al., 2019) which have become the main link between the cruise port of arrival and the cultural amenities of the city center. Based on these premises an indicator taking into consideration to evaluate the social impact is the 3.2 (Tourism attraction) which consider the potential of tourist attraction of the city (number of tourists per year), even if not strictly linked to the cruise sector. Even if cruise expeditions have different stop times for each port, it can be assumed that a cruise tourist would travel a maximum of 1.5 km by feet from the port to explore the cultural amenities of the surrounding urban area. In this view the criterion 3.1 takes into account the presence of tourist amenities within a 1.5 km walking threshold.

Safety for cruise passengers who decide to visit the port city is a fundamental issue; often the decision to choose a port as a destination for a cruise can also be linked to the city's criminality rate, since lines and global tourism boards know it's in their best interests financially to keep their guests safe. In this line, we decided to introduce Safety and security (3.3) in the port-city as one of the social indicators. Data for crime rate have been retrieved from Numbeo database ("Numbeo," 2020).

3.2.4 Economic criteria

Nowadays ports can be considered among the main engines of economic development in the regions where they are located, creating job opportunities.

In order to carry out an economic analysis of the performance of cruise ports, two indicators were introduced: regional number of jobs (4.1) and economic impact of direct expenditures of cruise passengers (4.2). Data for the analysis has been collected from official port reports, CLIA reports, MedCruise association reports (MedCruise, 2019) and from Eurostat statistic database (Eurostat, 2019). To estimate direct expenditures of cruise passengers we obtained data from CLIA report, where is reported that average expenditure per passenger across port of call destination is 62 €, and average expenditure per passenger in home port is 81€. We estimated that approximately 30% of all home port passengers stay at least one night in the city, and generate 292€ of direct expenditures according to the CLIA. Beside this every crew member spends at each port of call on average 23€. However, it needs to be taken into consideration that mid-sized cruise ships (1000-2000 passengers) that visit Mediterranean cruise ports have 600 crewmembers on average.

3.3 Spatial indicators evaluation

Evaluation of spatial indicators (1.2, 1.3, 1.4, 2.2, 3.1) has been performed through spatial analysis in the QGIS environment, using OpenStreetMap (OSM) data.

In particular, the use of the QuickOSM plug-in allows to extract spatial features from OSM database and include it in a GIS map, in order to perform spatial analysis. The plugin allows you to choose the spatial elements on the basis of a query that selects only those with certain attributes (defined keys) that qualify the element in a given typology (see the example of procedure for the spatial features extraction from OSM database for Catania public transport stops in Figure 1).

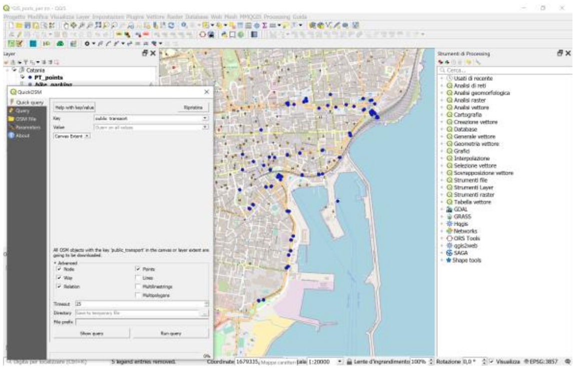

Figure 1: Screenshot of the OSM features download for public transport stops in Catania

For our analysis, features were extracted considering the keys reported in Table 2.

Table 2: OSM key and values and reference area for each attribute

Attribute	OSM key	Key value
number of transit stops/stations	Public transport	ALL
Length of cycleways	cycleway	ALL
number of bike stations and bike rentals	amenity	bicycle_parking, bicycle_rental
Length of footways	highway	footway, pedestrian
number of green areas	Leisure	park
no. of tourism attraction	Tourism	ALL

3.4 Best practice of international cruise ports

In order to select ideal solutions, best practice of international cruise ports have been taken into account and analyzed: five best practices' (ports of Barcelona, Pireus, Venice, Marseille and Genoa) have been selected to be analyzed as an ideal point for each of the indicators. Below are short descriptions of the five best practices ports. The Port of Barcelona is the leading port in Mediterranean regarding passenger movements per year and it is home port for many cruise itineraries. Port is located 10 minutes' walk away from city center of Barcelona with about 5.5 million inhabitants. Cruise ships berth at one of the 7 operating cruise terminals and various docks and facilities dedicated to cruise traffic (CruiseMapper, 2020) The Port of Piraeus is the largest port in Greece, and main gateway to the Greece capital city Athens, which are 10 km far away from the port. It has one passenger terminal for ferry and cruise traffic operating as home port. But it has 12 places for simultaneous berthing of vessels. The Athens International Airport is 45 km far away from port and connected with Metro and shuttle bus (CruiseMapper, 2020). The Port of Venice is one of the largest home ports of the world, and major gateway for cruising in the Adriatic Sea and Eastern Mediterranean. It has 10 multifunctional terminals, 6 dedicated quays for cruise ships and it is just 13 km far away from airport Marco Polo (CruiseMapper, 2020). France's leading cruise port is port of Marseille which is located 9km from the city center and 20 km far away from Marseille Provence Airport. Along with its 6 cruise terminals the port also has ferry terminals. It has also 8 dedicated quays for cruise ships. As passenger volume, in 2018 port handled over 15 million passenger movements (MedCruise, 2019). In West Mediterranean is located port of Genoa/Genova which serves as gateway to Milan. Several cruise ships can dock at the same time as it has 12 quays and 5 passenger terminals. The city center is within 1 km and airport is 5 km away from port. The port has yearly more than 1 million passenger movements (CruiseMapper, 2020). Best values of sub criteria found among these five ports are reported in Table 3, and they are basis for the TOPSIS procedure.

Table 3: Best practices' and case studies values to be used as ideal solution in TOPSIS procedure

Attribute	Best Practice	Value
Embarkation/disembarkation and transit passengers (total no. of passengers)	Barcelona	3041963 pax
Presence of Public Transport stops (no. of stops)	Pireus	313
Cycle facilities (number of bike POI)	Barcelona	202
Pedestrian/passenger facilities (length of pedestrian facilities)	Venice	87.407 km
Presence of stations/airports/arterial roads	Barcelona, Genoa, Marseille, Venice, Catania	3
Pollution index	Koper	8.62
Number of green areas	Genoa	26
Number of tourist amenities (PoI)	Barcelona	257
Presence of tourists in the city	Barcelona	62.24
Crime index (min)	Koper	14.32
Employment rate	Koper	78.3
Direct expenditures of cruise passengers	Barcelona	257335018 €

From the results of the analysis of the best practices shown in the table, it is possible to see that Barcelona is the city with the highest number of high-value indicators. It is not a case that it is the Mediterranean port that has recorded the highest number of cruise traffic in 2018: it is the largest cruise ship port in the Mediterranean, and the fifth in the world, following only to the main Caribbean ports. Its success in the cruise reception, which is evidenced by the high values obtained for the spatial indicators, is given by its proximity to the main tourist attractions of the city.

4 CASE STUDY APPLICATION: PORT OF KOPER AND PORT OF CATANIA

The case study entails two cruise ports with similar characteristics: both ports are located near the historical city in a medium-sized region, they are relatively new in the cruise market, and both have a port vocation with a mix of commercial activities, passenger and recreational maritime transport.

The port of Catania is part of the Eastern Sicily Port System, a public entity including also the Port of

Augusta. Both ports are located on the east coast of Sicily facing the Ionian Sea. Catania is a medium-sized city of about 300.000 inhabitants, with a commercial and touristic vocation. In particular, the location of the Port of Catania enhances its possibilities in the touristic sector since the port is located a few steps away from the city center of Catania. Anyway, Catania port is operating and managing transit, inter-porting and homeporting operations for cruise ships since 2011. The port has a connection with regional road network; within the terminal are parking lots (about 200 parking spaces) and taxi service; and is located within 10 minutes of walk to city center (2 km). However, it has not operative connection with the railway network and airport of Catania (distance only 4 km). The central railway station and the main bus stop is located 850 m far away from the passenger gate and the subway station is close. The Port Authority of Catania manages the port as a public actor.

The Port of Koper is located in the northern part of the Adriatic Sea, within small city of about 25.600 inhabitants. It is the only Slovenian port, which provides port and logistic services. Company Luka Koper manages the port, which is in ownership of the Slovenian government. In 2005 port opened passenger terminal for cruise traffic, and becomes an interesting destination for cruise ships (MedCruise, 2019). The cruise terminal of the port of Koper is located 300 meters from the city center, easily reached by walking. It has not operative connection with railway network, as it is located approximately 1,3 km from the port. However, the bus stop is present at the cruise terminal, and every other within every 300-500meters. The main bus station is located approximately 1,5 km far away from the passenger terminal, and the main Slovenian airport, in Ljubljana, is 125 km far away reachable by road (Emigma, 2020).

Table 4: Input attribute values for Catania and Koper used in TOPSIS procedure

Attribute	2018	
	Koper	**Catania**
Embarkation/disembarkation and transit passengers	101415	133341
Presence of Public Transport stops	24	105
Cycle POI	8	2
Pedestrian facilities	10338.50	15240.39
Presence of stations/airports/arterial roads	2	3
Pollution index	8.62	72.26
Number of green areas	13	3
Number of tourist amenities (PoI)	18	115
Presence of tourists in the city	50.1	39.6
Crime index (min)	14.32	61.31
Employment rate	78.3	44.5
Direct expenditures of cruise passengers	6301530	8871362

It must be noticed that at this stage of the study it was not possible to involve decision makers and stakeholders of the two communities, so it has been decided to assign the same weight to all criteria (equivalent to 1).

5 RESULTS

Results of relative closeness to ideal solution are showed in Table 5 and plotted in the radar chart in Figure 2. The results of the research are presented below the radar chart.

Table 5: Results of TOPSIS: relative closeness to the ideal solution for each criteria and globally

Port/ Criteria	Transp.	Soc.	Env.	Econom.	Glob.
Koper	0.29	0.54	**0.67**	0.50	0.47
Catania	0.39	0.43	0.09	0.34	0.36
Barcelona	**0.69**	0.74	0.49	**0.96**	**0.69**
Pireus	0.41	0.54	0.46	0.50	0.46
Geona/ Savona	0.51	0.57	0.63	0.74	0.58
Marseille	0.47	0.41	0.15	0.55	0.45
Venice	0.57	**0.77**	0.15	0.85	0.57

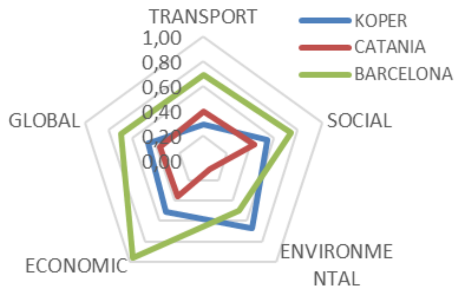

Figure 2: Radar chart for final TOPSIS results

Results show that port of Koper and port of Catania have similar global performance. In particular they both have to promote strategies to improve their economic accomplishments in compared to Barcelona score, even if Koper has better results due to the low employment rate in the region of Catania, Sicily. This suggests that incentivizing cruise activities at the port of Catania could also become a good opportunity to increase the number of jobs in the region.

The performances related to social criteria have comparable values, with Koper showing slightly better results; looking at the individual indicators, Catania shows a much higher value of tourist attraction, but at the same time it has obtained a decidedly more negative opinion regarding the crime index. Even if this is a subjective value, tourists often complain about the poor security of the city, and consequently the administration should act to improve its conditions in this regard.

The transport criteria show better values in the case of Catania, mainly due to the presence of two metro stations located in the center and very close to the port. Anyway, both cities show a lack of cycle routes and poor pedestrian facilities.

Finally, regarding the environmental criteria evaluating the presence of green areas and pollution index, Koper clearly achieves better results, even in comparison to port of Barcelona and with other best practices.

6 CONCLUSIONS

Over the last few years, the cruise sector assumed an increasing importance in the global economy, becoming a phenomenon accessible to a greater number of people. A bigger size of the ships and the related economies of scale made an annual growth in demand at very high rates possible, moreover in the Mediterranean, which routes remain among the most covered destinations in the world. In order to exploit all its potential, ports and cities need to improve the infrastructures to support cruise ships, not only at the port level, but also in terms of accessibility and intermodality.
A port performance evaluation does not only help to understand competitive position of port, but also provides a basis for policy makers to local and regional development. In this study the authors proposed a method to evaluate performances of ports in the cruise sector, based on multicriteria evaluation, using European best practices as top alternatives. In particular, the two ports of Koper and Catania were compared in the analysis. The decision to analyze these two ports lies in their similarities: both are located near the historic center of the city, in a medium-sized region and both have a port vocation with a mix of commercial activities, passenger and recreational maritime transport, including cruise activity. The ports have been evaluated from a transport, social, environmental and economic point of view: overall the two ports have obtained average scores, when compared with best practices. In particular, for the individual criteria, the two ports achieved similar results, with the exception of the environmental impact, in which the port of Koper achieved a definitely better result. Future research could include the port and city stakeholder's involvement in the analysis. This should be done (a) in order to assign different weights in the evaluation of criteria: the actors of the decision-making process and the citizens could in fact give different importance to the four impacts analyzed; (b) to have them providing new indicators to be taken into consideration when assessing the criteria.
Finally, it is clear that the recent impact of COVID-19 has heavily conditioned the cruise sector, which will need strong incentives to bring it back, but also new investments by the ports and cities of destination of the cruises. A multicriteria approach as the one presented in this study, improved with new criteria, could help in guiding decision-making in this new phase from a multidisciplinary perspective: transport, environmental, social and economic policies could be pursued, pushing decision makers to the optimum.

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AN EUROPEAN BENCHMARK OF STAKEHOLDERS' STRATEGIES IN MEDIUM SIZE PORT CITIES

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ABSTRACT

Facing a phase of liberalization and deregulation, the relation between cities and ports has been thoroughly analyzed from different perspective in the last 50 years. Beyond simple coexistence, the issue is the creation of synergies benefiting to both entities. These movements have an impact on the new trajectories of governance and partnerships between public and private actors. So port governance is marked by a new level of complexity which has caused a reshaping of the system of actors involved in the organization of ports. Consequently, the paper aims to provide some insights into this question by presenting the first results of a research project focusing on the relationship between ports and territories which are numerous.

Likewise, the paper also seeks to identify the characteristics, constraints and dynamics of the relationship between ports and cities and to study their potential impacts on spatial planning and territorial development. It specifically focuses on an intermediate scale of port-cities.

The methodology of this paper is primarily qualitative and based in part on interviews conducted among key actors and field studies. It mainly emphases on interrogations about the institutional status of the ports, the issues and consequences of the choices or the role of each category of actors in port and/or city governance. This analysis of decision-making processes will allow to describe and explain the dynamics of cooperation, but also conflictual logics.

Keywords: port-city, Europe, actors, port, governance.

1 INTRODUCTION

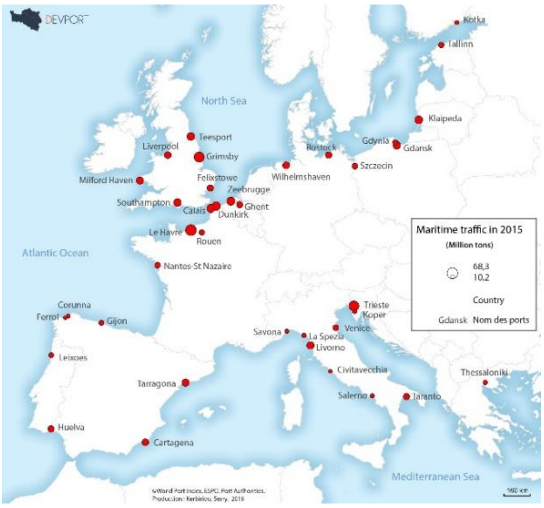
Port city, which serves as a link between local territories and the global economy, is an interaction of both urban and port systems, giving rise to its complex and dynamic nature (Xiao & Lam, 2017).

In the cotemporary globalization, managing port cities is a key issue. Historical links between ports and towns are clear. Moreover, during the last decades, these specific spaces have undergone major changes which have had consequences on their social and territorial dynamics. Today, port authorities, territorial communities and all the port city's stakeholders have to find modes of partnership in order to permit a better territorial development. Despite standardization of the modalities of governance according to the landlord port model (Verhoeven, 2010)

The main purpose of this paper is to analyze the interactions between the stakeholders who shape port dynamics by considering them as challenges in the development of the wider territory. Our study is reinforced by a European benchmark of medium-sized port-cities.

We have definite medium-sized port cities by means of this twofold component, population and traffic. The medium-sized port cities taken into consideration in this paper are therefore the following (Figure 1):

- Cities between 100 000 and 250 000 inhabitants with maritime traffic of over 10 million tons.
- And cities of over 20 000 inhabitants and fewer than 500 000 inhabitants with a port traffic of be-tween 10 and 50 million tons.



Source: Made by the Authors, 2020.

Figure 1: Medium-sized port cities in Europe

The present paper is presenting the cases of Le Havre (France), Klaipeda (Lithuania) and Kotka (Finland).

Therefore, we conducted a campaign of semi-directive interviews (around 25) with key players in port governance (elected councilors, chamber of commerce and industry directors, ports representatives, private companies…), enabling us as of now to identify some results and lines of thought. The aim of these interviews is to analyze the city-port relations and their impact on urban or port development. Once these interviews were recorded, they were integrated into two text analytics software (NVIVO and ALCESTE). So, the paper is organized according to a geographical organization in which each part is dedicated to one port city.

2 GOVERNANCE OF THE LE HAVRE PORT COMMUNITY

The governance of the Greater Maritime Port of Le Havre (GPMH) is the result of the general model following the 2008 port reform. Port Authority is a public body, performing sovereign functions as well as the development. A Management Board supervises the port and is responsible for its management. The Supervisory Board implements the strategic plans and exercises permanent control of its management. It is completed by a consultative body: the development council. The decision-making organization and leadership structure is clearly stated by the results from some ten interviews realized from April to September 2017 with different stakeholders from Le Havre. The State seems to be the most significant stakeholder. The economic importance of the port of Le Havre explains the particular attention paid to the development of this port community. The State ensures its control by means of senior civil representatives in all the decision-making bodies and especially the chairman of the port's management board (Loubet & Serry, 2019).

"At the GPMH, decisions are taken by the management board... They're presented to a supervisory board which validates them, apart from budget matters since it's under Bercy's administrative (ministry of economy) supervision". A stevedoring company director.

According to many interviewed actors, entrusting the port's management to nominated officials is a handicap to territorial and port development.

"One of the main problems with port management in France is that representatives of the State are senior officials who come to the supervisory board with no genuine political mandate … so they see to the management. There's no real vision, just management". A councillor of Le Havre.

In this context, the dual ministerial supervision (Transport Ministry, Economy and Finance Ministry) would complicate the management dimension and this would be to the detriment of more ambitious policies. With regard to the urban side, it appears to be in an ambivalent position. On the one hand, the urban community of Le Havre seems to have limited power:

"The city isn't a stakeholder with strong decision making powers […] We aren't the ones who make the decisions, we're simply invited to the discussions… you have to realize that the governance of a port like Le Havre is largely out of the hands of the local elected officials". A councilor of Le Havre.

"As an organizing body, the City Council and the CODAH have no impact on us in our business proper". A stevedoring company director.

On the other hand, strong informal relations between the president of the GPMH board and the mayor enable the latter to have a significant impact on the main directions involving the port. These dynamics are strengthened in view of the closeness that exists between the present mayor and his predecessor, today the Prime Minister. Mechanisms of fairly classic "cross regulation" can be observed where central and decentralized powers are interwoven (Crozier & Thoenig, 1975).

"If you have a mayor of one town who has a certain power nationally and a mayor of another town who has no power nationally, you don't have the same type of relationship… And the political factor carries tremendous weight; it's clear that the quality of an institution like ours facing the Region…". A GPMH representative.

So, one informal and powerful decision-making body (acknowledged by all) has constructive cooperation between state officials (namely the director of the port) and the mayor: "the quadripartite".

"The Quadripartite, a meeting which takes place three or four times a year and brings together the mayor of Le Havre, the president of the CODAH, who is in fact one and the same, the president of the CCI and the president of the port board of directors. This is a powerful, yet totally informal, decision-making body. […] On sensitive questions, where a choice has to be made between several scenarios, where arbitration is absolutely essential, that's what it's there for. Sometimes… it's just city and port". A councilor of Le Havre.

The municipal officials can also benefit from more leadership thanks to the role they play as mediators in the event of social conflicts. The municipality hovers between a form of neutrality and a mission of appeasement between the trades unions and the port management. The unions also emerge as influential players after the State and the municipality, especially in light of their ability to block agreements. This leadership appears as a very important component for representatives of port companies.

"If a decision issuing from the State doesn't go down well, you've got a month of strikes, a month with no work and several million euros lost... so as for me, I'd have said, the operating force: that means, the unions first". A UMEP representative.

In this context, private sector stakeholders (operators, logisticians, handlers, etc.) do not appear to have much influence in decision-making bodies.

"The share of the private sector should be increased in these decision-making groups. Sovereign power is clearly indisputable, but I think that the voice of the people on the ground should be heard, those who are involved". A UMEP representative.

Other stakeholders who could appear as key players in the system are mentioned last in our interviews or else are not cited. In order of importance, shipping companies are poorly represented in GPMH decision-making bodies, they exercise considerable influence. Their strategies, the size of their ships…, condition the directions and development of ports. As such, they influence economic models and port infrastructures

"Here is a very important player yet one who is rather infrequently to be seen in governing bodies. He is represented all the same, but there's no need, he dictates, in fact. He's not even represented on the port supervisory board". A councilor of Le Havre.

The regional level is virtually absent from our interviews. At a time when the regionalization of ports is under discussion, the regional council is not mentioned as an important player in Normandy's port system. The lack of clarity in the distribution of roles, skills and missions seems to disadvantage identification of this echelon:

"There is the big question of the respective place the State and the region should have in these governing bodies, since the Region is increasingly called upon to co-finance infrastructural projects and the place of the Region in the governance has not yet been determined". A councilor of Le Havre.

There is no citation from HAROPA which purpose is to coordinate the strategy of port development of the three ports on the Seine axis (Le Havre, Rouen, Paris) by promoting a pooling of strategic functions. It endorses the difficulty arising from the emergence of midway scales between the local (municipality and port community) and the national. It is clear that this structure does not appear, in the eyes of the stakeholders, as an echelon of reference in the development of a port like Le Havre's.

"HAROPA is better than nothing. But it's not enough. There must be much stronger integration in all the decision-making processes concerned with the Seine axis". A stevedoring company director.

Consequently, while the role of the region concerning port development, the creation of bodies of enhanced cooperation, or even mergers, seem to be under discussion, the major stakeholders remain the State (and its deconcentrated representatives), the municipal tiers (in relation to its political legitimacy) and the particularly powerful intermediary bodies (the Dockers' unions, for instance). In addition to this governance, ship-owners play a relatively solitary role. Contrary to the Klaipeda case, the workers' unions (such as Dockers') are often mentioned and they appear to carry a great deal of influence. Similarly, the intermediary territorial scales (the region, for example) seem hardly to be acknowledged (as is the case in Klaipeda).

3 DECISION-MAKING ORGANIZATION IN KLAIPEDA

The functions and the organization of the port of Klaipeda are defined by the 1996 law. Under the direct regulation of the Lithuanian ministry of transport, the main missions of the port authority (Klaipeda State Seaport Authority) are to manage the territory, ensure safety and security, build infrastructure and achieve strategic development plans. The port general director is appointed by the minister of transport.

The port development board formulates the development strategy and coordinates relations between the port and the municipal authority and governmental institutions. It is composed of representatives from the transport and finances ministries, the region, the Klaipeda municipality, representatives from the academic world, the port and its users. The port council, comprising representatives from almost the same bodies as those seen in the port development board does not have any supervisory functions. It prepares the development plans (Loubet & Serry, 2019).

The result of around ten interviews conducted in April 2017 with different actors in Klaipeda allow to analyze the decision-making organization in Klaipeda.

The institutional management of the port of Klaipeda, is based on great presence of central government.

Using the NVIVO software, we created a cloud of the most frequently used words by the urban-port actors surveyed which shows that the State[1] enjoys a very strong leadership:

"We are a state-run business and were set up by the ministry of transport. We are like a subsidiary of the ministry of transport". A manager of Klaipeda's port authority.

The institutional management of the port of Klaipeda, therefore, partly resembles that which was presented in the case of Le Havre. In this context, the city council finds it difficult to direct the port development in line with municipal policies:

"If I said that we have no impact on the port, this would almost be the truth. Lithuania only has one port. It's a state-run port and the municipality has no rights over it; other than the fact that we are convened to two advisory councils. The port council in which we don't have the right to vote. There's also the council for development in which we have four seats out of 23 and in which nobody pays any attention to us." The deputy mayor of Klaipeda.

So, local and central governments can face (over real-estate management, for example) in an environment where the municipality is not recognized by the port

[1] In French "L'état" means "State".

authority as a port stakeholder: "There's no problem [in finding an agreement], but the discussions with the municipality; but it isn't a port stakeholder". A manager of Klaipeda's port authority.

Concerning private sector stakeholders, they are important partners and are present in the majority of decision-making instances. These companies participate actively in port management by means of their associations for the defense of their interests:

"We represent our industry in parliament, in the Lithuanian government and we help it to take the right decisions … At the same time, we also discuss issues with the city council. We represent our members' interests with the city". A stevedoring company director, a manager of LJKKA.

"Our aim is to develop the port of Klaipeda together with state institutions, the port authority of Klaipeda... There are practices, such as: no direct face to face contact between the state institutions and businessmen. But generally, it's preferable to go along and negotiate with the government or ministries or the Lithuanian parliament as members of associations, for example for the port or for maritime activities". A stevedoring company director, also a manager of LJKKA.

Companies negotiate and cooperate with the government, building coalitions which result in the municipality being marginalized in issues relating to the development of the port community. The city council, on the other hand, appears to communicate more on the defense of inhabitants faced with the negative externalities of industrial port activities. Thus, positions are adopted which illustrate fairly classic land settlement where economic development (promoted by businesses and the State) seems to be in contradiction with the living environment and wellbeing of the residents (prioritized by the municipality). These tensions become exacerbated during the various electoral campaigns, be they local or national.

In such context, the lack of dialogue and the imbalance between the port authority and the municipality in their ability to wield influence (reported by a large number of port stakeholders) encourage the municipality to adopt a defensive attitude (perhaps to the detriment of the development of the port):

"I think that the city councilors should be part of the port council at the same level [as that of the port], but if the city wants to be part of the decision-making process, it should also contribute to port activities. As it stands, the city wants to take but doesn't like to give." A manager of the maritime academy of Lithuania.

Therefore, the State, the port authority, the businesses replaced by their associations, the municipality, have been described as major stakeholders. The workers' unions are not mentioned, as well as the intermediary territorial tiers (the region, for example).

4 GOVERNANCE OF THE HAMINA-KOTKA PORT COMMUNITY

Our third case study is also located in the Baltic Sea Region but the configuration is fundamentally different from the situations observed in the Baltic States. The Kotka and Hamina terminals are the most eastern in Finland and are thus an integral part of the eastern Baltic port range in close proximity to Russia.

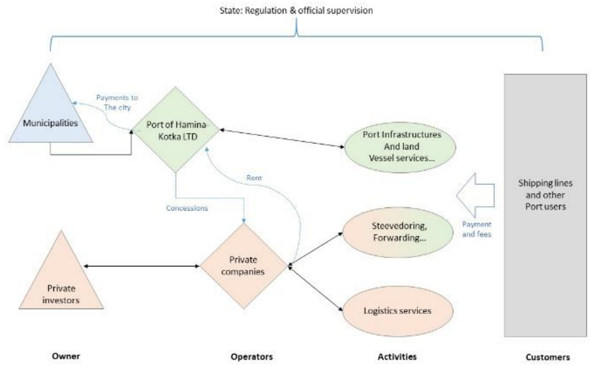
Before merging the two ports in 2011, these ports were two the first in Finland to be administered by municipal companies, commercial enterprises without societal obligations, unlike municipal companies that manage many Finnish ports. They received no financial support and were able to make profit and offer a reasonable return to the municipality (Finnila & al., 2011).

"We are owned by the municipality, of course we provide it some revenues". A port authority representative, December 2018.

Since the merger, the ports are a limited company, Port of HaminaKotka LTD, which is 60% owned by the municipality of Kotka and 40% by the municipality of Hamina. The company organizes and rules the port activities in both cities. It leases warehouses, offices and land in the port area.

"The port is a limited company owned by the city but operates independently. It has its own director, its own administration. The city is in charge of territorial planning." A Kotka city official, December 2018.

The role of the Finnish state in the governance of the port of Kotka-Hamina is minimal (Figure 2). It is also the only port in our study that does not define itself exclusively as a landlord port, in particular because of its action in port services and in financing of certain facilities.



Source: Made by the authors, according to Finnila & al., 2011.

Figure 2: Relationship system in the port of Hamina-Kotka

Thus, the governance of the port place of Kotka is structured with at its head, on one side the port's CEO and his team, and local elected officials on the other side. These two groups of stakeholders seem to be shaping a model that values regular cooperation and exchanges (formal and informal).

"The interactions are going well; the port regularly gives information about its operations". A Kotka city official, December 2018.

"Of course, the CEO and the mayor meet frequently with the influent people in the port". A Kotka city official, December 2018.

The port's CEO and his collaborators enjoy a significant leadership. They have a strong decision-making power in the realization of strategic and operational affairs. Also, although the port is owned by the municipality, it is a company that totally subscribes to the rules of liberalism.

"The port is a business company like any other one, even if we are owned by the municipality, that doesn't mean we don't work like a normal business entity. We work like any other company". A port authority representative, December 2018.

In this system "the port's customer base" is according to the leaders of the port company, the first decision-maker. It influences the development of the port and, according to that situation, would be a major player in urban-port governance.

"Customers need to be placed first. This must be so, otherwise there would be no business. For me, it's the clientele first. But if you ask anyone from our management or our team, they will tell you the same thing, because without the customers there is nothing, we would have no work and therefore no income". A port authority representative, December 2018.

However, municipal power remains strong, if not pervasive when it comes to strategic issues involving the territory, such as the merger of the ports of Kotka and Hamina.

"I think the most difficult decision was to merge the ports. [. . .] In the city [in Kotka], everyone was in favour of the merger. In Hamina, it was more difficult because they felt their independence threatened by the merger. They had to vote for the merger. But in Kotka, the merger was decided unanimously by the city council". A Kotka city official, December 2018.

As mentioned above, the power of the Finnish state within the port territory remains very weak. In addition, according to the interviewed actors, the port/state relationship subscribes to a comprehensive Finnish model that values "peaceful" relations and "cooperation".

"We are an independent company; it really means that we are independent. So we make our own decisions, we don't have to ask for state authorization. [...] We follow the market and that's it. It's not like in France, we don't have yellow vests, that's not working like this. Finland is a fairly peaceful society. People may be unhappy with something, but it is questionable and agreed, and it is the same with the state, we have constant meetings and discussions with the state and that is how we move forward". A port authority representative, December 2018

Finally, the main stakeholders, elected representatives or managers of the port authority seem particularly satisfied with the nature of cooperation and established governance.

"It's a small town so the decision-making is quite simple. [. . .] I think it's fine to be honest, we have a board of directors, we have a CEO and that's how it works. It's pretty simple. We do not have these different government agencies, which would constantly influence decision-making. It's not like that because we're a separate, independent and private company". A port authority representative, December 2018

5 COOPERATION BETWEEN STAKEHOLDERS AND DEVELOPMENT OF THE PORT PLACE

Mutations in international trade have forced ports to transform and generally move away from the city even if interactions between urban and port system persist. Nowadays, in order to be competitive, ports must effectively interact within their own territory. This contains building infrastructures, coordinating actors and cargo flows, creating long-term relationships with private entrepreneurs and public parties… (Debrie, Lavaud-Letilleul, Parola, 2013). So, it can be more difficult for municipal representatives, for instance, to understand what are the current trends in the maritime industry and the need for port development of any magnitude in order to remain competitive. There is a rising separation of the city from the port, fuelled by institutional and organizational rationales peculiar to each stakeholder and territory.

Consequently, despite standardisation of the modalities of governance according to the landlord port model (Verhoeven, 2010), there is no single archetype. For that matter, this model already distinguishes the hanseatic configuration. This model describes a "governance of proximity", striking the right balance between private port and Latin pattern (in which the port is under the influence of the State) (Tourret, 2014). Furthermore, each port is exposed on a variable basis to political bodies of the different institutional levels (municipal, regional, provincial, national, international). Associated to this is the impact of the mechanisms for delivering goods, which are decisions taken by the private sector. This variety of scales and the growing number of stakeholders make up the general framework in which the modes of governance of world seaport systems fit (Comtois, 2014).

In this context, the organization of the urban project and port project, spatial planning or the drafting of urban planning documents reveal the nature of relations between stakeholders as they represent the fundamental issues of territorial development. The geopolitics of urban-port development is based on conflicts of practices and is expressed fairly classically. National, regional or municipal interests are often at odds with each other (Brooks, Cullinane, Pallis, 2017). On this occasion, the imperatives concerning the environment, the economy, the well-being of inhabitants, fishing, logistics and industrial activities, etc., may raise objections to port development. In the case of Klaipeda, for example, the development of tourism and protection of living conditions, promoted by the municipality, encounter negative externalities and land requirements for port activity. In the case of Le Havre, the particular interests of the port authority (duplicated by its land management mission) might lead it to rein in the economic and industrial development of the territory. In Kotka, it seems that decentralized management (without strong state intervention) through municipal companies promotes cooperation between the municipal political power and the port enterprise.

Consequently, the ability of stakeholders to set up regulatory areas, formal and informal arenas likely to reconcile the different projects, is fundamental. At Le Havre, the alignment of port and urban projects benefits from the "quadripartite" regulation. Strong local government (municipal and intercommunal) guarantees that there is mutual recognition between stakeholders. In the Lithuanian case, the "interlocking/interconnecting" of projects seems to suffer from a form of manipulation of the port issue driven by the mayor in order to express his inclinations to resist in the face of central government. The lack of reciprocal recognition culminates in a development which would benefit from more reconciliation. In the Finnish case, "customer" demand appears to be the principal factor in decision-making. According to the interviewed stakeholders, this approach would encourage the search for consensus.

In both first cases, this unstable governance, where leadership of the local, central and port authorities is endlessly under discussion, accentuates the areas of uncertainty for economic stakeholders who require institutional stability.

The partisan dimension (political parties) also characterizes local governance des deux premiers cas. Depending on the context, it can have an impact on the dynamics of territorial development. In the case of Klaipeda, for example, national bipartite oppositions can be seen at local level in the port sector.

The drafting of territorial planning documents is therefore a considerable political issue. In the French and Lithuanian cases, they enable the communal block to "regain control" in a relationship where the State appears often as the privileged interlocutor of the port authority. In this, the communal block sees itself endowed with an excess of leadership. On the other hand, urban planning documents are also learning tools for cooperation (Loubet, 2012) and help to improve the dynamics of local development. In addition, "Spatial planning, urban planning and development documents therefore constitute territorial arenas for dialogue between stakeholders (Nadou, 2013). This makes port decision-makers re-examine their territorial anchorage, operate an "expansion of their baseline territorial status" (Loubet, 2011), here the port. Similarly, they incite councillors, technicians and even inhabitants, to question the port's integration in the city and the way in which they participate in building a sense of identity. As such, the procedure of drafting urban planning documents reconciles urban and port projects. It also constitutes a means for testing the organizational competence of local communities in a context of increasing complexity where account should be taken of the plurality of stakeholders and all of the issues. As in the management of social movements in the port of Le Havre, the "mediation" (Muller, 2000) used bolsters the municipal and intercommunal leadership. In Finland, the status of a municipal port and the low interventionism of the State, reduces the importance of planning documents as regulation tools for involded stakeholders.

So, structuring planning tools, different projects and multiple spatialities brings to light a multifaceted interplay: public/private relationships, institutional interference, effects of competition and a divergence in viewpoints between people of the sea and those of the land (Foulquier, 2009). Similarly, "the relationship with public authority remains ambivalent, between the need for strategic supervision to see ahead and calls for autonomy to act faster. " (Guillaume, 2014). Thus, the port authorities have been encouraged to think about the medium and long-term relevance of their development strategies. What is important is no longer the tons handled, but their impact on the territory, especially in terms of job creation (Lemaire, 2012).

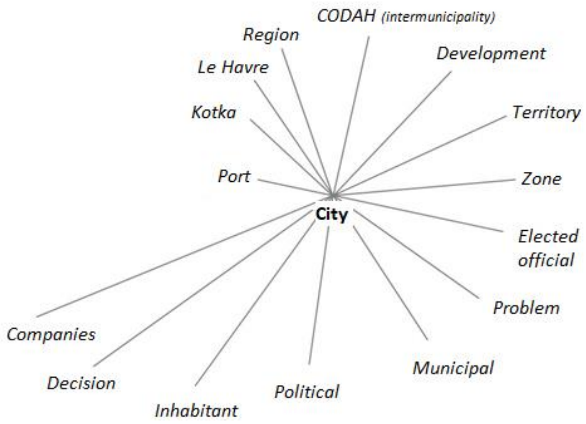
Moreover, the rescaling of ports means that cities have to go along with the new territorial recomposition. "The complexity and extremely contextual character of the issues make it indispensable that there is collaboration between the different stakeholders and the preliminary study of the strengths and weaknesses of the territory... A good city/port relationship would thus appear to be indispensable" (Jugie, 2014). As a consequence, scales and contexts are of primordial importance. A country with a big number of ports will conduct a different policy from another, boasting few ports, or ports having little impact on the domestic economy (Foulquier & Maugeri, 2014).

Furthermore, structural changes caused by global, intermodal logistics are redefining the relationships between the port and its region (Comtois, 2014). Ports today enlarge their activities and functional involvement above and beyond their metropolitan or regional borders. (Prelorenzo, 2011). There remains, however, an unfamiliarity with the advantages for the whole territory which are connected to maritime traffic (be it regional or national). It therefore seems imperative to reflect upon the scales in discussions, in a context where decentralizing ports enables the regions to exercise and impact on port infrastructures and the development of seafront and inland areas. Increasingly, the regional stakeholder is encouraged to strengthen his leadership in the governance of port communities. Yet according to the studied cases, its role appears to be only poorly identified.

6 CONCLUSION

Our primary results value the role of stakeholders, their aptitude to implement cooperative behaviors within particular territorial configurations. Beyond the institutional settings, the relationships between stakeholders need specific attention. The degree of dependence on central government, the interaction between deconcentrated and decentralized local authorities create an environment structuring the quality of cooperative relationships and local development.

To sum-up, we analyzed the network of shapes of the word "city" (Figure 3). The presence of the word "port" at the first place reflects the important functional proximity between the port and the city. But some words are also referring to conflicting relationships such as "problem" or "decision".



Source: Made by the Authors, 2020.

Figure 3: word « city » shape network

It would be interesting to extend the study to other medium-sized port cities in Europe in order to take into account a greater diversity of port and urban dynamics. These initial results provide several issues for reflection on the characteristics but also the roles of medium-sized port cities in Europe within the global, regional and even local port competition

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ENVIRONMENTAL IMPACT ASSESSMENT OF NAUTICAL PORTS PROJECTS

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ABSTRACT

Environmental impact of nautical tourism seaports is significant and that is the reason for the need to develop the system that would ensure permanent research and monitoring in order to preserve the environment and ecosystems. Each nautical port has specific sensitivity, operating in a different natural, social, and cultural environment. In order to achieve high level of marine environment protection, it is necessary to take the measures of prudence, prevention, as well as reasonable and rational use of marine natural resources. That can be achieved through ex-ante assessment of potential significant negative impacts. The paper elaborates the requirements for ports, yachts and boats in nautical seaports, the environmental impact assessment and screening procedures with a case study, and the action that involves prudent investment. The authors are urging for introducing Croatian national regulations which are stricter, aiming to better protect national particularly sensitive areas, since the internationally recognized regulations have their disadvantages and there is still room for improvement. The growth must correspond to the demands, complying with governance measures and pollution prevention. Nautical ports projects must be contemplated as a function of the quality of life, well-being of local community, and the preservation of natural and cultural heritage.

Keywords: nautical ports, environmental impact assessment, screening, regulatory framework

1 INTRODUCTION

Coastal areas in Croatia are subject to interventions by property developers in tourism and leisure sector. The construction of such accommodation facilities in pristine places where natural land cover is removed or in agricultural areas implies also the provision of water supply, wastewater treatment and waste management facilities, road networks, which further contribute to local land cover change, consume precious resources [1,2] and discharge emissions to the air, land, water and the sea, thus impairing entire ecosystems in the area.

While it is expected that nautical seaports comply with the highest environmental standards since the reason of their very existence is natural beauty and attractions of coastal areas where they are sited, that is not the case. The pollution impact of nautical tourism seaports is significant (air and seawater pollution, chemicals, impermeable land) and that is the reason for the need to develop the system of waste assessment and measures of permanent monitoring in order to preserve the environment and ecosystems for future well-being.

Besides ecological there are also social impacts [3] affecting people and communities in which they live as a result of tourism-related projects involving changes to community values and/or the way the community functions, impacts on communities' quality of life (air quality, noise levels etc.), impacts on their culture and history, impacts on exposure to hazards and risks, impacts on the access to control over resources, the access and quality of infrastructure, services and facilities, as well as economic well-being [4].

The paper analyses regulatory requirements applicable to nautical ports in Croatia and the instrument of environmental impact assessment, as well as the practice of ex-ante impacts analyses for nautical ports in Croatia shown on a case study of Vela Luka nautical port project.

2 REGULATORY REQUIREMENTS ON NAUTICAL PORTS

Nautical tourism in the Republic of Croatia is defined as sailing and staying of tourists on board of yachts, boats and cruisers for personal and business purposes, as well as berthing in nautical ports and nautical ports open to public transport for pleasure, recreation/leisure and cruises.

The yachts and small boats present an impact in the form of oil escape from engines, action of anti-fouling paints, of propellers in shallow waters and noise. Direct pressures on coastal zone are related to infrastructure construction such as roads, parking places, airports, marinas, jetties, mooring, hotels, waste and sewage, resource use and wildlife interaction.

According to Croatian legal framework requirements, ports for nautical tourism are classified by type as anchorage, mooring, dry storage marinas and marinas, it being determined by the type of services rendered at a certain port. Each type of port for nautical tourism, depending on the services rendered, must comply with prescribed minimum and special standards regarding its construction, appearance and equipment [5].

Among other sources of pollution, there is a significant contamination impact of sanitary waste waters, i.e. black water and grey water. Sewage or black water covers discharges and other residues from all kinds of water closets (lavatories), urinals and toilets, discharges from sinks, bathtubs and other installations in medical area (infirmary, hospital, etc.), discharges from livestock spaces and other waste waters, if they mix with the above-mentioned discharges. On the other hand, grey water is a waste water from laundry and accommodation which includes waste waters from sinks, showers, bathtubs and their discharges except for the abovementioned water, waste waters from laundries and waste waters from washing provisions, kitchen appliances and food stores and restaurants.

Sewage produced onboard is discharged directly into the sea, thus presenting a risk from pollution of the sea surface layer by sewage in coastal tourist areas, on beaches and in bays during summer months when boat and yacht traffic is increased.

According to Croatian Maritime Code boat is a vessel intended for navigation at sea certified to carry no more than 12 passengers, hull length of which exceeds 2.5 metres, but no more than 15 metres, or total power of propulsion machinery exceeding 5 kW. Yacht is a vessel intended for sports and recreation, whether used for personal needs or commercial activity, the hull length whereof exceeds 15 metres, is designated for longer stay at sea, and is apart from the crew certified for carrying up to 12 passengers [6].

The most important international regulation dealing with the problem of sea pollution from vessels is the International Convention for the Prevention of Pollution from Ships (MARPOL), 1973/78, as amended. In its Annex IV it covers only ships operating on international voyages having the capacity of 400 gross tonnage and above; or less than 400 gross tonnage when certified to carry more than 15 persons. Even in that case the ship is allowed to discharge sewage which is not comminuted and disinfected only at a distance of more than 12 nautical miles from the nearest land at moderate speed when the ship is en route and proceeding at not less than 4 knots [7].

Pollution by sewage wastewaters from a larger number of smaller vessels that are not subject to mentioned legal regulations may be higher in quantity than from larger vessels that have installed and utilize sewage treatment plants as prescribed by law. Also, the quantity of sewage produced onboard is directly related to the number of persons onboard, and not the size of the vessel.

3 ENVIRONMENTAL IMPACT ASSESSMENT

Environmental impact assessment along with neminem laedere (no-harm) and precaution represent legal principles in marine environment protection [8]. United Nations Conference of the Law of the Sea (UNCLOS) focusing on marine pollution identifies certain types of causation processes, including from land-based sources, the air, dumping, vessels, and installations. Addressing the marine environment in general, UNCLOS includes not only transboundary pollution but also causation chains within one national jurisdiction to areas beyond national jurisdiction [9].

No-harm imperative has the status of international customary law. It has its origin in the early years of environmental law when it grew out of police law that was based on restrictive preconditions of state interventions. The first step was to acknowledge that if the potential effect is disastrous, preventive measures must be taken if the event is uncertain or unlikely [8].

The precautionary principle is a guiding principle that provides helpful criteria to determine the most reasonable course of action in confronting situations of potential risk. It is an open-ended and flexible principle which creates a possibility and an incentive for social learning [10].

The procedure of environmental impact assessment (hereinafter: EIA) is briefly defined by the United Nations Economic Commission for Europe (UNECE) as an assessment of the impacts of a planned activity on the environment [11]. The definition by the International Association for Impact Assessment in 2009 states that it is the process of identifying, predicting, evaluating and mitigating the biophysical, social and other relevant effects of proposed development proposals prior to major decisions being taken and commitments made [12]. It is a process consisting of the preparation of an EIA report by the developer, the carrying out of consultations, the examination by the competent authority of the information presented in the EIA report, the reasoned conclusion by the competent authority on the significant effects of the project on the environment, and the integration of the competent authority's reasoned conclusion into any of the decisions [13].

The best practice commands for the application of precautionary principle, i.e. mitigation should be based on the possibility of a significant impact even though there may not be conclusive evidence that it would occur.

Simultaneously with facilitating sustainable economic activities in the area of maritime demesne, all citizens should be granted in an equal and equitable way the use of coastal area, provided its designated purpose is respected. Therefore, the investment in coastal areas command for prior comprehensive analysis of all pressures on the environment and impacts on the locals. [14].

Habitats Directive [15] on its part tries to reconcile nature conservation and numerous human activities that take place in and around the Natura 2000 through the mechanism of so-called appropriate assessment (AA) of plans and projects likely to adversely affect the Natura 2000 sites. A plan or project cannot be approved unless it has been established by "appropriate assessment" that it is not likely to have significant negative consequences for the habitats and species for which the given Natura 2000 site was designated (no adverse impact on site ecological integrity). The Appropriate Assessment (AA) as defined by the directive, must give clear and legally binding answer if significant negative impact on Natura 2000 site exists; if doubts remain, it should rely on precautionary principle in favour of nature. AA requires assessment of cumulative, direct and indirect impacts of existing and planned projects and establishes a case by case approach, which excludes formation of a list of specific types of projects or activities which are to be subject to assessment. In this way it can fill in some gaps in the scope of EIA and also strategic impact assessment (hereinafter: SEA) procedures relating to smaller developments [16].

4 EX-ANTE IMPACTS ANALYSES FOR NAUTICAL PORTS IN THE REPUBLIC OF CROATIA

The projects that may have significant impact on marine environment, and which are subject to compulsory EIA carried out by the Ministry of Environmental Protection and Energy (MEPE) are set out in Annex I of the EIA Regulation (hereinafter: Regulation) [17], among them being the sea ports open for public traffic of particular (international) economic interest for the Republic of Croatia and sea ports for special purposes of significance for the Republic of Croatia under lex specialis.

The projects assessed with regard to significance of their impact on marine environment for which the screening[1] procedure is undertaken by the Ministry of Environmental Protection and Energy and defined in Annex II of Regulation involve among others sea ports with more than 100 berths, all interventions involving sea coast backfilling, deepening and sea bottom draining as well as constructions in and at the sea with length of 50 m and above, and tourist zones with 15 ha area and above outside the limits of construction site of the settlement.

The screening is carried out on the basis of a screening report whose content is set out in Annex VII of the Regulation. Integral part of environmental report or screening report is conceptual design which comprises textual statement of reasons and graphic view of an undertaking.

Depending on site and characteristics of the project, pursuant to Article 26 of the Regulation, competent authority is obliged to seek opinions from the authorities and/or persons set out under lex specialis and/or local and regional self-government units on the significance of the impact on component of the environment or load on the environment, from within the scope of their competence.

In the procedure of establishing significance of environmental impact, only competent bodies listed in the application notice posted on web pages of the Ministry of Environmental Protection and Energy may take participation.

The opinion concerning the significance of an impact on nature is issued by the Directorate for nature protection, while with regard to impact on water and the sea it is issued by the Directorate for water management and protection of the sea. Both directorates are within the Ministry of Environmental Protection and Energy. With regard to planned project, the opinion is also sought from competent county and city/municipality. Where the city/municipality are the developers, they are then not called upon to issue their opinion. Other authorities listed in the tables issue opinions depending on the project type concerned.

The criteria establishing whether the project should be subject to EIA, or on the basis of which the decision on the necessity of undertaking EIA procedure is taken (Annex V of the Regulation) concern characteristics of the project, location of the project, and nature and type of potential impact of the project.

Should it be ascertained that significant environmental impacts are likely, the obligation to implement the EIA procedure is prescribed. Where established that environmental impacts are not significant, the environmental protection measures may be prescribed as well as the environmental state monitoring programme, but no obligation to implement the EIA procedure is prescribed.

With regard to prescribed protection measures and the program of monitoring the state of the environment, Article 89a of the Environment Protection Act [18] lays down that the measures and/or monitoring programme of the state of the environment set out in the administrative decision on environmental acceptability of the programme or administrative decision under screening procedure constitute the compulsory content of master project which makes an integral part of the act approving the construction or other acts for implementing the project issued under lex specialis.

Once the competent body pursuant to opinions received excludes the possibility of significant environmental impact, it issues administrative decision establishing that it is not necessary to implement the EIA procedure for the intervention.

[1] Screening means the examination of a development proposal to determine whether it requires EIA.

The terminology regarding EIA/screening procedures undertaken and listed on web page of the Ministry of Environment Protection and Energy [19] is not standardized by project types for statistics purposes. As a result, nautical tourism ports are often bear the name of various project titles such as pier or quay extension, port upgrading, port development, port reconstruction, harbour development, beach development, coast development, coastal belt development, nautical tourism port, modification of nautical tourist complex project, waters deepening, modification of nautical tourism complex project, etc. Only in 2019 there were more than 20 requirements for screening. Construction and reconstruction mainly concern piers, plateaus, extension or coast replenishment, dredging within port basin for achieving requisite depth to accommodate vessel draft, laying rubble mounds etc.

In practice communicating with the public throughout the assessment procedure is implemented in such a manner that the notification of planned intervention is posted on web page, followed by the notification on carrying out the public consultation accompanied by the report and non-technical summary. As for the screening procedure, communicating with the public is carried out by posting the notification concerning the request and screening report on web pages. The public may present the views on the report in course of 30 days from the date of posting the information note.

The 'no action' of not proceeding with the project is an option that is very rarely applied, although it would in many be justified had all the regulatory criteria be properly applied.

5 VELA LUKA CASE

Vela Luka in the Republic of Croatia is situated in western part of the island of Korčula, in its largest bay that is indented as much as 9,2 km into interior of the island, between two narrow peninsulas.

In 2013 screening procedure was undertaken with regard to construction of nautical tourism port with up to 200 berths capacity concluded in an administrative decision stating that is is not necessary to implement neither EIA nor appropriate assessment [20].

It is interesting to note that a very narrow strip of insular land around long and narrow bay remained outside protected areas pursuant to Birds Directive and Habitats Directive. Technically, there was no available data on the distribution of habitat types that had served as basis for singling out the surrounding two ecological network areas (posidonia communities, reefs and submerged and semi-submerged sea caves) resulting in bay not being included in the network. In fact, urbanized and industrialized areas did not become Natura 2000 sites. Also, as far as birds are concerned, nesting sites are critical.

The screening report [21] placed unusually great accent on safety of the port situated in a naturally sheltered bay. Besides, the chapter dealing with ecological network mostly discussed forthcoming expiry of ecological network charts following the recognition of proposed Natura 2000 sites, and the inaccuracy of its coordinates.

It also stated that part of the bay constitutes the areas of protection of endangered marine areas, but as the entire coastline in inner part of the bay is filled up and built, and till recently there has been no sewer network, the water is significantly loaded with sewage and technological waters and with former presence of a shipyard for smaller vessels.

It mentions that weak circulation of seawater, relatively low bay depth and substantial solid waste found at sea bottom led to intense eutrophication and occasional anoxic states. It claims that such a state is reversible by the construction of appropriate sewerage, which statement can hardly be associated with studying the impact of the marina. It also points out that although waters still preserve the status of natural landscape, natural characteristics of entire coast are devastated by the development and that preservation of posidonia is expected to maximum extent. Possible impacts on air during the use are of local character according to the screening report. There is no mention of the impact of coatings and chemicals.

Above claims hardly go in line with expert opinion of members of the Committee of the Union of natural sanatoria of Croatia in 1959 [22] which stated that climate of Vela Luka is the most beneficial of all medically-climatologically analysed littoral areas of Croatia. It states that in Kale cove of Vela Luka, owing to exposure and deposit of sea mud, there is a specific microclimate with curative source therein.

Therefore, curative character of Vela Luka results from the fact that there exists a series of natural curative media: sea mud, curative water source Kalac [23] and curative climate. The opinion also points out that there is an increasing demand for sanatoria in which difficult clinical states of various kinds might be healed.

In fact, in Kale bay, nearby mineral water source Kalac, Tabain family built in 1885 a chapel and dedicated it to Immaculate Conception. In less than 100 years later Vela Luka residents built a sanatorium for healing barren women. Therefore, curative mud in the bay, sanatorium and the Chapel of Immaculate Conception were described as constituting an invisible triangle in which each one of those had its designation, and common purpose – to heal the sick [22]. There is no mention of this aspect in the screening report.

In October 2019 the request was made by County Port Administration in Vela Luka for carrying out the screening procedure for construction of the fishing port stating that presently fishing boats are moored along entire coast of Vela Luka and in that way hinder the use of mooring wharfs for commercial use, such as nautical boats berthing [24].

That means that one of the impacts of building nautical port in a bay where fishing boats were traditionally moored results in another intervention, i.e. the construction of a new fishing port.

6 CONCLUSION

Tourism development must be contemplated as a function of the quality of life, well-being of local community, and the preservation of natural and cultural heritage. In addition, non-holistic approach could result in tourism that is no longer viable and can only be maintained through considerable financial effort or at lower profit margins.

East Adriatic coast has features that do not require substantial investments for providing nautical ports berth capacity, as there is sufficient depth, indented coast with sheltered bays, and rocky shoreline. On the other hand, Croatia has enormous natural capital which it must strive to preserve in the interest of its inhabitants and visitors, sustainability of ecosystems and the resulting economic profit in long-term. Thus, in order to prevent devastation and degradation of its coastal resources, Croatia should place particular emphasis on the considerations of acceptability for the environment and society of individual projects for which the environmental impact assessment/screening procedures are compulsory, nautical ports being among them.

Protected areas should be managed properly, but in no way be confined, leaving the surrounding areas that is no less attractive subject to much less regulation with regard to land use, emissions and natural resource exploitation, and waste that threatens precisely the protected areas.

Vela Luka case study challenges the principle that the entirety of impacts should be identified and assessed. There is no mention whatsoever in the screening report of the unique natural curative features present in the narrow bay and the threat thereto from new nautical port sited in close vicinity. At minimum, undertaking of the environmental impact assessment procedure should have been decided in the screening process undertaken.

The administrative decisions issued by the Ministry establishing that for a particular project it is not necessary to carry out the EIA procedure must state main reasons for which the assessment is not required, along with reference to respective criteria set out in Annex V of the Regulation.

Any EIA or screening report should incorporate surveys of population which could be affected by the project, meaning that local community would be involved in project planning in their area at the earliest stage. It would also be necessary to provide through appropriate cost-benefit analysis the elements for decision-making as to which tourist products such as nautical tourism (yachting and cruising), health tourism or other would represent a priority strategic goal for certain community and site.

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ADAPTATION OF AIRPORT INFRASTRUCTURE FOR OPERATION OF ICE-HYBRID AND FUEL-CELL AIRCRAFT

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ABSTRACT

In not-so-distant future, hybrid-electric aircraft are expected to enter the market and revolutionise the segment of local and regional flights. Hybrid-electric aircraft, either as a combination of internal combustion engine (ICE) and battery (ICE-hybrid) or fuel-cell hydrogen and battery (fuel-cell hybrid), will contribute to reduction of the negative environmental impact of aviation while reducing the dependence on fossil fuels. Their introduction will require adaptation of airport ground infrastructure as existing airport ground infrastructure is not suited for hybrid aircraft operations i.e. either is non-existing, insufficient, or inappropriate. A feasibility study aiming to assess the technical aspects of the needed ground airport infrastructure for fast charging of ICE-hybrid and refuelling of fuel-cell hydrogen hybrid aircraft is thoroughly explored and presented in this article. Two study cases, within the MAHEPA project were developed to estimate technical requirements for the relatively novel ground infrastructure needs at airports. The first study refers to multiple charging issues of ICE-hybrid aircraft, while the second study refers to refuelling of fuel-cell hydrogen hybrid aircraft. Since the charging technology for hybrid electric vehicles is already available in automotive industry and is transferable to aviation industry, initial investment is expected to be lower than the investment for fuel-cell hybrid aircraft. The article thoroughly examines various technical aspects of necessary adaptation of airport infrastructure in order to enable smooth operation of ICE-hybrid and fuel cell hybrid aircraft.

Keywords: MAHEPA, hybrid aircraft, ICE-hybrid, fuel-cell hybrid, ground airport infrastructure, airport, aviation

1 INTRODUCTION

Air traffic causes several negative impacts on the environment such as toxic gas, greenhouse gas and noise emissions. In order to reduce increasing pressure of aviation on the environment, the aviation industry has committed itself to certain targets such as: improving fuel efficiency for 1.5 % per year, achieving net carbon growth by 2020 and reducing global net aviation emissions for 50 % by 2050 (IATA, 2019). Efforts to mitigate the negative environmental impact of aviation have led to a variety of emission mitigation measures such as the introduction of alternative aviation fuels, fuel efficiency improvements (e.g. new design with lightweight composites) and operational measures (e.g. more efficient flight procedures) (Dray, Evans , & Schäfer, 2010; Hassan, et al., 2015; ICAO, 2016; Owen , Lee , & Lim, 2010; Schilling , Rötger, & Wicke, 2016). Momentarily, the aviation industry is strongly inclined to reduce its dependence on fossil fuels through introduction of Sustainable Aviation Fuels (SAF), which are mainly produced of sustainable feedstocks (e.g. waste oils, agricultural residues or non-fossil CO_2) (SkyNRG, 2020). Since SAF feedstock and thus the production of sustainable fuels is limited, the interest in substantial fuel efficiency improvements based on radically new propulsion technologies and designs, stills remains high (IATA, 2019). While all of the beforementioned mitigation measures contribute to reducing aviation emissions and have the potential to improve fuel efficiency up to 30 % by around 2030, more radical improvements will be needed after 2030, if we want to significantly reduce fuel consumption and carbon emissions (IATA, 2019). In this respect, further emission reductions could be achieved through revolutionary technologies, such as new aircraft configurations, new designs and propulsion systems, which include fully electric, ICE-hybrid or fuel cell hydrogen aircraft (Marksel, et al., 2019).

On average every 15 to 20 years aircraft are replaced by new generation of conventional aircraft, with improved average fuel efficiency up to 15 %. Hybrid- electric propulsion can achieve 40 % to 80 % of fuel savings, while fully electric propulsion up to 100 %. In addition, the hybrid-electric powered aircraft with blended wing body can achieve CO_2 emission reductions up to 40 %. Taking into account today available renewable energy sources for electricity, the electric aircraft, could completely eliminate CO_2 emissions compared to conventional aircraft (IATA, 2019). The German Aerospace Center (DLR) studies have revealed that the hybrid-electric aircraft could replace 60 % to 70 % of all conventional regional aircraft (Clean energy wire, 2018). Hybrid-electric propulsion technologies are attractive for the new airline business models because of their several advantages, such as low or no emissions, reduced noise, and low operating costs. Some question, their potential market penetration, because of consequently needed extensive adaptation of the pending airport infrastructure, remain open (Marksel, et al., 2019). The challenges do not arise only at the aircraft level, (e.g. such as the availability and standardization of batteries/hydrogen fuel-cells with sufficient energy density for regional flights), but also at the airport infrastructure level. The main challenges can be, for example, accessibility of ground services and new maintenance procedures, the need for high-power electricity supply and hydrogen supply, which would require several adaptation of the airport infrastructure (IATA, 2019).

The preliminary assessment, carried out in the MAHEPA project (Modular approach to hybrid- electric propulsion architecture), provides valuable understanding of how the existing airport infrastructure should be upgraded in order to enable the operation of hybrid-electric and hydrogen aircraft (Marksel, et al., 2019).

2 THE REASONS BEHIND APPLYING THE HYBRID TECHNOLOGY IN AVIATION

Conventional aircraft powered by an internal combustion engine (ICE) running on kerosene, emit exhaust gases and particles, such as carbon dioxide (CO_2), water vapor, hydrocarbons (HC), carbon monoxide (CO), nitrogen oxides (NO_x), sulphur oxides (SO_X), lead, and black carbon. These gases and particles have not only a negative impact on environment by causing smog, acid rain, the greenhouse effect etc.., but also on human health. Especially, in high concentrations they can cause poisoning, lung, liver, and heart disease and even cancer. Aviation is responsible for about 3 % of total EU greenhouse gas emissions and more than 2 % of global greenhouse gas emissions. Without action to reduce emissions, global annual emissions could increase by over 300 % by 2050 (European Commission, 2020).

One way to minimise the high levels of pollution and negative environmental impact of conventional aviation is to introduce cleaner aircraft propulsion technologies, that can partially or fully reduce the above-mentioned local toxic gas emissions, global greenhouse gas emissions and noise. The all- electric aircraft powered entirely by batteries has many advantages such as no local gas emissions and significant noise reduction. If the battery is powered by renewable sources, it has a significant impact on reduction of global CO_2 emissions. The serial ICE-hybrid aircraft, such as the Panthera hybrid aircraft developed in the MAHEPA project, is powered by an electric engine, fed by an ICE generator or battery which enables the electric take-off and landing. (Gaspari, 2018).Such a propulsion system enables the ICE-hybrid reduction of emissions in the vicinity of airports, while at the same time maintaining good flight characteristics of conventional aircraft, such as relatively low weight and long flight range (Righetti, Falger, Steffen, & Perkon, 2017). The fuel-cell hybrid aircraft developed within the MAHEPA project, such as Hy4, is similar in design to the serial ICE-hybrid aircraft, while the main generator consists of fuel-cells powered by gaseous hydrogen. The fuel-cell hybrid aircraft causes no local emissions, reduces noise and global CO_2 emissions when hydrogen is produced from renewable resources (Flade, 2018).

Although all-electric aircraft are more environmentally friendly than conventional aircraft powered by fossil fuels, their main disadvantage is higher weight load. Another disadvantage of all-electric aircraft is significantly shorter flight range compared to conventional and hybrid-electric aircraft. Currently, the hybrid-electric aircraft concept represents the best compromise between efficiency and flight range in field of light aircraft. The current limitations of battery technology are still too big to allow long-haul flights (HYPSTAIR project, 2019). This is successfully solved by a hybrid-electric propulsion technology, that allows a combination of conventional and electric propulsion, or in the case of FC hydrogen, a combination of hydrogen powered fuel- cell and batteries.

Due to the quiet, short take-off and landing capabilities with zero or low gas emissions, ICE-hybrid and fuel-cell hybrid aircraft can be used on today underutilised airports located in urban areas, in the vicinity of city centres. Revitalisation of existing underutilised airports is a great potential for new air transport routes and services. Additionally, there is also a possibility of replacing existing conventional aircraft in the categories 1-to-8-seater, 9-to-19-seater, and 20-to-70-seater, with cleaner aircraft ICE-hybrid and fuel cell hybrid aircraft. By scaling up new hybrid technologies to a larger aircraft, a greater reductions in emissions can be achieved, thereby supporting the aviation industry's efforts for environment (Marksel, et al., 2019). For introduction of ICE-hybrid and fuel cell hybrid aircraft, an assessment of necessary airport ground infrastructure is needed to enable their operation.

3 CASE STUDIES

Two case studies were carried out to assess the necessary adaptations in the airport's ground infrastructure. The first study refers to infrastructure needed for multiple charging of ICE- hybrid, while the second study refers to infrastructure for refueling of fuel-cell hydrogen hybrid. Both studies were based on the technology roadmap for ICE-hybrid and fuel cell hydrogen aircraft (IATA, 2019), and were limited to the smaller aircraft. Smaller aircraft, such as 9-to-19-seat and 20-to-70-seat ICE-hybrid or fuel cell hydrogen hybrid aircraft, are expected to enter the market earlier than the larger aircraft (e.g. 200-seat and more), so the replacement is expected to happen sooner in small size aircraft category than in large size category of aircraft.

The existing small passenger aircraft transport volume assessment for Europe is based on the OAG demo-database for 2017. The results show that there were 150 airports in Europe with regular scheduled flights of conventional 9-19-seater aircraft and 484 airports with regular scheduled flights of conventional 20-70-seater aircraft. As can be seen from the Table 1, there were many airports with less than 1 flight per day, but they were also significant share of airports (49 % in case of 9-19-seater and 63,4 % in case of 20-70-seater) operating more than 1 and in some case even more than 50 flights per day.

Table 1: Average number of daily flights

No. of daily flights (in average for 2017)	No. of airports with scheduled flights	
	9-19-seater	20-70-seater
Less than 1	76	177
1 – 2	33	84
2 – 3	27	66
3 – 4	6	35
4 – 5	2	22
5 – 6	1	17
6 – 7	2	16
7 – 8	1	9
8 – 9	1	6
9 – 10	1	7
10 – 15	-	22
15 – 20	-	7
20 – 30	-	9
30 – 50	-	5
More than 50	-	2
TOTAL	150	**484**

Source: OAG demo database, 2017.

As can be seen from the Table 2, the above mentioned aircraft fly different distances, (with 9-19-seater aircraft the most frequent flight distance is between 301 and 500 km, while 20-70-seater aircraft mainly fly distances between 101 and 300 km).

Table 2: Number of seats of aircraft by flight distance

9-19-seater aircraft		20-70-seater aircraft	
Flight distance [km]	Total seats	Flight distance [km]	Total seats
2 – 50	168,599	19 – 100	1,275,466
51 – 100	135,493	**101 – 300**	**12,751,554**
101 – 200	351,491	301 – 500	11,253,337
201 – 300	283,913	501 – 700	4,450,470
301 – 500	**371,915**	701 – 1,000	2,702,282
> 500	119,728	1,001 – 2,000	1,678,100
Sum	1,431,139	> 2,000	44,372

Source: OAG demo database, 2017.

The traffic volume and distance of existing conventional aircraft have been extrapolated in order to correctly estimate the necessary adoptions of airport's ground infrastructure, provided that this segment of air market would be replaced by the ICE-hybrid and fuel-cell hydrogen aircraft (Marksel, et al., 2019).

3.1 Assesment of airport ground infrastructure for hybrid-eletric aicraft

The airport's infrastructure for charging the batteries of ICE-hybrid aircraft requires adequate electricity system, the battery charging stations and optional battery swapping equipment. Although the possibility of battery swapping is very interesting approach to eliminate the time needed for recharging the batteries this was not taken into consideration based on the experiences in the automotive industry (e.g. different types of batteries and swapping methods, the question of responsibility for failures/accidents). With only slight changes, technology and standardization defined by an International Electro Technical Commission (standard name is IEC 62196), for land vehicles, can be fully used for aviation purposes as well. According to standard IEC 62196, a vehicle battery can be charged in one of the following modes:

- Mode 1: Battery is charged through a regular electric socket with a regular cable.
- Mode 2: Like mode 1, but with added protection device, mounted on a socket or cable.
- Mode 3: Charging through a charging station, which is directly connected to the electrical grid and provides alternating current (AC) to the battery.
- Mode 4: Charging through the charging station, which is directly connected to the electrical grid and provides direct current (DC) to the battery.

Only modes 3 and 4 should be considered, as they provide sufficient voltage, current output and power output to charge a hybrid-electric aircraft considered in the study.

Feasible combinations of charging stations are presented in Figure 1. The possibilities are either to use alternating current or direct current with different voltage, current and power output.

BATTERY CHARGING STATIONS							
CURRENT PROVIDED TO THE BATTERY	ALTERNATING CURRENT (EU NETWORK)					DIRECT CURRENT	
VOLTAGE	SINGLE PHASE EU NETWORK		THREE PHASE EU NETOWRK			300 V – 500 V (DC)	
CURRENT OUTPUT	16 A	32 A	16 A	32 A	63 A	100-125 A	300-350 A
POWER OUTPUT	3.3 kW	7.4 kW	11 kW	22 kW	43 kW	50 kW	120 kW
SOCKET TYPE	IEC 62196 -2 Type 1, 2 and 3		IEC 62196 – 2 Type 3			IEC 62196 – 3 AA, BB, CC, FF	

Source: (Marksel, et al., 2019)

Figure 1: Configurations of charging stations at airport

In case of charging through AC the charging station should be installed and connected to an electric grid network through a single-phase or a three-phase connection. In the case, where several charging stations must be connected to the grid, a transformer may be required. A charging station and a battery in the vehicle (or aircraft in our case) are then connected by a cable, which can be usually detached from both charging station and the vehicle (aircraft). In this case the charging station provides an AC and an AC / DC converter must be installed in the aircraft. For the charging station, connected to the EU grid (voltage difference of 230 V) the maximal power output can be 14 kW in the case of a single-phase connection and 44 kW in the case of a three-phase connection.

The DC charging station must be connected to the electrical network via a dedicated transformer. If several DC charging stations are installed at the same place, they can all be connected through the same transformer to the electrical grid. DC charging stations usually have cable attached and provide direct current directly to the battery management system (BMS), so that installation of AC / DC converter in an aircraft is not required. Current DC charging stations can provide up to 120 kW power, with voltage difference ranging from 300 V to 500 V and maximal current ranging from 300 A to 350 A.

For installation of charging stations, either DC or AC, several procedures and operation are needed, such as:

- Consent form authorities to build charging stations at airport premises.
- Preceding operations, such as excavation for cable ducting and pipe laying, foundation of the base for the charging station, installation of (freely standing) electric measuring boxes, connection to the transformer (no processing in the transformer), road crossing, unproblematic crossing of the electric cable with the water supply system, etc.
- In case that the electricity system does not provide sufficient power, the modification or installation of new transformer with sufficient power is required. A transformer can supply four to five DC charging stations.

To provide fast charging of ICE-hybrid aircraft, several aspects need to be taken in account, such as:

- A good battery condition with low internal resistance that allows fast charging.
- A moderate temperature (above 5oC) for performing fast charging.
- Fast charging should be applied only in the first charging phase (up to 70 % of SoC (State of Charge).
- Charging rate of 1 C (i.e. empty battery would be fully charged in one hour) should not be exceeded in the second phase of charging.
- When charging is completed, Li-ion batteries should be disconnected from the charging source.

The charging capacity estimation carried out in the study, considered the full landing and take-off cycle (LTO) of aircraft with lithium-ion batteries at technology level 2019 and with specific power (i.e. 2 kW/kg) and specific energy (i.e. 100 Wh/kg). The battery under consideration generates enough energy to enable fully electric take-offs and landings of ICE-hybrid aircraft. A battery of a 19-seat ICE-hybrid aircraft would have a capacity of 50 – 100 kWh, while the battery capacity of a 70-seat ICE-hybrid aircraft would be between 180 – 360 kWh.

As seen from Table 3, the charging time of 19- and 70-seat aircraft depend on the capacity of charging station.

Table 3: Charging time of a 19-seater and 70-seater aircraft with different charging stations

Power of the charging station [kW]	Charging time of a 19-seater aircraft [h]	Charging time of a 70-seater aircraft [h]
3.3	15 – 30	55 – 110
7.4	7 – 14	24 – 48
11	5 – 9	16 – 33
22	2 – 5	8 – 16
43	**1 – 2**	4 – 8
50	1 – 2	4 – 7
120	1	**1.5 – 3**

Source: (Marksel, et al., 2019)

The minimum time to fully charge the battery would be one hour. In order to achieve fast turnaround times (e.g. 20 minutes), one or two (depending on battery capacity) 120 kW charging stations would be required to charge a 19-seater aircraft simultaneously, whereas up to eight 120 kW charging stations would be required for a 70-seater aircraft. In both cases the batteries should be charged up to 80 % SoC to prolong battery life.

Taking into consideration charging time (Table 3) and average daily number of flights (Table 1), the single alternating current (AC) three-phase station with a charging capacity of 43 kW would be sufficient for charging a 19-seater ICE-hybrid aircraft at almost all airports. Moreover, a 43 kW AC charging station would also cover the needs for charging a 70-seater ICE-hybrid at 66 % of airports. At majority of airports (88 %), a 120-kW direct current (DC) charging station would be required to charge a 70-seat ICE-hybrid aircraft. The airport with the largest number of flights (i.e. Tromsø in Norway), accounting with more than 9 flights per day with 9-20 seat aircraft and almost 60-flights per day with 21-70 seat aircraft (OAG, 2017), would need up to 8 DC charging stations with 120 kW capacity or three times as many AC charging stations with 43 kW capacity to ensure multiple fast charging.

3.2 Assesment of airport ground infrastructure for fuell-cell hydrogen aicraft

The airport infrastructure and operations required for operation of fuel cell hybrid aircraft consist of operations and infrastructure necessary to enable hydrogen production, hydrogen transport, hydrogen liquefaction or hydrogen compression and to provide hydrogen refueling points. Various production methods exist for separating hydrogen from the elements to which it is naturally bound (e.g. oxygen and carbon). Recently, more and more attention has been paid to production of hydrogen from cleaner sources, such as electrolysis based on renewable energy, which might become an economically viable option in the future (Amy & Kunycky, 2019). Currently, steam reforming is still the most cost-effective method of producing hydrogen from either methane or other light hydrocarbons such as oil. It is therefore not surprising that steam reforming is today widely used especially in the chemical industry and is therefore considered in our case study.

Airport can be supplied with the required quantities of hydrogen by road (truck delivery) or rail, by pipelines or by on-site production, when bigger quantities are required (Yang & Odgen, 2007), (Amy & Kunycky, 2019).

In case of hydrogen delivery by tube truck trailer, hydrogen is compressed at the production site and transported to the local consumer site by the tube trailer trucks. It is assumed that the full trailer is dropped at the delivery site and that the empty trailer is picked up afterwards. The highest cost component of the hydrogen tube truck delivery scenario are the operating and maintenance costs of the truck, including drivers' labor cost. Therefore, transport distance has the greatest effect on the hydrogen delivery costs by the tube trailer and scales linearly with distance, while on the other hand, costs are relatively independent on hydrogen flow rate (amount of hydrogen delivered to the consumer per day) (Yang & Odgen, 2007).

In the case of delivery by cryogenic truck trailer, hydrogen is liquefied at the production site and transported to the consumer by cryogenic truck trailer. In such a case it is assumed that trailers are not left at consumers' site and that in each trip the truck empties its entire load and that the minimal capacity of hydrogen (H_2), used at the consumption site, is 30 tons per day. The largest cost component, if using cryogenic truck delivery scenario, is liquefaction (80 % - 95 % of all costs), therefore the overall costs of liquid hydrogen delivery, strongly depends on hydrogen flow and is almost independent on the driven distance (Yang & Odgen, 2007).

In the case of delivery by pipeline, hydrogen is first pre-compressed at the production site and then delivered to the consumer by pipeline. Depending upon the purpose of use, hydrogen can be further compressed at consumer's site as well. In this scenario, the most important cost component is the pipeline capital cost. Therefore, the overall costs depend both on the hydrogen flow rates and distance (Yang & Odgen, 2007).

One of the options for delivery of hydrogen, beside pipeline delivery, is also on-site production of hydrogen at airport. Because of the reasons mentioned before, most likely, the steam reforming method for producing hydrogen would prevail (Marksel, et al., 2019). There are some studies that consider the onsite production of hydrogen by using electrolyse in the future, as the case of Los Angeles airport (Amy & Kunycky, 2019) for short (i.e. 380 km) and long-haul (i.e. 3,985 km) flights. The theoretical study concluded that the cost of on-site production of hydrogen would result in twice higher fuel cost (i.e. hydrogen), if compared to existing jet fuel (i.e. kerosene).

Hydrogen can be stored as gas inside underground caverns, as a compressed supercritical fluid, as a liquid in a cryogenic tank, in materials based on H_2, as a slush hydrogen (solid state) in cryogenic tanks as cold-compressed or cryo-compressed hydrogen. Storage of gaseous hydrogen typically employs high-pressure spherical or cylindrical tanks with pressure ratings as high as 30 MPa, but low-pressure spherical tanks with large diameters are also used. Liquid hydrogen storage vessels are low pressure but have high capital costs because of the insulation required to prevent boil-off. Small vessels can be quite expensive, the economy of scale savings are not significant except with extra-large volumes (Howden, 2019).

3.3 Assesment of ground infrastructure for refuling fuell-cell aicraft with liquid hydrogen

Due to its low density, hydrogen, as a gas, has at normal temperature and pressure, large volume. Therefore, it is unpractical for storage and transportation purposes. Hydrogen is usually used in a compressed or liquefied form. Hydrogen liquefies at temperatures lower than 20 K. Most often used liquefaction methods are Linde's cycle or Claude's cycle. If hydrogen is liquefied too quickly, after liquefaction, transition from ortho- to para-hydrogen will cause considerable release of energy and consequential boil-off. Therefore, special catalysers are used to fasten the ortho- to para-hydrogen conversion and liquefaction (Timmerhaus & Mendelssohn, 2007).

All aircraft are not going to change to liquid hydrogen (LH_2) overnight, therefore must airport, during the transition period, be able to handle both LH_2 as well as kerosene aircraft. Most large airports have onsite kerosene fuel storage tanks. Similar tanks will need to be built to store LH_2, below 25 K (e.g. kelvin). The easiest solution would be to subsequently deliver the fuel to the aircraft via a well-insulated refuelling truck. Special care must also be taken for airport vehicles servicing LH_2 powered aircraft (Van Zon, 2018).

Hydrogen refueling point which are defined with standard ISO/PASS 15594 outlines various services that the airport should enable for fueling of fuel cell hybrid aircraft, such as:

- Normal refueling during aircrafts' turnaround between two flights (a cold system fueling).
- De-fueling due to planned maintenance activities and troubleshooting.
- First refueling of new aircraft or refueling an aircraft after maintenance and troubleshooting (warm system refueling).
- Boil-off management due to overnight parking, long-time overhauls, or failure cases.

For minimal requirements, hydrogen can be pursued from hydrogen production facilities and transported to the airport. In this case, no stationary storage of the fuel at airport is needed or recommended – fuelling should take place directly from movable storage, in which hydrogen was transported to the airport (e.g. truck). At the aircraft interface refuelling point, the temperature of the liquid hydrogen should be 20 K or lower. The pressure should be higher than 700 kPa to achieve acceptable fuelling times (20 min). A refuelling coupling unit for a small aircraft, defined as Type I in ISO/PASS 15594, can be manual and must include a refuelling hose, a refuelling connector, and safety monitoring equipment. A refuelling connector, together with the attached part of refuelling hose, cannot exceed 10 kg (or preferably 7 kg). Connector should have a diameter of 30 mm to meet the requirements of the connectors used for road vehicles. A system should include a filter for filtering particles larger than 5 micrometres. Filter should be detachable and cleanable. The safety equipment should include also monitoring equipment powered by batteries that would measure pressure, temperature, flow rate, filling level of the tank, hydrogen leak, valve position and a transportable detector of hydrogen concentration and heat.

In our case study, the liquid form of hydrogen was considered, because it enables a lower load weight of aircraft, better aerodynamics, and lower consumption in comparison to compressed gaseous hydrogen. Since hydrogen fuel cell aircraft with 19- and 70-seats are not yet available on the market (i.e for an accurate calculation we would need aircraft shape and tank size), the feasible assumption of the potential aircraft fuel consumption was assessed, assuming that their energy consumption is similar or slightly lower than the consumption of the conventional aircraft. Although hydrogen burned in fuel cells has a better energy efficiency than kerosene in conventional combustion engine, the overall fuel consumption of hydrogen fuel-cell aircraft increases due to the higher weight of the aircraft (e.g. larger aircraft surfaces and tanks). Therefore, we shall consider, for our estimation that the energy consumption level of fuel-cell hydrogen aircraft is similar to conventional one. Based on these assumptions, we can conclude that a 19-seat aircraft would need approximately 200 kg of hydrogen for a flight over 500 km, while a 70-seat aircraft would need approximately 700 kg of hydrogen for the same range (Marksel, et al., 2019).

According to average number of flights (Table) and assuming that 96 % of airports operating with 19-seater aircraft and 50 % of airports operating with 70-seater aircraft would need less than 1 ton of hydrogen per day. The busiest airport in Europe with flights operated by 19-seater and 70-seater aircraft (i.e. Tromsø airport) would need around 44 tons of hydrogen per day. In our case, because of relatively small quantities of liquid hydrogen required, delivery by a cryogenic truck is preferable scenario for supplying hydrogen to airports as on-site production and liquification which should take place at the airport. Additional reason for liquid hydrogen is the fact that compared to pressure gas vessels, a higher amount of hydrogen can be carried out with a LH_2 trailer, as the density of liquid hydrogen is higher than that of gaseous hydrogen. Over longer distances it is usually more cost-effective to transport hydrogen in a liquid form, since a liquid hydrogen tank can substantially hold more hydrogen than a pressurized gas tank. Hydrogen is loaded into insulated cryogenic tanks for transportation of liquid hydrogen. LH_2 trailers have a range of approximately 4 000 km. Although there are some down back of transportation of the liquid hydrogen. During the transport of the hydrogen to its destination, the cryogenic hydrogen heats up, causing the pressure in the container to rise. However, if considering the financial part, the cost of liquid tank truck delivery is still much lower as in case of tube trailer (i.e. about 10 % of the tube trailer delivery) (Dillich, 2012). Therefore, as a main mode of delivery in case of small quantities of liquid hydrogen necessary for fuel-cell hydrogen aircraft, the delivery by cryogenic truck and direct fueling from truck would prevail.

4 FINAL REMARKS

In the coming years it is expected that a wide range of hybrid-electric aircraft from single-seater ultralights, micro-feeder aircraft to regional airliners will be entering into existing air transport markets., New markets for commercial flights are expected to emerge too. As hybrid propulsion technologies are novel, several aspects of technical, as well as, economic assessment of the ground infrastructure needed for their operation is still largely unexplored. There is no doubt that ground infrastructure at airports will have to be adopted for the operation of ICE-hybrid and fuel-cell hybrid aircraft.

Sufficient number and capacity of charging stations supported by adequate power network will need to be available at the airports for multiple fast charging of ICE-hybrid aircraft airports. Depending on to the average daily flights and charging times, a single AC three-phase station with a capacity of 43 kW, would be sufficient at the most of airports to meet the needs for recharging the 19-seat ICE-hybrid aircraft. At 66% of airports a single 43 kw, AC station would be sufficient to charge 70-seat ICE-hybrid aircraft. Majority of airports, a 120-kW DC charging station would require charging 70-seat ICE-hybrid aircraft. At the busiest airport Tromsø in Norway with more than 9 flights per day with 9-20 seat aircraft and almost 60-flights per day with 21-70 seat aircraft (OAG, 2017), up to 8 DC charging stations with 120 kW capacity or three times as many AC charging stations with 43 kW capacity would be required to ensure multiple fast charging.

In the case of fuel cell hybrid aircraft, the main challenge will be in the field of hydrogen supply. One option for required bigger quantities is local production, the other is establishment of reliable hydrogen delivery (transport) system. While the technology for electric charging of ground vehicles is already developed in automotive industry and largely transferable to ICE-hybrid aircraft, the technology for fuel cell hydrogen aircraft is relatively immature, resulting in high initial investments. The level of investment required in airport infrastructure varies greatly between ICE-hybrid and fuel cell hybrid aircraft. Several airport adoptions and modifications will be necessary to provide airports with necessary amounts of hydrogen. There are many open questions about hydrogen production, transport, liquefaction or compression, storage, and refueling point/station at airports. The latter will have to meet several legal and technical requirements due to flammability of hydrogen to achieve the required level of safety. Regarding the hydrogen delivery scenarios, it can be concluded that delivery of a compressed gas by truck is an optimal solution for short distances and small quantities of hydrogen. Delivery by a cryogenic truck is optimal for long distances and low hydrogen flow rates, while delivery by pipeline is optimal for high hydrogen flow rates and long distances. The case study revealed that less than 1 ton of liquid hydrogen per day would be required at 96% of airports with 19-seat aircraft and 50% of airports with 70-seat aircraft, provided the existing frequency of daily flights and average estimated aircraft hydrogen consumption is taken into account. The busiest airport, Tromsø, would need about 44 tons of hydrogen per day. Accordingly, due to high cost of liquefaction in case on-site production, which is economically justifiable only in case of high quantities of needed hydrogen, in our case where the quantities are relatively small, delivery by cryogenic truck has proven to be the preferred option for delivering liquid hydrogen to the airport.

In summary, although the study was limited to the smaller aircraft (i.e. aircraft with 19- and 70-seats), hybrid technology and in particular hydrogen is much more suited for use in larger aircraft (i.e. aircraft with 200 or more seats). As hydrogen technology will evolve over the coming decades, its application to larger aircraft will be technologically and economically more feasible, so there is no doubt that such studies will need to be extend also to the large aircraft segment.

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RELATIONS BETWEEN ENVIRONMENTAL, SOCIAL AND ECONOMIC VARIABLES OF THE NAUTICAL PORT SYSTEM: A CROATIAN CASE

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ABSTRACT

This paper investigates relationships between environmental, social, and economic dimensions mapped as sustainability input variables in the recreational boating industry, on the example of the Croatian Nautical Port System (CNPS). All three dimensions can be presented as the following sets: the usage of natural resources, employment, income, and nautical demand. Nowadays, in a dynamic organizational environment, to make a decision, it is important to consider and integrate as many variables as possible, which fall into the categories mentioned above. The paper proposes the model-based analysis with a correlation matrix to determine a minimal number of input variables. The results show strong hidden relations between the input variables from the different dimensions. Consequently, the optimal number of input variables is less than then the number of the dimensions.

Keywords: nautical ports; economic performance; sustainability dimensions; correlation matrix.

1 INTRODUCTION

Nautical port and recreational boating create jobs, encourage small business, economic growth, and social welfare in the coastal and island areas of tourism and maritime oriented countries. As a part of nautical tourism, the sector plays a vital role in Croatian tourism and maritime affair [1-7].

The importance of nautical tourism in the maritime economy, as a subsector of coastal and maritime tourism, is recognized in numerous strategic documents and policies [8-11].

There is no single definition of nautical tourism in the available literature [5, 12, 13], and various terms are used to describe its content (e.g., marine tourism, maritime tourism). In a broader sense, nautical tourism can be associated with the term maritime tourism, which is primarily considered as water-based tourism (e.g., recreational boating/boating, yachting, sailing, cruising, and nautical sports). Maritime tourism includes the waterfront operations and landside facilities (e.g., marinas and other tourist harbors), manufacturing of equipment (e.g., small craft harbors), and other services necessary for this segment of tourism. [8]. In a narrower sense, the term nautical tourism is often used as a synonym for recreational boating (i.e., boating, sailing, yachting, and motor yachting), as its vital sub-segment. Marušić et al. [12] consider yachting as one of the two major nautical tourism activities that relate to navigation and stay on recreational vessels.

Nautical tourism generates annual revenues of between €20 and €28 billion per year and employing between 200,000 and 234,000 people [9] The services sector, which includes nautical port activities, accounts for around half of this value. Although recreational boating is a growing sector, its true potential to contribute to the maritime economy is still not sufficiently activated [4, 7, 8-11].

Nautical ports are specialized in providing basic and additional services to the boat owners, crew, and other maritime tourists [7]. In Croatia, nautical ports are divided into four categories: an anchorage, mooring, land marina, and marina [14-16]. According to the Croatian Bureau of Statistics [14], in 2018, there were 142 nautical ports on the Croatian coast, of which 72 were marinas and 70 other ports.

Many economic, social, and environmental issues affecting the recreational boating sector and nautical tourism have been identified [1-3, 8-11, 13]. The main strategic objectives concerning sustainable growth and overall competitiveness of the sector include environmental protection, skills development related to job creation, fluctuation in demand, demographic changes, business climate and investments, and more.

Understanding the problem of sustainability in nautical tourism, and analyzing different dimensions of the problem requires a systematic scientific approach. Academics' interest in recreational boating and nautical tourism has grown over the years [4, 13]. Also, activities related to nautical ports and recreational boating are continuously growing, creating numerous economic, social, environmental effects [4-6, 13, 17]. Consequently, there is a growing number of studies, policies, and strategic plans related to the sustainability issue [1-3, 8-11]. These documents emphasize the requirements for creating analytical frameworks and models focused on sustainability issues to foster sustainable economic growth and competitiveness of the sector [1-3].

It is evident from the literature a lack of sustainability indicators (SI) for the recreational boating/yachting industry [17]. Therefore, this paper investigates a set of input variables related to nautical port's performance as sustainability indicators of the system. The input variables will be classified into three dimensions: environmental, social, and economic.

On the example of the Croatian Nautical Port System (CNPS), the following input variables will be analyzed: Water Surface Area (WSA), Number of Employees (NoE), Vessels in Transit (ViT), and Total Income (TI).

Natural resources significantly contribute to the development of nautical ports and form the basis of their attractiveness. The water surface area (WSA) as the input variable presents an environmental aspect of CNPS sustainability in this research. The variable refers to the sea area of a nautical port, including piers [14-16]. According to the Croatian Bureau of Statistics [16], CNPS used a total of 4075400 m2 of water surface area (WSA) in 2018.

Recreational boating is a natural resource-intensive industry, and at the same time, it depends on a healthy marine environment and the sustainable use of natural resources [10]. Ecological preservation and attractive marine environment are the basis of sustainability and competitiveness of the Croatian nautical tourism. The Croatian nautical port operations and recreational boating activities are overgrowing and thus generating a significant impact on the marine environment.

Some of the sector's adverse effects may include the over-construction of waterfront facilities, and increased risks of soil sealing and biodiversity degradation, harmful impacts of reinforced plastic used in the manufacturing industry, the problem of end-of-use plastic boat storage and recycling, a vast increase in water demand, wastewater spillover, and solid waste disposal, and other negative impacts (e.g., generation of waves, noise). [8-11, 18] Excessive use and contamination of natural resources can consequently jeopardize the survival of companies operating in nautical tourism, as they are highly dependent on the environment [13]. It has to be stressed that many nautical ports in Croatia integrate sustainability issues in their strategies, policies, and operations.

Recreational boating and nautical tourism is a dynamic sector with relatively large potential for growth and job creation [4, 7, 11]. The number of employees (NoE) as the input variable presents a social aspect of CNPS sustainability in this research. In addition to direct employment, this sector supports the additional engagement of the local population in the various tourism-related services (e.g., transport, sport, recreation, and wellness, accommodation, trade, etc.). Besides, recreational boating activities provide many social benefits to society like relaxation, exercise, and experience of nature [11]. The social benefits of this sector also include the transfer of information, knowledge, culture, and lifestyle [4].

The level of nautical demand should be well blended with the usage of the natural resource available to maximize the potential economic gains and mid-term and long-term sustainability of the sector [10]. The high level of nautical demand poses challenges to environmental sustainability, which can deteriorate the quality of the offered services and experience, and therefore affect the potential attraction of new visitors [10]. Recreational boating demand fluctuates significantly due to the continuous changing of the environment (economic, social, political). It has to be highlighted that seasonal oscillations in recreational boating demand are one of the critical factors of the sector's sustainability [7].

Vessels in transit (ViT) along with total income (TI), as the input variables, present an economic aspect of the CNPS sustainability in this research. Vessels for entertainment, sport, and recreation are classified as motor yachts, sailboats, and other vessels. [14-16] Expenditures on berthing services in nautical ports, as well as spendings on renting/leasing of vessels and related transport services, are particularly important in the yachting tourists' expenditures [12]. CNP provides a wide range of services and amenities and often achieves a higher rate of return on equity (ROE), compared to other tourism systems. Jugović et al. [4] point out that the Croatian nautical port system (CNPS) is changing rapidly and requires constant monitoring and research. Furthermore, environmental, social, and economic performance must be taken into consideration [13, 17].

2 RESEARCH METHODOLOGY

This research paper aims to select the data from different aspects of business operations and performance of the CNPS. Also, it is necessary to optimally determine the number of input variables for analyzing organizational performance. The proposed analytical framework enables the selection and minimization of the number of input variables (i.e., reduction of input space). The paper focuses on the variables that could present the three different dimensions of CNPS sustainability. Therefore, the following hypotheses could be stated:

H1: There are relationships between input variables presenting the three different dimensions of CNPS sustainability.

H2: There are hidden relationships between variables presenting the three different dimensions of CNPS sustainability.

Furthermore, the main research question of this paper is: "Is it possible to determine the optimal number of variables that will present the input variables of the CNPS analysis." To answer the previously mentioned question, the main research goals of the paper are: i) To investigate the relations between the selected variables, presenting different aspects of the nautical port system sustainability in this research; ii) To identify hidden possible relations between the investigated variables, iii)

To minimize the number of the input variables (i.e., a reduction of the input space).

Figure 1 shows hypothesized correlations between the three dimensions of the observed system sustainability, i.e., input space.

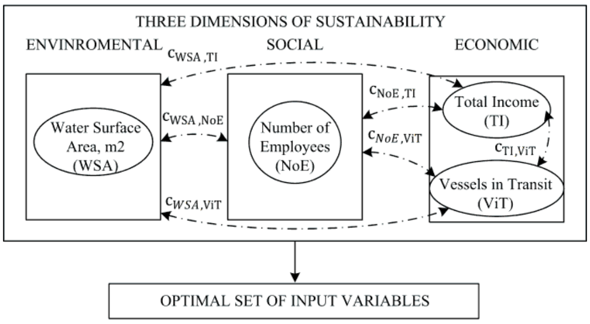

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Figure 1: Relationships between the three sustainability dimensions

The variable water surface area (WSA) is classified as an environmental dimension, the variable number of employees (NoE) as a social dimension, and the variables vessels in transit (ViT), and total income (TI) are both classified as an economic dimension (Figure 1). The input variables are observed in the period from 2008 to 2018. Correlations between the sustainability dimensions and variables are depicted with dotted lines.

The following section presents the mathematical foundations used in the paper, together with their associated references. The following random variables $X_{env}, X_{soc}, X_{ecn}$ in the vector notation:

$$\begin{aligned} X_{env} &= [x_{env1}, x_{env2}, \cdots, x_{envi}] \\ X_{soc} &= [x_{soc1}, x_{soc2}, \cdots, x_{soci}] \\ X_{ecn} &= [x_{ecn1}, x_{ecn2}, \cdots, x_{ecni}] \end{aligned} \tag{1}$$

represent environmental, social, and economic dimensions with 11 data samples obtained from 2008 to 2018.

Standard statistical metrics such as expectation or the average value, standard deviation, and correlation coefficient are used to study the random variables. The average value of the random variable x or the expectation can be represented by equation [19]:

$$E[x] = \bar{x} = \frac{1}{N} \cdot \sum_{i=1}^{11} x_i = \frac{1}{N}(X \cdot X^T) \tag{2}$$

where $E[x]$ represents the expectation of a random variable x, and N is the number of measured samples. The standard deviation of the random variable x can be represented by equation [19]:

$$\sigma_{\bar{X}} = \sqrt{\frac{1}{N-1} \cdot \sum_{i=1}^{11} (x_i - \bar{x})^2} = \sqrt{E[x^2] - E[x]^2} \tag{3}$$

where σ_x represents the standard deviation of the random variable x. The transformation of coordinates from one coordinate system to another is shown by equation [19]:

$$\begin{aligned} x_p^* &= \frac{(x_{ip} - \overline{x_p})}{\sigma_{xp}} = \frac{1}{\sigma_{xp}} \cdot \left(\left(X_{ip} - \overline{X_p} \right) \cdot \left(X_{ip} - \overline{X_p} \right)^T \right) \\ x_v^* &= \frac{(x_{iv} - \overline{x_v})}{\sigma_{xv}} = \frac{1}{\sigma_{xv}} \cdot \left((X_{iv} - \overline{X_v}) \cdot (X_{iv} - \overline{X_v})^T \right) \end{aligned} \tag{4}$$

where x_p* i x_v* are transformed coordinates of random variables x_p and x_v.

The statistical metric used to quantify the similarity and/or dependence among variables, x_p, and x_v, is the correlation coefficient between random variables. The correlation coefficient can be calculated from the following equation [19]:

$$r = \frac{1}{N-1} \cdot \frac{\sum_{i=1}^{11} (x_{ip} - \overline{x_p}) \cdot (x_{iv} - \overline{x_v})}{\sigma_{xp} \cdot \sigma_{xv}} \tag{5}$$

where r represents the correlation coefficient, N- is the number of measurements, while σ_{xp} and σ_{xv} represent the standard deviations of the random variables x_p and x_v. Furthermore, a model matrix A can be created using the following equation:

$$A = \begin{bmatrix} X_{env} \\ X_{soc} \\ X_{ecn} \end{bmatrix} = \begin{bmatrix} x_{env1} & \cdots & x_{env11} \\ x_{soc1} & \cdots & x_{soc11} \\ x_{ecn1} & \cdots & x_{ecn11} \end{bmatrix}_{(3x11)} \tag{6}$$

where $X_{env}, X_{soc}, X_{ecn}$ are vectors of the random variables. The following equation defines the correlation matrix C_A [20]:

$$C_A = \frac{1}{N-1} \cdot (A \cdot A^T) \tag{7}$$

Using (1), (6), and (7) the correlation matrix C_A is defined as follows:

$$C_A = \begin{bmatrix} c_{xenv,xenv} & c_{xenv,xsoc} & c_{xenv,xecn} \\ c_{xsoc,xenv} & c_{xsoc,xsoc} & c_{xsoc,xecn} \\ c_{xecn,xenv} & c_{xecn,xsoc} & c_{xecn,xecn} \end{bmatrix} \tag{8}$$

The correlation matrix, C_A, shows the correlations between the observed variables.

Presented statistical measures would give an insight into relationships between the input variables.

3 RESULTS AND DISCUSSION

Data were collected from the Croatian Bureau of Statistics (CBS), referring to the capacity and turnover of nautical ports (i.e., marina, anchorage, land marina, mooring) [14-16]. Table 1 shows data of the CNPS from 2008 to 2018 of the following four variables: water surface area (WSA), number of employees (NoE), number of vessels in transit (ViT), and total income (TI) along with the statistical measures of a mean, standard deviation.

Table 1: Statistical data of the CNPS variables

Year	Water surface area (m^2)	No. of employees	No. of vessels in transit	Total income (EUR)
	WSA	NoE	ViT	TI
2008	3387879	1283	217024	65509
2009	3293558	1319	204137	72450
2010	3313110	1327	206028	76548
2011	3293891	1328	188457	80030
2012	3266746	1347	181628	87999
2013	3278064	1387	182921	91555
2014	3322650	1516	181322	95541
2015	3614784	1586	193450	100455
2016	3764124	1686	198151	102525
2017	3711951	1665	201896	114022
2018	4075400	1741	194164	114207
MEAN	3483832	1471	195380	90986
STD	269032	171	11418	16260

Source: [14-16]

Furthermore, it is necessary to perform the transformation of WSA, NoE, ViT, and TI, using statistical measures, such as average and standard deviation in (4), to compare the investigated variables (Figure 2).

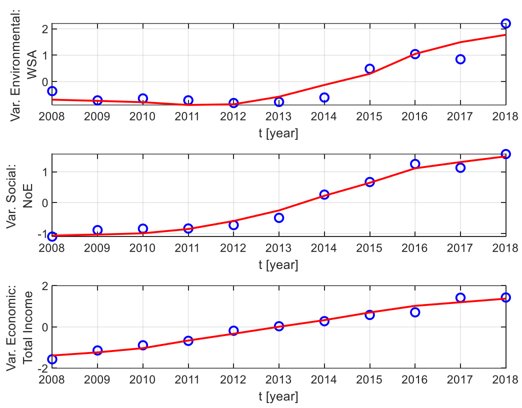

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Figure 2: Graphical presentation of transformed variables (WSA, NoE, and TI)

Figure 2 shows three graphical presentations of the analyzed variables in CNPS. Blue circles present transformed data, and the red line shows the trend in the observed period, from 2008 to 2018. The trend is performed by using a moving average algorithm (MA) with a window width of 5. The first graph (Figure 2) shows that WSA has a constant trend from 2008 to 2012, and a linear rise in trend from 2013 to 2018. The second graph shows a continuous increase in the trend of the NoE, from 2008 to 2018. The last graph shows a steady rise in the variable TI over the observed period. The trend analysis of WSA, NoE, and TI (Figure 2) shows that from 2008 to 2012, there was no change (constant) in WSA, whereas from 2013 to 2018, there is the growth of the variable. At the same time, the trends of NoE and TI show a constant rise over the observed period. A correlation matrix is necessary to determine the relationship between the variables (9).

$$C_{WSA,NoE,TI} = \begin{bmatrix} 1 & 0.9595 & 0.8952 \\ 0.9595 & 1 & 0.9814 \\ 0.8952 & 0.9814 & 1 \end{bmatrix} \quad (9)$$

Equation 9 shows a full correlation matrix obtained from (6), (7), and (8) on WSA, NoE, and TI. On the main diagonal, there are autocorrelations of the three variables. Lower and upper diagonal coefficients are mirrored, henceforth they have the same values. Correlation coefficients from (9) are presented in Figure 3.

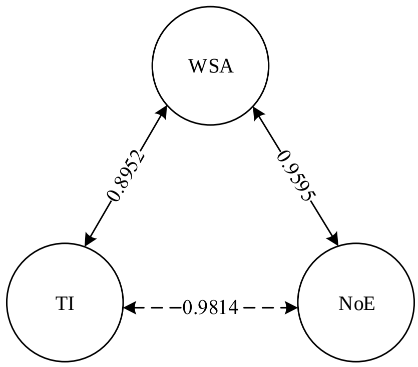

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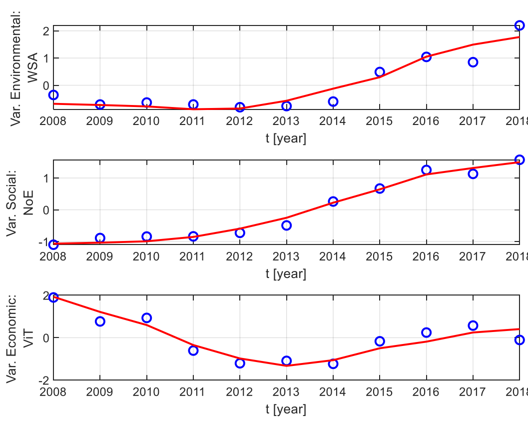
Figure 3: Correlations between the WSA, NoE, and TI

Figure 3 shows correlation coefficients between the three investigated variables. It can be seen that the variable WSA is strongly correlated with NoE (0.9595), and with TI (0.8952). Also, the correlation between NoE and TI variables is 0.9814, which is almost perfect 1. It can be concluded that high correlation leads to the conclusion that all three variables are dependent.

The results show high correlations between WSA, NoE, and TI, and it is necessary to perform analysis on another variable. Therefore, the TI is substituted with the variable ViT. In this paper, TI and ViT are both perceived as economic variables.



Source: Author

Figure 4: Graphical presentation of WSA, NoE, and ViT

Figure 4 shows the graphical presentation of the water surface area (WSA), the number of employees (NoE), and the vessels in transit (ViT) variables in the CNPS. It can be seen that the first two graphs are the same as in Figure 2; therefore, they have the same explanation. The last graph shows changes in the variable ViT over the observed period. It can be seen that from 2008 to 2013, the trend in ViT is negative, and from 2013 to 2018, the trend is positive. It can be seen that trend in ViT is negative from 2008 to 2013, while it is positive from 2013 to 2018. A correlation matrix is necessary to determine the relationship between the variables (10).

$$C_{WSA,NoE,ViT} = \begin{bmatrix} 1 & 0.9595 & 0.0113 \\ 0.9595 & 1 & -0.2521 \\ 0.0113 & -0.2521 & 1 \end{bmatrix} \quad (10)$$

Equation 10 shows a full correlation matrix of the variables WSA, NoE, and ViT. Correlation coefficients from (10) are presented in Figure 5.

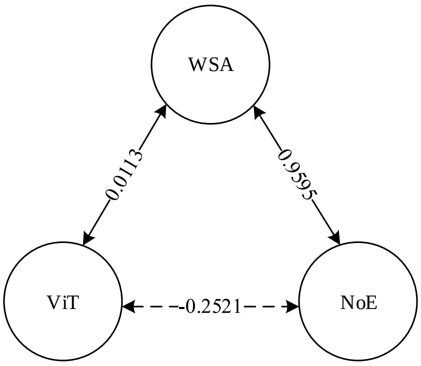


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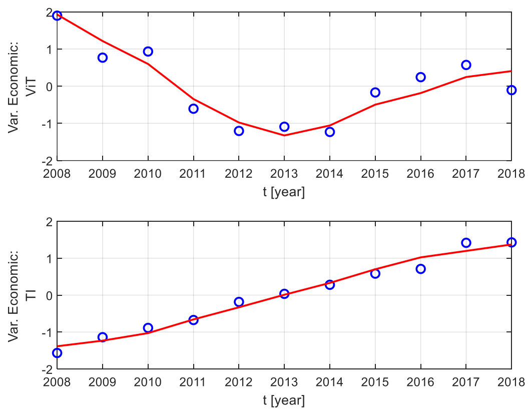
Figure 5: Correlations between WSA, NoE, and ViT

Figure 5 shows correlation coefficients between the three investigated variables. It can be seen that, as previously (Figure 3), the variable WSA is strongly correlated with NoE (0.9595), but variable ViT exhibits weak correlations with WSA (0.0113) and NoE (-0.2521). It can be concluded that variable ViT is independent in relation to WSA and NoE. Also, the variable TI is strongly correlated with WSA and NoE, and the variable ViT is not correlated with WSA and weakly correlated with NoE, it is necessary to investigate the relationship between the two economic variables ViT and TI (Figure 6).



Source: Author

Figure 6: Graphical presentation of the two economic variables

Figure 6 shows the graphical presentation of ViT and TI in the observed period. The correlation matrix in (11) determines the relationship between variables.

$$C_{ViT,TI} = \begin{bmatrix} 1 & -0.4278 \\ -0.4278 & 1 \end{bmatrix} \quad (11)$$

Equation 11 shows a full correlation matrix between the variables ViT and TI. It can be seen that they are weakly correlated. Therefore variable ViT and TI are recommended to be used as optimal input variables for analysis of the nautical port system and its sustainability.

Furthermore, statistical measures of growth rates of the observed variables are calculated (Table 2) to get a better insight into CNPS sustainability characteristics.

Table 2: Average growth rate of the CNPS variables

Year	Water surface area (m2)	No. of employees	No. of vessels in transit	Total income (EUR)
	WSA	NoE	ViT	TI
Mean	1.98	3.41	-1.08	6.94
Min	-2.78	-1.25	-8.53	0.16
Max	9.79	9.30	6.69	18.63
STD	4.07	3.14	4.27	5.22
VAR	16.56	9.84	18.23	27.28

Source: Authors

From Table 2, it can be seen that on average, variables WSA, NoE, and TI have a positive growth rate (1.98%, 3.41%, and 6.94%), whereas the ViT variable has a negative growth rate (-1.08%). From min and max growth rate values, it can be seen that the minimum growth rate per year for WSA is -2.78%, and the maximum growth rate per year is 9.79%. Variable NoE has -1.25% for the minimum growth rate per year and 9.30% for the maximum growth rate per year. As for the TI variable, it can be observed that the minimum growth rate per year was 0.16%, and the maximum growth rate per year was 18.63%. Of all the explained variables, only the TI has a positive growth rate over the observed period. The variable ViT has a -8.53% minimum growth rate per year and a 6.69% maximum growth rate per year.

Results show that both hypotheses (H1 and H2) are proofed, i.e., variables WSA, NoE, and TI, from all three dimensions of sustainability, have strong correlations. Furthermore, the variable ViT (from economic dimension) has weak correlations with all other variables (from environmental and social dimensions), so it must be included in the analytical framework as one of the optimal variables.

Also, the variables TI and ViT could be used as an optimal set of input variables because the variable TI has strong correlations with WSA and NoE. Next, from the results, the optimal set of variables could be formed from the following sets ViT and NoE (since NoE has strong correlations with WSA and TI), and ViT and WSA (since WSA strongly correlates with NoE and TI).

4 CONCLUSION

This paper investigates variables related to the capacity and operations of the Croatian Nautical Port System

(CNPS), i.e., water surface area (WSA), number of employees (NoE), vessels in transit (ViT), and total income (TI), to determine optimal number variables for analyzing different dimensions of the system sustainability.

The variable WSA is perceived as an environmental dimension, the variable NoE as the social dimension, whereas variables ViT and TI as the economic dimension. To test hypotheses, variables WSA, NoE, and TI are analyzed, and the results showed strong correlations between them. Therefore, by substituting the TI with the ViT, the results show that the variable ViT is weakly correlated with variables WSA and NoE. So, it is concluded that ViT is the independent variable concerning WSA and NoE. Finally, the analysis of ViT and TI shows the weak correlation between them. From a growth rate, it can be seen that the economic variable TI has a continuous rise in trend over the observed period, whereas the max and min values have considerably higher values comparing to other variables. The other variables have fluctuations over the observed period.

Furthermore, these results indicate that it is important to include additional variables into the more comprehensive sustainability analysis (due to hidden correlations between variables) for each of the three dimensions, which implies that further research of the Croatian nautical ports system is necessary.

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APPLICATION OF THE INDUCTION MACHINES ON THE SHIPS WITH DIESEL ELECTRIC PROPULSION

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ABSTRACT

Thanks to the developments in AC drive technology, nowadays, diesel electric propulsion has wider application. Furthermore, the power distribution with the mentioned propulsion is very complex and various. However, the central parts in any distribution network type are induction machines. This paper describes the application of induction machines on the ships with diesel electric propulsion. The review of induction machines, their application and position in distribution networks is commented. Therefore, this paper gives a good base for further research in the field of specific induction machine applications on the ships with diesel electric propulsion.

Keywords: induction machine, synchronous machine, power distribution

1 INTRODUCTION

A significant impact on ships electrification, which occurred in the 50s of the last century, was the transition to a three-phase electrical system. Since then electricity on ships has been used to power a huge amount of variety consumers where the most important are electrical motors. Electrical motors are used onboard ship for conversion from electrical to mechanical power and driving ship's electrical propulsion, bow thrusters, air conditioning (AC) compressors, pumps, fans, winches, lifts, etc. [1 − 3].

Cruise ships have employed diesel-electric propulsion systems to take advantage of the flexibility of diesel, as opposed to steam engines, and because the electric plant can also be used for hotel loads. Research vessels, ferries, tankers, and special purpose vessels have also taken advantage of increased flexibility and fuel efficiency with diesel electric propulsion [4]. The evolution of ship propulsion has brought greater use of diesel-electric technology to meet challenges of reliability, redundancy and increasingly stringent environmental standards [5].

Diesel electric drives takes less space than the equivalent direct drive two-stroke engines allowing the aft section of the ship to be slimmer and gives better flow over the propeller. Diesel electric drive train is lighter than a two-stroke engine and its weight can be distributed more evenly. There is no need for auxiliary generators for this type of propulsion.

More and more vessels are fitted with diesel electric propulsion plant that have succeeded in cruise ships, icebreakers, ferries, shuttle tankers, chemical carriers, research vessels, LNG tankers, etc. For offshore vessels this drive concept may be selected for flexibility. When the vessel has to be efficient under numerous operating conditions, propulsion is sometimes only one of several requirements, such in case of drill ships where the main propulsion system is used in transit, otherwise the power is split between dynamic positioning (DP) and deck power consumption for equipment. A special case are icebreakers where diesel electric propulsion in various forms is a favorite one since it meets the requirements for maximum output at very low speeds.

Power distribution network onboard ship with diesel electric propulsion is complex and consists of numerous switchboards and consumers on various voltage levels. High voltage network has ringed or radial configuration with synchronous generators connected on the supply side and huge high voltage consumers on the load side. Usually, high voltage consumers are synchronous machines such as main propulsion synchronous motors and induction motors, used to drive bow thruster and main air condition compressors. On the low voltage switchboards are connected to all engine auxiliary plants such as different pumps, air compressors, separators, evaporators, reverse osmosis plants, steam boilers, etc. All of them are driven by induction motors which are the biggest consumers of electrical power produced onboard [3, 4]. They have a wide application because of their simple construction and they are convenient for maintenance in the ship environment where they are running on high ambient temperatures and are exposed to different vibrations and movements of ship contraction. In this paper different applications of induction motors in engine auxiliary plants are presented.

This paper is organized as follows. Power distribution system on ships with diesel electric propulsion is complex and is explained in section number 2. Applications of induction motors onboard ships with examples are described in Section 3. Some basic characteristics of the ship's working environment and AC motors maintenance are given in Section 4. Section 5 gives concluding remarks.

2 POWER DISTRIBUTION SYSTEM ONBOARD

Shipboard power is generated using a prime mover and an alternator working together. As the most common power source onboard ships, synchronous generators are usually self-excited, compound, with automatic voltage regulation. Prime mover is diesel engine, but in some applications can be also steam or gas turbine. Synchronous generator and its prime mover, diesel engine (Wartsila 12V46C), in one ship installation are shown in Fig. 1 and Fig. 2 respectively. Rated power of generator is 12600kW and it is one of four to six gensets installed onboard.

Figure 1: Synchronous generator

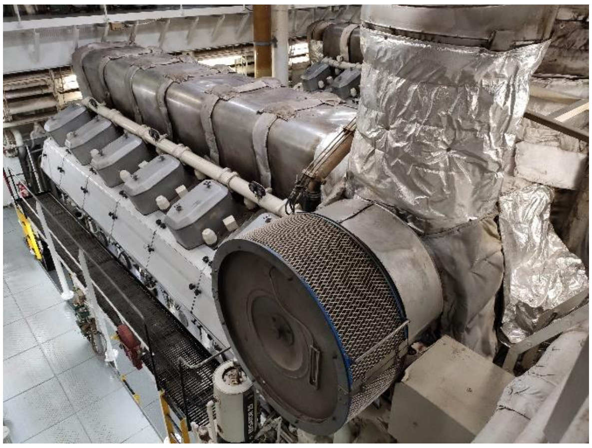

Figure 2: Diesel engine (prime mover)

Generators are connected to the main switchboard which is intended to distribute electrical energy to the variety of ship consumers. The main switchboard nominal high voltage levels are usually 11kV, 6.6kV, or 3.3kV and low voltage levels of 690V, 440V, 380V, 220V and 110V are obtained by use of power transformers. Main switchboard is usually distributed in two or three sections in order to obtain redundancy requirements of the vessel and they are physically separated and located in different rooms. In a two-split configuration (with equally shared generator capacity and load on both sides of main high voltage switchboard) in case that we have a failure in one part of the system, we will still have the availability of half generator and load capacity. In this operating mode one network including its connected propulsion units is lost if one switchboard fails but all equipment connected to the other one will be still powered and operable. During regular operation switchboards are normally connected between themselves. Part of the ships power distribution system is presented in Fig. 3.

In this case produced voltage has a level of 11kV in 60Hz alternating current network and it is presented one of three main switchboards with a part of the distribution system. High voltage main switchboard number 2 (HMS02) is supplied from three synchronous generators marked as G1, G2 and G3. Other ship's generators are connected to the other main switchboard which is connected with switchboard HMS02 into ring network because of redundancy and reliability of the electrical system. Each synchronous generator has the same characteristics, 17600kVA apparent power, nominal current of 924A, and three phase 11kV nominal voltage at 60Hz. Different high voltage electrical consumers are connected straight on the other side of main switchboard. As it is shown on Fig. 3. there are two bow thrusters (BT) motors with nominal power of 3000kW and two air conditioning (AC) compressors motors (induction motors) with nominal power of 1060kW each and nominal current of 65.5A. All other electrical equipment onboard is connected to a low voltage ships network supplied from main switchboard through step-down transformers, presented in Fig. 3. respectively, T1 and T2.

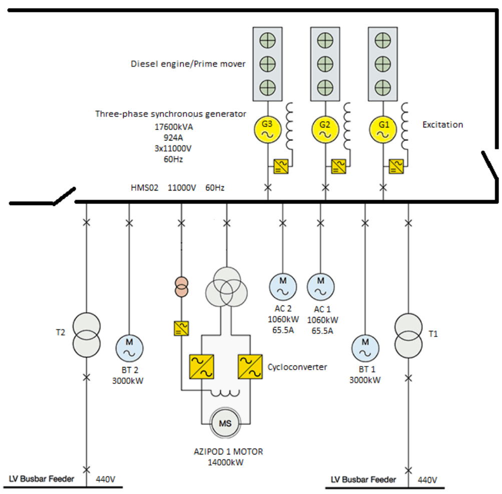

Figure 3: Partial drawing of ship power distribution system

High voltage fields from 06 to 11 of main switchboard HMS02 with generators connected on the supply side and different consumers on load side are presented in Fig. 4. For example, inside field number 7 is connected main generator number 3 (Diesel generator 3, DG3) and inside and from the front side panel are installed protection relay and different analogue meters (ammeter, voltmeter, frequency meter). Propulsion motor is supplied from fields 08 and 10, and its auxiliaries (cooling system, excitation, lubricating system, etc.) are supplied from the high voltage breaker in field 06. One step down transformer (11kv to 440V) is supplied from the field 11.

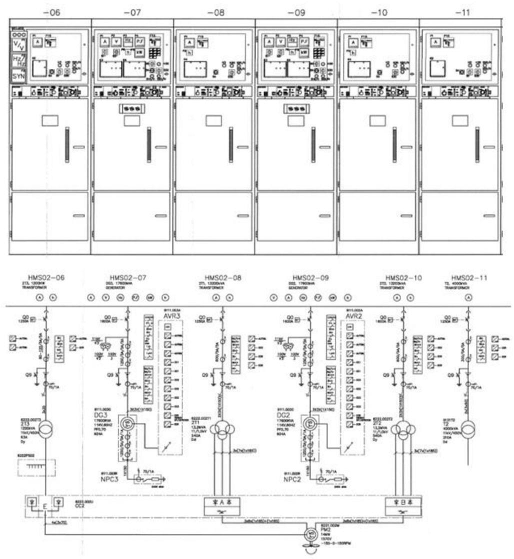

Figure 4: Main switchboard high voltage fields

The main propulsion motor connected to main switchboard HMS02, is marked as Azipod® number 1 [6]. Azipod® is a marine propulsion unit consisting of a fixed pitch propeller mounted on a steerable gondola ("pod") with the electric motor inside which is driving the propeller. Propulsion motor is synchronous motor with two stators, because of harmonics and redundancy, supplied through cycloconverter for fine speed and torque regulation and with excitation rectifier bridge. Instead of cycloconverter main propulsion synchronous motor can be fully controlled by synchroconverter, which is in common use in the newer systems. In this case propulsion motor has a power of 14MW and is supplied through moving set of round circle busbars with carbon brushes called slip rings because hole gondola rotates for 360°. One sample of gondola with main construction parts and synchronous motor is presented in Fig. 5 [4].

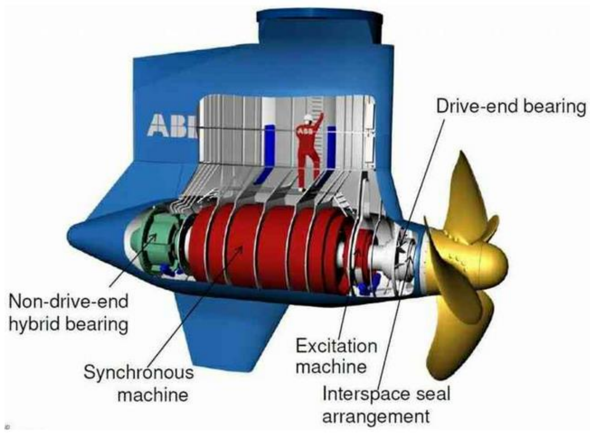

Figure 5: Azipod® gondola with synchronous motor inside [4]

3 APPLICATIONS OF INDUCTION MACHINES ONBOARD

An induction motor is the most common machine used for industrial drives and onboard ships due to its robust construction, relatively low cost and high-reliability factor in the sea environment. In isolated electrical network, such as marine and offshore power systems, induction motors are the most power-consuming loads and are used for different applications with various speed and load requirements, in continuous mode or intermittently, such as lifts, cranes, large capacity supply and exhaust fans, engine auxiliary pumps, engine room heavy load pumps (ballast, fire, freshwater, sea water cooling), winches, and other onboard applications. In some applications induction motors are direct-on-line switch-started, but in the new systems are usually controlled by variable frequency drives (VFD) for smooth speed control and soft start [7 −8].

Commonly used induction machines are three-phase squirrel cage induction motors that consume more than 70% of electricity produced on board. In use are also one phase squirrel cage induction motors for low power applications and slip ring induction motors.

In this section will be presented some of the most common induction motor onboard applications with different motor characteristics and work environments.

3.1 Applications of Single-phase Induction Motor Onboard

Single-phase induction motor is supplied with single phase alternating current power supply, which is carried in the main winding of the motor. They are used for supply voltage of 220V and for low power appliances up to 0.5kW because it is a more economical solution than same power three-phase induction motor. The main disadvantages compared to the three-phase induction motors are the lack of starting torque, less power for the same magnetic circuit and worse power factor.

Depends on starting arrangement, there are different types of single-phase induction motors. Onboard most common in use is a capacitor start induction motor. This single-phase induction motor employs a capacitor in the auxiliary winding circuit to produce a greater phase difference between the current in the main and the auxiliary windings. Also, capacitor is used for the purpose of starting.

Single-phase induction motors are mostly used in low power applications, usually to drive small centrifugal pumps, portable compressors, fans, drilling machines, etc. One example of application of capacitor start induction motor is shown on Fig. 6. In this case motor is used to drive attached centrifugal pump to discharge overflow water tank. Nominal motor data can be read from the nameplate and includes nominal voltage of 230V, nominal power of 0.28kW or 0.14kW at 40°C, nominal current of 1.35A and is constructed for 50Hz frequency network. Capacitor is installed inside motor connection box.

a)

b)

Figure 6: a) Start Capacitor single-phase motor onboard ship, b) Nameplate data

3.2 Applications of Three-phase Induction Motor Onboard

Three-phase induction motor is widely used onboard ships for heavier loads. There are two types of them used onboard, squirrel cage and slip ring motors. Squirrel cage motors are widely used on ships due to their rugged construction and simple design, and some of their applications are to power lifts, elevators, cranes, large capacity exhaust fans, engine auxiliary pumps, engine room supply and exhaust fan motors, engine room heavy load pumps (ballast, fire, freshwater, sea water cooling pumps, reverse osmosis and evaporator supply and high pressure pumps, etc.) [7].

Squirrel cage induction motors are in wide use because they are robust and simple in construction with very few moving parts, as they can efficiently operate in a rugged and harsh environment such as on seagoing vessels with much simpler and cheaper maintenance than DC or synchronous motors. This type of motor does not need any additional starting mechanism or arrangement as it can generate self-starting torque, unlike synchronous motors. They have a high starting current which causes a dip in voltage during the starting period. In order to solve this problem, there are in use different soft start techniques, but most common in practice are star-delta starter and variable frequency drive (VFD) for soft start and fine torque and speed control. Even this kind of motor does not have any moving part except rotor, regular maintenance should be done in order to keep it in proper working condition. Motor bearings condition, terminal connections and windings insulation should be checked on a regular basis. Further, a couple of different applications of induction motor onboard ship will be shown.

In Fig. 7 is shown fuel oil feed pump induction motor with connection drawing. This is a sample of low power three-phase induction motor onboard, with nominal power of 5.7kW and rated current of 10.2A. As it is shown on drawing, motor is connected to 440V, 60Hz power supply network through circuit breaker Q1 which has incorporated overload (bimetal) and over-current protection. Motor operation (start/stop) is controlled with electromagnetic relay K1.

Sea water cooling pump induction motor with connection drawing is presented in Fig. 8. This motor is sample of low voltage medium size three-phase induction motor onboard, with nominal power of 88kW and nominal current 142A. As it is shown on drawing, motor is connected to 440V, 60Hz power supply network through circuit breaker Q1 which has in this case incorporated over current protection. Motor operation (start/stop) and torque and speed control in this case is regulated with variable frequency drive (VFD). VFD is continuously monitoring motors parameters. Also, it has incorporated protections for power lines and motor. Therefore, it is a reason why in this case we do not have additional protections in supply circuit.

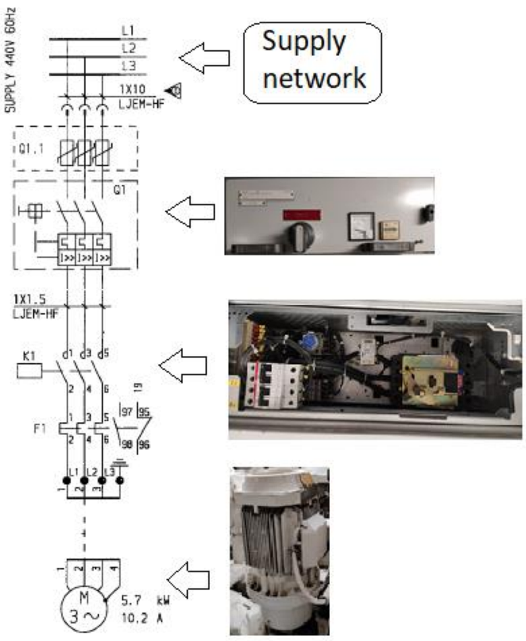

Figure 7: Fuel oil feed pump electrical motor

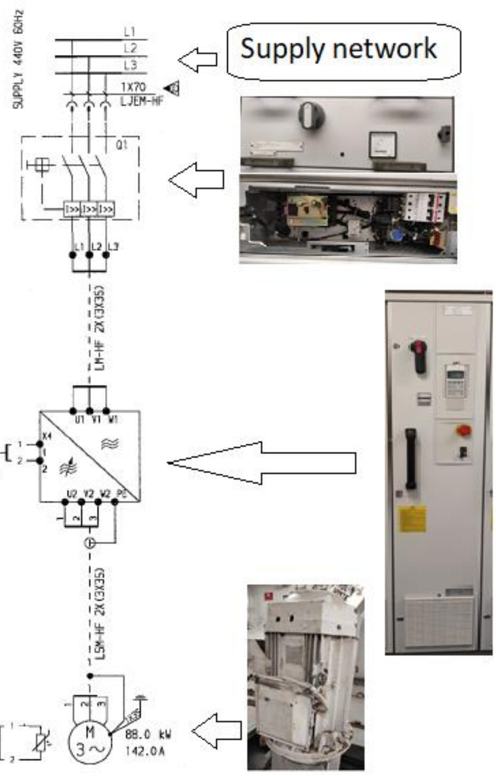

Figure 8: Sea water cooling pump electrical motor

3.3 Application of Slip Ring Induction Motors Onboard

This kind of electric motor is not in common use onboard ships as they require complex and regular maintenance. Here is presented the slip ring induction motor and its practical use for anchor and windlass winches. Fig. 9 shows parts of the disassembled motor.

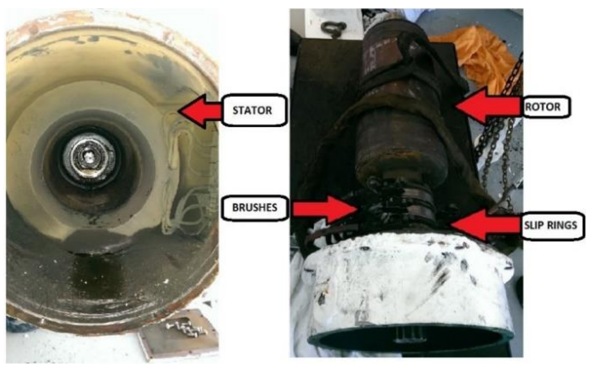

Figure 9: Slip ring induction motor, main parts

3.4 Applications of High Voltage Three-phase Induction Motors Onboard Ship

High voltage induction motors onboard are usually used to drive bow thrusters (BT) and air condition compressors as it was shown on drawing (Fig. 3). We can see from the drawing that nominal power of bow thruster electrical motor is 3000kW and air conditioning (AC) compressor is powered with 1060kW induction motor. In Fig. 10 is presented AC compressor with its induction motor and control panel which is used for cooling ship accommodation and hotel areas (on the cruise ship). Electrical motor data is: 1) Nominal power 1060kW; 2) Nominal voltage 11000V; 3) Nominal current 65.5A; 4) Frequency 60Hz; 5) Nominal speed 3575 r/min; 6) Power factor cosφ=0.89. Regular maintenance of this electrical motor includes general check once per year and consists of checking connections in motor connection box, motors winding resistance measurements and insulation test. This motor has a special kind of bearings that are submerged in the oil bath with constant temperature and vibration monitoring.

Figure 10: AC compressor unit

4 OPERATION ENVIRONMENT ONBOARD AND BASIC MAINTENANCE

Ships present unique operational environment for all electrical equipment, including electrical motors. The harsh environment of the sea may take a toll on the ships' machinery at an early stage if they are not properly maintained. The ambient temperature and the moisture content in the air at sea will affect the operational performance of the electrical motors inside main engine room which is not additionally cooled. While they are running, main engines have their own vibrating frequencies which are spreading to other equipment installed in their vicinity. If the electrical motor is exposed to high temperatures for a long time, in case that thermal protection does not exist, motor winding will burn out.

The surrounding environment of the electrical motors onboard is highly corrosive. The moisture present in the atmosphere or the water present in the lubrication grease will result with corrosion of the bearings, motor shaft and rotor. The insulation can also be affected by the corrosion and it can cause short circuit between the windings.

A wrong electrical motor installation, the loose foundation of the motor or misalignment with load may result with lower motor efficiency and can cause that motor will fail.

5 CONCLUSION

Ships present a unique operational environment for all electrical equipment. The induction motor is the most common electrical machine onboard with a wide spectrum of applications. Most of the systems onboard ships use squirrel cage induction motor as a drive and they are consuming more than 70% of the power produced onboard.

This paper gives a review of induction machines that can be found in ship electric systems. The induction machine specific application as well as its position in ship electric system is discussed. Also, some examples of ship distribution systems as well as operation environment onboard and basic maintenance are given, too.

In future work, the impact of the induction machine on the ship electric voltage sags will be analyzed.

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ARTIFICIAL NETWORK BOAT SEAKEEPING MODEL BASED ON FULL SCALE MEASUREMENTS

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ABSTRACT

Heave response of a boat is evaluated based on full scale seakeeping measurements. Vessel motions, position, speed and heading are recorded during sea trials in small-to-medium waves relative to the boat size. Motion data is collected by a navigation grade inertial motion sensor unit and the sea state is noted from a numerical wave model available for the test region. Small vessels are subject to non-linear response and, with sensor recordings delivering large quantities of motion data, artificial neural networks (ANN) are a proven tool to tool to map such behavior. The collected data is analyzed and a heave response prediction model is developed and optimized. The work presents preliminary communication of efforts to combine the disciplines of experimental seakeeping and artificial intelligence data analysis. The evaluation of ANN's capability and accuracy in predicting seakeeping response of a small vessel in moderate waves can be used to set directions for further investigation.

Keywords: seakeeping response, small boat, full scale measurements, artificial neural network

1 INTRODUCTION

Vessel design and optimization is traditionally approached by experimental model testing and calculation models. The former is limited to the appropriate facilities and the later grows in power and complexity along with growth in affordable computational power and development of simulation model in various ship design sub-disciplines. Numerical simulations gain a wider professional audience due to the practical fact that they are generally more attainable than experimental research facilities. In recent years, various measurement sensors are also becoming ever more attainable due to decrease in cost and data transfer possibilities. This has related to development of new engineering disciplines, such as big data, data science, machine learning and artificial intelligence. Sensor data in various fields is gathered in large databases, enabling validation of design, real-time monitoring of the overall system or its individual components and optimization of its parameters.

The work in the present study utilizes an inertial motion unit (IMU) sensor unit to record boat motion response in waves and to apply the data to: demonstrate an experimental seakeeping (boat response) measurement campaign; and to employ the acquired data to train a neural network model and provide a heave prediction model. The work presents preliminary communication of work started in fields of full-scale experimental seakeeping and artificial intelligence (AI) in data evaluation.

AI has already been tested for seakeeping problems. Zhao et al. [1] prediction surge, sway, heave, roll, pitch, yaw using Minor Component Analysis (MCA) predicting data 5-20 seconds and comparing performance to other AI models. De Masi et al. [2] verified the possibility to use RBF artificial neural network to predict heave signal response envelope. Li et al. [3] predicted heading, roll and pitch using NARX artificial neural network (ANN) based on past time series. Different learning strategies were tested and, comparing to other approaches, they argued that ANN comes superior to linear regression, support vector machine, extended Kalman filter, fuzzy logic and decision tree. In paper from Binglei et al. [4], a method for roll motion predication is proposed based on the extreme learning machine (ELM). Wen-yang et al. [5] presented a hybrid autoregressive (AR) - empirical model decomposition (EMD) - support vector regression (SVR) model for short-term nonlinear and non-stationary ship pitch and heave forecast. Gonzales et al. [6] used ANN to model ship roll and stated to achieve accurate predictions up to 10 seconds. Jain and Deo [7] bring an overview of neural networks application in ocean engineering predictive modeling and concluded they provide a better alternative to traditional computational schemes. It is also noted that ANN's could be used solely or in hybrid (input-output) combinations with statistical regression, genetic algorithms etc. Li et al. [8] used back-propagation neural network to predict roll motion based on ship roll, wind speed and direction time-series at sea state 4. Huang et al. [9] proposed a prediction approach for ocean vessel heave compensation based on echo state network (ESN). They have reported that ESN can be found in many applications for system identification and control.

From the review above, of artificial intelligence and machine learning models used to predict ship motion in waves, it is possible to conclude that it is a current topic with various models actively being tested and compared. This is especially important in the wider context of strategic research and development towards autonomous ships. Predictive ANN short term motion models have possible practical implementation in the fields of active vessel roll stabilization, heave compensation and dynamic positioning.

2 DATA AND METHODOLOGY

A sailboat is run in small-to-moderate size waves (compared to its size). Sea state is noted based on the numerical wave forecast available at the time and visual observations while the boat response in waves is recorded by a navigation grade IMU sensor. The collected data is analyzed and post-processed afterwards on-shore.

The boat was a Dufour 31 (Figure 1), a mastheaded sloop,

Figure 1: Sailboat used for measurements

Measuring:

LOA = 9.40 m	length-over-all
LWL = 7.01 m	waterline length
B = 3.20 m	beam
T = 1.73 m	draft
D = 4350 kg	displacement

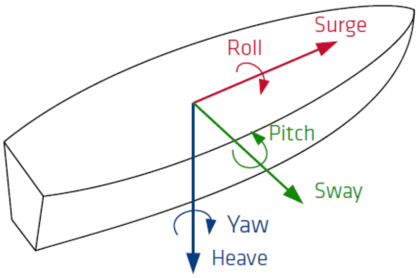

Figure 2: Boat motion convention

The measurement sensor was installed close to the boat center of floatation (CoF) in order to minimize vertical motion due to the lever while exhibiting pitching motion.

The motion sensor used is an SBG Ellipse 2N inertial measurement unit (IMU). The unit consists of three-axis gyroscopes, three-axis accelerometers, magnetometer and a GPS receiver. Running in real-time it applies a high frequency integrator (coning and sculling integrals) and an Extended Kalman Filter (EKF) to calculate ship motion (Figure 3). It provides accuracy within 0.1° for roll and pitch over 360°, 0.5° for heading (GNSS aided), 5 cm for real-time heave and 2 m GNSS Position (GPS, GALLILEO, GLONASS, BEIDOU are supported).

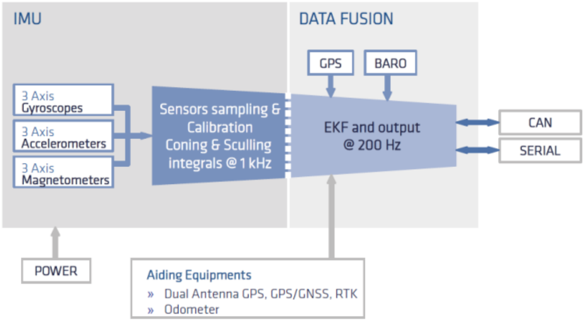

Figure 3: Sensor simplified block diagram

The analysis within its parameter was focused on heave (vertical translation) boat motion in waves (Figure 2).

Measurements were taken in the Adriatic Sea (close to Split, Croatia) on waves arriving from the south-east in circumstances of decaying wind (sirocco, jugo). Thus, the waves were a combination of wind-waves and swell. Significant wave height and period were noted based on available numerical forecast provided by company Gekom in high resolution for area of interest which is based on WWM-III (Wind Wave Model III), Figure 4 and Figure 5, and visual observation on-board.

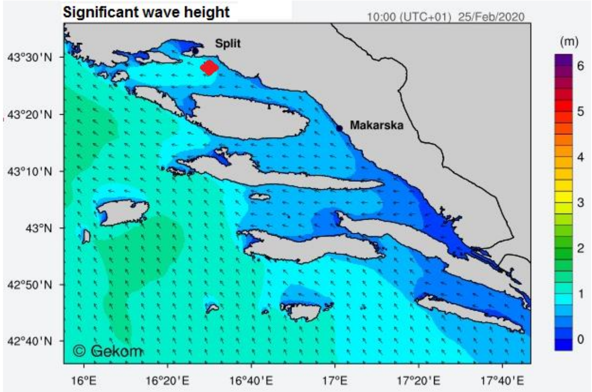

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Figure 4: Significant wave height numerical forecast; Red mark denotes measurement location

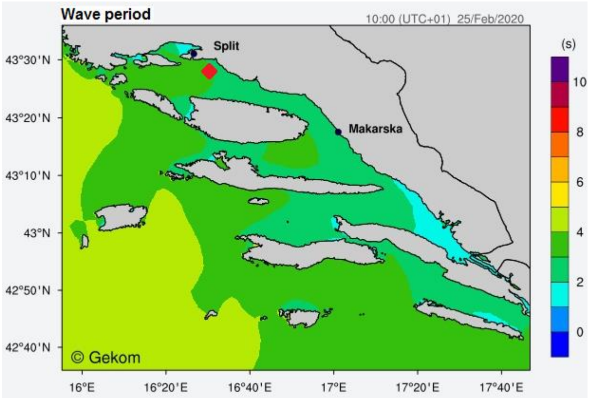

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Figure 5: Wave period numerical forecast; Red mark denoted measurement location

The boat was run with constant engine load and different heading relative to waves. The collected data where divided in five groups corresponding to the five courses of navigation, relative to the incoming waves, used in data acquisition process denoted with C1 to C5 in Figure 6.

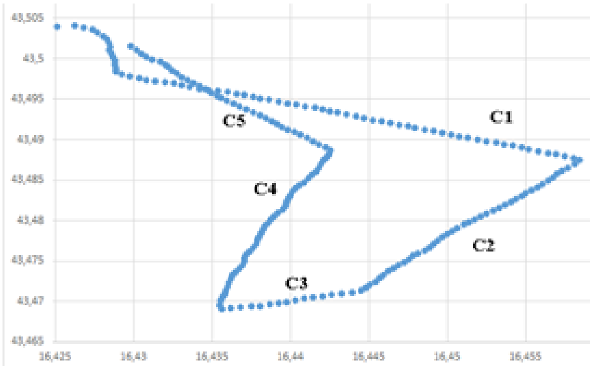

Figure 6: Boat navigation route for data acquisition

The total number of 8878 recordings of heave, roll, pitch, yaw, latitude and longitude were collected with frequency of 2 Hz, i.e. two values per second. Out of the total number of recorded heave data, 3577 values correspond to the C1, 1862 correspond to the C2, 519 correspond to the C3, 1801 correspond to the C4 and 861 correspond to the C5, while 258 values were faulty recorded and had to be removed from the data.

3 ARTIFICIAL NEURAL NETWORK - HEAVE PREDICTION MODEL

Multi-Layer Perceptron (MLP), Feed-forward (FF), artificial neural network (ANN) and Bayesian-regularization (BR) algorithm were used to form the model. In order to determine the time series neural heave prediction model, optimal number of hidden neurons, optimal number of time series elements at the input (number of input neurons) and prediction horizon have to be determined. The model has one output neuron that sums up the prediction of the model into the value of heave prediction.

Optimal number of inputs corresponds to the number of delays of the heave time series (d) and is determined through an experiment by varying "d" from 1 to 20, where the smallest number that provides the same quality of prediction is adopted as optimal.

One of the benefits of the BR algorithm is that it optimizes the number of network parameters while adjusting their values in order to reduce the error. If an adequate number of hidden neurons (h) is used, the algorithm should reduce the size of the network to the optimal value while optimizing the performance in terms of an error reduction. It is initially assumed that 50 hidden neurons should enable satisfactory model performance once the model is trained using the BR algorithm. To validate the assumption, the same was tested using the larger and smaller number of hidden neurons, and finally it is decided to use the number that provides the quality of performance as well as computational efficiency and that number is 50 neurons. The illustration of the MLPFF model using d = 4 and h = 50 is provided in Figure 7. Where, x(t) = h(t-1), h(t-2), … h(t-d) represents the input variable, heave time series, and y(t) = h(t+P) represents the output variable, heave prediction of P steps ahead.

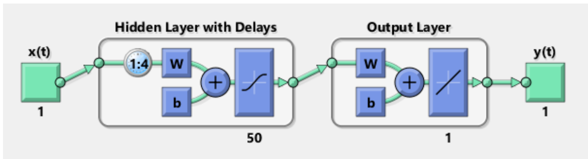

Figure 7: Neural model for heave prediction in Matlab

Model based experiment was conducted in order to determine an optimal prediction horizon (P). That has the meaning of number of steps ahead of the heave motion that can be predicted by the model.

4 RESULTS

In this paper course C1 heave prediction is presented. The model was created using 2497 points. In accordance to the algorithm used, 2497 points were additionally divided into three groups by the algorithm, and 1747 (70%) data points were used for calibrating the model, 375 (15%) data points were used for validation and the same amount was used for testing the model performances during the training process. After the model was trained, additional test was performed using the 1070 data points of the same navigation course (C1) to test the model in unknown circumstances, i.e. using the separate data set, not provided to the model during the training process.

In terms of quality, mean square error (MSE) and correlation coefficient (R) values are used to estimate model's performance, were satisfactory predictions were treated as those providing the R > 0,7. Numerical results are shown in Table 1. The model performances were also evaluated by the graphical representations of the model response in comparison to the actual events, as well as error plots, as shown in Figure 8 to Figure 11.

Table 1: Numerical results of the experiment

	Training		Test during calibration		Independent Test	
Model	MSE	R	MSE	R	MSE	R
I-O (t+2), d = 10, h = 100	$1{,}097 \cdot 10^{-3}$	0,903	$1{,}172 \cdot 10^{-3}$	0,881	$1.265 \cdot 10^{-3}$	0,884
I-O (t+1), d = 6, h = 50	$0{,}721 \cdot 10^{-3}$	0,938	$0{,}878 \cdot 10^{-3}$	0,908	$0{,}848 \cdot 10^{-3}$	0,924
I-O (t+1), d = 10, h = 50	$0{,}641 \cdot 10^{-3}$	0,942	$0{,}739 \cdot 10^{-3}$	0,973	$0{,}740 \cdot 10^{-3}$	0,934
I-O (t+1), d = 10, h = 100	$0{,}653 \cdot 10^{-3}$	0,942	$0{,}667 \cdot 10^{-3}$	0,942	$0{,}728 \cdot 10^{-3}$	0,935
I-O (t+2), d = 10, h = 50	$1{,}131 \cdot 10^{-3}$	0,896	$1{,}105 \cdot 10^{-3}$	0,908	$1{,}255 \cdot 10^{-3}$	0,885
I-O (t+3), d = 10, h = 50	$1{,}776 \cdot 10^{-3}$	0,835	$1{,}815 \cdot 10^{-3}$	0,817	$2{,}081 \cdot 10^{-3}$	0,801
I-O (t+4), d = 10, h = 50	$2{,}006 \cdot 10^{-3}$	0,813	$2{,}129 \cdot 10^{-3}$	0,776	$2{,}458 \cdot 10^{-3}$	0,761
I-O (t+4), d = 20, h = 50	$1{,}812 \cdot 10^{-3}$	0,827	$2{,}401 \cdot 10^{-3}$	0,784	$2{,}440 \cdot 10^{-3}$	0,764
I-O (t+4), d = 30, h = 50	$1{,}812 \cdot 10^{-3}$	0,828	$2{,}145 \cdot 10^{-3}$	0,805	$2{,}533 \cdot 10^{-3}$	0,757
I-O (t+4), d = 5, h = 50	$2{,}161 \cdot 10^{-3}$	0,795	$2{,}220 \cdot 10^{-3}$	0,771	$2{,}432 \cdot 10^{-3}$	0,762
I-O (t+4), d = 4, h = 50	$2{,}224 \cdot 10^{-3}$	0,782	$2{,}194 \cdot 10^{-3}$	0,807	$2{,}415 \cdot 10^{-3}$	0,763
I-O (t+4), d = 3, h = 50	$2{,}252 \cdot 10^{-3}$	0,783	$2{,}703 \cdot 10^{-3}$	0,731	$2{,}485 \cdot 10^{-3}$	0,755
I-O (t+4), d = 1, h = 50	$2{,}459 \cdot 10^{-3}$	0,761	$2{,}711 \cdot 10^{-3}$	0,718	$3{,}093 \cdot 10^{-3}$	0,690
I-O (t+4), d = 10, h = 100	$1{,}998 \cdot 10^{-3}$	0,810	$2{,}222 \cdot 10^{-3}$	0,787	$2{,}479 \cdot 10^{-3}$	0,758
I-O (t+4), d = 1+3, h = 50	$2{,}308 \cdot 10^{-3}$	0,776	$2{,}626 \cdot 10^{-3}$	0,743	$2{,}595 \cdot 10^{-3}$	0,744
I-O (t+5), d = 10, h = 50	$2{,}982 \cdot 10^{-3}$	0,701	$3{,}216 \cdot 10^{-3}$	0,646	$3{,}638 \cdot 10^{-3}$	0,616
I-O (t+5), d = 10, h = 100	$2{,}987 \cdot 10^{-3}$	0,688	$3{,}296 \cdot 10^{-3}$	0,708	$3{,}606 \cdot 10^{-3}$	0,618
I-O (t+5), d = 6, h = 50	$3{,}189 \cdot 10^{-3}$	0,673	$2{,}962 \cdot 10^{-3}$	0,695	$3{,}7 \cdot 10^{-3}$	0,605

Numerical measures presented in Table 1 evaluate I-O (t+1), d = 10, h = 100 as the best model, while the I-O (t+4), d = 4, h = 50 is considered as an optimal prediction model since it can provide predictions of four steps ahead accurate enough and is computationally effective. In a practical sense, predicting fours steps ahead (with step frequency of 2 Hz) means that heave motion can be predicted 2 seconds ahead which can be used as an input for vessel stabilization or a dynamic positioning system. Vessels, due to large mass and inertia, provide delayed response and predictive control can serve to enhance these systems.

Graphical representations of the boat response on a complete data set for the course C1 is shown in Figure 8, while enlarged display for better evaluation is shown in Figure 9. Since graphical representation of the whole set does not provide clear information on model performances, in other cases only enlarged display is provided, as in Figure 10 and Figure 11.

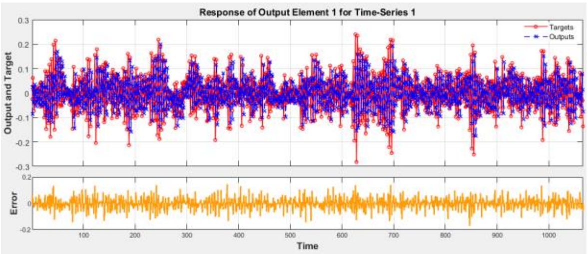

Figure 8: Heave prediction of the model (I-O (t+4), d = 4, h = 50) on C1

Figure 8 and Figure 9 show the performance of the model using four time series elements at the input to predict heave motion four steps ahead (Outputs) in comparison to the actual event (Targets), and Figure 10 and Figure 11 show the same thing for a single step and five steps ahead, respectively. As can be seen from Figure 10 the model is preforming extremely accurate predictions one step ahead, while as shown in Figure 9, the model is still accurate enough, doing a fair job in predicting the heave motion of the boat four steps ahead. As shown in Figure 11, the error is larger, and as numerical measures show, this is no longer a satisfactory prediction.

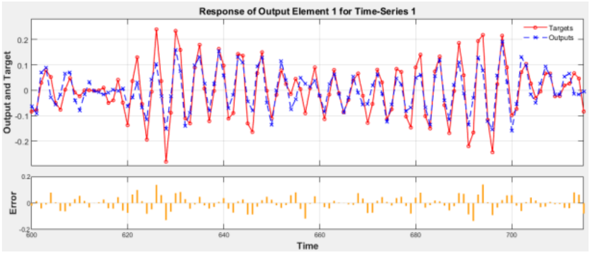

Figure 9: Four steps ahead heave prediction on C1

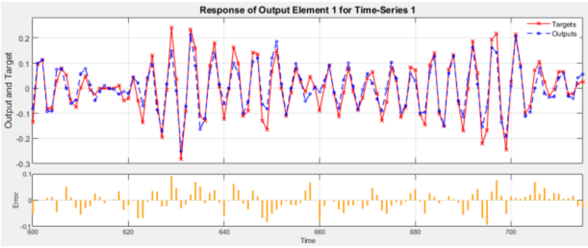

Figure 10: Single step ahead heave prediction on C1

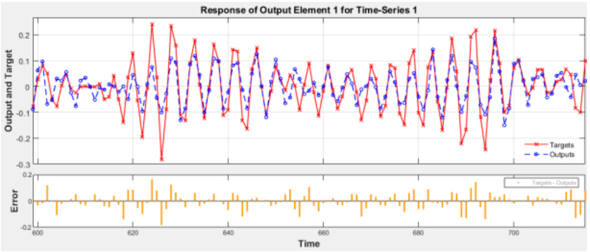

Figure 11: Five steps ahead heave prediction on C1

5 CONCLUSION

Seakeeping response was measured on a 9.40 meter sailboat using a navigational grade inertial measurement unit while running trials on small-to-moderate waves relative to its size. The IMU sensor uses data from accelerometers and gyroscopes and applies advanced post-processing algorithms to output accurate motion components. Based on the measured and analyzed data an artificial neural network heave prediction model for the boat was developed. It is concluded that the prediction horizon is equal to four steps (P = 4), meaning that 2 seconds prediction of a boat motion with satisfactory degree of accuracy is possible for the presented study on course C1. To perform such prediction MLP neural network with 50 hidden neurons is used, and the network is trained with BP algorithm. Increasing the number does not produce significant improvement to the network performances, while it does produce more complex models with longer computational time needed to train the network. Four elements of heave time series are found optimal to be used as inputs. Larger number can produce minor improvements but on the expense of model complexity and significant calibration time extension. A two-second prediction horizon can be found useful for predictive control algorithms.

ANN short-term prediction models of vessel motion have possible practical implementation in the fields of active vessel roll stabilization, heave compensation or dynamic positioning. This is especially important in the wider context of strategic research and development towards autonomous ships.

In further research, the aim is to investigate the idea of a single model for different boat courses and sea states.

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OIL PRICE AND HIRE RATES OF SUPPLY VESSELS – REVIEW

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ABSTRACT

Platform Supply Vessel – PSV and Anchor Handling Tug Supply Vessels – AHTS purpose is delivering various equipment from shore facilities to oilfields/platforms. Supply and demand for PSV and AHTS fleet depends on world's consumption energy. Fossil fuels (oil & gas) make one of the most important energy sources in word energy production. Although future trends show that the dependence on oil and gas as an energy source will decrease, oil and gas remain a major source of consumption representing more than 50% of market share. The PSV market is highly cyclical. Utilization and rates highly correlated to the oil price. Volatility between supply and demand of those ships is what causes the low daily/monthly rates of this ship. The main cause is a small number of active platforms and a large number of PSV & AHTS. The daily/monthly rates fallen below the operating cost of the ships. The value of the market for ships supplying oil fields and platforms was $ 20.06 billion in 2018. The projection is that the market could reach an amount of $ 25.66 billion by 2023. This paper focuses on the market for platform supply ships and the number of a crew working on-board these vessels. Further, oil price trends and the impact of that price on the offshore industry will be analyzed.

Keywords: platform supply vessel, oil rig, price of crude oil, daily rates

1 INTRODUCTION

Today, offshore and gas industries are one of the most important industries in the world, with the direct impact on the economies throughout the globe.

Overview of the existing industrial practices and literature suggests that the activities in exploration and production at sea will move to deeper waters, away from the shore and as a result the demands in terms of supply are going to become significantly higher.

The production of oil at sea differs from the scenario of production at land as the equipment is exposed to water and all the transport and supply are done by vessels. Supplying a platform is a complex logistical problem, influenced by many factors and significant uncertainties. The basic logistical support of offshore business is reflected in technological, operational and financial planning.

The main factors in offshore vessel utilization and business are daily rent rates. Since the type and duration of hire contract directly impact the project budget, oil companies weigh those factors against the budget estimations before deciding on a vessel. The vessel market is closely connected with the crude oil price that can vary significantly on a daily base.

Offshore operations can be divided into drilling and production. In general, the production is a long-term venture with the life span of at least 30 years. In this case, the vessels are rented for a longer period, thus making the rental price lower. Drilling and exploration, on the other hand, include a lot more dynamic and uncertain demands, as well as the higher range of maritime service and equipment. In the case scenario, vessels are engaged in a lot more business which consequently makes the rental price higher, and contracts shorter.

Responsibility for the offshore vessels and the schedule is upon charters, and with the daily rates that go up to several hundred thousand dollars per day, it is in their best interest to keep the daily schedule full. With long term contrast, that can last several years, hirers must plan future supply demands and make sure the vessels meet every demand, expected and unexpected. Offshore vessels help oil companies at sea reach budget projections during the entire process of crude oil exports.

2 OFFSHORE VESSELS

Offshore vessels can be divided into two main groups: PSV and AHTS vessels, as other vessels engaged in offshore operations are not that relevant to the offshore market being that they are used in less than 5 % cases.

2.1 Platform Supply Vessels (PSV)

PSVs are offshore vessel generally used for transiting needed equipment and additional labor force to bolster the high seas' operations.

This means that, among other things, they help carry weighty structural apparatus as well as smaller structural components such as paving material (cement and concrete) and chemical compounds that help in efficient sub-water boring operations. The vessels also carry food and provisions for the crew and personnel working on the high seas. Incoming supply vessels transport the discharged members of the crew that have been involved in operations in the high sea to the nearest harbor. Operators can have their PSV custom made. This way, they ensure the vessel will perfectly fit their needs. They are also utilized for the purposes of curbing the extent of oil spilled in the high seas and as handy vessels with fire-controlling instrumentation [1].

These vessels are constructed in a way to ensure large and spacious aft decks, as long and as wide as possible, in order to carry different cargoes and specialty tools. They are usually classified into 4 main categories according to DWT of the vessel:

- Less than 1,999 DTW.
- 2,000 – 2,999 DWT.
- 3,000 – 3,999 DWT.
- More than 4000 DWT

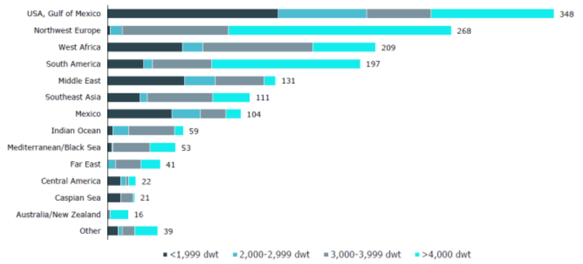

Figure 1: Geographical distribution of PSV fleet [2]

Although these vessels have primarily been built to carry cargo, they need to be highly maneuverable while working aside other vessels engaged in static operations. For the same reason, they must have reinforced hull of the vessel and firm fenders in order to absorb and soothe contact with other vessels [3].

2.2 Anchor handling tug supply (AHTS)

AHTS vessels are specially designed to provide anchor handling services and to tow offshore platforms, barges and production modules/vessels. The vessels are also often used as standby rescue vessels for oil fields in production. The AHTS are then often equipped for firefighting, rescue operations and oil recovery. Apart from this, the AHTS are used as supply vessels for different kinds of platforms, transporting wet, dry and deck cargo.

The focus has been on the vessels' winch and engine capacities as the activity of the oil companies has moved into deeper and deeper water. The AHTS fleet is differentiated by the Breaking Horsepower (bhp) of the vessel:

- Less than 4,999 BHP.
- 5,000 – 6,999 BHP.
- 7,000- 9,999 BHP.
- 10,000 – 14,999 BHP.
- 15,000 – 17,999 BHP.
- More than 18,0000 BHP.

The increase in deep water exploration has led to higher horsepower vessels to operate at such depths [4].

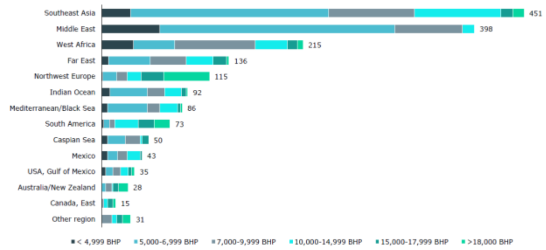

Figure 2: Geographical distribution of AHTS fleet [2]

The design of winches is to provide for adequate dynamic and holding braking capacity to control normal combinations of loads from the anchor, anchor line and anchor handling vessel during deploying or retrieving of the anchors at the maximum operating speed of the winch. The mechanical units of the winch, which is the main part of the AHTS vessel, should be able to sustain the maximum forces caused by the hoisting, rendering and braking including all other dynamic effects without permanent deformation. Operational braking capability is at least 1.5 times of the maximum torque created by the anchor handling line. The brake is capable of stopping the rotation of the drum (winch) from its maximum rotating speed. [5].

Since the AHTS provide a multi-utility facility, as naval vessels they are demanded in a higher coverage area in the offshore industry. In addition to towing and tugging oil rigs they also act as rescue vessels for other ships in times of some emergency, they can be used as effective tools to prevent oil rig capsizing and other types of mishaps occurring in the high sea waters. The increase in demand and usage of AHTS is a result of the increase in deep water oil exploration [5].

3 PLATFORMS

Offshore platforms are huge structures equipped with resources to drill wells and extract oil and gas deep inside the ocean. They boast storage facilities for crude and gas till they are transported to refineries. Since there are few people working on these platforms, they may also have facilities to provide accommodation to the workforce. Depending on the requirements, a platform may be floating or fixed to the ocean floor.

Shallow water is suitable for fixed platforms that are fitted directly onto the seabed with large steel legs. That is why this type of platform is extremely stable. Fixed platform has space for drilling rigs and production facilities, and accommodation facilities for the crew. Fixed platforms are usually installed in water depth up to 520 m, depths greater than this makes it impractical due to the length of the steel legs [6].

Floating platforms are tugged to the drilling location where they are, depending on the depth, anchored or they work on a principal of dynamic positioning. During drilling operation, the platform floats partially submerged. In case of using anchors for positioning, AHTS vessels move the giant anchors into the right place. With the help of the anchors, the platform is put into the right drilling place. These types of platforms can operate in water depths up to 3,000 m (10 000 ft) [6].

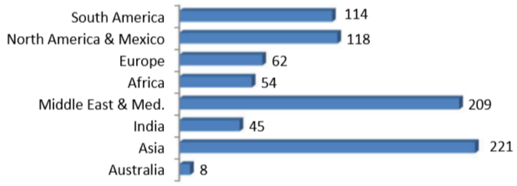

Figure 3: Geographical distribution of world rig fleet [7]

The exact number of platforms in the world varies on the daily basis and cannot be précised but is said to be somewhere around 800. In the period from 2010 to 2014., when the oil price was significantly higher, this number was 15% higher. However, with the drop in oil price came the drop in the number of oil platforms and during the past several years there was not a more significant change.

4 OIL MARKET

Will petroleum markets be as volatile as they were in the 10 years that spanned Jan. 1, 2010, through Dec. 31, 2019?. Most would be surprised to learn that the lows and highs of the just-completed decade varied by about $100/bbl for crude, even more. The lowest intraday price was reflected on January 27, 2016, at $27.10 /bbl. The highest occurred on March 01, 2012, at $128.40 bbl. [9].

The difference between the two shows just how much the market was unstable. But, the decade before this showed even more extreme price difference. Thanks in part to prices barely above $20/bbl in the wake of the 9/11 economic climate and the rise to more than $165/bbl in July 2008, prices spanned more than $140/bbl. [7] Looking back on these prices over the last two decades suggests the next decade should also show the same pricing extremes. However, you are not very likely to find any trade publication, investment bank or think tanks predicting the numbers that would vary by $100/bbl [8].

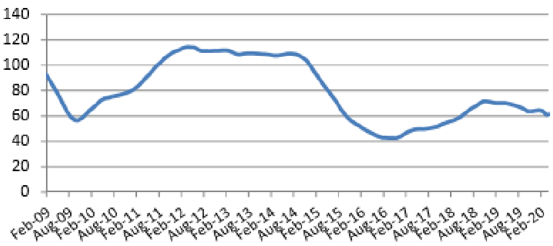

Figure 4: Average Brent oil price US$[7]

The new decade begins with some extremist views. Media coverage of ambitious targets for electric vehicles have provoked some considerations of incredibly low benchmark prices. We suspect that these considerations will get louder in 2022-2025.

The geopolitical tensions could become a decisive factor in oil price. This can be seen in the nearly four-year period during which benchmark Brent averaged close to $100/bbl per calendar quarter was triggered first by the Arab Spring and then by various outages that impacted the Middle Eastern and North African countries. There is an argument to be made, however, that the massive participation by banks, algorithmic traders and commodity funds has reduced some of the day-to-day, or even month-to-month, volatility. Evidence can be seen in the Sept. 14 drone-and-missile attacks on the key Saudi Arabian crude processing facility at Abqaiq. That action temporarily removed 5.7 million barrels of crude oil. Oil markets predictably spiked, but “day after” buying was surprisingly orderly. The losses from Saudi Arabia was quickly replaced and all contractual obligations were met for crude oil exports. [9].

Forecasting market direction is a difficult enough task on a short-term basis, let alone trying to state with any degree of certainty events of the next decade.

Year	Average Daily Demand Millions b/d (EIA)	National Daily Average (OPIS)	Fuel Spending Per Day	Approximate Annual Cost	
2010	8.993	$2.782	$1,050,778,092.00	$383,534,003,580.00	2010-2014 cost
2011	8.753	$3.510	$1,290,367,260.00	$470,984,049,900.00	$2,265,434,823,750.00
2012	8.682	$3.607	$1,315,270,908.00	$480,073,881,420.00	
2013	8.843	$3.494	$1,297,692,564.00	$473,657,785,860.00	
2014	8.921	$3.343	$1,252,561,926.00	$457,185,102,990.00	
2015	9.178	$2.399	$924,756,924.00	$337,536,277,260.00	2015-2019 cost
2016	9.329	$2.123	$831,672,886.80	$303,560,603,682.00	$1,406,271,093,486.00
2017	9.327	$2.390	$936,244,260.00	$341,729,154,900.00	
2018	9.329	$2.720	$1,065,744,960.00	$388,996,910,400.00	
2019*	9.292	$2.611	$1,019,135,409.60	$371,984,424,504.00	
2020**	9.287	$2.599	$1,013,750,346.00	$370,018,876,290.00	

Figure 5: Annual fuel bill [3]

The table shows a fall in a daily oil demand through a 4-year period. The beginning of the year, before the Corona crisis, came with the expectations of change in this trend. However, the Corona crisis has made changes that are yet to be seen in the upcoming period.

At this moment, the market is at its minimum due to the Corona crisis, the oil reached the lowest price in April 2020., at under $ 5 /bbl. The results will be seen within the next couple of months. According to the first reports, the oil price in May is slowly rising and is up to $40 /bbl, but this is still not the price from the beginning of this year where we had around $ 60 /bbl.[7]

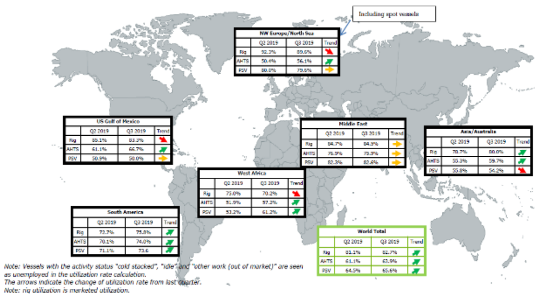

Figure 6: Global utilization increased lightly in Q3 2019[2]

The above image shows that the 2019. ended with growth in utilization of vessels in 1-2 %. About 30 % of the world's offshore fleet were out of work, but it was estimated that the growth in this year could be up to 10 %. Research showed that the growth in South America, Africa and Australia was supposed to shift to the Middle East and Europe as the most important areas in terms of pricing in offshore contracts.

Unfortunately, the turn of events at the end of this year's first trimester had a negative impact on the offshore vessel industry. The cancellations of projects we have heard about in this short period will seriously impact the utilization in all markets. Many projects have been postponed or cancelled, and some research shows the oil companies will reduce their explorations by around 25% in 2020. Under the assumption that the world is going to open again during summer, the Covid-19 prevention measures could stop and thus the offshore market could go back to their usual business. The news of early terminations, cancellations, and lower number of offers and demands are coming from every market area, from The North Sea to the Southeast Asia. There is a constant concern over Covid-19 spreading among seamen on both platforms and vessels. The Norwegian offshore vessels had already confirmed first cases. We expect this year to be disappointing in terms of vessel demand, and this is more than likely to put a stop on a growing number we have witnessed since 2016.

The OPEC + meeting in April will undoubtedly impact the oil price by the end of the year since the group agreed on the biggest production cut in history. Looking ahead, the exploration companies may decide the money is enough to start investments before the predicted period. But when this is about to happen is a guessing game [10].

As we have all witnessed, the world can change very fast. We cannot forget that the offshore industry was prepared for a comeback in 2020., a year before Covid-19. The demand is slow, and will probably stay so for some time, but as the world begins to go back to its usual pace, so will the demand on oil and vessels. Prices will probably be lower this year, but the search for favorable oil and vessel prices will continue.

5 DISCUSSION AND CONCLUSION

The daily rent price for offshore vessels depends on supply and demand as well as political stability, especially in oil depending economies. Speculations and instabilities in oil rich economies can influence the oil price throughout the world, as well as the offshore vessels rental price. The prices in long term daily rents are about 15 – 20 % lower than short term. The advantage of a long-term lease is in secure income.

With the end of 2019. and the beginning of 2020. offshore vessels marked increase in business, and it seemed like a market recovery and coming back to the numbers before the year of 2016. Unfortunately, the outbreak of COVID-19 led to the world industrial market collapse. It is safe to say that for the offshore industry, this means starting from scratch. Oil companies are reducing their budgets and, of course, it shows in the vessel market also. There are cuts in exploration investments as well as all other oil related projects. This means that the daily rental price will continue to drop, not only for short term, but for long term leases also, even those several years long. We are expecting to hear more news on contract terminations, reorganization, and drop in daily rental prices. Some leading companies have already started with the business reorganization because of their fleets' decrease in value. Many vessels are in danger of ending up in ship breaking yards, even though the prices of metal are not high, so it is not profitable for the companies. Now, the market has around 1000 vessels more than necessary, because of falling demand in the oil market. This will reflect on the number of seafarers employed on those vessels as they are expected to end up in ship breaking yards.

The expecting, significant transformation of vessel market is going to present a challenging task for all the participants. Although such a downfall in such a short period of time has not been seen in the market, the hope persists that recovery will happen in the year 2022., when the numbers will reach those from before 2016.

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THE INFLUENCE OF PASSENGER BEHAVIOR AND ECONOMY MEASURES ON AIR TRAFFIC RECOVERY AFTER COVID-19 CRISIS

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ABSTRACT

Nowadays, air transport industry is faced with the incredible crises cause by COVID-19. Therefore, the most important performance indicators related to aircraft operations and safety are now replaced by more important issue dedicated to establish normal operations worldwide. Aviation and tourism are the most infected industries with expected annual profit less than any historically recorded minimum. According to the facts, this paper deals with customers respond to the global crisis which is based on how fast passengers will chose the aviation as a transport mode for their needs regarding passenger behavior and government economy measures. Therefore, several scenarios are analyzed and the pattern is provided on the Serbian case. Data are related to March 2020 when the aviation sector has broken down. The lessons learned could be used for other industries or cases worldwide.

Keywords: Aviation; Aircraft; Operations; COVID-19; Passenger Behavior; Republic of Serbia.

1 INTRODUCTION

Aircraft operations have been suspended globally during the crises tailored by COVID 19. Aviation economy records unexpected and disappointing results with a low possibility to increase profits in all aviation sectors as it was before the crisis.

Nowadays, aviation sector has been experienced with two types of crisis. One is regarding emergency crisis and passenger behavior during the certain situation. It could be any of safety issues during the incident or accident. Another is dealing with behavior after the safety risks are in the red zone, and accident happen. It is not includes direct involvement of the passengers, but it is based on public opinion to use certain airline for their needs. In that cases airlines are faced with the loss of their reputation on the global market, and those costs are calculated as indirect costs of accident with approximation up to 380M$ (Čavka and Čokorilo, 2012). This case is typical on the routs where there is only one operator, and when this airline records and accident. Therefore, variety of passengers on those routes would chose their competitor for a long time.

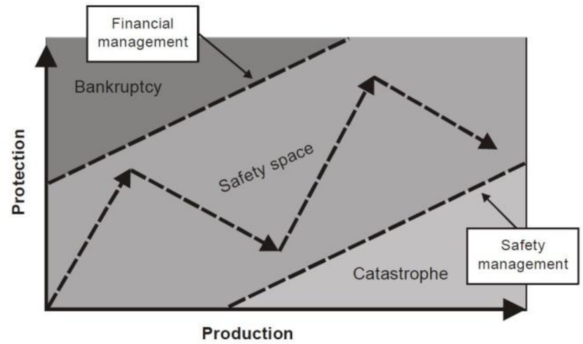
Today, aviation industry is facing the third scenario with global economical impact and influence on the whole society. Therefore, it is equally important to understand economical issues and customers behavior which are the base for aviation recovery.

2 THE MANAGEMENT DILEMA

Nowadays, it is insufficient aviation industry evolution from aviation 1.0 to aviation 4.0 industry (Čokorilo, 2020). Moreover, evolution of safety, from technical era, human factor era, organizational era to contemporary total system era does not guarantee total safety caused by COVID-19 (ICAO, 2018).

Aviation industry counts finite resources which are balanced from production side to system protection. Resource allocation is being known and 2Ps dilemma or management dilemma. Safety management system defines processes for hazard identification and safety risks assessment. General overview over the aviation system shows final limits from low economy measures (bankruptcy) to low safety level (catastrophe). It means that high investments in aviation company production could unbalance the whole system and generate catastrophically event. On the other hand forced investments into system protection (safety) could bring the whole system into bankruptcy. This case was studied as a theoretical view before the COVID-19, but consequences could bring this worst case in many aviation companies worldwide. Therefore, it is of high importance to establish adequate processes in aviation industry. These processes should also provide effective and objective mechanisms to assess the safety risk presented by hazards and implement ways to eliminate these hazards or mitigate the risks associated with them. The result of these processes is to facilitate achievement of an acceptable level of safety while balancing the allocation of resources between production and protection. From a resource allocation perspective, the concept of a safety space is especially useful in describing how this balance is achieved (ICAO, 2013).

This balance is equally applicable to the State's management of its SSP - State Safety Program, given the requirement to balance resources required for State protective functions that include certification and surveillance (ICAO, 2013).



Source: (ICAO, 2013)

Figure 1: The safety space

The resources available to aviation organizations are finite. There is no aviation organization with infinite resources. Resources are essential to conduct the core business functions of an organization that directly and indirectly support delivery of services.

2.1 Global economical impacts

Data published by International Air Transport Association (IATA) show European airlines will bear a significant part of the global hit caused by the COVID-19, which has resulted in an unprecedented decline in the number of passengers. For example, Europe's airlines are expected to lose $76bn in passenger revenue.

IATA estimated that demand for passenger flights fall by 38%, causing global revenues to fall by $252bn in 2020 (almost halving the aviation industry's revenues compared with 2019). Flight cancellations (until 30 June) is estimated to 3.8 million in total. Revenue passenger kilometer - RPK (year to year) is expected to fall down by 82% (Q2), 56%(Q3) and 33%(Q4) (IATA, 2020).

Before the COVID-19 crisis, air transport is expected to has very high growth rates, particularly in the distances more than 250km. This is the distance when air transport can be competitive with land modes. According to (EC, 2005) it is estimated aviation growth in 2050 over 2005 around 2.58 times (from 1,026 Gpkm in 2005 to 3,226 Gpkm in 2050). Therefore, modal split in long-distance passenger transport is presented in table below (ETAG, 2008).

Table 1: Relative passenger transport volumes

	2005	2025	2050
Aviation	56%	64%	71%
Private cars and motorcycles	38%	31%	26%
Rail	4%	3%	2%
Inland Waterways	2%	2%	1%

Source: ETAG, 2008

3 BACKCASTING METHODOLOGY

Placing possible government measures and future passengers behaviors for air transport realization requires adequate scenario building. A scenario is a description of possible future consequences caused by COVID-19, that seem plausible under different sets of assumptions. There are numerous ways of building scenarios as a means to clarify government policy options and passenger behavior after the crisis.

This paper deals with backcasting approach method (Robinson, 1990) since in aviation industry it cannot be the aim to make an exact prognosis (forecast) of passenger behavior and industry recover after the crisis. Therefore, the focus would be to reach desirable future, based on known passenger behavior patterns and reached traffic in the past.

Backcasting is holistic approach, focusing on targets and "desirable" future. That future is based on long-term sustainable transport system designed by providing government policy packages and appropriate socio-economical environment to attract new/old customers (passengers) in air transport system.

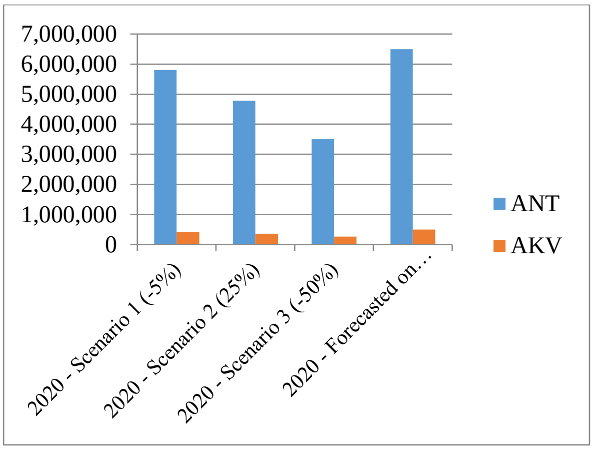


Figure 2: Different scenarios for 2020 upon forecast on regular basis

The applied methodology includes four steps:

- Identification of problem and targets,
- Calculation of a baseline to illustrate what scale of change is needed to meet the "normal" air traffic after the crisis,
- Design of future scenarios (end of 2020 and beyond),
- Analysis and assessment of policy measures to the targeted period and vice versa.

Each scenario is compared to forecasted traffic on regular basis for year 2020 (before the COVID-19 crisis).

3.1 Scenario 1: Strong and rich high-tech Serbia

The first scenario is based on "strong and rich high-tech Serbia". Dominant influence depends on government policy measures and economy (GDP growth). It is expected that Serbia is cohesive and has a leading role in the region. Regarding economy issues it is expected very high growth of GDP with cheap mass products increasing usage. Furthermore, Serbian economic strength would be mainly based on growth in the high-tech sector and transport and infrastructure sectors. Those parameters will expand passengers behavior oriented toward Consumption oriented and fast lifestyles. Backcasting methodology recognized -5% passengers in air transport in general (compared to year 2019), measured for the rest of the year 2020 after the crisis.

Table 2: Scenario 1 - Strong and rich high-tech Serbia

Government policy measures	Serbia is cohesive and has a leading role in the region.
Economy/GDP growth	Very high growth of GDP with cheap mass products increasing usage. Serbian economic strength is mainly based on growth in the high-tech sector and transport and infrastructure sectors.
Population	Slightly growing with significant migration from Serbian Diaspora to Serbia after the consequences of COVID-19
Lifestyles	Consumption oriented, fast.
	Comparatively homogeneous standard of living throughout Serbian regions. Generally, "extremes" are visible; poor and rich regions exist. Consumption-oriented lifestyles. Status symbols are highly important.
Social values	Individualistic. Trust in democracy and information. Price important in consumption. Status symbols are important. Optimistic view on technologies.
Development of transport infrastructure	Highly sophisticated infrastructure building. Continual construction works and building of high-quality Serbian transport network for all modes. Investment in railway related infrastructure has been given priority. In many urban areas the transport networks are supplemented by sophisticated but very expensive tunnel systems.
General	Sophisticated but expansive transport system with high growth rates but lower than in the baseline 2019.
Passenger air transport in general	**-5% (compared to year 2019)**

Source: adjusted based on (ETAG, 2008)

Analyzed scenario provides inputs for evaluation of the total number of passengers on two main Serbian international airports, and potential revenues for 2020. Revenue evaluation for all 3 scenarios is based on the flat rate, expressed in average revenue per passenger (including direct and indirect, total costs) at the end of baseline, year 2017. Average revenue/passenger is 14.85€ for Airport Nikola Tesla Belgrade (ANT), and 10.39€ for Airport Constantine the Great Nis (AKV).

3.2 Scenario 2: Slow and reflexive lifestyles

Scenario 2 is less optimistic, with reduction of -25% of passengers per equivalent month (compared to year 2019).

Table 3: Scenario 2 - Slow and reflexive lifestyles

Government policy measures	Strong EU has established successful climate instruments.
Economy/GDP growth	Moderate growth of GDP where high quality regional products are in focus. Serbia has a tendency to export knowledge instead of goods.
Population	Migration to and from other parts of the world.
Lifestyles	Focus on health and quality of life.
	Serbia: strong middle. Global: more even distribution of wealth. 'Reflexive' slow lifestyle. Slow food; slow travelling. Global and regional networks are important for travel patterns.
Social values	Strong focus on quality of life, on health, well-being, recreation, on safety and on the different ways to achieve these goals. Opposite direction society movements from stress dominated lifestyle.

	Generally critical view on technologies.
Development of transport infrastructure	Advanced and intelligent infrastructure whereas some bottlenecks still exist. Strong focus on safety. Priorities given to investment in an extra freight rail infrastructure. High-speed network was not built that much. Dynamic speed control.
General	High degree of decoupling and substitution of transport.
Passenger air transport in general	**-25% (compared to year 2019)**

Source: adjusted based on (ETAG, 2008)

3.3 Scenario 3: (Contrast image): economic pressure and very expensive energy

Scenario 3 is pessimistic scenario based on "economic pressure and very expensive energy". It assumes that government policy measures perform weak Serbia with limited international cooperation. This implicit low GDP and passenger behavior oriented through fast oriented lifestyles where international networks are not that strong (-50% passengers in air transport in general, compared to year 2019).

Table 4: Scenario 3 - (contrast image): economic pressure and very expensive energy

Government policy measures	Weak Serbia, weak EU, limited international cooperation.
Economy/GDP growth	Low growth of GDP with technological progress triggered by competition with a mixture of cheap mass products and regional products; Serbia has potential trade barriers.
Population	Immigration mainly restricted to well-educated (economically useful) people.
Lifestyles	Consumption oriented, fast.
	Very heterogeneous society with very rich and very poor people living in Serbia. Middle-class is very weak. Global: inhomogeneity. Consumption oriented 'fast' lifestyles. International networks are not that strong.
Social values	Individualization, competition, strong affinity to private property and status symbols.
Development of transport infrastructure	No harmonized development of infrastructure in Serbia. A lot of bottlenecks, especially for railways.
General	Transport growth is hampered by high-energy prices, international trade barriers and low GDP growth.
Passenger air transport in general	**-50% (compared to year 2019)**

Source: adjusted based on (ETAG, 2008)

4 ANALYSIS AND RESULTS

Different scenarios present possible outcome after the crisis basically initialed by passenger behavior and their habits. The level of resilience for each potential air transport traveler would depend on government respond and recovery measures. Building aviation industry from zero traveler to forecasted number of travelers after the crisis would request plenty of economical and psychological measures to attract "new" and "old" travelers. Backcasting methodology allows to predict "desirable" conditions, and therefore provided research is based on expert opinion which defined 3 possible conditions (scenarios).

Final results are shown on figures 3 and 4.

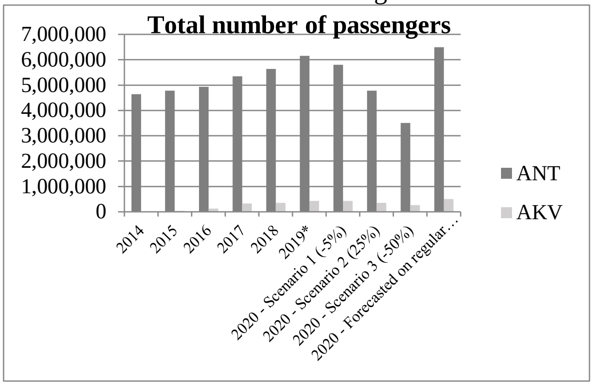


Figure 3: Total number of passengers in 2020 according to different scenarios

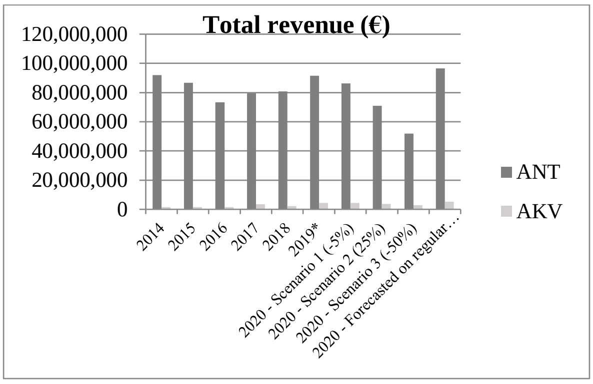


Figure 4: Total revenue (€) in 2020 according to different scenarios

It could be found that the best scenario assumed that the total number of passengers at the end of 2020 would be 5.805.647 instead of expected 6.500.000 for Airport Nikola Tesla Belgrade. Therefore, expected annual revenue is estimated to 86.22M€ instead of forecasted 96.54M€. On the other hand, Airport Constantine the Great Nis could expect in the best scenario 424.570 passengers in total instead of forecasted 500.000. Regarding revenue, the best solution provides 6.23M€ instead of 7.00M€.

More precise estimations could be generated after the COVID-19 crisis.

5 CONCLUSION

During March and April 2020, Republic of Serbia provides country measures related to the 2019 NCoV outbreak (IATA, 2020): "Passengers are not allowed to enter and transit in Serbia; this does not apply to nationals and residents of Serbia; this does not apply to airline crew; this does not apply to passengers with a special permission issued by the Ministry of Health, the Ministry of Foreign Affairs, the Ministry of Interior or the Ministry of Construction, Transport and Infrastructure; this does not apply to accredited members of diplomatic missions, international organizations, humanitarian missions, and their family members". Therefore, such uncertainty is present in current scenario development.

Air traffic recovery after the COVID-19 crisis is very complex for estimation due to a range of possible outcomes and in some cases those might be very serious. This paper presents systematic approach provided by backcasting methodology which allows more realistic evaluation than classical forecast and it could be used for general evaluation for other countries.

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A REMINDER OF THE IMPORTANCE OF IMPLEMENTING HEALTH PREVENTIVE MEASURES ON BOARD

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ABSTRACT

The aim of this paper is to remind the importance of implementation of general and specific health prevention measures on ships, which are, due to new threats (pirates, cybercrime) pushed into the background. Still, they did not lose its importance. The importance of the implementation of general and specific preventive measures on board has been recognized since ancient times. Infectious diseases were and remained a threat in which ships could play an important role. Danger of various diseases has not disappeared: instead of plague and cholera there are Ebola, SARS, COVID-19 etc. Ship, as a mean of disease transmission, is still in the background of aircraft that is faster and therefore, in terms of infectious diseases spreading, more dangerous. On the other hand, large agglomerations of passengers on cruisers which usually sail in international trade bring new health hazards including outbreaks of infectious diseases.
Probably, through the history rats' parasites that inhabited ships brought most of the plague epidemic. Quarantine, as one of the most effective preventive measures, developed in time (1377) when disease transmissions were not known to Europeans.
Since the transport of passengers and goods, without jeopardizing the health status and health safety, is of international importance no matter of international traffic, this area is regulated by a number of international documents that have changed over the years. International Health Regulation is an international document which regulates the movement of people and goods, meanwhile trying to get health safety and a smooth flow.

Keywords: infectious diseases, ships, public health significance

1 INTRODUCTION

The features of modern ships include optimal technical solutions, advanced working conditions, high accommodation comfort and efficient ship-to-shore and ship-to-ship communications. Over the last fifty years, there has been a tenfold increase in the average deadweight tonnage of deep-sea ships, their navigation, propulsion and communication systems have been considerably enhanced, while hard labour, exposure to excessive temperatures and heat emission at critical physiological limits have become exceptions to the rule under standard sailing conditions. Except for a small number of old vessels, there has been a decrease in risk of uncontrolled occurrence of toxic atmosphere, lack of water, poor diet without fresh provisions and overcrowded, uncomfortable crew accommodation. On the other hand, low body activity, abundance of food, smoking and stress due to fast tempo and short turnovers in ports have become likely causes of obesity, diabetes, cardiovascular diseases and various psychical disorders in the seafaring population [1].

The importance of implementing health preventative measures in everyday life, aboard and ashore, has been globally recognized. When defining the public health priorities, it is necessary to develop health care policies that deal with new technologies and place the health care incentives and the implementation of preventative measures at the center of the public health interest. The responsibilities for health preservation are shared by the state, the individual and the community where the individual lives. The health preservation profession has to support the individual, the community and the state, and become their partner in achieving the sustainable level of health [1,2]. For instance, the International Health Regulations (IHR 2005) recommends the implementation of health preventative measures without impeding the flow of people and goods [3].

2 REGULATIONS ON IMPLEMENTING THE PREVENTATIVE HEALTH MEASURES IN THE REPUBLIC OF CROATIA

Preventive health measures are of vital importance to any community or state and, as such, are regulated by legislation. Croatia's Law on the Protection of the Population from Infectious Diseases (Official Gazette No. 114 /2018) defines these measures as: general, specific, safety, and other [4].

General measures aimed at prevention and containment of the infectious diseases are carried out in the facilities subject to sanitary supervision, i.e. buildings, plants, rooms, equipment and gear used by persons engaged in economic activities and in the areas of health care, child care, education, social care, catering, tourism, crafts and services, sport and recreation, in public water supply and wastewater removal facilities, in the areas of communal garbage disposal, public transportation, in habitation buildings and their immediate surroundings, public areas and objects in populated areas, and in other areas of communal and public health importance.

General measures for prevention and containment of the infectious diseases include:

1. providing health food safety, including the supervision of zoonosis and its causes, consumer goods and ensuring sanitary and hygienic conditions for producing and distributing consumer goods in line with specific measures and regulations;
2. ensuring drinking water, including sanitary safety of the sources and facilities, i.e. equipment used for public water supply in compliance with specific regulations;
3. ensuring sanitary safety of bathing, recreation, pool, fountain and other waters of public health interest;
4. providing hygienic and sanitary conditions in the above-mentioned areas and facilities;
5. providing hygienic and sanitary conditions for the removal of waste waters, ballast waters and solid waste;
6. implementation of measures of preventive disinfection, pest and rodent control in the above-mentioned areas and facilities.

The surveillance of the implementation of the general preventative measures is under jurisdiction of the competent sanitary epidemiological surveyors of The State Sanitary Inspectorate of the Republic of Croatia [4].

Special measures for prevention and containment of the infectious diseases include:

1. early detection of sources and ways of conveying communicable diseases;
2. laboratory testing to determine the cause of communicable disease and the cause of epidemic diseases;
3. reporting,
4. transportation, isolation and treatment of communicable diseases,
5. performing the preventative and mandatory disinfection, deratting and disinsection,
6. health checks of certain groups, carriers and employees,
7. health counselling,
8. immunoprophylaxis, seroprophylaxis and haemioprophylaxis, and
9. informing health care providers and general public.

All the above-mentioned preventive activities are incorporated in the International Health Regulations (IHR 2005), referring to the flow of people and goods, which is mandatory for all signatories, including Croatia [1, 3, 4].

3 GENERAL PREVENTIVE MEASURES ON BOARD SHIPS

As far as maritime shipping is concerned, the preventive and counter-epidemics measures have been defined by the World Health Organization in the IHR (2005) and the Guide to Ship Sanitation. They have been adopted and implemented by the signatory states, in addition to their national legislations [2].

Various infectious diseases can be conveyed from one country to another via sea-going vessels, aircraft and other means of transport. They can contribute to some frequent epidemics such as flue, but also some rare types of epidemics that require quarantine. Due to the length of the voyage, ships have certain advantage over other forms of transportation because clinical signs or symptoms have time to develop on board, so that adequate timely measures can be taken before the vessel’s arrival to port.

Basic preventative measures on board ship include:

- providing adequate toilet and washing facilities for the crew to maintain personal hygiene,
- maintenance and housekeeping of the working and accommodation areas, in particular the galley, messroom, food storeroom and refrigerators,
- food, water and materials taken on board should be properly stored and controlled,
- potable water supply,
- appropriate solid and liquid waste disposal,
- health checks of the personnel dealing with food and water [2,5].

3.1 Water supply

Modern ships usually feature separate systems of potable, technical and ballast waters. The potable water systems must be entirely separated from any other system.

A ship officer in charge has to be familiarized with disinfection of smaller amounts of potable water, with the purpose of providing enough water until the ship reaches port. Adding wine or other alcoholic drinks does not disinfect water.

The International Convention on Safety of Life at Sea (SOLAS) defines that lifeboats must be provided with at least 3 liters of water per person per day, for a minimum period of ten days. This water is meant for drinking only and represents a physiological minimum. Potable water in lifeboats is held in closed plastic canisters and is replenished once a month [2].

3.2 Food provision

These days, diet on board does not differ much from diet ashore. However, there is a difference in energy consumption between the seafaring and land-based populations. Due to limited onboard space and advanced marine technologies, most seafarers are not physically active. This may lead to obesity and disorders related to inappropriate diet.

Catering for crewmembers is an important and responsible task. Food must be provided by safe suppliers, recognized and/or recommended by the shipping agents. Meat has to be inspected and verified by veterinary seal. It must be adequately cooked or frozen. All food must bear health quality certificates [2, 8].

The ship's master must ensure that all food-handlers aboard have proper health certification and that they are kept under regular surveillance for infections [2, 7, 8].

3.3 Maintaining the general and personal hygiene

International and national regulations and rule-books on preventive hygienic and technical measures on sea-going ships describe actions to be taken for the purpose of preventing and eliminating the threats to life and health of the people employed or accommodated on ships and other marine structures [2].

The ship's master assigns the personnel in charge of cleanliness and good housekeeping. Exceptionally, the bed and the surrounding area is the responsibility of the person using it. Floors in the accommodation area must be washed at least once a week. Dedicated staff take care of the linen [9].

3.3.1 Regular DDD measures

Disinfection, deratting and disinsection are performed as hygienic-prophylactic and counter-epidemics measures for impeding the occurrence (prevention) and spreading infectious diseases on board (counter-epidemics action). The IHR (2005) state that DDD and other sanitary procedures shall be carried out so as to avoid injury and as far as possible discomfort to persons, or damage to the ship or environment. Furthermore, these procedures shall be carried out so as to avoid fire hazard and, as far as possible, damage to baggage, cargo, equipment and other objects [2,4].

3.4 Hygienic disposal of waste

Waste may be in liquid and solid form. Liquid waste include sewage waters, as well as sink, laundry, and washroom wastes, and other degradable materials.

Solid wastes are discarded materials not readily degradable without heat or pressure, including surgical dressings, refuse and other food waste. Waste also includes fuels and lubricants [2, 5]. Both liquid and solid wastes are health hazards.

3.4.1 Disposal of waste waters and liquid waste

The International Convention for the Prevention of Pollution from Ships (MARPOL) 73/78 states that all seaports and terminals must ensure adequate capacities for reception of hazardous liquid waste (MARPOL 73/78, Rule 18, Chapter II). The reception facilities must be designed according to the amount and type of waste that may be expected from the ships, without impeding their turnover. The same provisions apply to repair and overhauling ports and shipyards [10].

3.4.2 Solid waste storing facilities

Ship solid waste, whose quantity depends on the number of crewmembers, type of vessel and cargo, is removed from the vessel various ways. The average amount of waste produced in one day on a medium-sized merchant vessel is considered to range from 20 to 40 kg, plus 2 kg per each member of the crew. Potentially hazardous waste includes food as rats, flies and other beings thrive on solid wastes. These wastes must be disposed of carefully so as not to endanger the health of persons aboard the vessel or in off-ship areas. In addition, there are toxic wastes. According to MARPOL, plastic waste must not be discarded into the marine environment. Solid waste can be incinerated in dedicated ship plants or, if a vessel does not have such facilities, it can be collected in plastic bags and delivered to the dedicated port communal service [2].

MARPOL Annex V forbids any disposal of waste into the sea, unless otherwise stipulated by the regulations contained by Annex V, defining the procedures for disposing food waste, cargo refuse, cleaning products, additives and carcass [5].

4 SPECIAL PREVENTIVE MEASURES IN BOARD SHIPS

Special measures for preventing infectious diseases include vaccination, passive immunisation (seroprophylaxis) and prophylactic medication (chemoprophylaxis) [2,4].

Vaccination is one of the most efficient measures against infectious diseases. Seafarers must hold a valid international certificate of vaccination, the so-called Yellow Book, where the relevant vaccination records are entered. Presently all seafarers must be inoculated against yellow fever. Some countries may require vaccination against cholera before calling at their ports. Some treatments, e.g. vaccination against typhoid fever, tetanus or viral hepatitis A and B, are desirable but not mandatory [1, 8].

Seroprophylaxis is the injection of an immune serum for the purpose of preventing infectious diseases. A relatively short-term passive immunity is produced, lasting one to four weeks. In unrestricted world-wide navigation, some ship hospitals may have gamma globulin being used in seroprophylaxis and human hyper immune globulin against tetanus.

Chemoprophylaxis is prophylactic medication, i.e. preventive administration of drugs through a strict procedure. The procedures vary with the sailing area and are recommended by WHO or Center for Communicable Diseases Control (CDC, Atlanta, Georgia, USA). Chemoprophylaxis of seafarers is obligatory when sailing to the regions affected by malaria [1, 8]. There are other preventive measures against malaria as well.

5 COVID 19 AND SEAFARING

Coronavirus disease (COVID-19) is an infectious disease caused by a new virus (sars-cov-2). COVID-19 spreads through respiratory droplets that can land on people who are less than 1 meter away, and probably through objects of general use contaminated with these droplets. People with respiratory symptoms such as a cough, are more likely to transmit the disease than asymptomatic and presymptomatic people (without symptoms). The disease causes respiratory illness with signs and symptoms such as a cough, fever, fatigue, and in more severe cases, difficulty breathing (pneumonia). At diagnosis, approximately 80% of cases are mild/moderate; 15% severe; 5% critical.

On March 12, 2020 the World Health Organization declared the COVID-19 outbreak a pandemic.

The World Health Organization, the International Maritime Organization (IMO) and the International Maritime Health Association (IMHA) are carefully observing and monitoring the situation concerning COVID-19 in the World and have coordinated with preventative measures. All crew members have to be familiarized with protective measures against COVID-19 based on WHO advice.

These organizations have produced, during the pandemic period, many documents with different instructions. One of these documents is the recommended framework of protocols for ensuring safe ship crew changes and travel during the COVID-19 pandemic, proposed by a broad cross-section of global industry associations and containing input from the international air transport association. The document includes protocols for joining a ship and protocols for leaving a ship and the repatriation of crew members.

One critical issue of the pandemic is increasingly taking on a humanitarian dimension: there are crews that have already spent many months at sea and that urgently need to be repatriated to their home countries and replaced. Apart from the need for shipping companies to comply with international regulations and contractual obligations, service periods on board ships cannot be extended indefinitely due to the dangerous impacts this has for the well-being of ship crew and safe ship operations.

A special problem is represented by COVID-19 on cruise ships, due to the agglomeration of a large number of mostly elderly people (as travelers or tourists) in a relatively small and closed space. Thousands of cruise ship passengers and crew members have fallen ill with COVID-19 since the global coronavirus pandemic began. It is likely that the number of COVID-19 cases linked to cruise ship crew members and passengers will only go up in the weeks to come, as thousands of crew members are still stranded on infected ships.

6 CONCLUSION

Ships represent the seafarers' working and living environments. This is one of the essential features of this profession: a vessel is, at the same time, a means of transport, a workplace and a living area. This arrangement results in a number of technical and hygienic issues and requires a systematic control of the crew's working and living conditions, including the environment, i.e. the set of climatological, physical and biological factors that directly affect the health and life of people. In this time of globalization, with a rapid and varied transfer of people and goods across the world, there is a risk of conveying and spreading infection. Therefore, the implementation of health preventative measures is very important, aboard and ashore.

The seafarers' health and quality of living depend, to a large extent, on their own resources and abilities to maintain optimal physical and mental efficiency, on the availability and organization of physical environmental conditions for maintaining health and efficiency, and on the coordination and support provided by other crewmembers and shipping company staff, in terms of ensuring necessary working and living conditions, which represents an essential prerequisite for health preservation. Personal attitudes and responsibilities of each crewmember are also essential for maintaining good environment conditions on board.

For these reasons, various national and international regulations have defined mandatory hygienic, technical and safety measures aiming at prevention and elimination of threats to the health and life of the staff employed and accommodated on board ships and other marine structures.

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SOCIOECONOMIC AND REGIONAL DIFFERENCES OF TRAVEL-BASED MULTITASKING IN HUNGARY

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ABSTRACT

Value of travel time is highly affected by the changing patterns of activities while travelling, especially in light of the increasing penetration of mobile devices and extending access to internet. In this contribution, data from a travel survey in approx. 4700 households in rural Hungary are analyzed by advanced statistic methods (discriminant analysis) to understand socioeconomic charecteristics and regional differences in travel-based multitasking patterns. Results indicate that 45 to 55% of travel-based multitasking actvities can be correctly estimated by the knowledge of socioeconomic characteristics of public transport and car passengers.

Keywords: travel-based multitasking, value of travel time, Hungary

1 INTRODUCTION

Observations indicate that, on average, a person dedicates the same time (approximately 1 or 1.1 hour per day) to travel [1-2]. In Hungary, Fleischer and Tir [3] reviewed the previous research on time budget, getting to the same conclusion (59.4 to 65.2 minutes per day) about the average time spent in transport per day since the 1970s. This time is traditionally considered wasted (valueless, ineffectual, etc.) time. However, technology development, especially the increasing penetration of mobile devices and the general availability of internet, i.e., the opportunity of work while travelling on-board public transport, have changed the minds of researcher and transport planners about the value of travel time [4]. And this put into focus not only the activities that may be directly linked to (financial) value but also those that may be valuable (even priceless) for the individual, e.g., reading a book, taking a nap, talking to other people while travelling.

Recently, travel-based multitasking is a growing field of research (e.g., [5-7]). In this article, on the basis of previous results, a statistical analysis is carried out to understand if travel-based multitasking activities are predictable by certain socioeconomic characteristics, including some regional aspects.

The above mentioned previous study [8] aimed to define relatively homogeneous groups of journeys, in order to describe multitasking by passengers, including features related to personal and socioeconomic characteristics like age and employment status. For this, K-means clustering was applied. It concluded that travel-based multitasking is different in age-based clusters.

2 METHODS

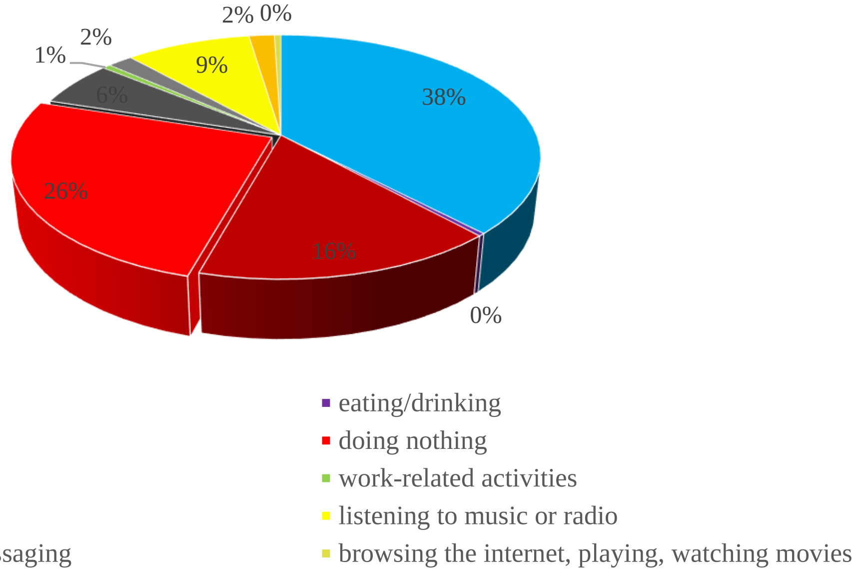
There are diverse methods to survey travel-based multitasking. This study is based on a household survey for a large-scale national project (for the development of OD matrices) in the autumn of 2016 [9-10]. People from approx. 4700 households in rural Hungary were interviewed about travel patterns. Responses include, among others, full information about all trips on the day before the survey, including the activities while travelling. Although travel-based multitasking was not a core element of this questionnaire, the large sample and the detailed knowledge about respondents allows us to thoroughly understand socioeconomic background and travel behaviour.

Although the respondents had to report on their local trips, as well, only journeys between different settlements (and local legs of interurban or regional journeys) are considered here (hereinafter: interurban journeys). This is due to the fact the project aimed to reveal regional and national travel ODs, thus most large towns and cities were omitted in the household survey. Obviously, without information about urban context, local journeys cannot be analysed and generalised.

In terms of their journeys on the last working day before the survey, respondents had to indicate their activities while travelling, namely: reading; work-related activities; studying; talking to others; listening to music or radio; talking on the phone; messaging; browsing the internet, playing, watching movies (on mobile devices); eating or drinking; relaxing; doing nothing; other (Figure 1). On the basis of the outcomes of our previous research [8], three activity groups have been created:

- ’SELF-TIME’ relaxing, doing nothing, eating, drinking;

- ’BUSY’: reading, work-related activities, studying, listening to music or radio, messaging, browsing the internet, playing, watching movies;
- ’TALKING’: talking to others, talking on the phone.



Source: Authors’ own edition

Figure 1: Proportion of travel-based multitasking activities in the sample (“What were you doing while travelling?”)

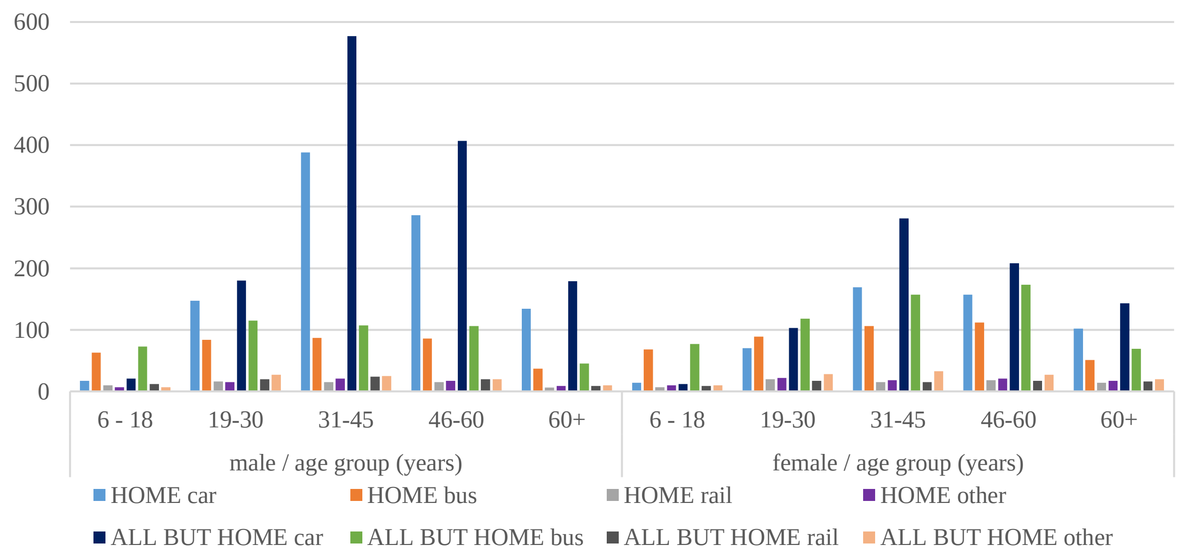
Based on the previous analysis of the same dataset, journeys are considered in two large groups of trip purposes: 1) going home (’HOME’), 2) any other purposes (’ALL BUT HOME’).

To understand travel-based multitasking in general in the sample, basic statistics is applied to analyse data from the household survey. To reveal further aspects about the specific groups of passengers on public transport and chartered commuter bus services, i.e. to classify the observations about them into groups, discriminant analysis has been used.

3 RESULTS

3.1 Description of the sample

Out of the 7956 interurban journeys in the sample, 6138 were travelled on working days. Respondents reported on activities while travelling for 3355 of these journeys (55%). In the remaining 2783 cases (ignored here), there is no information about travel-based multitasking. However, it may be supposed that most of them were just driving their cars or vans (2737 journeys). A brief description of this sample may be seen in Figure 2.



Source: Authors’ own edition

Figure 2: Journey purposes by transport mode and age group (by sex)

3.2 Results of the discriminant analysis

The aim of this analysis is to define groups in the population whose members are more similar to each other than to members of other groups. This is similar to clustering techniques but here not only clusters are formed but the ’extent’ of the difference between groups is also ’measured’. In this analysis, in which group a member would fit the best (i.e. dependent variable) is estimated by the characteristics of the group members (i.e. independent variables). Although characteristics could only be measured on ordinal scales, the discriminant function helps to specify membership (with a certain probability).

On HOME journeys, variables of transport modes, age, level of education and (subjective or perceived) financial status are significant (Table 1), but Wilks’ Lambda is close to 1, which means that these variables are not significant for the discriminant function.

Table 1: Wilks’ Lambda (HOME journeys)

	Wilks' Lambda	F	df1	df2	Sig.
transport mode	,910	68,900	2	1392	,000
age group	,951	35,532	2	1392	,000
level of education	,976	17,236	2	1392	,000
financial status	,987	9,235	2	1392	,000

Source: Authors’ own calculation and edition

On ALL BUT HOME journeys further variables are significant (Table 2), but their contribution to the function is that same: not significant (Wilks’ Lambda is close to 1 or nearly equal to 1.)

Only some weak correlation may be identified between variables (such as, in the case of age and journeys with the same purpose; the region and the no. of inhabitants of the respondent’s place of residence), multicollinearity seems to be ignorable (Table 3).

Table 2: Wilks’ Lambda (ALL BUT HOME journeys)

	Wilks' Lambda	F	df1	df2	Sig.
trip purpose	0,992	6,912	2	1826	0,001
transport mode	0,898	103,670	2	1826	0,000
age group	0,961	36,632	2	1826	0,000
level of education	0,965	32,639	2	1826	0,000
financial status	0,982	16,389	2	1826	0,000
region (place of residence)	0,964	33,983	2	1826	0,000
inhabitants (place of residence)	0,973	25,349	2	1826	0,000

Source: Authors’ own calculation and edition

Table 3: Correlation matrix

	trip purpose	transport mode	age group	level of education	financial status	region (place of residence)	inhabitants (place of residence)
trip purpose	1,000	-0,104	0,266	-0,047	0,032	0,026	0,034
transport mode	-0,104	1,000	-0,110	0,002	-0,022	-0,028	-0,030
age group	0,266	-0,110	1,000	0,203	0,049	0,032	0,025
level of education	-0,047	0,002	0,203	1,000	-0,235	-0,160	0,219
financial status	0,032	-0,022	0,049	-0,235	1,000	0,158	-0,112
region (place of residence)	0,026	-0,028	0,032	-0,160	0,158	1,000	-0,298
inhabitants (place of residence)	0,034	-0,030	0,025	0,219	-0,112	-0,298	1,000

Source: Authors’ own calculation and edition

Box’s M indicate inhomogeneity of the variance-covariance matrices in all cases (Table 4), but this test is sensitive to the assumption of multivariate normality in case of journeys of both HOME and ALL BUT HOME.

Table 4: Box’s M

Test Results		HOME	ALL BUT HOME
Box’s M		70,575	174,094
F	Approx.	3,511	3,090
	df1	20	56
	df2	2 040 233	4 440 236
	Sig.	0,000	0,000

Source: Authors’ own calculation and edition

Table 5: Log Determinants

Activity while travelling	Rank		Log Determinant	
	HOME	ALL BUT HOME	HOME	ALL BUT HOME
BUSY	4	7	-1,344	0,822
TALKING	4	7	-0,409	1,603
SELF-TIME	4	7	-0,587	1,331
Pooled within-groups	4	7	-0,586	1,433

Source: Authors' own calculation and edition

Log determinants also indicate that there are differences among covariance matrices (Table 5), due to the large differences in case of HOME journeys by people that are BUSY while travelling (excluding those who are talking to others).

In case of ALL BUT HOME journeys, discriminant functions explain variance among groups and the lack of variance (indicated by canonical correlation) only in part (Table 6).

Although Wilks' Lambda shows their non-relevance, discriminant functions are significant in case of trip purposes (Table 7).

Table 6: Eigenvalues

Function	Eigenvalue		% of Variance		Cumulative %		Canonical Correlation	
	HOME	ALL BUT HOME	HOME	ALL BUT HOME	HOME	ALL BUT HOME	HOME	ALL BUT HOME
1	0,122	0,181	64,3	72,7	64,3	72,7	0,329	0,392
2	0,068	0,068	35,7	27,3	100,0	100,0	0,252	0,252

Source: Authors' own calculation and edition

Table 7: Wilks' Lambda (discriminant functions)

Test of Function(s)	Wilks' Lambda		Chi-square		df		Sig.	
	HOME	ALL BUT HOME	HOME	ALL BUT HOME	HOME	ALL BUT HOME	HOME	ALL BUT HOME
1 through 2	0,835	0,792	250,979	423,989	8	14	0,000	0,000
2	0,937	0,936	91,171	119,953	3	6	0,000	0,000

Source: Authors' own calculation and edition

In case of HOME journeys, Pearson correlation coefficients (Table 8) show that the first discriminant function is strongly linked to the transport mode (0.901) and –to a moderate extent– the level of education (0.428) and the other one, to the age (0.867) and the financial status of the respondent (0.433).

Table 8: Structure Matrix (HOME)

	Function	
	1	2
transport mode	0,901*	0,042
level of education	0,428*	-0,192
age group	0,032	0,867*
financial status	-0,068	0,433*

Source: Authors' own calculation and edition

The same applies for ALL BUT HOME journeys (Table 9), however, some other variables are weakly influential to the discriminant functions.

Table 9: Structure Matrix (ALL BUT HOME)

	Function	
	1	2
transport mode	0,790*	0,062
district region	-0,445*	-0,142
level of education	0,428*	-0,193
inhabitants (place of residence)	0,371*	-0,202
age group	-0,057	0,762*
financial status	-0,062	0,504*
trip purpose	-0,159	0,210*

Source: Authors' own calculation and edition

The discriminant analysis indicates the differences of the averages in the defined groups (Table 10): these averages are standardised, specified as the linear combinations of independent variables (centroids).

Table 10: Functions at Group Centroids

Activity while travelling	HOME		ALL BUT HOME	
	1	2	1	2
BUSY	0,335	-0,527	0,375	-0,474
TALKING	-0,407	-0,016	-0,530	-0,014
SELF-TIME	0,283	0,228	0,326	0,240

On all kinds of journey, centroids of TALKING is in a different 'space' than BUSY and SELF-TIME groups. Centroids of groups on HOME journeys are slightly closer to each other than in case of other trip purpose (Figure 3).

In light of the study of some socioeconomic characteristics, there are differences among groups, as follows:

- Centroids of young people (less than 30 years of age) indicate more BUSY travel-based multitasking activities than in older age groups; there is no other relevant differences among groups in terms of SELF-TIME or TALKING (Figure 4).
- The BUSY group of people may be differentiated by financial status (in comparison to other activities); and there are some further exceptions, e.g., in case of TALKING, centroids of people without financial problems seem to be located separately from others (Figure 5).
- Centroids of highly educated people are in a different 'space' than others. With this regards, mid-level education is more similar to low than high level (Figure 6).

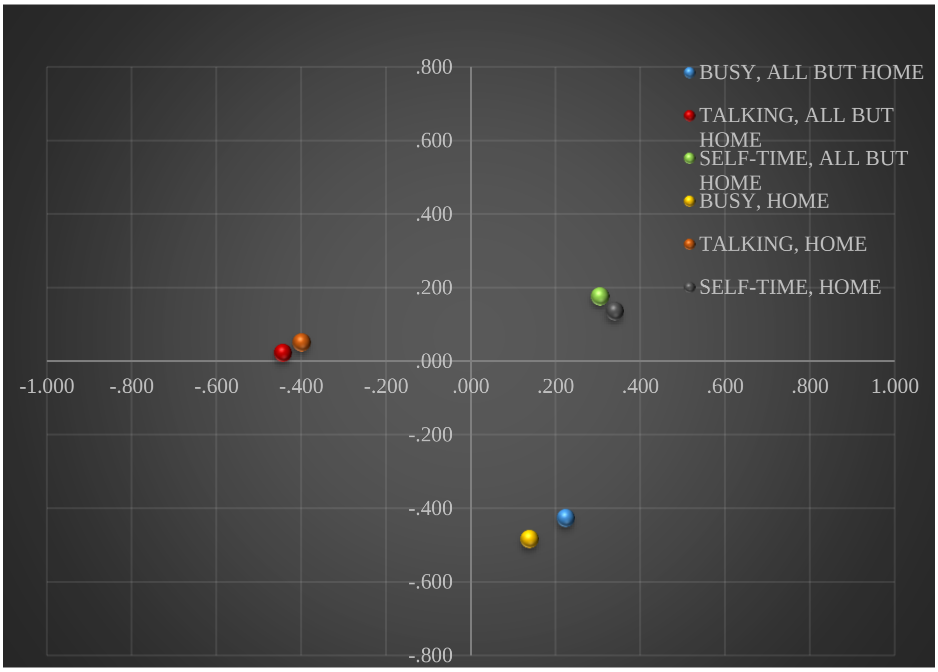


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Figure 3: Group centroids (travel-based multitasking and trip purpose)

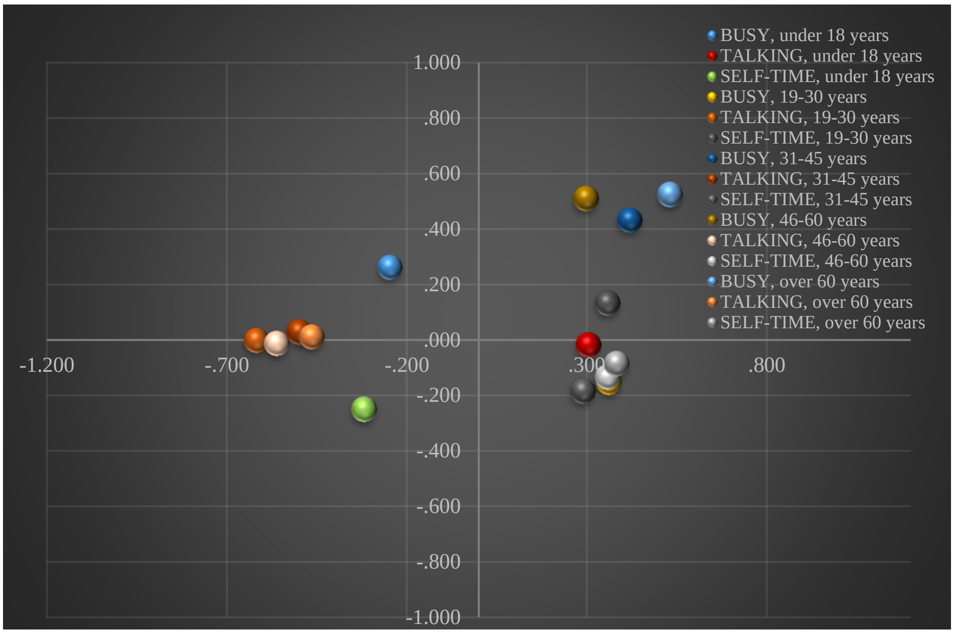

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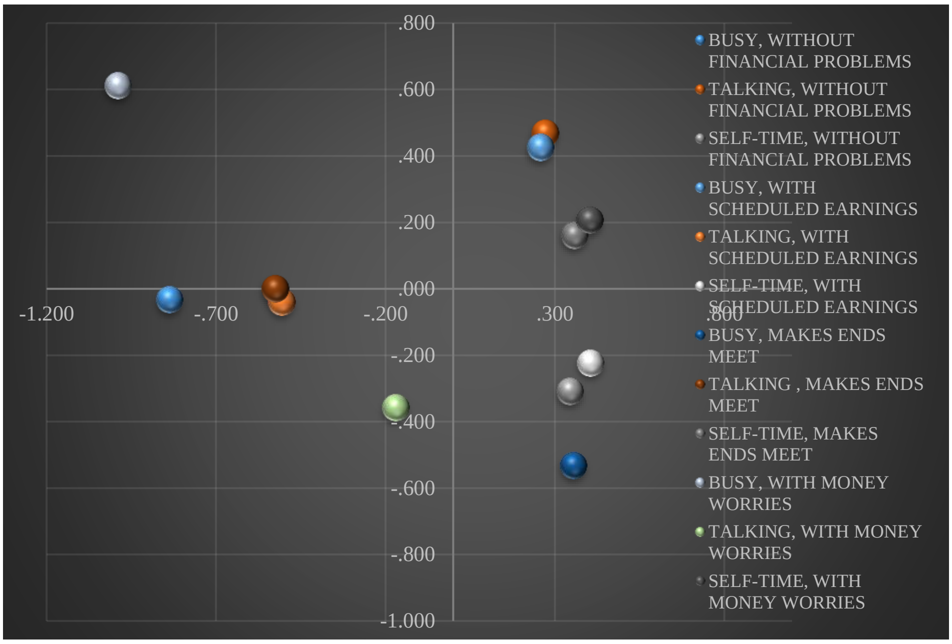
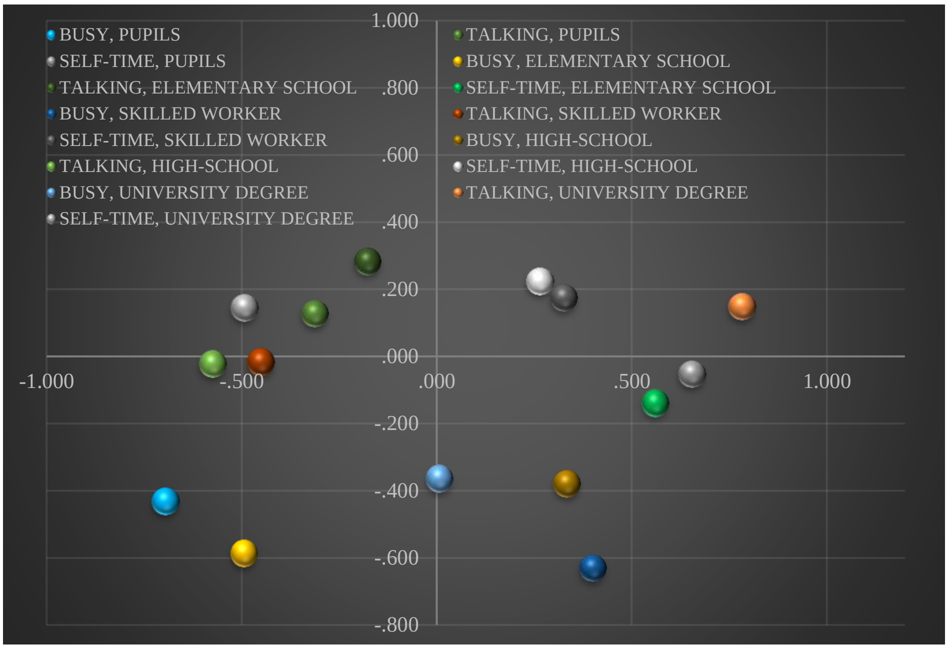
Figure 4: Group centroids (travel-based multitasking and age group)



Source: Authors' own edition

Figure 5: Group centroids (travel-based multitasking and subjective financial status)



Source: Authors' own edition

Figure 6: Group centroids (travel-based multitasking and level of education)

This classification indicates the 'performance' of the discriminant analysis, i.e., the proportion of correctly classified group memberships. In Table 11 and 12, dependent variables and observed values are in the lines and estimated values by the independent variables (in the categories of dependent variables) are in the columns. Hit rates are marked in bold on the diagonals, i.e., if these are equal to the original observations, estimations are fully correct.

As it may be seen, active travel-base multitasking is the better estimated on HOME journeys (57.1%). Nearly half of the observations could have been estimated in case of TALKING (49.9%) and SELF-TIME group members (49.4%). The total proportion of correct hits would have been 50.9%. This is slightly better in case of ALL BUT HOME journeys: 52.2% in total (57.2% for BUSY, 54.7% for TALKING, 47.5% for SELF-TIME group membership).

In sum, correct hits are very similar even for these large groups of trip purposes and travel-based multitasking categories. Not correct hits seem to be approximately the half of the correct estimations (for HOME journeys: 18.6 to 27.0%, for all other trip purposes: 16.4 to 28.9%). Cross-validation indicates that values are not more relevant that in the original classification.

Table 11: Classification results (HOME)

		Activity while travelling	Predicted Group Membership			Total
			BUSY	TALKING	SELF-TIME	
Original	Count	BUSY	**132**	43	56	231
		TALKING	145	**294**	150	589
		SELF-TIME	155	136	**284**	575
	%	BUSY	**57,1**	18,6	24,2	100,0
		TALKING	24,6	**49,9**	25,5	100,0
		SELF-TIME	27,0	23,7	**49,4**	100,0
Cross-validated	Count	BUSY	**129**	45	57	231
		TALKING	151	**288**	150	589
		SELF-TIME	156	136	**283**	575
	%	BUSY	**55,8**	19,5	24,7	100,0
		TALKING	25,6	**48,9**	25,5	100,0
		SELF-TIME	27,1	23,7	**49,2**	100,0

Source: Authors' own edition

Table 12: Classification results (ALL BUT HOME)

		Activity while travelling	Predicted Group Membership			Total
			BUSY	TALKING	SELF-TIME	
Original	Count	BUSY	**206**	59	95	360
		TALKING	177	**392**	148	717
		SELF-TIME	217	178	**357**	752
	%	BUSY	**57,2**	16,4	26,4	100,0
		TALKING	24,7	**54,7**	20,6	100,0
		SELF-TIME	28,9	23,7	**47,5**	100,0
Cross-validated	Count	BUSY	**201**	64	95	360
		TALKING	178	**390**	149	717
		SELF-TIME	219	184	**349**	752
	%	BUSY	**55,8**	17,8	26,4	100,0
		TALKING	24,8	**54,4**	20,8	100,0
		SELF-TIME	29,1	24,5	**46,4**	100,0

Source: Authors' own edition

4 CONCLUSION

A discriminant analysis has been done to understand travel-based multitasking on interurban journeys. Based on previous outcomes, three large activity categories have been defined (BUSY, TALKING, SELF-TIME) and two trip purposes have been considered (HOME and ALL BUT HOME). The main conclusions are as follows:

- There are some differences among groups defined by socioeconomic characteristics, such as young (below 30 years of age), highly educated people and those without financial problems have specific patterns in terms of travel-based multitasking.
- There is only weak partial correlation between trip purpose and frequency (R=0.41), level of development and number of inhabitants of the place of residence (R=0.37) and there is no correlation between other variables.
- In spite of considering large trip purpose and activity groups, only 45 to 55% of the travel-based multitasking can be correctly estimated, thus socioeconomic characteristics shape activities only to this extent. In other words, sex, age, level of education, (subjective or perceived) financial status and attributes of the place of residence may classify travellers into the three travel-based multitasking categories (active, talking to others, inactive) on a medium level.
- What we do know about interurban travellers on the basis of this and previous study of the same dataset is that:
  - Most people are talking to others on-board public transport. This means that they are travelling in company, start a conversation with fellow travellers, or talk on the phone. Talking to others, as a travel-based multitasking activity, is decreasing by age.
  - The different kinds of active travel-based multitasking are prevailing in younger age groups, such as reading (19 to 30 years of age), working (30 to 60), studying and the use of smart devices (below 30).
  - In contrast, the proportion of inactive activities increasingly prevails by age.

These findings may be relevant for transport operators (e.g. to adapt services to passenger needs), vehicle manufacturers (to adapt vehicle design to the needs of future customers) and decision-makers. Future research directions of this project are expected to be based on new data, i.e., to understand the change of travel-based multitasking over time (taking into consideration of the increasing penetration of mobile devices with reliable internet connection) and to compare new observations with datasets from other sources.

ACKNOWLEDGMENT

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SAFETY ANALYSIS OF PEDESTRIAN-VEHICLE CONFLICTS USING MICROSIMULATION TOOL

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ABSTRACT

The main objective of this paper is to analyze the safety measures of unsignalized pedestrian crossings at the area of Zagreb Central Station, Croatia. Traffic data of vehicles and pedestrians in the study area were collected using an unmanned aerial vehicle (UAV) and processed in a specialized computer program. Traffic flows were simulated using the VISSIM microsimulation tool. The trajectories obtained with the microsimulation tool were analyzed in the Surrogate Safety Assessment Model (SSAM) to evaluate potential simulated conflicts.

Keywords: Pedestrian Safety, Microsimulation, Surrogate Safety Assessment Model, Unmanned Aerial Vehicle, City of Zagreb

1 INTRODUCTION

Traffic safety is one of the most critical qualitative characteristics, which points to the many factors of the organization of the transport system, and especially to the traffic culture of the participants. Pedestrians, cyclists, children, elderly and disabled are the most vulnerable entities of the transport system in the road safety segment. According to Eurostat [1], in 2017 in the EU Member States, pedestrians were involved in 21% of the total number of road accidents, while in the United States this number is around 16% [2]. In the Republic of Croatia, 61 pedestrians were killed in 2019, accounting for 20.5% of the total number of deaths (297) [3].

In recent years, microsimulation tools have become an indispensable aid to traffic engineers in analyzing and evaluating different traffic situations before these solutions are transmitted in the real world. Microsimulation tools are extremely useful when comparing the performance of multiple proposed variants. In terms of safety measures, existing simulation tools do not provide the ability to analyze safety parameters. A new approach entitled "Surrogate Safety Assessment Model (SSAM)" was proposed by a research team in SIEMENS and was sponsored by the Federal Highway Administration (FHWA) of the United States [4]. Surrogate safety measures (SSMs) serve as near-crash indicators to measure spatial and temporal proximity of road users. In the context of safety assessment and improvement of urban intersections, the conflict between pedestrians and turning vehicles needs special attention. Video detection, as alternative data collection procedure to relieve the issues and limitations of manual data collection, has attracted considerable interest. It provides a reliable way to collect road users' positions in time and space, that is, trajectories, that benefit the detailed analysis of pedestrian-vehicle conflict. However, this method is relatively expensive and in practice it is difficult to collect and process video data at a large scale over a long period. To enable a view of both pedestrians and conflicting vehicles at the monitored intersection, video cameras should be installed high enough, for example, mounted on existing poles located near the intersection. This usually brings heavy labor work and high cost of maintenance and even is not allowed due to security restrictions. Furthermore, the synchronization among multiple cameras for one intersection is complicated and requires much extra effort. Last, to extract pedestrian and vehicle trajectory data from videos with a desirable accuracy and efficiency remains a difficult problem [5].

In recent years, the use of drones to collect different types of traffic data (the number of vehicles or pedestrians, vehicle speed, acceleration, travel time, etc.) has been increasing. The benefits of an unmanned aerial vehicle are evident in the collection of data from a high altitude, far from the eyes of pedestrians and drivers, and thus their behavior is not affected. When collecting ground data using various devices (cameras, magnetic counters, and radars) that are visible to drivers, drivers seek to change their behavior (e.g. reduce speed) because they feel that they are being recorded for punishment. Unmanned aerial vehicles can collect images and videos in high resolution, providing maximum precision when processing data. The lack of unmanned aircraft is reflected in the technical characteristics of the aircraft itself, such as battery capacity, number of propellers, number of sensors, system failure, and drone crash. The latter is extremely dangerous if data is collected above pedestrians or above intersections with a large number of vehicles. If a system failure occurs, a significant accident can be eliminated by using a parachute. Unmanned Aerial Systems (UASs) or Unmanned Aerial Vehicles (UAVs), known for easy maneuvering, outstanding flexibility, and low costs, are considered to be a novel aerial sensor. UAVs can be launched and deployed within minutes and exchange with the control center in real-time. While in the last decade, UAVs have been frequently employed in the military, civilian applications of UAVs still face several technical and institutional barriers; for example, strict airspace and route restrictions [6].

As an alternative to crash risk estimation based on limited crash data, SSMs serve as near-crash indicators to measure the severity and frequency of traffic conflict events. In general, a SSM is supposed to satisfy two conditions in order to be useful for safety applications: (1) a measurable or observable noncrash event that is physically related in a predictable and reliable way to crashes and (2) a practical method for converting or calibrating the non-crash event into a corresponding crash frequency and/or severity. Under the mixed impact of the surrounding environment, crosswalk geometry, signal operation, and pedestrians moving in different directions, turning vehicles might take risky behavior by not yielding to pedestrians or passing through small gaps in pedestrian flow, which poses a threat to pedestrian safety. The main objective of this paper is to analyze the safety measures of unsignalized pedestrian crossing, comparing observed and simulated potential conflict points [5].

2 METHODOLOGY

Data was collected at a pedestrian crossing in front of the main train station building using an unmanned aerial vehicle in the morning peak period on a typical business day. The specificity of this pedestrian crossing is evident in the large number of pedestrians arriving by train at the railway station and continuing their journey by public transport. Pedestrians must cross the road to get to the public transport stop. Very low vehicle speeds, significant average delays, and potentially dangerous situations due to driver impatience and lack of traffic culture have been reported.

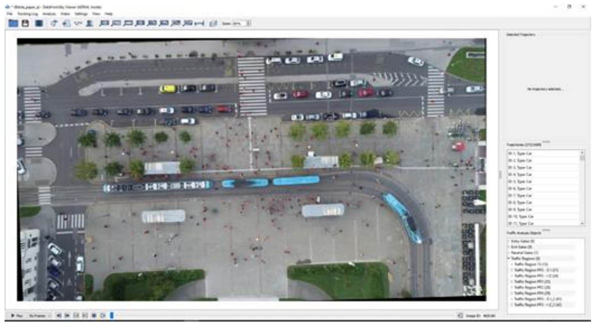


Figure 1: Study area

The video footage obtained from the drone is processed in a specialized computer program called DataFromSky. DataFromSky is a video-analytics platform for fully automated extraction of accurate traffic data using artificial intelligence and machine learning methods [7]. With this computer program, it is possible to obtain information such as speed, acceleration, trajectories, origin and destination and headway for each vehicle, pedestrians, and cyclists. The average speed of pedestrians across the pedestrian crossing is 5.36 km\h with standard deviation σ = 0.97 km\h. Figure 2. shows an example of a potential conflict in DataFromSky software. It should be emphasized that in this paper, due to the geometry and features of the road, the possible side impact of vehicles on pedestrians was analyzed (crossing conflict).

Figure 2: Potential conflict analyzed in DataFromSky software

The data collected was used to develop, calibrate, and validate the VISSIM [8] simulation model as well as to simulate traffic conflicts. It should be mentioned that in this study, a Viswalk module was not used to simulate pedestrian behavior since it is not possible to obtain pedestrian trajectories from the specified module. The average pedestrian and vehicle speeds in the microsimulation model were adjusted according to the data collected. The estimated duration of the simulation is 4500 seconds, of which 900 seconds is the warm-up of the simulation and 3600 seconds for data collection for evaluation purposes. Data such as number of vehicles and pedestrians, average speeds and trajectories were collected. Vehicle trajectories obtained from a calibrated microsimulation model were analyzed in the Surrogate Safety Assessment Model (SSAM).

The Surrogate Safety Assessment Model (SSAM) is a software application developed to automatically identify, classify, and evaluate traffic conflicts in the vehicle trajectory data output from microscopic traffic simulation models. The SSAM also has built-in statistical analysis features for conflict frequency and severity measures that can aid analysts in the design of safe traffic facilities.

The most used SSMs for pedestrian conflict assessment include, but not limited to the following measures:

(i) Time to Collision (TTC), which is defined as the time that remains until a collision between two road users would have occurred if the collision course and speed difference are maintained.

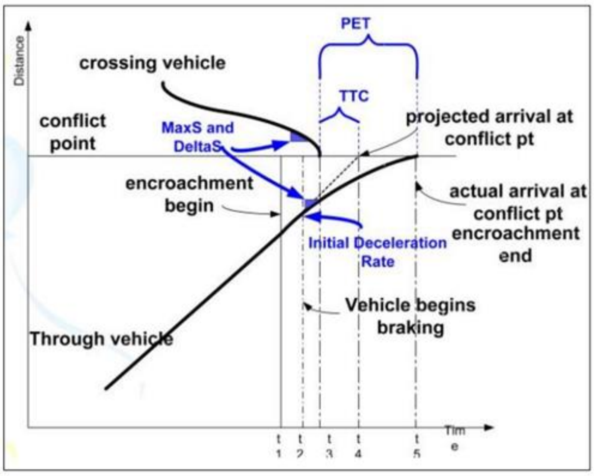
(ii) Postencroachment Time (PET), which is defined as the time difference between the moment when an offending road user leaves an area of a potential collision and the moment of arrival of a conflicted road user possessing the right of way.

(iii) Time to Zebra (TTZ), which is a variation of TTC to estimate the frequency and severity of critical encounters between crossing pedestrians and vehicles that are approaching the crosswalk.

(iv) Deceleration-to-Safety Time (DST), which is the necessary deceleration to reach a nonnegative PET value if the movement of the conflicting road users remains unchanged.

(v) Gap Time (GT), which is defined as the time lapse between the completion time of encroachment by one road user and the arrival time of the interacting road user if they continue with the same speed and path [5][9].

Figure 3. shows definition of Time-To-Collision (TTC) in the time-space domain.



Source: [5]

Figure 3: Definition of Time-To-Collision (TTC) in the time-space

3 RESULTS

A total of 1689 vehicle and pedestrian trajectories were collected using DataFromSky computer software. Due to the low average speeds of vehicles and pedestrians, a Time-To-Collision of two seconds is defined in the DataFromSky and SSAM programs. After processing the data at the observed pedestrian crossing, nine potential pedestrian-vehicle crossing conflicts were identified and analyzed in more detail. Figure 4. shows a comparison of the observed TTC times and simulated using the SSAM program. Table I. shows the statistical comparison between the observed values and simulated, the Mean Absolute Percentage Error (MAPE) of the observed and simulated potential conflict points is 14.6%.

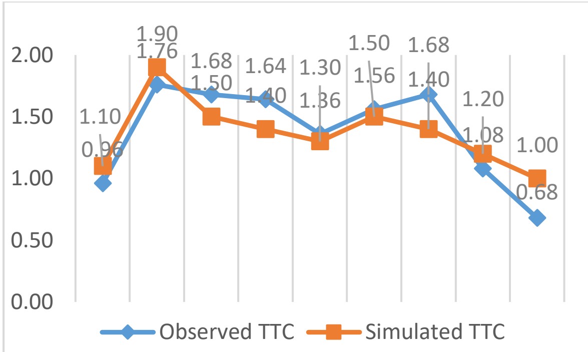


Figure 4: Observed and simulated potential pedestrian-vehicle conflicts

Table 1: Relationship between simulated and observed conflicts

Actual TTC	Simulated TTC	Error	Absolute Value of Error	Square of Error	Absolute Values of Errors Divided by Actual Values
0,96	1,10	-0,140	0,14	0,0196	0,1458
1,76	1,90	-0,140	0,14	0,0196	0,0795
1,68	1,50	0,180	0,18	0,0324	0,1071
1,64	1,40	0,240	0,24	0,0576	0,1463
1,36	1,30	0,060	0,06	0,0036	0,0441
1,56	1,50	0,060	0,06	0,0036	0,0385
1,68	1,40	0,280	0,28	0,0784	0,1667
1,08	1,20	-0,120	0,12	0,0144	0,1111
0,68	1,00	-0,320	0,32	0,1024	0,4706

Correlation analysis was conducted to provide a relationship between actual and simulated Time-To-Collision values. Tables II and III show simple statistics and Pearson Correlation and Figure IV scatter plot of observed and simulated TTC values. It is shown that the correlation coefficient is 0,8673 and the p-value of 0,0025.

Table 2: Simple statistics

Simple Statistics							
Variable	N	Mean	Std Dev	Sum	Minimum	Maximum	Label
Simulated_TTC	9	1.36667	0.26458	12.30000	1.00000	1.90000	Simulated TTC
Observed_TTC	9	1.37778	0.38425	12.40000	0.68000	1.76000	Observed TTC

Table 3: Pearson correlation coefficients

Pearson Correlation Coefficients, N = 9 Prob > |r| under H0: Rho=0	
Simulated_TTC Simulated TTC	Observed_TTC 0.86726 0.0025

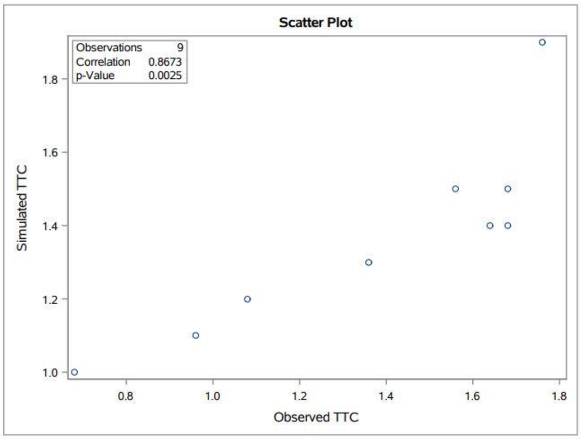


Figure 5: Correlation between observed and simulated TTC values

Linear regression analysis was conducted to identify if the simulated traffic conflicts provided reasonable estimates for the observed traffic conflicts. Linear regression models were fitted to relate the simulated crossing conflicts. It was found that the relationships between the simulated and the observed conflicts were statistically significant. The R2 value for crossing conflict model was 0.7521, indicating that the simulated conflicts explained 75.21% variation in the field measured crossing conflicts.

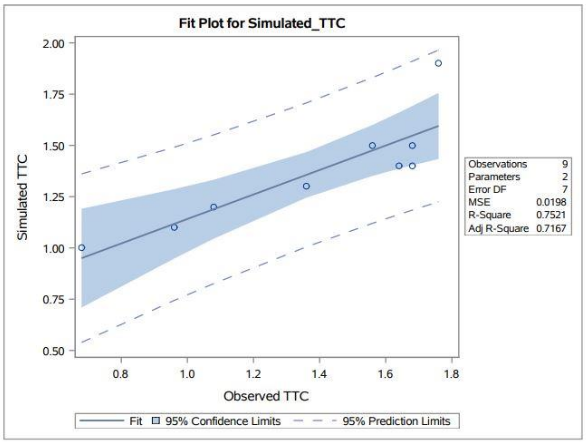


Figure 6: Relationship between observed and simulated TTC values

4 DISCUSSION AND CONCLUSION

In this study, the validity of using VISSIM simulation models and the SSAM approach for safety assessment at unsignalized pedestrian crossing was tested by comparing the simulated conflicts generated by the VISSIM simulation models and identified by SSAM to those measured in the field using DataFromSky software. Traffic data of vehicles and pedestrians in the study area were collected using an unmanned aerial vehicle (UAV) and processed in a specialized computer program. After data filtering, it was defined nine potential crossing conflicts which were simulated in VISSIM microsimulation tool. After microsimulation model calibration, it was found that using the simulated conflicts as independent variables; the conflict prediction models provided acceptable prediction performance for crossing conflicts with a MAPE value of 14,6%. Linear regression models and correlation coefficient were also developed to study the relationship between the simulated and the observed conflicts. Data analysis results showed that there was a reasonable consistency between the simulated and the observed crossing conflicts. The R2 value for crossing conflict model was 0.7521, indicating that the simulated conflicts explained 75.21% variation in the field measured crossing conflicts.

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IMPLEMENTATION OF RENEWABLE SOURCES OF ENERGY ON CROATIAN COAST GUARD LOGISTIC SUPPORT VESSEL PT-71

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ABSTRACT

Usage of renewable energy sources is something that modern shipping tends to, therefore naval shipbuilding shouldn't be excluded from it's implementation. This paper shows an example of possible implementation of „green energy“ on logistic support vessel PT-71, that is a part of Coast Guard of Republic of Croatia. It presents the possibility of installation of renewable energy sources and its economic and ecological effectiveness. The system is made of photovoltaic panels, batteries, solar „all in one “inverter and wiring. Considering the possibilities of positioning the photovoltaic panels on ship's outer free surfaces, it is estimated to install 56 panels of total nominal power 9240 W. The features of all other system elements are fitted to photovoltaic panels. The paper specifies costs of acquiring all system elements, and it also considers the costs of installation and maintenance of the entire renewable energy source. Conclusion shows the advantages of applying this kind of renewable energy system on vessels.

Keywords: renewable energy sources, photovoltaic panel, power network optimization

1 INTRODUCTION

The Republic of Croatia has signed The Kyoto Protocol in 1997 and by doing that has obligated to reduce the emissions of greenhouse gases. According to the EU's climate and energy strategy, the reduction of domestic greenhouse gas emissions should be at least 40% below 1990 levels by 2030.

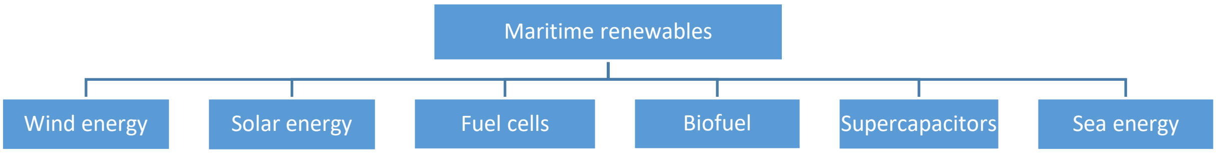
Although the expectations about the reduction of emissions of greenhouse gases globally are encouraging, it is expected that there will be significant increase of pollution in maritime traffic. It is mainly because of two reasons: first one is sort of fuel used and second reason is anticipated increase of maritime transport. Considering the global emissions, pollution from ships takes part about 3% in overall air pollution [1].

2 SORTS OF RENEWABLE ENERGY SOURCES

Usage of renewable energy sources is something that modern shipping tends to. It is a paradox that two centuries ago wind energy has propelled overseas sailing ships and they have sailed by speed higher than 16 knots without using fossil fuels. Therefore, it is necessary to make the most of existing knowledge to apply renewable energy sources by using currently available modern technologies.

Improvements in the efficiency of naval systems and pollution response solutions should be applied not only to the construction of new ships but also as improvements to existing ships.

Available renewables in maritime are: wind energy, solar energy, fuel cells, biofuel, super capacitors charged by renewables and marine power, as shown on Picture 1 [2].



Picture 1: Available renewables in maritime

Wind energy is in fact a form of solar energy. Wind is a horizontal flow of air that is created by the difference in air pressure on earth. Two main characteristics of wind are its speed and direction. The sun radiates a large amount of energy to the earth every hour, and about 1% - 2% of this energy is converted into wind energy. The sun heats different parts of the earth unevenly, which leads to different air pressure. As a result, wind is created because it tends to balance out.

The amount of wind energy transferred on the wind turbine rotor directly depends on air density, rotor's surface and wind speed [3]. Considering the relatively small dimensions of the ship as a platform for installing wind turbines, possibilities for wind turbine accommodation are limited to smaller wind turbines with smaller nominal power. Pictures 2. and 3. show the concepts of wind energy usage on a ship.

Picture 2: Two ways of wind energy usage; Wallenius Wilhelmsen's E/S Orcelle

Picture 3: Flettner Freighter by C-Job Naval Architects

The sun is the main source of the electromagnetic radiation that penetrates the atmosphere and it is naturally inexhaustible. It gives energy that sustains life, directs the atmosphere and, through various movements, shapes the weather and climate. Since solar energy is a highly acceptable renewable energy source, it could become the most important vehicle for environmentally sustainable energy development in the very near future. For this reason, experts are intensively searching for new ways and methods to convert solar energy into electrical, heating or cooling energy [4]. Pictures 4 and 5 show concepts of solar energy use on ships.

Picture 4: Example of solar energy application on ships; Electric Vehicles Research

Picture 5: Example of solar energy application on ships; MS tûranor planetsolar

Fuel cells use hydrogen as fuel, and this process has no negative impact on the atmosphere because the only by-product is pure water. By reacting hydrogen from the fuel cell tank with atmospheric oxygen, chemical energy is converted into electrical energy. There are many examples of the use of fuel cell technology, with the greatest advances being made in the automotive industry. On the other hand, the implementation of this technology in the maritime sector has many difficulties. On the one hand, there is no offshore infrastructure for hydrogen supply. Also the lack of ship space and strong vibrations lead to malfunctions in this type of ship propulsion systems [5]. The advantages of using fuel cells are undisputed, but the future of their application depends mainly on the price of the technology and the availability and price of hydrogen.

Biofuel is a type of energy that was used in internal combustion engines before the invention of cheaper fossil fuels, which replaced ethanol and other plant-based energy sources at the beginning of the twentieth century. Biofuel is made from biomass - organic matter, in most cases plant material, but it can also be of animal origin. Biomass is used to produce biogas, biodiesel, ethanol and dry matter that can be burned in ovens to produce heat or electricity. Biofuel produced from unused waste biomass is an acceptable form of energy, but if biomass is used only for energy production needs, it would certainly have a negative impact on the environment.

Supercapacitors work on the same principles as regular capacitors, but the technology of the production is based on nanomaterials which allows greater surface od electrodes and smaller distance between them. Supercapacitors have up to 1000 times greater capacity compared to regular capacitors and their power density is much larger than in conventional batteries. Except from small mass, they have other advantages like a large number of charge and discharge cycles and very quick recharge. Given the extraordinary progress made in a relatively short period of time, supercapacitors will certainly play an important role in renewable energy systems.

The energy of the sea includes the energy of the waves, tidal energy, sea current energy, thermal energy and the energy produced by salinity difference [6].

3 POSSIBILITIES OF APPLYING RENEWABLES ON SHIP

International Maritime Organization (IMO) in London have adopted an initial strategy on the reduction of greenhouse gas emissions from ships, setting out a vision to reduce green-house gasses (GHG) emissions from international shipping and phase them out, as soon as possible in this century. More specifically, under the identified “levels of ambition”, the initial strategy envisages for the first time a reduction in total GHG emissions from international shipping which, it says, should peak as soon as possible and to reduce the total annual GHG emissions by at least 50% by 2050 compared to 2008, while, at the same time, pursuing efforts towards phasing them out entirely [7].

The lack of comprehensive information makes it rather difficult to identify precisely the possible advantages of one approach over another.

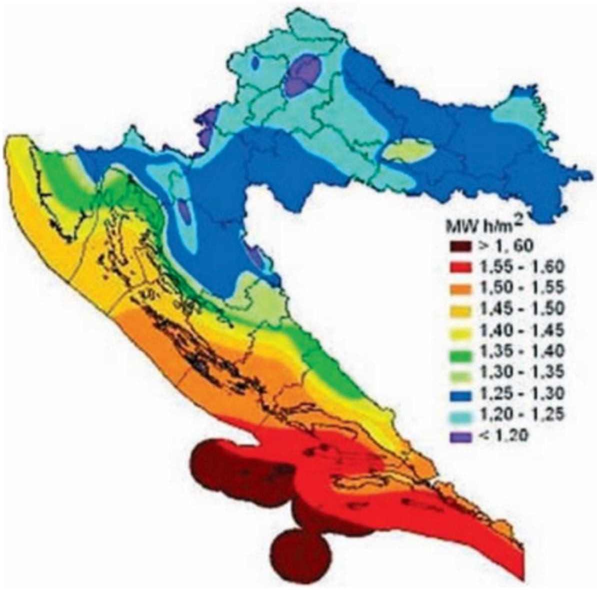
Although the renewable energy systems are installed mostly on large overseas ships, their appliance is more suitable for smaller ships that operate on shorter relations. There are examples of smaller ships that are already completely independent from using fossil fuels.

In this paper is presented the possibility of installation of photovoltaic panels on logistic ship PT-71 shown on picture 6. Overall length of this ship is 43,7 m, her width is 8,2 m and her draft is 3,5 m. She is propelled by diesel engine with 684 kW power that allows maximum speed of 10 knots.

The vessel PT-71 is a part of Croatian Cost Guard. The main purpose of this ship is fresh water supply to remote consumer on mainland and on remoted islands. This vessel is chosen because is relatively big horizontal surface suitable for installation of photovoltaic panels.

Picture 6: Republic of Croatia Coast Guard vessel, PT-71[1]

In order to approach the projecting of photovoltaic system it is necessary to know the irradiation of the locality on which the system would be installed. Picture 7 shows the average annual irradiation of horizontal surface (Ljubomir Majdandžić, Fotonaponski sustavi, priručnik).



Picture 7: Average annual irradiation for the Republic of Croatia area

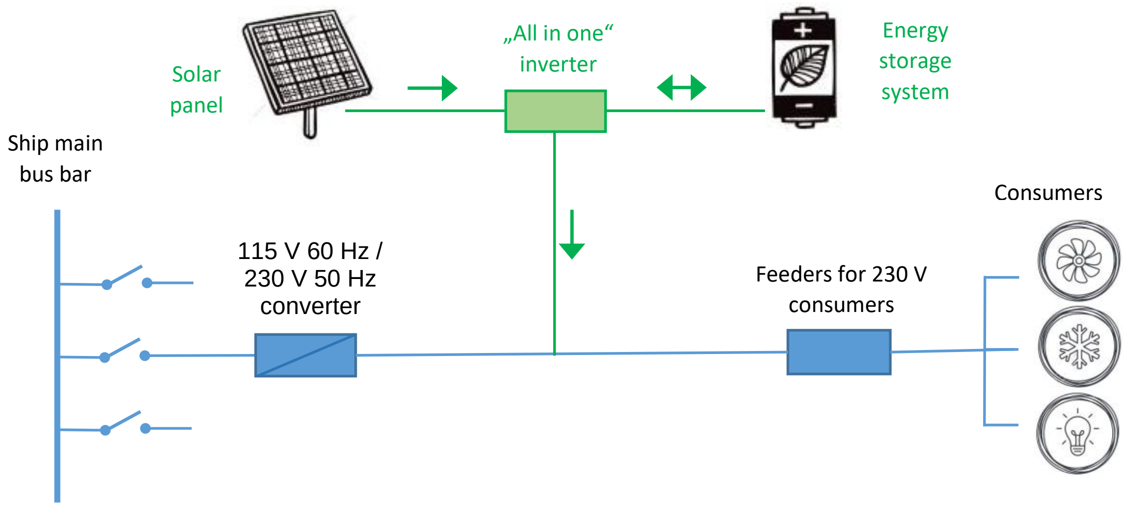
Diesel electric generators are the sources of electric energy on ship that supply all consumers via main control panel. Renewable energy system consists of photovoltaic module, batteries and hybrid “all-in-one” inverter that regulates the electric energy flow. Picture 8 shows the schematic energy flow of renewable energy systems from the source towards the consumers.

The consumers of electrical energy that are supplied from the renewable systems are heating, ventilation and air condition, radio devices, navigational devices and household appliances (refrigerators, irons, TV sets etc.).

[1] Source: https://hr.wikipedia.org/wiki/PT-71

Based on network parameters, "all-in-one" inverter regulates the current flow. In periods when there is no sunshine irradiation, consumers of 230 voltage level are supplied by diesel electric generator. When photovoltaic modules produce electric energy they use inverter to supply the consumers. When the production of electrical energy on PV modules exceeds the consumption of consumers, this excess energy is stored in batteries. Energy stored in batteries is used when PV modules stop producing electrical energy.

During the planning of this renewable energy system, losses of all system elements are taken into consideration.



Picture 8: Electrical energy scheme

Table 1. shows the expenses of all parts of the system. Costs of the purchase, implementation and maintenance of the whole system of the renewable energy sources have been taken into consideration. Certain elements of the system are chosen based on independent reviews without favoring certain manufacturer.

Total expenses of the purchase, implementation and maintenance of the system during the period of 25 years of exploitation is 61 204 €. Considering the annual production of 10 700 kWh, this system should generate 267 500 kWh in the period of 25 years. The price of the kWh generated from the renewable energy system in the observed period is 0,2288 €/kWh. The cost of the electric energy produced by the photovoltaic panels is less than half the price of the energy produced by a diesel electric generator. The price of certain elements of the system is available on the official websites of the manufacturers, while the cost of maintenance is based on estimated costs, taking into account the experience gained in the maintenance of marine electrical systems.

Table 1: Expenses of all parts of the system in €.

No.	Item	Total expenses of purchase	Maintenance expenses (25 years period)	Total expenses
1.	PV panel Rigid 165W	24 610	2 100	26 710
2.	Battery Trojan Spre 12225Ah (three sets)	18 136	2 000	20 136
3.	Inverter IMEON 9.12	4 358	5 000	9 358
4.	Installation	2 000	3 000	5 000
	TOTAL	**49104**	**12 100**	**61 204**

4 CONCLUSION

Although the economic and environmental aspects of naval shipbuilding are not a priority, much more effort should be made to design new ships and also to modernize existing ships to make them more environmentally friendly. The use of renewable energy sources is suitable for use on logistics vessels and on Coast Guard ships. This paper shows the example of possible implementation of photovoltaic panels on Croatian Coast Guard logistic ship. The cost of the electric energy produced from the photovoltaic panels is more than two times cheaper compared to the price of the energy produced by diesel electric generator. Implementation of the presented system encourages all companies that participate in the production, installation and maintenance of renewables. This way of renewable sources application can be adapted on any other vessel considering its specific characteristics and limitations.

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DIFFERENCES IN CONTRACTING OF HARBOUR, COASTAL AND OCEAN TOWAGE

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ABSTRACT

Taking into account the area where it is performed, towing at sea covers harbour, coastal and ocean towage. Harbour towage includes towage in the area of a harbour and its anchorage, coastal towage takes place outside of the harbour, in other parts of inland seawater, in the territorial sea and in well protected channels, while ocean towage is done in the ocean area. Each type of towage has its own specifics of contracting: from very simple contracting of harbour and coastal towage, with several provisions on the rights and obligations of the contracting parties, to a complex contractual relationship such as ocean towage, with a range of rights and obligations of the contracting parties. However, what is specific about ocean towage contracting is the regular use of standard contract forms with pre-printed contents of the provisions. Examples of such standard contracting are BIMCO's standard towage forms: TOWHIRE 2008 and TOWCON 2008.

The purpose of this study is to determine the specifics of contracting of harbour, coastal and ocean towage and to determine the content of the articles of agreement for each type of towage. The goal of this paper is to ascertain the differences in the manner of contracting the towing and in the contents of the rights and obligations of the contracting parties regarding particular types of towage. It is concluded that the rights and obligations of the contracting parties regarding harbour, coastal and ocean towage contracts have been created in accordance with the complexity of the type of contracted towage.

Key words: harbour towage, coastal towage, ocean towage, TOWHIRE 2008, TOWCON 2008

1 INTRODUCTION

Towing at sea is a special form of maritime-navigation activity which consists of a tug placing its motive power at the disposal of a towed vessel by pulling it, keeping the vessel in place or helping the vessel to perform a certain manoeuvre. Towing can be described as putting into motion or assisting the movement of a vessel that either does not have any motive power of its own or is unable to use its power under certain circumstances [1, 2]. Towing can also be described as moving a vessel by towing where the towed vessel is located behind or along the side of the tugboat [3].

If we compare the size and the motive power of individual tugboats, we can see that they vary greatly, from very small tugboats to very large harbour tugboats and tugboats which venture farther from shore and are capable of towing on all the oceans [4]. Size and motive power of a tugboat is primarily dependent on the area where the towing is performed.

Harbour towage includes towage in an area of a single harbour, including its anchorage, and is performed by harbour tugboats of smaller displacement with exceptionally strong engines and a hull built specifically for harbour towing [1]. Harbour towing is an exceptionally important activity in harbours [5] and is most often needed by larger ships which cannot manoeuvre in the confined area of the harbour without the help of tugboats, without the risk of impact, collision or interference to other ships [1]. Harbour towing assists with and facilitates the manoeuvre of the entry of a ship into the harbour, passage through the harbour, docking at the harbour, moving from shore to shore or leaving the harbour.

Furthermore, anything not covered by the described term of harbour towing represents out-of-harbour towing which is in "contact" with the harbour in the sense that is begins or ends at the harbour. Harbour towing takes places outside of the harbour, i.e. along the coast or out on the ocean, and in this sense it is divided into coastal and ocean towing.

Coastal towing takes place in internal seawaters (except for the harbours), in the territorial waters and in well-protected channels [6]. In coastal towing, one ship, which is unable to move under its own power, frequently needs to be towed from one place to another for the purpose of repairs. In such cases, the destination can be far from the starting point, and tugboat(s) chosen for this task must conform to different requirements than those set out for tugboats in harbour towing. Tugboats which perform coastal towing must primarily be able to withstand rough stormy sea on their own in order to successfully tow the towed ship to the destination. When it comes to its characteristics, coastal towing is in many respects closer to the towing on high seas. Ocean tugboats are capable of performing towing and rescue operations on all high seas, in any weather, and with a large range, and of providing effective assistance to passenger, cargo and other ships [8]. Therefore, the preparation for carrying out ocean towing is extremely important, because this type of towing is a delicate maritime risk.

Starting from the described differences between towing performed in different areas, there is a question of whether there are differences in the manner of contracting for individual type of towing. Lacking the legal scientific knowledge of different manners of contracting for individual type of towing, we believe that the subject differences cannot be determined without carrying out a research.

Therefore, the subject of this paper is to determine the specificities of contracting and the contents of the rights and obligations of parties in harbour, coastal and ocean towing. Research materials are examples of the autonomous legal sources: towing contracts, general towing terms and conditions and tug tariffs from several tug owners based in European Union member states (one from Slovenia and two from Croatia and Italy). Also, in the paper we will consider available legal sources dealing with towing contracts. For that purpose, laws from the field of maritime law of the Republic of Croatia, Republic of Slovenia, Italian Republic, French Republic and the Republic of Poland have been selected. We will use the analysis method and comparative method, comparing the manner of conclusion of the contracts and the contents of the contract.

Finally, research of the towing contractual relations deserves our attention because these are a "useful tool in understanding" different contracts in the field of maritime law [10].

2 CONTRACTING HARBOUR, COASTAL AND OCEAN TOWING

Towing is usually carried out by concluding a contract either in writing or orally.

From the analysis of legal sources dealing with towing contracts, we can determine that maritime regulations which regulate towing do not prescribe special form for concluding towing contracts, and therefore a towing contract is not of a strict formal character, and written form is not a requirement for their validity. The same can be concluded from numerous maritime laws of the countries of the so-called continental law system. For example, according to the Croatian, Slovenian and Italian maritime law, there is no prescribed form for the towing contracts [14, 15, 16]. Also, according to common law, a towing contract does not have to be made in writing [2].

In practice, an oral conclusion of the towing contract is especially common in harbour towing. Specifically, in an orally concluded contract, a *tug report* is usually delivered to the master of the ship being towed for (co)signature and it serves as proof of the concluded towing contract.

It is common practice to use this model of contracting when the ships of the towing hirer regularly or frequently dock at a certain harbour, where the tug owner and the towing hirer conclude a framework contract in writing, and then agree orally on each individual towing within the scope of such framework contract. The framework contract is usually concluded for a period of one year with an option for termination in accordance with the terms of the contract. By examining the collected harbour towing contracts, we found that they are usually contracted with an option to terminate the contract by virtue of a written notice given six months before the expiry of the contract.

When it comes to towing outside of the harbour, which is most often of longer duration and involves towing of complex objects, the contract conclusion form is also stricter, and for such towing the parties conclude the contract in writing. Therefore, it is difficult to imagine out-of-harbour towing, i.e. coastal and ocean towing without a contract concluded in writing.

In practice, towing contracts, whether they are harbour or out-of-harbour, are often concluded as adhesion (upon accession) or model (standard-form) contracts where individual towing companies (tug owners) print their own contract forms. There is no single contract form for towing; instead, large shipping companies which perform towing services, especially those which are members of the *International Salvage Union* regularly use their own contract forms for towing contracts [17]. In some countries these forms are standardized and therefore take on a form of national towing terms, for example in Great Britain, where national towing terms called *U.K. Standard Conditions for Towage and Other Services* are in use [18]. In some countries, national towing terms are used (only) for certain types of towing, for example in

Denmark, *Dutch Harbour Towage Conditions 2007* are used for harbour towing [19].

What all these standard-form contracts have in common is that the content and the terms under which one party agrees to conclude such contract are set out in advance. Such contracts will be standardized when they are issued by commercial or other organisations (for example, ship operator organisation) regardless of the specific parties [8]. When using standard-form contracts, one party presents the other with a prepared draft of the contract they use regularly. This is an offer for the conclusion of the contract which in principle allows for deviations from the proposed forms and gives an option to negotiate on the terms of the future contract. By concluding standard-form contracts, it is possible to avoid negotiations and simplify operations, therefore, the advantage of standard-form contracts is fast conclusion and saving time. However, there are some downsides to such concluding of contracts. To a certain extent, the fact that standard-form contracts are an expression of the will of the economically superior party and that they are often written in favour of the bidder can be considered a drawback [9, 11]. For example, in harbours in which one tug owner has a monopoly on towing based on a concession, there is an imbalance in the strength of the contracting position of the parties. This is only exacerbated if the towing is mandatory in such particular harbour, and the tug owners offer their own contract forms, which leaves little room for disposition of will of the other party to the contract.

Standard-form towing contracts usually contain or refer to general towing terms and conditions. Towing companies usually have their own towing terms and conditions published in usual ways, and the towing hirers cannot claim that they are not familiar with the general terms and conditions of towing. Sometimes, specific terms are added to general towing terms and conditions, which can be contracted by mutual addition by the parties. Finally, the acceptance of general towing terms and conditions is considered the first step of the conclusion of the towing contract [20].

Regular use of standard-form contracts with predetermined rights and obligations of the parties is especially common in contracting out-of-harbour and ocean towing. Examples of such contracts are standard-form contracts on ocean towing compiled and recommended by the Baltic and International Maritime Council (BIMCO). BIMCO's activity is focused on maintaining and standardizing activities related to shipping and are considered to be a significant contribution to unification in shipping. Most well-known standard-form contracts on ocean towing used for concluding the majority of international ocean towing contracts are TOWHIRE 2008 – International Ocean Towage Agreement (Daily Hire) [21] and TOWCON 2008 – International Ocean Towage Agreement (Lump Sum) [22]. These are also the most recent ocean towing contract forms drafted by the BIMCO association [12, 13].

3 CONTENTS OF THE CONTRACT ON HARBOUR, COASTAL AND OCEAN TOWING

Towing contracts establish mutual obligations between two parties; therefore, each party has their own rights and obligations.

Regardless of whether we are talking about harbour, coastal or ocean towing, the principal obligation of the tug owner is to tow another object, and of the towing hirer is to pay the towing price. Principal obligations of the parties stem from the very definition of the term of a towing contract.

When the contract has been concluded orally, as is often the case in harbour towing, proof of the existence of the contract is the tug report in which essential elements of performed towing are given. Therefore, the tug report states the tug report number, data on the number of tug boats, duration of the towing, name, flag and tonnage of the towed vessel, information on where the towing is taking place, information on the ship's agency for account, name of the harbour, date on which the towing was carried out, and the space for signatures of authorised persons. The tug report is signed by the master of the towed vessel, who keeps one copy, while other copies are retained by the tug owner who issues an invoice for the towing service based on the signed tug report. Price of the towing service is determined by the tug owner's tariff and depends on the particulars of the performed towing.

If the harbour towing is being carried out based on the framework harbour towing contract or if out-of-harbour towing has been contracted, apart from the essential contractual elements (names of the parties, name of the harbour in which the towing is to take place, etc.), these contracts also contain a provision referring to the mandatory application of the general towing terms and conditions, which define the rights and obligations of the parties in detail and which form an integral part of the contract.

The general towing terms and conditions can be described as the rights of the tug owner, but also as the obligations of the towing hirer, because the rights of one party are the obligations of the other party.

The usual content of the rights and obligations of the parties, according to general towing terms and conditions, are payment provisions, provisions on the rights of the tug owner in the event of non-payment or partial or late payment of an amount due, provision on cancellation in the event that the hirer has terminated the contract before the performance is completed, including the situation that the performance has not commenced at all. The general towing terms and conditions usually contain a provision titled *Complaints*, according to which the towing hirer is responsible for checking or having someone check the conformity of the performance during towing. According to the general towing terms and conditions, complaints must be made in writing, stating the reasons for the complaint and, if possible, accompanied by proof. There are also provisions on the right to the exclusion, i.e. limitation of the tug owner's liability according to which a tug owner is not liable for any damage, except for the direct damage resulting from an intentional act or wilful recklessness, indirect loss of any kind, including consequential loss and/or non-material loss, suffered by the towing hirer or by a third party or a person to whom they are liable under the law for failing in the performance of the contract. The general towing terms and conditions usually contain provisions by virtue of which the tug owner reserves the right to divert to an intermediate harbour. Also, the general towing terms and conditions usually contain provisions on the tug owner's right to refuse to obey the commands of the master of the ship in tow. Even though they are contracted in favour of the tug owner, these provisions are useful in the event of compromising the safety. Some of the general towing terms and conditions contain provisions which give the tug owner's master the right to refuse to obey the commands of the master of the towing hirer even when there is not an issue of compromising the safety.

Finally, it can be established from the subject analysis of the contents of the general towing terms and conditions, which are an integral part of the towing contract, that the rights and obligations of the parties are regulated by several provisions, and that the rights and obligations of the parties are set out in greater detail in the general towing terms and condition to which the contract on harbour and coastal towing refers. However, the general towing terms and conditions do not put the parties in equal positions, i.e. they are drafted so as to set out the tug owner's rights and the towing hirer's obligations. In other words, the contents of the rights and obligations of the parties from the contract on harbour and coastal towing should be viewed through the prism of autonomous legal sources that apply to these contracts.

Unlike the contracts on harbour and coastal towing, which refer to the general towing terms and conditions, ocean towing contracts prescribe a series of rights and obligations of the parties in their "basic" content. When, for example, ocean towing has been contracted using standard forms, such forms contain various rights and obligations of the parties. However, in some cases of contracting ocean towing based on a form, examples from practice show that the parties agreed only on the use of some of the provisions and disregarded others by crossing them out.

Given that ocean towing contracts are most often concluded using TOWCON 2008 and TOWHIRE 2008 forms in business practice, we shall mention the rights and obligations of the parties from these forms as an example of an ocean towing contract.

TOWCON 2008 and TOWHIRE 2008 forms differ from each other in their contents. Pursuant to the TOWCON 2008, the towing ship is paid for the towage services on a lump sum basis as in the case of a voyage charter, whereas under the TOWHIRE 2008, the towing ship is paid on a daily hire basis as in the case of a time charter. TOWCON 2008 and TOWHIRE 2008 forms consist of two parts: the first part contains spaces for entering the information on the essential parts of the contract (the so-called box layout system), and the general towing terms and conditions are given in the second part. The sections in the first part of the form pertain to the entry of the information on the parties, towing object and other towing details, such as the place of departure, date of departure, contemplated route, etc. Certain sections from the first part of the form refer to relevant provisions from the second part. For example, as specified by the forms, obligation of the tug owner is "to render the service(s) to the Tow as set out in Box 22" [21, 22]. Therefore, forms only refer to the box from the first section, which is used for entering the nature of service(s). The second part, the central, most important and most extensive part of the forms consists of contractual provisions which set out the rights and obligations of the parties. Some rights and obligations from the TOWCON 2008 and TOWHIRE 2008 forms are set out by the provisions with the following titles: *Price and Conditions of Payment*, *Bunkers*, *Bunker Quality*, *Extension to Cancelling Date*, *Ice Clause for Tug and Tow*, *Additional Charges and Extra Costs*, *War Risk Escalation Clause*, *Interest*, *Financial Security*, *Place of Departure*, *Place of Destination*, *Riding Crew*, *Towing Gear and Use of Tow's Gear*, *Permits and Certification*, *Tow-worthiness of the Tow*, *Seaworthiness of the Tug*, *Substitution of Tugs*, *Salvage*, *Termination by the Hirer*, *Termination by the Tug Owner*, *Necessary Deviation*, *Liability and Indemnity*, *Himalaya Clause*, *War and Other Risks*, *Lien*, *Warranty of Authority*, *Dispute Resolution Clause*, *Security for Claims and Notices Clause* [21, 22].

In the TOWCON 2008 and TOWHIRE 2008 forms some of these provisions differ from each other in their content. For example, according to the provision titled *Price and Conditions of Payment* in the TOWCON 2008 form, the towing hirer shall pay the tug owner the sum set out in the first part of form (called "the lump sum"). The lump sum and all other sums payable to the tug owner shall be payable without any discount, deduction, set-off, lien, claim or counter-claim. Also, each instalment of the lump sum shall be fully and irrevocably earned at the moment it is due as set out in first part of the form [22]. On the other hand, according to the provision titled *Price and Conditions of Payment* in the TOWHIRE 2008 form, the towing hirer shall pay the tug owner the amount of hire set out in the first part of the form per day or pro rata for part of a day (called the "tug's daily rate of hire") from and until the time stated in the first part of the form. The tug's daily rate of hire shall be payable in advance as set out in the first part of the TOWHIRE 2008 form and all hire due shall be fully and irrevocably earned and non-returnable on a daily basis [21].

Furthermore, some rights and obligations of the parties from the TOWCON 2008 and TOWHIRE 2008 cannot be found in the content of the harbour and coastal towing contracts or in the general towing terms and conditions which form an integral part of such contracts. For example, harbour and coastal towing contracts do not contain provisions titled *Bunker*, which regulate the obligation to pay for the bunker, and the provision on the Bunker Quality, which, among other things, prescribes that fuels must be of "stable and homogeneous nature" [21, 22]. Also, some common rights and obligations of the parties in towing, such as tow-worthiness of the tow and seaworthiness of the tug, is regulated in more detail in the contract forms on ocean towing compared to the harbour and coastal towing contracts. The reason for this is the complexity of carrying out ocean towing, and the rights and obligations of the parties from the ocean towing contract must be comprehensive, unlike harbour and coastal towing, in which the scope of rights and obligations of the parties is narrower than in ocean towing.

4 TOWING CONTRACTS IN THE LEGISLATION OF EUROPEAN UNION MEMBER STATES

Autonomous legal sources are the most important legal sources for defining the contents of harbour, coastal and ocean towing contracts. However, in addition to these sources, it is also necessary to take into account legal sources and determine which contents of a towing contract are prescribed by law for all those cases when certain rights and obligations of the parties are not clearly defined by autonomous legal sources. As an example of standardization of towing contracts in the legal sources, we shall take a look at the legal provisions of several European Union countries: Republic of Croatia, Republic of Slovenia, the Italian Republic, the French Republic, and the Republic of Poland.

The subject matter of the towing contract in the Republic of Croatia is regulated by the *Pomorski zakonik* [14] (hereinafter: Croatian Maritime Code). According to the Croatian Maritime Code, the division of towing according to the space where the towing is being performed (harbour towing, internal seawaters, and in territorial waters) is the relevant division. However, the Croatian Maritime Code does not contain special provisions on the contents of harbour, coastal and ocean towing contracts; rather, it contains several provisions which pertain to towing contracts in general. Primarily, the Croatian Maritime Code defines the contract, and fundamental rights and obligations of the parties, defines who manages the towing and the start and the end of the towing. It also defines the way in which the price of towage is set, and it also lists cases in which a tug owner is not entitled to towage fee. Within the provisions on towing, the Croatian Maritime Code also standardizes the transport of cargo by towing and, in addition to the towing contract, it also identifies the contract on cargo transport by towing by their own or by someone else's ship. The provisions of the towing contract also contain provisions on liability for damages caused by a collision of vessels during the execution of the towing, it sets out the relationship between towing and rescue and towing and general average and it defines the period of limitation for claims arising from the towing contract [14].

In the Republic of Slovenia, maritime legal relations are defined by *Pomorski zakonik* [15] (hereinafter: Slovenian Maritime Code) which, within the provisions on the "mandatory towing of waterborne crafts", states that the for the purpose of navigation safety, mandatory towing of waterborne crafts is defined, whose terms and manner of execution are set out by the minister in charge of maritime affairs. For the performance of mandatory towing, sufficient number of appropriately equipped tug boats must be available (primarily with firefighting equipment) or such equipment can be located at the land facilities. In addition to this maritime administrative provision, the Slovenian Maritime Code regulates the contractual towing in part dedicated to maritime contractual relationships. These provisions are very similar to the provisions on towing contracts from the Croatian Maritime Code. Similar to the Croatian Maritime Code, the Slovenian Maritime Code does not contain special provisions on the contents of the contracts for harbour, coastal and ocean towing. Instead, it contains several provisions which pertain to towing contracts in general [15].

In the Italian Republic, provisions of the *Codice della navigazine* [16] (hereinafter: Italian Maritime Code) apply on the maritime legal relationships. According to the Italian Maritime Code, towing is defined as a separate harbour service, together with pilotage and by its legal nature it represents *location operis.* The tug owner and the towing hirer remain entrepreneurs, each within the limits of their undertaking, and their liability is divided in accordance with the share in the work. According to the Italian Maritime Code, the towing contract content includes the towing (*trazione*) of the towed object, however, if the tug owner took over the management of the towed vessel, the contract shall be judged by the provisions on the transport of goods. In principle, the Italian Maritime Code differentiates between *rimorchio-transporto* and *rimorchio-manovra* and the criteria for this subdivision are the handover element (*consegna*) of the object under tow. For towing being performed for the purpose of completing a manoeuvre, the towed object is not handed over to the tug owner whereas the towing for the purpose of transport is characterized by this handover. *Rimorchio-transporto* and *rimorchio-manovra* are not different in their spatial scope because the former can be a case of towing as transport (*transporto)* from one place to another within the harbour, whereas towing of a ship on the open seas, with its own crew, must be designated as manoeuvring towing (*manovra*). Although the Italian Maritime Code does not take the spatial element as the decisive element in the division of towing, it does introduce differentiation between the harbour and the out-of-harbour towing in a roundabout way [16].

Towing contract in the French Republic is regulated by the Act on Shipping Companies and Maritime Purchases (*Relative a l'armement et aux ventes maritimes*) [23] (hereinafter: the French Maritime Code). The provisions on towing are given in the third part of the French Maritime Code, under the name *Des opérations de remorquage.* The entire subject of towing is covered by only a few articles. The provisions of the French Maritime Code divide the contractual towing into harbour and out-of-harbour towing. For harbour towing, the French Maritime Code envisages that the towing shall be commanded by the master of the towed vessel, unless the parties expressly and in writing entrust the towing to the master of the tug boat. For out-of-harbour towing, the French Maritime Code envisages that the towing shall be managed by the master of the tug boat, unless the parties expressly agree otherwise (written form is not required). The French Maritime Code does not expressly stipulate the contractual and non-contractual obligations in towing, and the damages which occur during towing are "borne" (*sont à la charge*) by the vessel controlling the towing, unless the said vessel is able to prove that the other vessel in tow was at fault. This definition of liability in towing contracts means that it is unclear which damages are covered by it – only those between the tug boat and the towed vessel or if they also include damages to third parties [23].

In the Republic of Poland, the towing provisions are defined by the Maritime Code (*Kodeks morski*) [24] (hereinafter: Polish Maritime Code). The provisions are given in only a few articles and do not contain special provision which would apply to the contents of a specific type of a towing contract; instead, it uses the general wording "towing contract". The Polish Maritime Code contains the provisions on towing performed by a "group of tug boats" which is created at the moment when several tug boats are ready to perform necessary manoeuvres, in accordance with the orders of the head of the group of tug boats. The said group shall stop its operations after the final manoeuvre is completed and after the tug boats move to a safe distance. The navigation of vessels comprising a group of tugboats is commanded by the master of the towed vessel, unless specified otherwise in the contract. The tug owner who provides the towing services must deliver a tug boat capable of providing contracted services, appropriately equipped and crewed at the agreed time and at the agreed location. The towing services must be performed in accordance with the circumstances, without unnecessary interruptions and delays and in accordance with the maritime rules. Also, the ship whose navigation is commanded by the commander of another vessel must take care of the safety of the group of tug boats and the safety of navigation. The amount of towage fee is set out by the contract, and if there is no contract, the tug owner is entitled to fair and equitable remuneration [24].

Finally, what all the legal sources for towing contracts of the selected countries have in common is the small number of provisions dedicated to towing. For determining the rights and obligations of the parties, the legal sources most often use the wording "towing contract" and in rare provisions they define separate rights and obligations pertaining to a specific type of towing. Several provisions are specifically dedicated to the rights and obligations of the parties in harbour towing, and the use of the wording "towing contract" implies the use of statutory provisions on all types of towing.

5 CONCLUSION

By recapitulating the modalities of the conclusion of the contracts of harbour, coastal and ocean towage, we can conclude that the harbour towing contracts are concluded orally, whereas it is difficult to imagine concluding coastal or ocean towing contracts without previously concluding a written contract. Freedom to choose the form of the conclusion of the contract stems from legal sources for towing, which most often do not prescribe the mandatory form of the towing contracts, and therefore the contract can be made orally.

In harbour towing, the often used model for concluding the contract is the model in which the tug owner and towing hirer conclude the framework, written, harbour towing contracts, and then agree orally on each individual towing in the harbour based on the framework contract. In orally concluded contract on harbour towing, the tug report is usually given to the master of the towed ship for signature.

Standard-form contracts are regularly used in written conclusion of the contract. Some tug owners operate using their own contract forms, and in some cases these forms are standardized. For example, standard forms TOWCON 2008 and TOWHIRE 2008 of the BIMCO association are most commonly used in the business practice of concluding ocean towing contracts with international elements.

Regardless of whether the towing in question is harbour, coastal or ocean towing, the principal obligation of the parties stems from the very definition of the term towing contract, but the scope of other rights and obligations of the parties depends on the type and complexity of the towing. The rights and obligations of the parties are contracted in much greater detail in ocean towing than in coastal and harbour towing. In harbour and coastal towing, a reference to the use of the general towing terms and conditions is given in the provisions which are drafted so at to place the parties in equal position, i.e. they are drafted as the rights for tug owners and obligations of the towing hirer. Unlike the harbour and coastal towing contracts, which refer to the general towing terms and conditions, the "basic" content of the ocean towing contracts prescribes a series of rights and obligations of the parties. For example, by analysing the contents of the TOWCON 2008 and TOWHIRE 2008 forms and the collected harbour and coastal towing contracts, we found that certain rights and obligations of the parties from the TOWCON 2008 and TOWHIRE 2008 forms are not contained in the harbour and coastal towing contracts or in the general towing terms and conditions which form an integral part of such contracts, whereas some common rights and obligations of the parties in towing are regulated in greater detail in the ocean towing contracts compared to the harbour and coastal towing contracts.

Ocean towing is a complex activity, and therefore the rights and obligations of the parties from the ocean towing contract are more comprehensive, i.e. regulated in greater detail. Harbour towing or coastal towing are less complex than ocean towing and the contracts for these types of towing have only several provisions in the basic part and refer to the general towing terms and condition, which form an integral part of such contracts. In some cases, these contracts are not even made in writing. Therefore, the rights and obligations of the parties from the harbour, coastal and ocean towing are created with regard to the complexity of the type of the towing being contracted.

From the analysis of the selected maritime codes of the European Union member states, we have seen that the legal sources most often dedicate only a few provisions to towing contracts and that they use the general wording "towing contract" and do not contain special provisions which would pertain to the contents of harbour, coastal and ocean towing.

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NOTE

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CYBER RISK MANAGEMENT WITH IMPACT ON MARITIME INDUSTRY

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ABSTRACT

The advanced information technology has extensively been used in maritime industry over the last decade. This has resulted in an increased number of threats influencing the industry. Cyber-attacks are a relatively new area of maritime industry. This growth in the number of attacks worries not only the IT industry, but also the entire maritime industry. The ability of businesses and people to balance between cyber threats and regulations on the one hand and to embrace innovation on the other is essential to furthering business success. Managing cyber risks in maritime industry and improving security of ships engaged in international transport is crucial for the future of global economy as about 90 percent of goods are transported via international shipping industry. Since the number of cyber-attacks has shown a tendency of rapid growth, the aim of this paper is to emphasize the seriousness of these occurrences in maritime industry, the importance of taking timely action and managing cyber risks at the material and human resources level.

Keywords: maritime industry, cyber risk management, growth, threat, human resources

1 INTRODUCTION

At a time of rapid development of technology and networking, more attention should be paid to the financial and economic aspects of information security, therefore cyber risk management is becoming increasingly important (Polatid et al. 2018). Managing a company and its business affairs in maritime industry is unthinkable and impossible without the usage of technology. The usage of technology increases productivity and results in better efficiency. Therefore, shipping companies and companies related with the shipping industry are faced with a growing number of cyber risks.

Cyber risk is a fundamental issue for the progress of the shipping industry, particularly when it is known that a cyber-attack could ultimately result in the loss of a vessel and in the loss of human lives. In today's connected world, the usage of cyber technology enables shipping companies to transport goods in a quicker and more efficient way, which accordingly increases security risks.

A complete cyber risk management program is not only a necessity for many companies, but it is of crucial importance for their survival and financial viability. In 2017, through the Guidelines on maritime cyber risk management, IMO identified the functional elements which contribute to an effective cyber risk management.

Th goal of this paper is to show the effects of cyber-attacks in maritime industry, the possibilities of taking timely and appropriate actions, and the ability to manage risks in an acceptable way using new skills and abilities.

2 THE IMPORTANCE OF CYBER RISK MANAGEMENT

Recognizing the importance of cyber risk management and in order to prevent future cyber-attacks, several documents on cyber risk management and mitigation have been created.

In 2017 IMO issued MSC-FAL.1/Circ.3 Guidelines on maritime cyber risk management. In the same year, the Maritime Safety Committee adopted Resolution MSC.428(98) - Maritime Cyber Risk Management in Safety Management Systems. The International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) jointly published ISO/IEC 27001 standard on Information technology – Security techniques – Information security management systems – Requirements in 2018 And Guidelines on Cyber Security on board Ships were issued by BIMCO, CLIA, ICS, INTERCARGO, INTERMANAGER, INTERTANKO, OCIMF, IUMI and World Shipping Council.

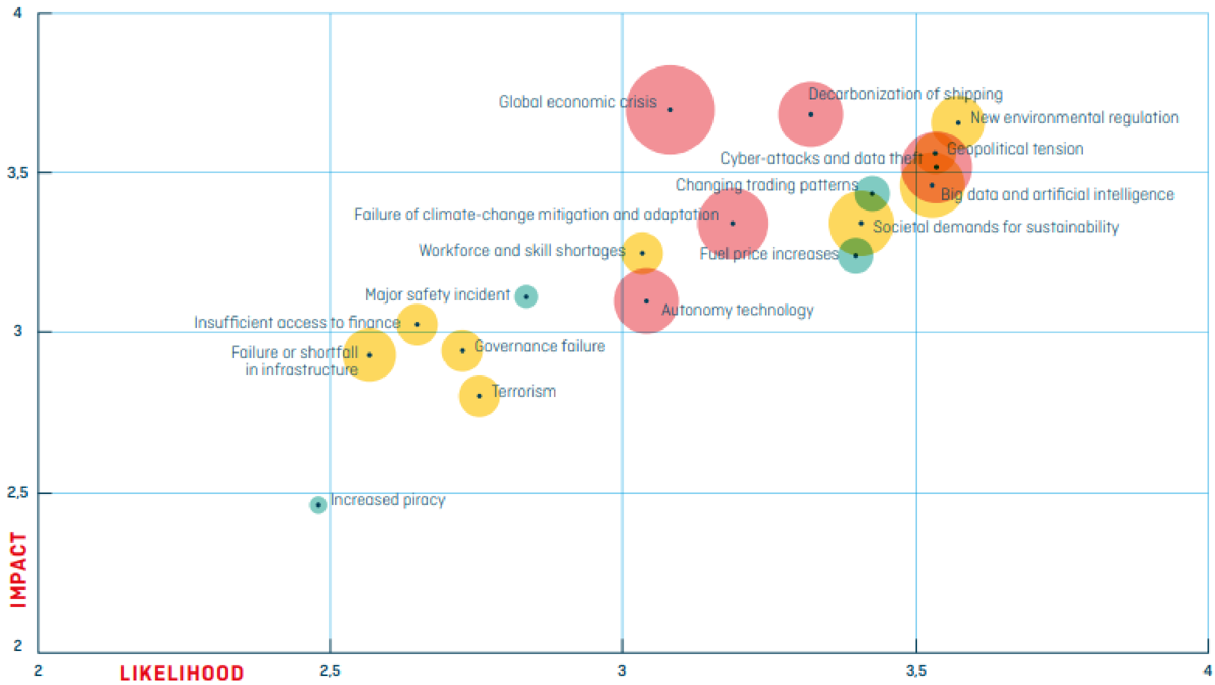
Cyber risk management is essential for identifying the limitations and weakness of a shipping company, and according to the International Maritime Organization (IMO, 2017) it consists of the following: identifying, analyzing, assessing and communicating risk and accepting, avoiding, transferring or mitigating risk to an acceptable level.

Malicious software and tools (malware) are most commonly used to initiate a cyber-attack. They are used to hijack, alter, steal, encrypt and delegate sensitive system data without knowledge or a permission from the data owner. Different forms of malicious software are used:

- malware – a worm which can self-replicate and spread infecting all vulnerable programs and files;
- Trojan horse – appears as a genuine and authentic tool, but once when activated, it performs malicious activities;
- spyware – a software that spies on and collects user's sensitive data without the knowledge of user;
- ransomware – is designed to encrypt system data after the infection;
- phishing e-mails – e-mails which appear to be sent from a reputable company containing malicious attachments or links. They steal sensitive data such as login credentials, bank details, etc.

Taking into consideration all above mentioned, the costs of the actions taken and the benefits to all stakeholders should be considered.

The Global Maritime Issue Monitor (Global Maritime Issues Monitor, 2019) compiled a report, based on a survey of senior maritime stakeholders from 46 countries, on critical issues that are in the focus of maritime industry. The Global Maritime Issues Map (Figure 1) is presented on the basis of a number of issues that have a potential for high impact. The Issues Map also gives an insight how well the shipping sector is prepared to meet the challenges (Figure 1).



Source: Global Maritime Forum; Marsh; International Union of Marine Insurance

Figure 1: Global maritime issues map

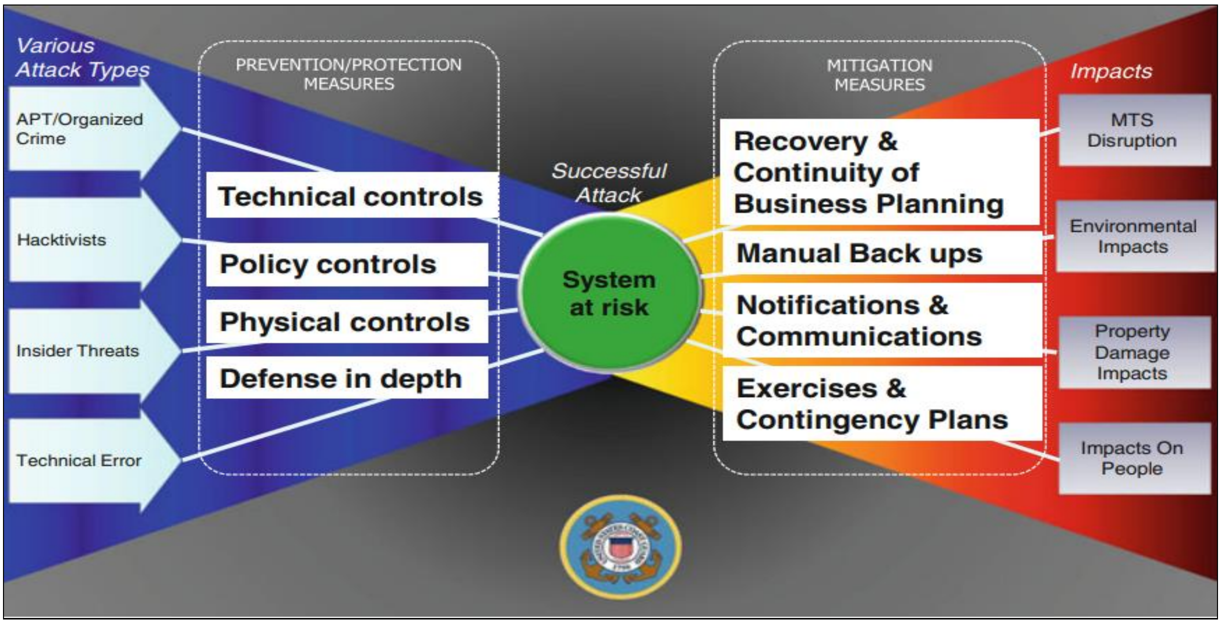
As can be seen in Figure 1, in addition to the problem of cyber-attacks, some other challenges also need to be addressed, such as geopolitical tension, artificial intelligence, data theft, social demands for sustainability, etc. Cyber-attacks are qualified as a risk that has the potential to lead to a major security incident.

According to the survey, the problem of cyber-attacks holds the third place in terms of the likelihood for an attack to occur and the preparedness to deal to it. This undoubtedly reflects the experience of maritime industry with major cyber-attacks in recent years.

This experience could also be useful to analyze other sectors such as aviation, to see how this sector manages risks with rapid changes in technology (Global Maritime Issues Monitor, 2019). According to the survey, the threats posed by cyber-attacks, as in the previous year, are among the top concerns of shipping companies, and this will also remain so in the future.

BeCyberAwareAtSea international initiative, which supports the global sharing of research findings to understand and face the challenges, is a kind of assistance to seafarers. It contains practical cyber guidelines and articles to help seafarers and others to understand the challenges of the digital age.

Figure 2 shows activities related to cyber risk management .



Source: Tucci (2017, 128)

Figure 2: Model cyber risk management activities.

The model shows activities of cyber risk management. On the left side, the model shows several types of attacks or threats. They are classified as: organized crime, hacktivists, insider threats and technical errors. They range from sophisticated, targeted attacks from "advanced persistent threats" to simple technical errors such as incorrect software updates. The term "insider threat" also represents a wide range of actors - from those with special access and the desire to intentionally harm an organization to those who unknowingly install a malware by clicking on the wrong link or plugging their personal smartphone or other device into a USB drive or other port.

Reducing the likelihood of an attack can be achieved through the implementation of barriers to a malware or other measures that may compromise the system. These include technical measures, policies and training, and the control of physical access. Once an incident has occurred, communication, response and contingency plans reduce the impact of the event and promote rapid recovery. An organization with strong cyber resilience will consider all types of threats and introduce both protection and response processes in order to reduce risk and promote a strong cyber security culture through training, education and leadership. In this regard, a group of international shipping companies has developed guidelines that would assist maritime organizations in establishing individual approaches to risk management.

As part of Cyber Risk Management (CyRiM) project, an assessment of cyber-attacks at 15 major ports in Asia was made. It forecast the spread of a potential virus called Shen, and the damage was estimated to 110 billion dollars. In this case, taking into consideration the losses, the spread of the virus would not only affect the shipping industry but also the entire economy.

3 A HUMAN - THE WEAKEST LINK

The damage from cyber-attacks, as shown in Figure 1, is mentioned in different contexts, therefore the impact on people is very important, given that employees are the weakest link. In the event of an attack, a quick reaction is important throughout the whole organization, in order to protect employees, customers, suppliers and the future of the organization itself, as the responsibility of seafarers and shipping companies is equal. The key to understanding the new dangers is that seafarers not only understand and adopt these new technologies but are also cautious and aware that things can go wrong in a very short period of time.

The study conducted in 2019 on 211 seafarers (Bolat and Kayişoğlu, 2019), serves as a guide for shipowners to raise employees' awareness regarding cyber security. The authors find the topic extremely important as there are still many issues that need to be solved. Education is found to be a significant factor in enhancing the awareness of employees' maritime cyber security.

In another research (Bolat, et al., 2016), a survey on 249 seafarers from the Turkish maritime sector was conducted. Almost 50% of the surveyed seafarers answered negatively when asked about the possibility of identifying errors in the data and the possibility of testing the accuracy of the data. This indicates that the crew cannot sufficiently understand security protocols for Internet traffic and operations. This research once again confirms lack of sufficient awareness on cyber threats in the maritime sector, and suggests that the human factor is crucial. Employees need to be educated

– the actual costs are negligible in relation to the costs that may be incurred in the event of a cyber-attack (Mraković & Vojinović, 2019, 138).

From all the mentioned, it should be kept in mind that the people are the fundamental strength of the organization. Therefore, the key to ultimate success lies in the way organizations select and organize people. Sometimes the first step in accepting the need for change is to educate them about the state of the business and how to understand it. Organizations and people have no choice: they must change in order to survive. However, they can choose how they will change. A decision to implement a change by applying an organized, structured methodology is the right choice of successful companies. In this way, changes are introduced faster, cheaper and with minimal losses and disagreements. As all companies strive to implement changes, those that can successfully do that have an advantage over their competitors (Džubor, 2003, 47). Cyber risk management is not something that can just be trained. This must be done at the level of the entire shipping organization. In situations which require greater commitment, vigilance, attention and control increases the risk of overlooking important new elements that can significantly affect the conscientious performance of duty (Russo et al, 2013, 100).

4 CRISIS MANAGEMENT PLAN

Global organizations are more confident than ever that they can anticipate sophisticated cyber-attacks and adequately resist them. However, they still neither invest enough nor systematically plan to recover from them, according to the conclusions of the Global Information Security Survey 2016 - a global survey on information security carried out by EY advisory - consulting services.

What should maritime organizations actually do? The following are some of the preventive measures that shipowners should adopt (Tehnology innovators, 2020):

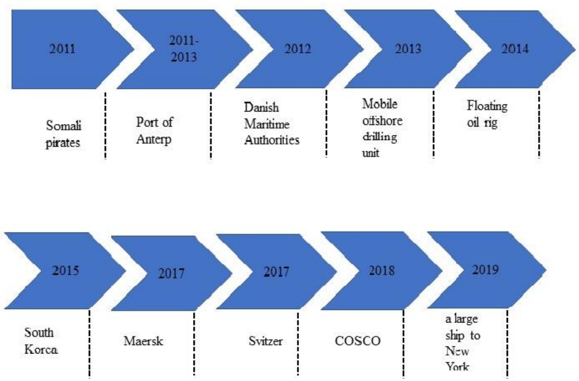
1. raise awareness on cyber-attack issues at the executive level,
2. adopt good “cyber hygiene” to deter attacks,
3. prevent accidental security compromises, develop and implement appropriate IT policies and maintain top-down approach,
4. backup data regularly,
5. maintain strong users access controls,
6. set up strong network access controls,
7. constantly update all software programs,
8. train employees to recognize cyber-attacks and seek immediate support to prevent losses,
9. develop strong policies regarding external storage of data, such as a USB memory stick and other external drivers.

On the other hand, according to IMO guidelines, there are five functional approaches for adopting cyber risk management. These range from identification (identifying systems, policies, and procedures that are vulnerable to attack), security (implementing security procedures such as training, technical protection, control), detection (systems and processes for detecting cyber incidents such as systems for detection of intrusion, analysis of anomaly), conversation (organization's plan to respond to cyber-attacks through communication, response planning, etc.) and recovery (procedures for recovering critical data, backing up systems, etc.).

Boyes and Isbell (2017, 27) mention the introduction of cyber security officers (CySO) for coordination and cyber security. Their responsibility is related to the security aspects of cyber-attacks. CySO should be empowered, educated and certified to coordinate and perform such tasks (Mrakovic & Vojinovic, 2019, 138).

5 OVERVIEW OF MARITIME CYBER-ATTACKS

The exact number of maritime cyber-attacks cannot be precisely defined as many of these attacks have either passed unnoticed or have not been reported. They usually result in a breach of data, systems and equipment causing huge and serous financial and time losses. The victims of these attacks vary from ships, shipping companies and offshore drilling units, to ports and maritime authorities. In the following sections some of the recent incidents are described.



Source: the authors

Figure 3: Timeline of maritime cyber-attacks.

In 2011 Somali pirates used “key log” malware to highjack ships. Together with their allies, they were hacking unprotected communication channels to obtain data on vessels’ itinerary, location, crew, cargo and insurance. Using the collected data, the pirates were able to plan their actions. They extorted ransoms in the amount of $160 million from various ship owners (Frodl, 2012).

Port of Antwerp was a victim of the IT system breach from 2011 until 2013. It was a phishing attack to the staff - a malicious software was sent via employee’s e-mail (Bateman, 2013). The malware was controlling the movement and location of cargo containers containing narcotics and the hackers gained remote access to port data. For two years, the cargo was being stolen from the port, until the port authorities realized that something was going on. The damage was estimated to approximately 170 million dollars.

The Danish Maritime Authorities and Business and Growth Ministry suffered an attack in 2012. An e-mail, containing a virus in the attachment in a form of a PDF document, was opened by an employee. The hackers gained access to the entire IT system of Maritime Authority network and to employees' computers obtaining sensitive business information on the merchant navy and Danish shipping companies (The Local, 2014). The entire IT system was shut down for a few days and the exact loss in money could not be estimated.

In the Gulf of Mexico, Mobile Offshore Drilling Unit drifted off in 2013. This was as a result of a malware attack which disabled the signals on a thruster system of dynamic positioning system. The malware virus was spread through crew's smartphones, USBs laptops, and other personal devices. The Mobile Offshore Drilling Unit was supposed to stay in a small radius as this was vital for its operations. This attack exposed the workers and the environment to danger (Knox, 2015). In 2014 hackers also used malware to shut down a floating oilrig and it was shut down for 19 days.

A year later, South Korea suffered a GPS jamming (blocking or stopping of signal) incident in which over 250 ships were affected. The ships were unable to identify their exact locations to either continue their voyage or to return to the port. GPS jamming affected the AIS, the ECDIS and the VDR devices – some GPS receivers could not provide any information, and some provided false information (Graham, 2017).

Maersk, the biggest shipping company with 16% of world's market share and a company that transports around 25% of all containers on the route from Asia to Europe was a victim of NotPetya ransomware in 2017. It infected all devices in the entire organization – the attack affected all business units, port operations, container shipping, tugboat operations, drilling, oil tankers, etc. The company covered 80% of all shipping volume without any IT for ten days. It had to reinstall the entire infrastructure – to put it in numbers: 4000 servers, 45000 PCs and 2500 applications (Cimpanu, 2018).

Also in 2017, Svitzer company suffered a data theft – employees' e-mails were forwarded outside the company revealing sensitive information on finance, payroll and operations. Also 50000 to 60000 e-mails with employees' personal information were hacked and the data were sent to addresses outside the company. Around 500 employees were affected by this data breach. It took almost 11 months before the company realized it was being hacked (Bogle, 2018).

China Ocean Shipping Company (COSCO) was a victim of a ransomware infection – communication channels were disabled. The damage was limited to business operations in the America's - the whole American Region IT infrastructure was down, including e-mail servers and telephone networks. The incident was described as a "network breakdown (Cimpanu, 2019).

The last incident was reported in 2019 – a large ship bound to New York experienced a malware attack that infected ship's systems and consequently degraded their functionalities. Luckily, the essential systems for the control of the vessel were untouched (DarkReading, 2019).

6 CONCLUSION

Cyber risk represents a new area for the maritime industry. It requires new capabilities and skillsets of the workforce. With the increasing digitalization of the maritime industry, it is extremely important to educate seafarers about the growing threat of cyber-attacks and how to prevent them. Managing cyber risks represents a new challenge in maritime industry. According to current knowledge, maritime industry is not fully prepared for cyber risks. It is worrying, that the problems for which the industry is least prepared, are those that are thought to have the greatest potential impact on the sector. It is essential that the cyber security management and incident response management plan are timely and up-to-date. The solution is to train employees as much as possible and keep them up-to-date with current cyber-attacks. Taking appropriate cyber risk measures will ensure, at least to a certain extent, undisturbed running of business. Shipowners need to invest more in multi-level cyber security, including their expanded activities, to ensure that key information is stored securely, no matter where it is stored.

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POTENTIAL OF GEOSPATIAL BUSINESS INTELIGENCE SOLUTIONS FOR AIR TRAFFIC MANAGEMENT

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ABSTRACT

By establishing the Single European Sky (SES) initiative, data describing European Air Traffic Management (ATM) network' performance has become highly available - like never before. Since data sharing problem is minimized, the strategic planning and development boards of ATM related stakeholders face with a new challenging situation; how to deal with large amounts of data and how to interpret it correctly. Consequently, that led to development of different Information Technology (IT) solutions with an ability to obtain, storage and process large amounts of data. But more importantly, that has also led to the development of IT solutions that can help e.g. Air Navigation Service Providers (ANSPs) by gaining them insight about their business environment, how it might change or about performance interdependencies. However, despite the technological developments, one correlating indication is still remained left out. Considering that the spatial component of data set is often underutilized, this research paper aims to highlight importance of the development of Geospatial Business Intelligence (Geo-BI) solutions for ATM related stakeholders. Hence, the opportunities and benefits of applying Geo-BI solutions in the context of ATM and its strategic planning and development have been studied and presented throughout this research paper.

Keywords: Air traffic management; strategic planning and development; performance interdependencies

1 INTRODUCTION

Nowadays, many successful aviation businesses manage to grow simply because they understand their business environment [1]. However, still in most business reports usually only two data' components are indicated. Besides its value and temporal component, data is also described by a spatial component. From the above arise the question of quality of the information provided and problem of the lack of understanding of components interrelation. Especially since it's recognized that high share of data has geography disseminated across them. So, for businesses it is of high interest to receive business reports which are supported by mathematical models (solutions) that quantifies all three data components. Particularly, because nowadays it's easier than ever before execute data processing (through application of data mining, machine learning etc. technologies) [2].

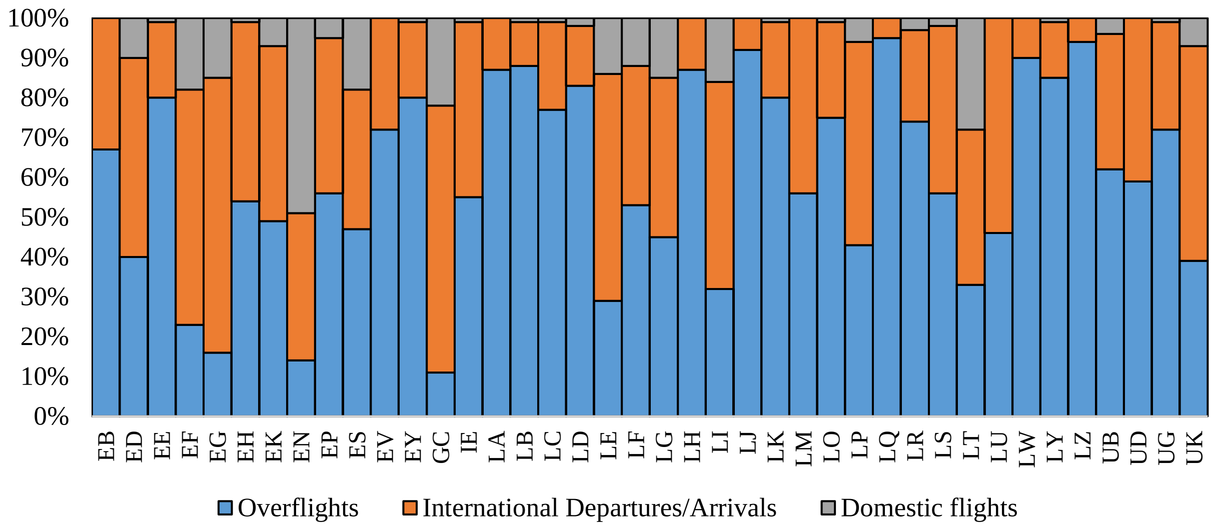
However, despite technological and methodological advances, spatial component of data is still often left behind and is not considered within development of IT solutions designed either for business-to-business (B2B) or business-to-consumer (B2C) applications. In order to reduce such an improper practice, Business Intelligence (BI) and Geographic Information Systems (GIS) solutions have started to become more closely integrated [3]. Ultimately, that has led to the development of Geo-BI solutions.

Humans think visually, therefore spatially. Accordingly, as more advanced research methods and technologies are seen those solutions that are based on spatial analytics. Since spatial analytics operate Geo-BI solutions, an increasing number of transportation related businesses have already started to adopt Geo-BI solutions to support development of their businesses. Usually the main purpose of such innovative solutions is to provide new or strengthen existing understanding of their business environment or performance interdependencies, to valorise the effects of applied strategies or concepts etc.

Considering that functionality of future ATM system is based on collaborative and coordinated airspace and air traffic flow management [4] and on respecting the adopted development guidelines in sense of ATM regionalization, Geo-BI solutions have great potential within framework of Air Traffic Management system. Therefore, the further content of this paper gives an overview of performance interdependencies in context of Air Traffic Management, provides information about Geo-BI solutions and lastly identifies their applicability areas and gives recommendations how they can support further development of ATM system in domain of its strategic planning and development.

2 PERFOMANCE INTERDEPENDENCIES IN AIR TRAFFIC MANAGEMENT

European ATM system represents a complex system with a high number of participating stakeholders which may in different areas have a greater or smaller impact on the performance of total European ATM Network [5]. Moreover, by its nature, international air transport does not end at one States' borders. If an international flight is subject to Air Traffic Control (ATC) services in one State, service provision must be also continued in adjacent State (into which the aircraft intends to enter) and so on until aircraft reaches its destination. Accordingly, it can be inferred that the prerequisites that enable functionality of ATM system are interoperability and cross-border cooperation between Air Traffic Services (ATS) units concerned. In that context Figure 1 shows the distribution of provided Air Navigation Services (ANS) per State (according International Civil Aviation Organization nomenclature) in 2017. Since "*a picture is worth a thousand words*" it in the best possible way depicts scale of inter-connectivity between ANSPs. Moreover, it shows areas where understanding of performance interdependencies between ANSPs is of high importance.



Source: EUROCONTROL. Local Single Sky implementation monitoring (LSSIP), 8 November 2019, available at: https://www.eurocontrol.int/service/local-single-sky-implementation-monitoring

Figure 1: Distribution of provided Air Navigation Services (2017)

Figure 1 provides additional relevant information which depicts international nature of ATM business environment. If we categorize ANS provided during 2017 in terms of whether service was provided to international or domestic flight, it can be concluded that averagely 93.43% of total number of ANS provided in 2017 were conducted in cooperation of two or more ANSP. Furthermore, it can be defined that a bit more than ¼ of observed ANSPs have provided their services only to international flights overflying ANSP's Area of Responsibility (AoR) or to the international flights departing or arriving within ANSP's AoR. Spatially observed, that means that in area of 663,000 km^2 (3.58% of total controlled area in Europe) which is differently scattered within the European airspace, there is no delivery of services to commercial flights operating within one State's boundaries. That primary refers to ANSPs managing airspace above Albania, Armenia, Belgium, Bosnia and Herzegovina, Hungary, Latvia, Malta, Moldova, North Republic of Macedonia and Slovakia. Hence those areas can be singled out as the most exposed ones. On the other hand, in 2017 averagely 6.58 % of total ANS were provided to commercial flights which have only operated within one State's boundaries and so were managed by only one ANSP.

Beside stats review, performance interferences can be also spotted throughout empirical approach. In theory, performance interdependencies between ANSPs should not be detrimental to neighbouring ANSP, but in practice (day-to-day operations) this is not the case.

The best examples of aforementioned are reflected when extreme events occur - such as Eyjafjallajökull volcano eruptions, airspace closure due to military activities and safety hazards in Ukraine or ATC industrial actions which are nowadays occurring more frequent and lasting longer than ever before [7]. Their occurrence in the best possible way depicts performance interdependencies between ANSPs since then it's easy to notice so-called *spill-over effect*. According to its definition, if an activity or situation spills over, it begins to affect another situation or group of people, especially in an unpleasant or unwanted way [8]. So empirically, in case of extreme events it's not that hard to spot an area(s) and scales of performance interdependencies in-between ANSPs.

When it comes to understanding of performance interdependencies in-between ANSPs it's crucial to emphasize that, unlike e.g. ATC industrial actions, performance interdependencies do not have expiration date or precisely defined period of their occurrence. Within ATM system, they are occurring continuously and so influence execution of day-to-day operations.

Moreover, performance interdependencies should be seen as the result of tactical and pre-tactical, but especially of strategic management and decision-making activities of each individual ANSP.

Lastly, it can be concluded that it's not reliable to base strategic planning and development of national ATM potentials just on data review or on empirical approach. Especially since within complex European ATM Network, unfortunately, it's difficult to improve one performance segment without compromising other segment(s) [12]. So, the need for application of more advanced IT solutions that can e.g. determine performance interdependencies in-between ANSPs has become the *Conditio sine qua non*.

3 GEOSPATIAL BUSINESS INTELIGENCE

The process of merging different technologies has resulted with creation of powerful visualization and intelligence systems among which are Geo-BI solutions. Usually they can provide comprehensive analyses (reports) by executing more advanced data manipulation processes and have possibility of efficient data browsing and storing in very large spatial-temporal data bases [13]. In this regard, Geo-BI solutions can be defined as innovative and powerful solutions that outstrip traditional methods enabled through merging of GIS and BI technologies.

Although Geo-BI solutions may vary in terms of applied technologies, the main purpose of their application does not change - to improve the efficiency of business activities [14]. For example, Geo-BI solutions can be applied to evaluate achieved results, to support execution of planning and decision-making functions or to optimize service delivery [15]. Moreover, they can support businesses development by identifying business advantages, shortcomings or opportunities and so help to, where it's needed, adjust service delivery in regard to business environment.

Usually, Geo-BI solutions are supported with good data visualization capabilities. However, this is not what sets them apart from other data processing and visualization tools. Although data visualization capabilities built in Geo-BI solutions are of high importance, that is not the reason of Geo-BI solutions' advantage over other technological solutions. The greatest advantage of Geo-BI solutions is in their analytical systems that can perform complex analytics in very short time and with a high level of accuracy. The analytics behind Geo-BI solutions blends business data with geographic data to (*a*) reveal the relationship of location to (*b*) data describing e.g. people, events, transportation, transactions, investments, facilities, assets etc. by (*c*) placing new information in the context of interest of business enterprise. Thereby, it's important to highlight that Geo-BI solutions do not add more data to the existing plethora of data, but utilizing the geographic information disseminated across existing databases and hence enrich information provided.

Lastly, it's important to highlight that Geo-BI solutions can lead to reduction of business risks by providing new insights. But, as a tool, Geo-BI solutions have the ability only to describe business environment as that much precisely as the applied indicators and data are reflecting the real-world situations. So, in order to maximise utilization of information provided by Geo-BI solutions, they should be operated by trained staff members having sufficient level of education and experience. Only the combination of those elements can lead to creation of more competent information and hence effectively support decision making process.

4 APPLICABILITY AREAS IN ATM

Considering that aviation industry continuously tries to achieve process and resources optimization and that Geo-BI solutions can be of great help to achieve that, there is no barrier as to why not to use them in the ATM context. For example, information provided by Geo-BI solutions can be used by ANSPs to optimize their resources, to evaluate the effects of their business decisions, to monitor and keep in line their performances in relation to local, FAB or performances of entire European ATM Network, to capture local performance interdependencies, etc. Moreover, since ANSPs are financed by Airspace Users such solution can help ANSPs to understand their customers behaviour (Figure 2) by providing answers on questions: how much of performance improvement is enough, when "much" turns into "too much", is it worth it to do, how some changes may reflect in near future and why some measures were not sufficient or have failed etc.

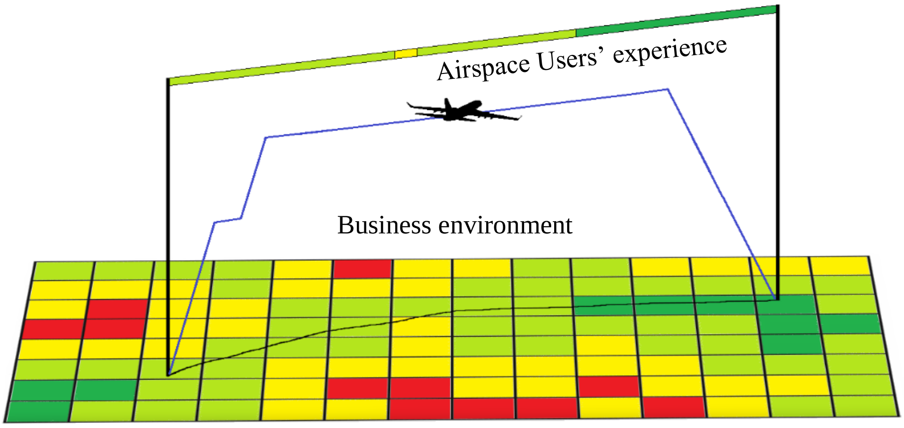


Figure 2: Understanding Airspace Users behaviour through application of Geo-BI solution

So, as it's shown by Figure 3, Geo-BI solutions in context of ATM can be also utilized to obtain better understanding of the historical, current and future aspects of business operations, to improve the efficiency of business activities and services delivery and to make most effective decisions by capturing the extent to which some decision will have a spatial reflection. So, they can be also used to derive useful insights about ANSP's future position within ATM Network or to support determination of performance targets for future Reference Periods of the European Union performance scheme. Therefore, the potential of Geo-BI solutions can undoubtedly improve entire European ATM systems design by providing answers on the key questions of further development.

Furthermore, it's expected that Geo-BI solutions will have a great potential primarily in Europe – where the current application of strategic air traffic planning has caused an unbalanced air traffic development [9]. That is not surprising because from methodological and technological view, on-going situation (where strategic planning and development boards find it hard to valorise the impacts of their decisions) also rises because many currently applicable traditional methods of data manipulation do not take into consideration a spatial component. As the result, spatial component of data set is often underutilized. This is also problematic because 80% of information requirements of policy makers are related to spatial location [10-11]. Therefore, since Geo-Bi solutions take into consideration spatial component and analyse the spatial distribution of observed variable, they go far beyond traditional methods of data processing and visualization.

Nowadays in ATM data is being continuously collected by different business entities. Accordingly, the preconditions for application of Geo-BI solutions in ATM context already exist. However, enterprises are frequently not aware of the fact that some solutions (tools) can provide them more competent information. So, beside already mentioned benefits, the synthesised potentials of Geo-BI solutions for Air Traffic Management and its stakeholders are in the following major components of business:

- Performance targets based on local potentials
  The application of Geo-BI solutions can offer an overview of how local operations are performing on different scales (individual, regional, FAB, etc.). Moreover, Geo-BI solutions are very helpful when it comes to interpretation of e.g. different ANSPs' or Key Performance Indicators' interdependencies. Especially because they can help ANSPs to target the appropriate level of performance sufficient to succeed at the chosen scale. That can be also supported by setting up alerts which are sent to User with a goal to improve quality control of delivered services.
- Forecasting and its better understanding
  In order to make efficient use of forecasts (and so optimize available capacities), Geo-BI solutions can provide forecasts that are easily understood by, and acceptable to, the decision maker or other End user.
- Information sharing
  Information provided by Geo-BI solution can helpful to desegregate global business plan at the lowest local level. That means that they can help ANSPs to communicate and share local objectives within an organization. Thus, application of Geo-BI solution can ensure that all employees view the same objective. That is of particular importance when it's needed to represent organizations' interests at meetings with other ANSPs, Airspace Users, National Supervisory Authorities (NSAs), etc. Lastly, organization with more competent information can decide whether to share information with the meeting participants (and so encourage collaborative work) or to keep information for themselves (and so improve their negotiations position) [16].
- Business process automation
  Business process automation improves control and reduces exposure to costly delays, errors and omissions [17]. In this regard, Geo-BI solutions are enabling benefits such as: (1) man-hours savings (financial savings), (2) time savings, (3) workload reduction, (4)

continuous availability of information, (5) reduction of error appearance, (6) avoidance of incorrect results interpretation, (7) optimization of human and machine interactions with a goal to achieve a high degree of safety, (8) process standardization and its quality increase, etc.

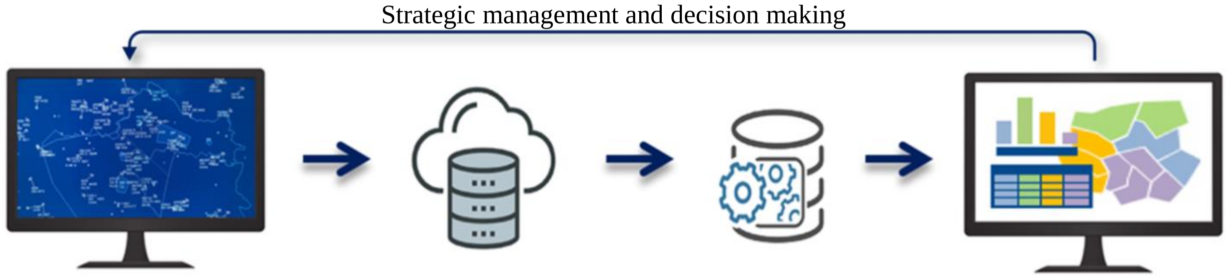


Figure 3: Air Traffic Management' strategic decision-making process supported by Geo-BI solution

5 CONCLUSION

As demand for Air Navigation Services is increasing, problem of not understanding business environment and performance interdependencies in-between ANSPs gets bigger over time. One of the reasons why is that so is that most of currently applicable traditional methods and technologies processing data do not reflect real-world situations in best manner. In addition, considering the advent of the big data era it can be concluded that the management and strategic development boards of ANSPs and NSAs will face with challenging issue of dealing with large amounts of data and its interpretation.

The combination of GIS and BI technologies has led to the development of Geo-BI solutions. Those solutions are frequently based on application of more complex methodologies (than traditional ones). Therefore, there is no surprise that they can better describe performances of European ATM Network and so help within its further development. However, it's important to highlight that Geo-BI solutions are not designed to make ATM system look more complex. Although their creation and applied technologies can be very complex, their output (information provided) must be as simple as possible.

As it's shown in the paper, European ANSPs are highly interconnected and interdependent. The result of such system arrangement is that performance interdependencies occur between ANSPs. Considering that performance interdependencies reflect on day-to-day operations and have an impact on ANSPs' primary activity - delivery of Air Navigation Services, their better understanding and monitoring are of high importance. Hence, aviation industry should aim for more competitive information which can be provided by applications of innovative Geo-BI solutions. Particularly because provided information can be of great help in enhancing cooperation between ANSPs itself, ANSPs and Airspace Users or ANSPs and NSAs/Civil Aviation Authorities. Lastly, it can be concluded that already in near future there will be ANSPs and NSAs which, based on the information provided, will know how to achieve business advantages (often to the detriment of others).

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THE GENESIS OF COST-EFFICIENCY BASED EUROPEAN AIRSPACE FRAGMENTATION

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ABSTRACT

When it comes to discussion about efficiency of Air Traffic Management (ATM) system in Europe, European airspace fragmentation is frequently mentioned as barrier limiting further efficiency improvement of ATM system. Thereby, it should be noted that European airspace fragmentation can be studied from multiple different aspects. It can be analysed from organisational, operational, technical, functional or performance-based aspect. All this fragmentation aspects have their pros and cons. For example, from operational aspect, fragmenting airspace into smaller patterns (sectors) is normal operational practice (performed in order to adjust demand with capacity), while from performance-based aspect highly fragmented airspace is not preferred. In spite of, the European airspace fragmentation is mainly considered as the negative feature. By analysing situation from 1998 till 2020 this paper aims to answer research question whether and how European airspace is fragmented from cost-efficiency aspect. Thereby, the research is based on the examination of the spatiotemporal autocorrelation structures of the European airspace. After their determination, their spatial and temporal variability level was also studied. As research findings indicate that, from performance-based aspect, fragmentation of European airspace is dynamic and heterogeneous in both space and time, they were placed in wider context. Accordingly, the genesis of cost-efficiency based European airspace fragmentation is placed in the context of conceptual framework of currently applicable strategic planning practice whereby their causal relationship was identified.

Keywords: Air traffic management; strategic planning; airspace fragmentation; cost-efficiency; genesis

1 INTRODUCTION

Airspace fragmentation is generally recognized as one of causes of ATM system's inefficiency, especially from the economic viewpoint. In such circumstances, Airspace Users (AUs) seek to utilise every opportunity to reduce their operational costs. One method of making savings is through utilisation of the cheapest flight route. Due to occurrence of different national en-route unit rate values along the flight route, AUs for the same Air Navigation Service pay different route charges. In such circumstances, it's often the case that the aircraft, if there is an alternative, fly on longer but economically more acceptable routes – as it goes through cheaper charging zones. As a result of such practice, different business interests occur. While one can strive for utilisation of the shortest route (e.g. in order to achieve timetable punctuality), others will as much possibly go for cheaper route option (especially when slot isn't allocated), while most of AUs will try to balance between those two options. Thereby, most of AUs make such decisions within tactical planning phase, i.e. after receiving more precise information (e.g. about weather, airspace capacity availability, aircraft type selected, payload etc.).

The thing that is problematic in application of such a business practice is that it's environmentally harmful. In other words, making financial savings have higher priority over adverse effects on the environment. Thereby, one thing needs to be clear. AUs aren't the ones who should be criticised – as such circumstances are result of airspace fragmentation. Moreover, AUs should be seen as gear wheels that function in the way that the system is designed. The better system design, the less irregularities will occur. In other words, the less fragmented airspace it is in terms of cost-efficiency, there is less chance of occurrence of adverse effects.

Although airspace fragmentation became a frequently mentioned issue, during the past decades it hasn't been frequently studied neither comprehensively addressed. Accordingly, a minor progress has been made to describe this issue more in-depth [1]. Hence, this research paper studies the genesis of cost-efficiency based European airspace fragmentation. It provides answer on the research question whether the European airspace is fragmented from cost-efficiency aspect. Also, spatiotemporal variability level and fragmentation repercussions were studied as well.

2 METHODOLOGICAL FRAMEWORK

This research answers the research question of whether and how European airspace was fragmented from cost-efficiency aspect during the period from 1998 till 2020. Thereby, as an input data national en-route unit rate values published by EUROCONTROL [2] were used. National en-route unit rate values are calculated by dividing charging zone's forecasted en-route facility cost-base by the forecasted number of service units generated in the same charging zone. As so, they represent a final cost-related product of every ANSP and are used within calculation of AUs route charges. For the purpose of answering posed research question, the research is based on application of spatial autocorrelation method. Accordingly, to examine spatial autocorrelation, methodological framework includes computation of the local and global Moran's I index. Fotheringham et al. [3] denote local Moran's I index by following equation:

$$I_i = \frac{(x_i - \bar{x}) \sum_{j=1}^{n} w_{ij} \, (x_j - \bar{x})}{\sum_{j=1}^{n} (x_j - \bar{x})^2 / n} \tag{1}$$

where x_i denotes the value of observed area, $\bar{x}$ average value of observed dataset, w_{ij} spatial weight matrix (Figure 1), x_j the value of the adjacent area and n indicates the number of observed values. After local Moran's indexes estimation, global Moran's I can be obtained as an average value of all local Moran's indexes. The results of spatial autocorrelation measurement are further interpreted within the context of the null hypothesis - which states that the national en-route unit rate values are randomly distributed over studied area. In other words, it states that the European airspace is fragmented from cost-efficiency aspect. Thereby, the significance testing of the local and global Moran's I index is based on z-score computation. After estimation of the expected value and the variance, z-score can be obtained as follows:

$$z - score = \frac{I - E(I)}{\sqrt{Var(I)}} \tag{2}$$

Thereby, within significance testing, the confidence level (α) was set at 95%. As the global Moran's I index doesn't indicate local grouping tendencies, methodological framework was complemented with additional analysis that places a focus on the local level. Hence, with a goal to determine resemblance between neighbouring spatial units, the method of Moran's scatter plot was also applied.

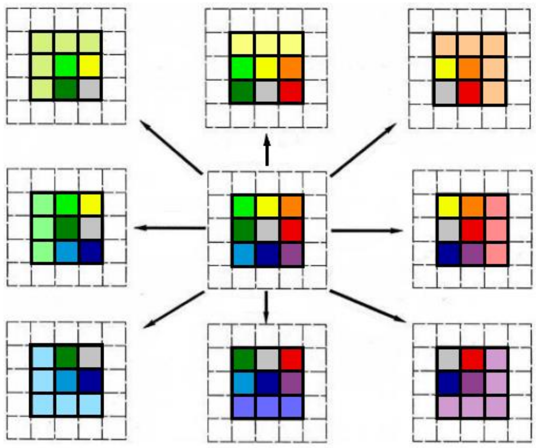


Figure 1: Conceptual framework of spatial weight matrix computation

3 MAIN RESEARCH FINDINGS

Spatial autocorrelation can be defined as the relationship among values that comes from the geographic arrangement of spatial units in which these values occur. Obtained research findings indicate that the null hypothesis cannot be rejected (as it is shown by Figure 2). That means that European airspace is fragmented from cost-efficiency aspect since 1998 (as within studied period at no point z-score and p-value aren't significant). Thereby, within studied period spatial autocorrelation is continuously positive. That indicates that spatial units of similar values continuously tend to group. Also, it could be defined that, as from 2011, national en-route unit rate values tend to be more spatially similar.

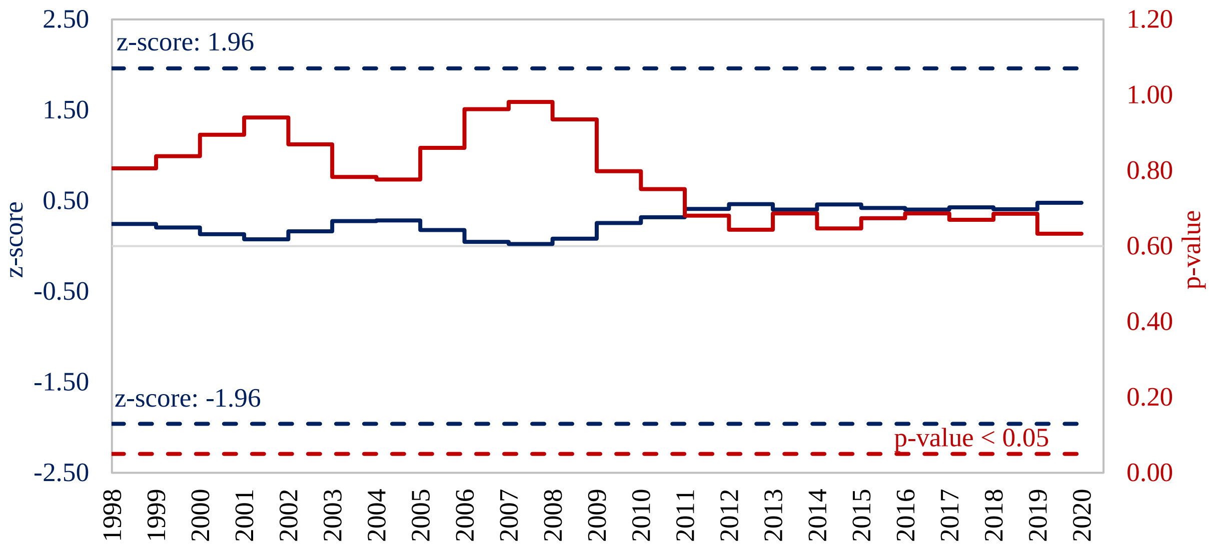
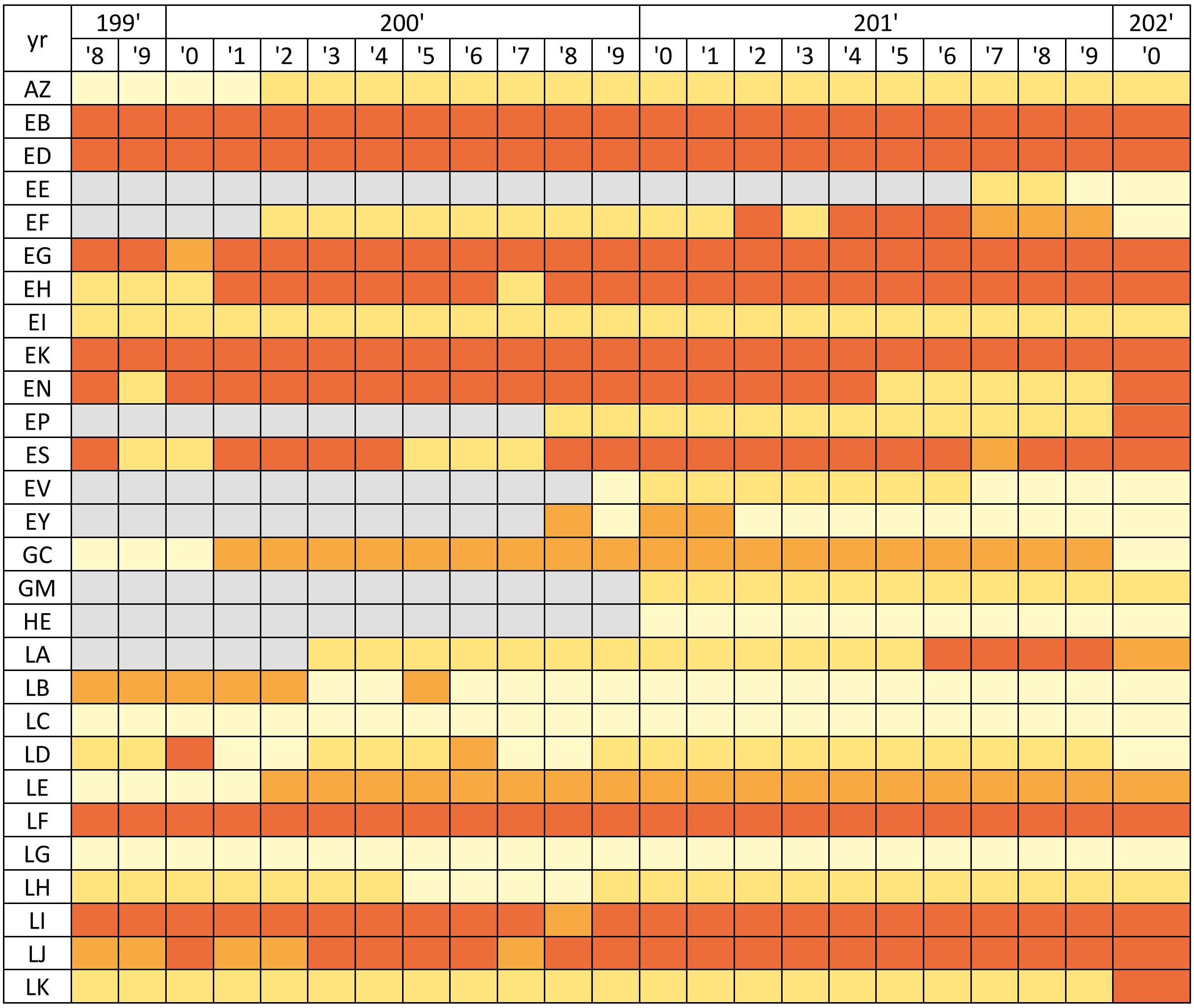


Figure 2: Overview of European airspace fragmentation in terms of cost-efficiency

Resemblance level between neighbouring spatial units is shown by Figure 3. These research findings reveal local grouping tendencies. Accordingly, they indicate patterns of spatial association and spatial outliers. Thereby, in accordance of Moran's scatter plot, four indicator were used: (1) HH indicator denoting spatial units of high neighbouring values, (2) HL indicator marking high value area surrounded with a low value neighbourhood, (3) LH indicator that specifies a low value area surrounded with a high value neighbourhood and (4) LL indicating spatial units of low neighbouring values.



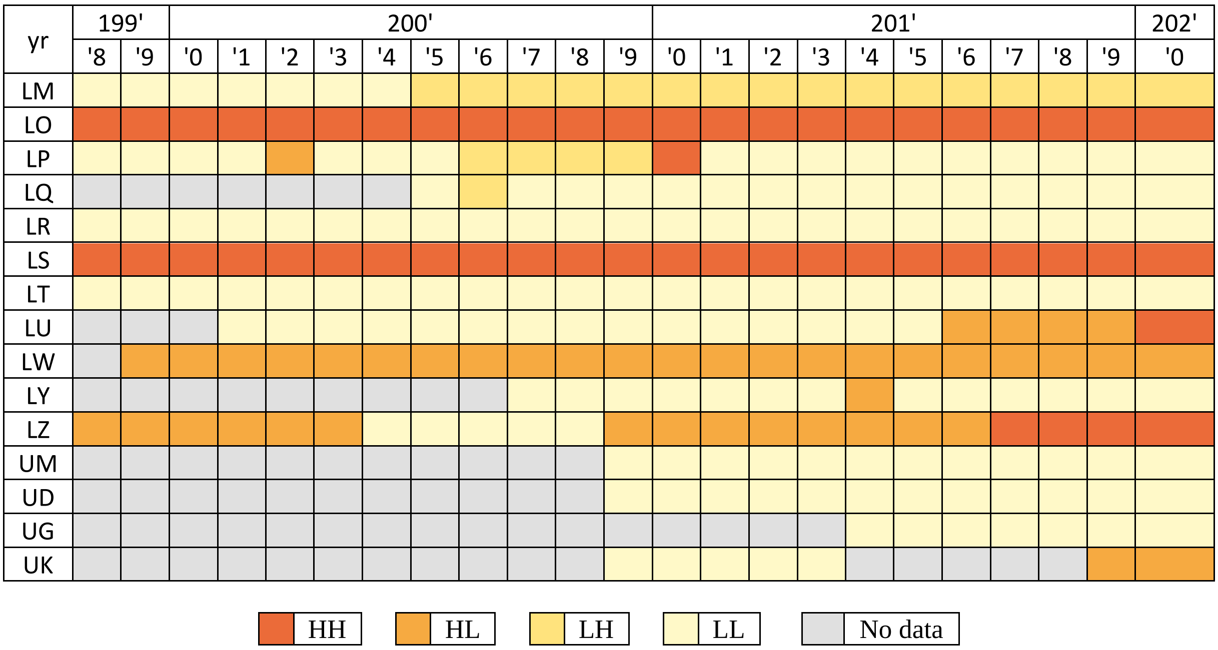


Figure 3: National en-route unit rate values variability overview (ICAO nomenclature)

4 DISCUSION

The genesis of cost-efficiency based airspace fragmentation streams from currently applicable framework of strategic air traffic planning. This is so because it is led by the "demand-oriented" option. The result of such an approach is creation of unbalanced air traffic development. Consequently, through establishment of different national en-route unit rate values that are applicable and scattered within different parts of the European airspace, that contributes to the existence of cost-efficiency based European airspace fragmentation. This is supported by the fact that national en-route charges are determined by dividing the charging zone's forecasted en-route facility cost-base by the forecasted number of service units generated in the same charging zone.

As Castelli and Ranieri [4] indicate, in the previous years it was possible to notice a high variability of unit rate values in the different charging zones across the European airspace. As Figure 4 shows, as of 2011, variability of unit rate values began to become more pronounced. That primarily relates to higher unit rate values - which began to deviate even more from the arithmetic mean value of dataset.

This research studied the genesis of the European airspace fragmentation from cost-efficiency aspect by placing unit rate values into their spatial context – thereby measuring their spatial similarity and variability level over time. That was achieved by application of method of spatial autocorrelation, i.e. by correlating every national en-route unit rate value with its application area within the European airspace.

Considering obtained research results it can be defined that European airspace is fragmented from cost-efficiency aspect. Also, the main research findings indicate existence of homogeneous areas, i.e. areas with similar national en-route unit rate values that are unevenly sized and are scattered over the European airspace. Lastly, their variability level was determined. As such results indicate that during studied period from 1998 till 2020, the global Moran's I index is far from being significant. On the other hand, the way how airspace was fragmented during the same period did change over time. In that context Figure 5 shows variability level in-between spatial neighbours recorded from 1998 till 2020.

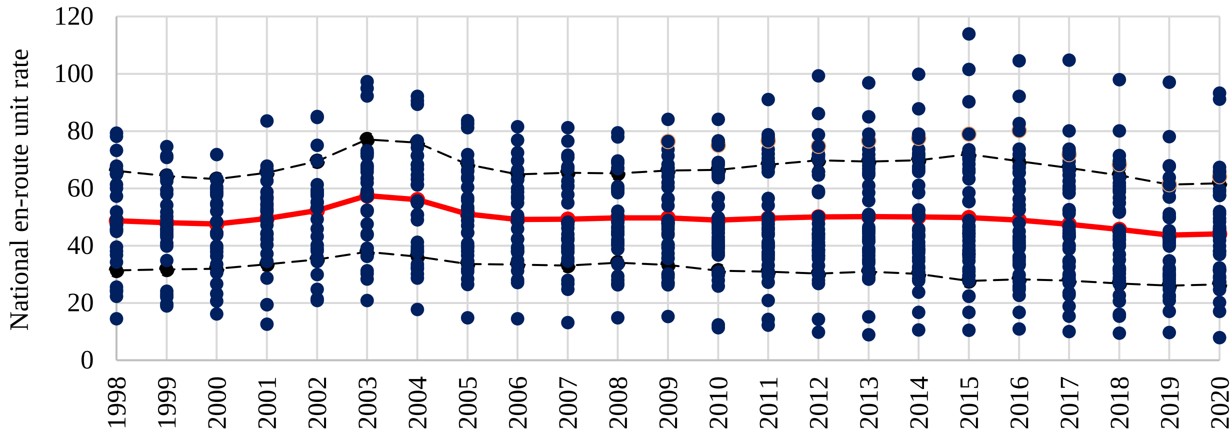


Figure 4: Overview of national en-route unit rate variability

The highest variability level in-between spatial neighbours have been recorded in Area of Responsibility of Croatia Control. In other words, in sense of cost-efficiency based European airspace fragmentation, that area can be singled out as most dynamic. This is so due to variability of Croatia Control's unit rate values, but also due to variability of neighbouring unit rate values. Also, as dynamic areas can be distinguished Finnish, Swedish, Slovenian and Portuguese charging zones. Thereby, it should be noted that size of studied area did change during observed period. As that may have a smaller impact on the results, variability level was also placed in respect to number of spatial units studied (Figure 6).

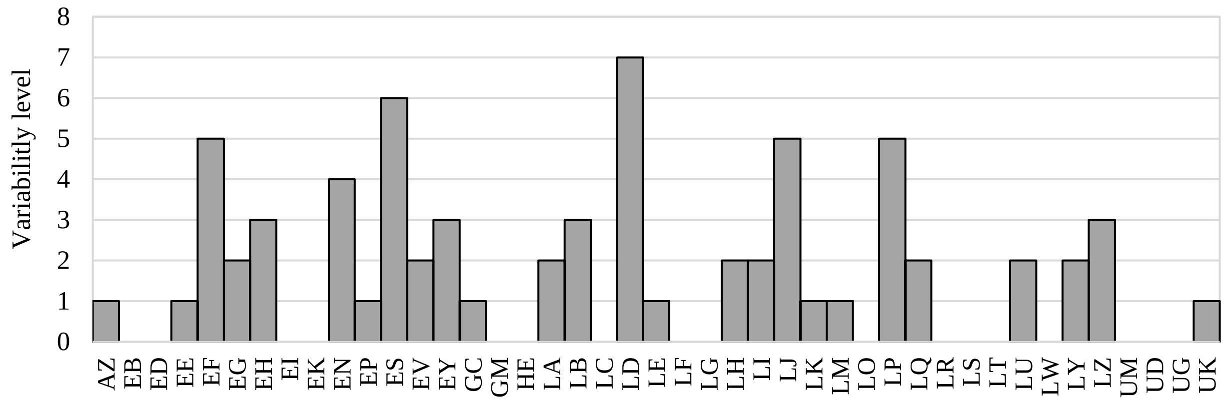


Figure 5: Variability level between spatial neighbours

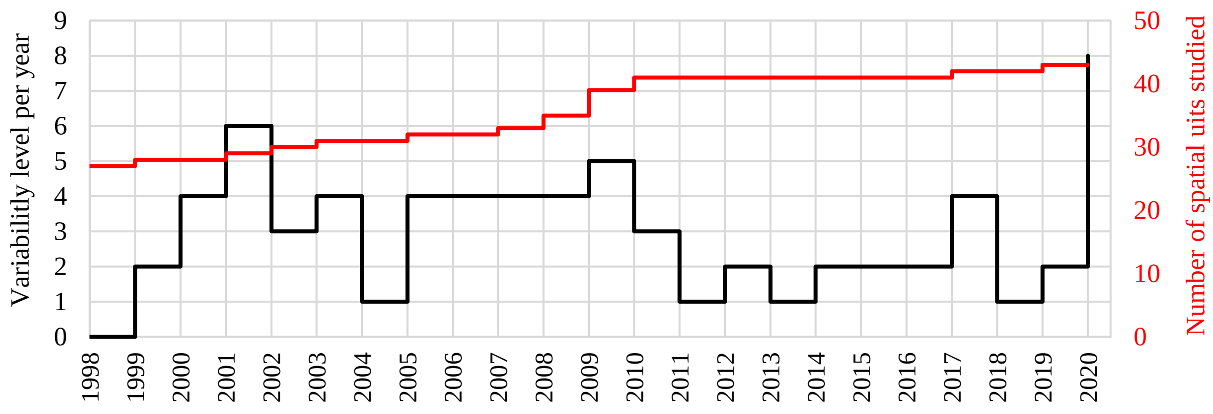


Figure 6: Annual variability level between spatial neighbours in respect to number of studied spatial units

Through determination of cost-efficiency based European airspace fragmentation level, decision makers can get a clear picture of their business environment. Also, they can improve their knowledge and understanding of AUs "behaviour". In that context, the effect of airspace fragmentation in terms of cost-efficiency can be valorised on practical example. Figure 7 shows an example of two route options between Cardiff International Airport and Corfu International Airport. Blue route indicates the cheapest option, while green one represents the shortest route option. Those two routes are also placed in respect to main research findings.

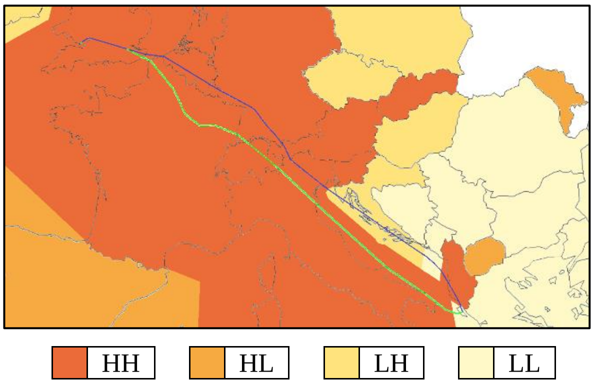


Figure 7: Cost-efficiency based airspace fragmentation effects on flight planning [5]

In order to valorise the effects of such airspace fragmentation, few assumptions need to be made:

- flight will be operated by Airbus A320;
- no en-route capacity constraints;
- assigned optimal flight level;
- summer flight schedule (7 months duration);
- four flight frequencies per weak;
- 2018 national en-route unit rate values [6];
- A320 fuel burn rate: 38.5 (kg/min) [7];
- The cost of fuel: 0.31 (EUR/kg) [8];
- CO_2 emitted: 3.15 kg (per burned fuel kg) [9];
- H_2O emitted: 1.230 kg (per burned fuel kg) [9];
- SO_2 emitted: 0.00084 kg (per burned fuel kg) [9];

After running simulation by NEST [10] and SET [11] tools obtained results were consolidated as the differences between cheapest rout option in respect to shortest route option. In respect given assumptions, utilization of cheapest rout option (instead of shortest route option) would result with: (1) 510.72 NM additionally travelled, (2) 41,720 EUR savings in route charges, (3) 2,800 kg of fuel additionally burnt, (4) for 868 EUR higher fuel costs, (5) 8,820 kg higher CO_2 emission, (6) 3,444 kg higher H_2O emission and (7) 2.352 kg higher SO_2 emission. Furthermore, by subtracting the additional costs resulting (due to higher fuel consumption) from the savings achieved by utilization of cheaper route option, a final estimation is obtained. Through utilization of cheapest route options AU would save approximatively 40,852 EUR. On the other hand, the question arises whether the additional environmental pollution is worth that money? The answer could be found in already mentioned fact that AUs should be seen as gear wheels that function in the way that the system is designed. The better system design, the less irregularities will occur. In other words, the less fragmented airspace it is from cost-efficiency aspect, there's less chance of occurrence of adverse effects on the environment. From there it stems that negative effect of ATM system on the environment can be reduced through spatially balancing unit rate values.

As example show, cost-efficiency based airspace fragmentation is problematic as it enables AUs to purposely impairment their flight efficiency (with a goal to make financial savings). In that way this kind of airspace fragmentation have negative effect on the environment (as it leads to higher fuel consumption and consequently higher emissions level). In order to defragment European airspace from cost-efficiency aspect, certain conceptual changes need to be made within the framework of the strategic planning. In that context, the aim of strategic planning should be oriented towards achieving better performances that will lead to spatial cohesion [12]. To achieve that, few conceptual assumptions of currently applicable strategic planning framework needs to be modified. One of the causes contributing to existence of the airspace fragmentation is fact that European ATM system is still mainly organized at national scale [13]. This is problematic because ATM system in Europe involves a high number of stakeholders which may, in different areas, have a greater or smaller impact on the overall efficiency of the ATM system in Europe [14].

Another conceptual assumption that contributes to airspace fragmentation needs to be modified. Performance measurement scheme represents one of strategic planning mechanisms by which it seeks to contribute to ATM system development in Europe. However, it's based on the individualistic approach in evaluation of achieved performance level. Whether or not an ASNP is successful is purely determined by comparing its performance achievements with those regulatory determined. Such practice is problematic as the spatial component of the data is completely ignored. For example, if in following year ANSP achieves reduction of 1.9% of national en-route unit rate value, according to performance targets of 3rd Reference Period (RP3) [15], that will be considered as a success. However, currently that success at no point is assessed in respect to situation and performances achieved at local level. Given that "positions are already taken" and that in following years every ANSP will be obliged to respect RP3 targets, application of such an approach will result with the fact that future outlook will be proportionally equal to the pre-existing situation. In other words, higher and lower values will remain so, only what, with certain time lag, their values may in greater or lower volume variate (as shown earlier). Thereby, as long as individualistic approach in evaluation of achieved performances is applicable, that will contribute to existence of cost-efficiency based European airspace fragmentation.

5 CONCLUSION

Even though the problem of airspace fragmentation has been recognized in the 1990s, obtained research findings indicate that over time a little has been done to resolve this issue or to minimize associated negative impacts. The main contribution of this paper is identification of the genesis of cost-efficiency based airspace fragmentation. Research confirms that, although the way how it was fragmented from 1998 till 2020 did change, European airspace continuously remained fragmented from cost-efficiency aspect. Also, research findings indicate that as of 2011, from spatial aspect, national en-route unit rate values tend to be more similar, but still that is far away of being characterised as spatially aligned. Furthermore, spatial and temporal variability level was also identified. In addition, repercussions of cost-efficiency based airspace fragmentation have been presented by introduction of example from practice. Lastly, the research topic was placed in wider context. That included identification of causal relationship between the genesis of cost-efficiency based European airspace fragmentation and conceptual framework of currently applicable strategic planning practice. In that context, it was concluded that conceptual assumptions of strategic planning of ATM system development in Europe need to turn to new perspectives that would lead to the smart, inclusive and spatially oriented development. Thereby, as long as individualistic approach in evaluation of achieved performances is applicable, that will contribute to existence of cost-efficiency based European airspace fragmentation.

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SHIPPING IN PERIPHERAL SEAS: THE CASE OF BALTIC SEA REGION AND ADRIATIC SEA

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ABSTRACT

World trade has changed in the twenty years such that container traffic flows are oriented towards more parts of the European continent. The European container port system is not a homogeneous set of ports; instead it consists of several big ports (e.g., Rotterdam, Hamburg, Algeciras...) and a large number of medium and small ports.
The main focus of the paper is on the container network in two peripheral seas, the Baltic Sea Region and in the Adriatic Sea, studying contemporary changes and organization, as well as explaining the main driving forces of this situation. The geographical configurations of the region naturally place both seas away from major global shipping lines. This situation is accentuated by the organization of maritime regular lines, centred in Northern European ports or Mediterranean transhipment hubs. So, the idea is to compare flows and networks in these two European peripheral seas having welcomed a remarkable growth during the last decade.
The Baltic Sea is a transport corridor between Eastern and Western Europe. Over the last decade maritime transport in the Baltic Sea area has changed significantly. The disintegration of the Soviet Union forced Russia to start developing its own Baltic ports and terminals and to find new routes to export its oil and gas.
The Adriatic Sea looks also like a transport corridor between Southern and Central Europe. Adriatic ports, Rijeka, Koper, Trieste, Venice and Ravenna…, are small ports. Each of these ports have different development plans but in varying degrees' common hinterlands and costumers.

Keywords: Containerization, Baltic, Adriatic, AIS, maritime network

1 INTRODUCTION

According to Notteboom (2010), the European container port system is concentrated in the Hamburg-Le Havre range, which is of primary importance as they handle close to half of total container throughput in Europe; the Mediterranean range, which has the fastest-growing container throughput; and the UK, Atlantic, Baltic, and Black Sea ranges.

Maritime traffic has evolved significantly over the last few decades. The biggest ships operate on multi-port itineraries calling at a restricted number of ports (Ducruet, Notteboom, 2012). The main transoceanic services link a series of key ports in Europe. These ports connect regional port systems, including the Baltic and the Adriatic ones, to transoceanic routes, mainly through hub-and-spoke and feeder services (Rodrigue, 2012). Extensive hub-feeder container systems and short-sea shipping networks are used to manage increasing volumes and to connect to other port ranges (Rodrigue, Notteboom, 2010).

"Peripheral" (or marginal) seas are parts of an ocean bordering the continental landmass and partly enclosed by peninsulas or archipelagos, such as the East China Sea (Vego 2015). More specifically, enclosed seas, such as the Baltic or the Adriatic, lie wholly within the continental shelf and are surrounded by a landmass except for a strait connecting them to an ocean. Because of their restricted communication with the open ocean, enclosed seas have several specificities, physical ones as well as economical ones. Furthermore, most peripheral seas suffer from poor accessibility in terms of few route options, low frequency of services, long travel times and high transport costs.

From a transportation perspective, peripherality has been increasing by the development and innovations in transport such as shipping technology and the development of hubs – spokes (Knowles 2006). Peripheral ports are smaller ports which are competing for feeder traffic from larger ports (Hayuth 1981). Peripheral ports will eventually be able to capture traffic when the larger ports are congested, which is mentioned (Wiradanti, 2019). In the specific context of seaports, peripheral ports can generally be identified by the size. They are primarily small and 'desperate' for cargoes brought by carriers from load center ports (Hayuth 1981).

2 GENERAL CHARACTERISTICS OF CONTAINER SHIPPING IN ADRIATIC AND BALTIC SEA

Both seas, Baltic and Adriatic, are very transport-intense. Maritime traffic is relatively diffused throughout the whole seas. Baltic Sea traffic growth is particularly significant in the field of containerisation (Serry

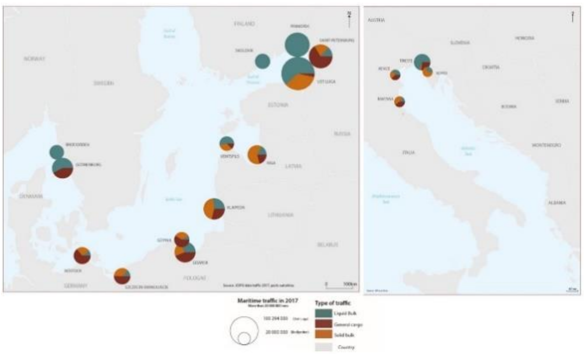
Transnav 2017) and this is also the case in the Adriatic Sea, like in Koper. In particular, large container vessels, ro-ro and tanker traffic has been increasing throughout the last decade (Perkovic, Harsch, Ferraro, 2016).

Since the end of the nineties flows in Baltic Sea and Adriatic Sea ports have grown quite constantly what has (inevitably) required a necessary modernization of harbour facilities and also their extensions. Thus, In the BSR, the maritime traffic has almost doubled between 1997 and 2018, from 420 million tons (Mt) to nearly 800 Mt while during the same period, the growth of world maritime traffic was by nearly 65% (Serry, 2019). When Central Europe becomes more closely integrated into international commerce, new markets take shape for the ports of the Adriatic Sea. Though still with modest tonnage levels compared to their counterparts in the North Sea and the Western Mediterranean, these ports, given European perspectives and recent dynamism tied to new ambitions. The Adriatic Sea becomes more transport-intense. For instance, in the bulk sector, Adriatic ports are a natural gateway for Central and Eastern European traffic and are well placed take advantage of any hinterland infrastructure improvements to attract cargo currently routed via Northern European ports.

In both areas, this development can be attributed to three factors:

- Worldwide economic growth has led to an increase in the volume of goods carried by sea;
- The profound geopolitical changes in the central and eastern Europe which have (re)opened the shores to the market economy;
- The needs of port capacity for Russia or central European countries.

In both areas, even if container traffic is not the dominant one (Figure 1), its progression is fast. Adriatic and Baltic ports operate in a relatively closed system in which the market and customers are restricted. Container throughput in the Adriatic Sea is significant and even during the global financial and economic crisis of 2008, the decline in overall container throughput in was insignificant. We can establish the reason for this is the good geographical location: maritime transport from China to the EU is shorter using Adriatic ports compared to North-European ports (Twrdy, Batista, 2016).



Source: Port Authorities, 2018.

Figure 1: Traffic Structure in 2017

Particularly, the northern Adriatic is at the crossroads of the European Union transport Corridor V between Lisbon and Kiev and the Baltic-Adriatic corridor which is one of the trans-European-road and railway axes in Central Europe on 2400 kilometers. It goes from the Baltic seaports of Gdansk, Gdynia, Szczecin or Świnoujście, to the Adriatic ports of Koper, Trieste, Venice and Ravenna, crossing the industrial regions of Central and Southern Poland, Czech Republic Slovakia and Austria. So, sea ports in the Adriatic - Baltic Corridor offers a favourable competitive conditions. That allows their logistical potential and getting better developed network of road and rail transport. The railway that links the Baltic and Adriatic seas exemplifies this opportunity. Two trains a week to and from the Slovenian port of Koper at the northern tip of the Adriatic Sea are already handled by Baltic Container Terminal in Gdynia (Lorentzon, 2014).

3 SIMILAR CONSIDERATIONS BUT DIFFERENT CARGO STUCTURES

Due to their peripherality, the Baltic and the Adriatic Seas are facing several common issues and adopting similar strategies.

One interesting point of comparison between Baltic and Adriatic cases is the fact that ports are interesting in far hinterlands. Unlike the Italian (Genoa, La Spezia), French (Marseilles, Le Havre) or German ports (Hamburg, Bremerhaven), where industries in direct proximity of the port generate a large shipping demand, the Adriatic ports actively aspire on serving contestable hinterlands in the Central and Eastern Europe, aside from their immediate vicinity (Stamatovića, De Langen, Groznika, 2018) when Baltic ports are looking to Ukraine or Central Asia. Northern Italian ports, in particular northern Adriatic ones, are in a favorable position to attract in their hinterland Central European countries, especially Austria and southern Germany (Acciaro & al., 2017). In the Baltic Space, new operators are setting up block-trains between the Baltic States and FSU or China. Block-trains enable “door-to-door” delivery, safety and easy border crossing as well as customs procedures (CIS/EU border in 30 min). The most successful pattern is the shuttle train Viking, launched in 2003, between Klaipeda (Lithuania), Odessa and Illichivsk which carries about 40,000 TEUs per year. Railways and shipping companies, ports of Lithuania and Ukraine, cooperate to simplify customs procedures, so trains can travel in 52 hours the 1,734 kilometers that separate the two ports. The second good example is the Baltica transit, a twice weekly block-train service between Riga and Almaty (Kazakhstan). Transit time is 8-10 days. In Latvia, the train is operated by LDZ Cargo in cooperation with FESCO (Far Eastern Shipping Co.) for the Russian part.

We could also show how cruise development is a common characteristic of the both seas. The Mediterranean region is divided into four sub regions; among which the Adriatic is the second most visited, only falling behind the Western Mediterranean (Zanne, Beškovnik, 2018). The Adriatic Sea is an attractive region for cruising, Venice and Dubrovnik were ranked 3rd and 7th, respectively, in the leading Mediterranean cities visited by cruise passengers in 2010 (Perucic, Puh, 2012). Cruise tourism in Croatia started to grow steadily in the first decade of 21st century with Dubrovnik as the prime destination, and Croatia is important not only for cruises within the Adriatic Sea, but also for cruises from the Greek Islands to Venice (Caric, Mackelworth, 2014). The maritime cruise industry in the Baltic Sea is changing, especially rapidly growing. This activity is now becoming increasingly popular in Baltic ports and port cities. The figures, provided by Cruise Baltic, prove that in 2018 cruise ships carried 5.8 million passengers (Kizielewicz, 2019).

As quite closed seas, Adriatic and Baltic Sea are very vulnerable to environmental problems. As a result of its intense traffic, they are unfortunately subject to illicit operational discharges and dumping from ships. Numerous environmental issues connected to maritime transportation are present in the studied spaces. For instance, as semi-enclosed seas and vulnerable environments, special attention has to be paid regarding the risk of introducing Harmful Aquatic Organisms and Pathogens via ships' ballast water (Rak & al., 2019).

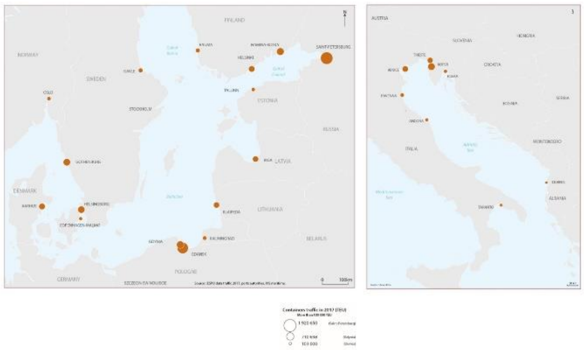
The first significant difference between this two spaces is that there are more ports in the BSR and often biggest ones (Figure 1). This situation is mainly the consequence of a biggest market but it is also connected to some geographical specificities: The Baltic Sea is the main exit door for Russian exports by sea, like crude oil, coal or fertilisers. So, in volume, liquid bulk is the main transported good in the BSR and also in Adriatic Sea but total volumes are very different. In the main field, dry bulk is strongly present in the Baltic ports but not in the Adriatic ones.

For these reasons, it is much more interesting to compare containerized networks. In volume, the Baltic market is again much more important than the Adriatic one but it is relevant to compare how containerization is developing in the both area because of their peripheral location.

The quantity of containers transported in the Baltic Sea is determined by the proximity of consumer markets, Russia being the key destination point. Only a minority of ports handle large quantities of containers. The largest regional container port, Saint-Petersburg, stands only 15th in Europe. In 2019, the number of containers handled among Baltic Sea ports amounted to 10.9 million TEUs. The configuration of the 20 largest container ports remained stable: St. Petersburg is clearly the undisputable leader in this segment, while Gdansk recorded considerable and continued growth in container traffic (Serry, 2017). Container traffic in Gdansk has increased tenfold in the last 10 years. The port is now at the second regional position behind St. Petersburg and competes heavily in Gothenburg (Figure 2). Gdansk has benefited from PSA's investments in the Deep Sea Container Terminal (DCT), which alone accounts for nearly two-thirds of Poland's container traffic.

In Russia, the containerized port system in the Gulf of Finland is completed with the Ust-Luga facilities and the new terminal of Bronka. The ambitions for Ust-Luga are considerable. Ubiquitous investment already placed the port as the regional leader in terms of total volume with 103,43 Mt in 2017. These two ports provide 70% of container traffic originating from or destined to Russia in the BSR. The rest of Russian traffic provides transit traffic mainly to Hamina-Kotka (Finland), Riga (Latvia) and Klaipeda (Lithuania).

Concerning ocean-going container ships, the Baltic Sea is restricted by physical prerequisites. Small markets and limited hinterlands may also reduce the competitiveness of ports (Lorentzon, 2014). Baltic ports are therefore essentially served by a feeder network. Starting from Northern Range ports, the rotations of the feeder ships are either circular, serving a few number of ports, either direct to one or two ports. So Baltic ports are not relays of large European and global flows but rather secondary nodes in the maritime network, even the most developed of them are connected through feeder services to some other ports' range.



Source: Port Authorities, 2018.

Figure 2: Container traffic in 2017

The Adriatic Sea container traffic is concentrated in the northern part. The north Adriatic multiport gateway system is made up by the Italian ports of Ravenna, Venice, and Trieste, Koper in Slovenia and the Croatian port of Rijeka (Luipi, 2019).

In 2017 the Port of Trieste achieved a container traffic of 616.156 TEU and was the leader on the Italian shore, in front of Venice with 611.383 TEU. The port of Ravenna is an interesting case study: it is the second largest dry bulk and general cargo port in Italy (and the first in the Adriatic Sea), even if it appears smaller - in general terms - in comparison with the other main Adriatic ports (Acciaro & al., 2017).

The port of Koper is handling various types of goods and practised a significant increase of throughput in the last years: it has become the first container port of the North Adriatic with a container traffic of over 911.528 TEUs in 2017. The main characteristics of container ports are different in all ports. The throughput in Koper and Trieste is limited by the capacity of terminals, while in Rijeka, utilization is quite low. Trieste and Koper have the shortest land routes, connected with more direct maritime services from Asia. There is no doubt that with the steady increase in container traffic, these two ports are on the verge of reaching the necessary threshold to play a gateway role (Beyer, Sevin, 2008).

Rijeka instead recorded a much slighter throughput, handling 249.975 TEU which is approximately 40% more compared to 2007 (Host, Pavlić Skender, Mirković, 2018). Like in the Baltic Sea, the majority of container traffic of northern Adriatic ports refers to feeder services with transhipment at the hub ports of Gioia Tauro, Marsaxlokk (Malta), Piraeus (Greece), and Port Said (Egypt). Adriatic ports instead play only a negligible role in direct deep sea services.

Consequently, mainly because theirs trade volume remain too small to attract pendulum services, Adriatic and Baltic ports have limited global connectivity (Arvis, Vesin, Carruthers, Ducruet, Langen, 2018).

4 CONTAINER NETWORK ANALYSIS

4.1 Data & methodology

Thanks to the AIS data and in relationship with external databases, we are able to reconstruct each vessel's trajectory in such a way as to identify the navigation lanes then to match the daily traffic in its temporal and quantitative dimensions. It is then possible to analyse the maritime networks.

Automatic Identification System (AIS) is a system of monitoring ship movements that was made obligatory by the International Maritime Organisation (IMO) in 2004. AIS benefits to maritime transportation actors: improvements in safety or in the management of fleets and navigation. The data acquired from AIS systems also constitute a new means of information for the maritime community, or the wider public. Thus, it provides valuable material, not only to crews but also to terrestrial regulatory authorities, not forgetting individuals and research scientists. This material was first used for works based principally on the subject of security or on coastal spaces. Subsequently it has spread in many other fields including international maritime law, physics, signal processing, geopolitics... One of the most fruitful areas of research is in the analysis of shipping networks (Faury & al., 2019).

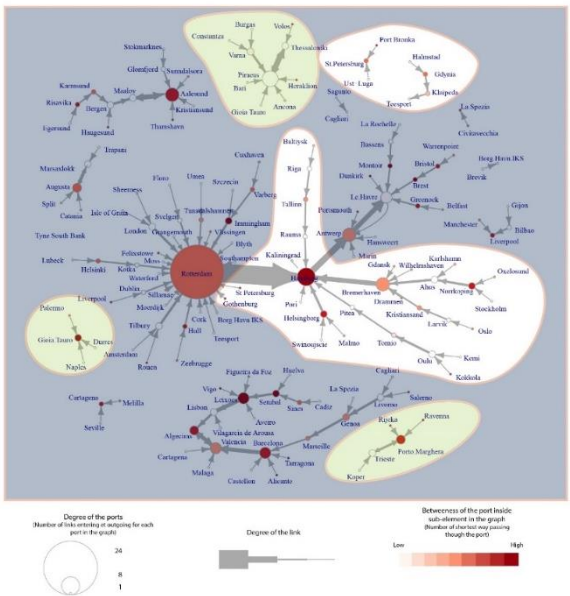
We have elaborated a platform which receives, decodes, cleans, stores and analyses AIS messages. Data is collected on the port of destination, the navigation status, the draught of the ship and ETA (estimated time of arrival). In this way it is possible to identify the maritime networks. The method used in this paper involves a spatial analysis within a geographical information system (GIS) combined with a database server, that makes it possible to rebuild each vessel's trajectory. It is then possible to analyse whole maritime networks.

4.2 Network and shipping companies

Then, AIS data combined to network analysis illustrates strong differences in both containerised networks (Figure 3). This graph of the containerships' maritime network in Europe was made using the so-called "major flows" method. This method consists of retaining for each node (here the ports) only the strongest link (in value) and to remove all the other ones (Ducruet, 2011).

The Baltic network is strongly connected to a major external node, Hamburg. Already in 2015, 88% of Baltic container ports maintained at least a link with Hamburg. 34 ports were served by regular lines departing from Hamburg (12 in Sweden, 9 in Finland, 4 in Denmark, 3 in Russia and Poland, 1 in Estonia, Latvia or Lithuania). There is also a strong internal connectivity with some local particularities like southern axis Gdynia-Klaipeda or a Bothnian axis. In the BSR, regionalisation is evident because of the concentration of sea connections on a low number of north European ports. New emerging nodes, like Gdansk, tend to centralise sub-regional dynamics.

The Adriatic network is quite different and less connected than the Baltic one: it is clearly more diffuse and burst even if the container terminal of Porto Marghera and Gioia Tauro seem to act as transshipment nodes for the region.



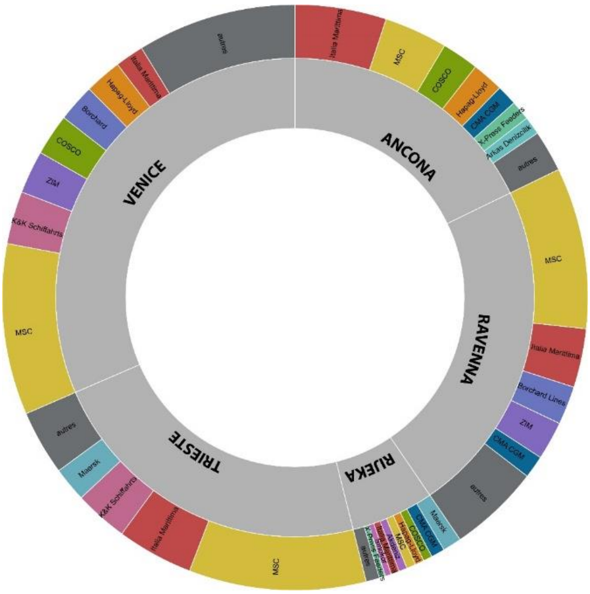
Source: IHS Maritime, 2019.

Figure 3: European containerized networks in 2018

Containerised network analysis also shows some quantitative differences. In 2018, there were 2 times more containerships' calls in the Baltic Sea (11716) than in the Adriatic Sea (6060). These ships were also coming back more often in the BSR than in the Adriatic ports but average ships' size is bigger in the Adriatic Sea (2919 TEU) than in the Baltic Sea region (1574 TEU). This last result can surely be explained by the different strategies of shipping companies which are analysed below.

So, to reinforce the analysis, we can also use AIS data to study container shipping companies and operators' strategies. At first, AIS data clearly shows that when there are a lot of companies acting in the BSR in 2018, their number was really smaller in the Adriatic area: 34 shipping companies were present in the Saint-Petersburg about twice as much as in the biggest Adriatic port.

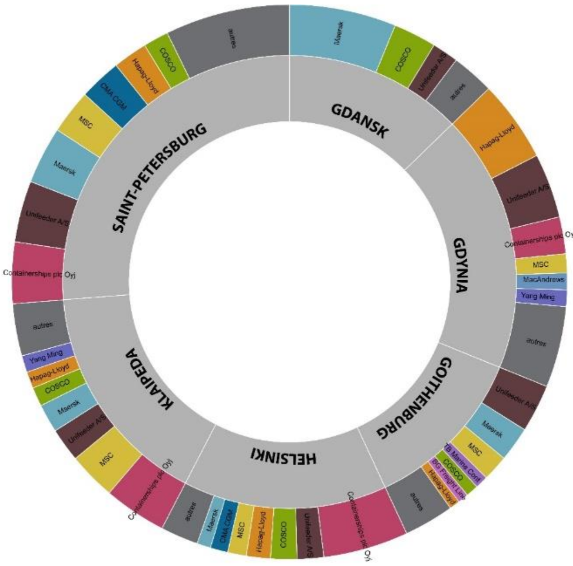
Secondly, this result also proves that there is less interest (and less competition?) from shipping companies in the Adriatic market than in the Baltic one.



Source: IHS Maritime, 2019.

Figure 4: Operators in the Adriatic Sea in 2018

In the Adriatic Sea, MSC (Mediterranean Shipping Company) seems to be the leading company (Figure 4) when in the Baltic Sea, the traffic is much more balanced between several companies (Figure 5). The place of specific feeder companies is also more important in the BSR than in the Adriatic. We can focus on operators, their strategies or their networks. So some companies like Joy Marine have quite local strategies with ships calling only in Bari when others like MSC propose services to almost all the ports. In addition, it is also possible to determine the capacity offered by each company in each port. It is an interesting way to focus on the three different types of actors present in the region: some major ones in the feeder field, some global carriers (MSC or CMA-CGM) and regional ones (Tarros SpA, Bia Shipping…).



Source: IHS Maritime, 2019.

Figure 5: Operators in the Baltic Sea in 2018

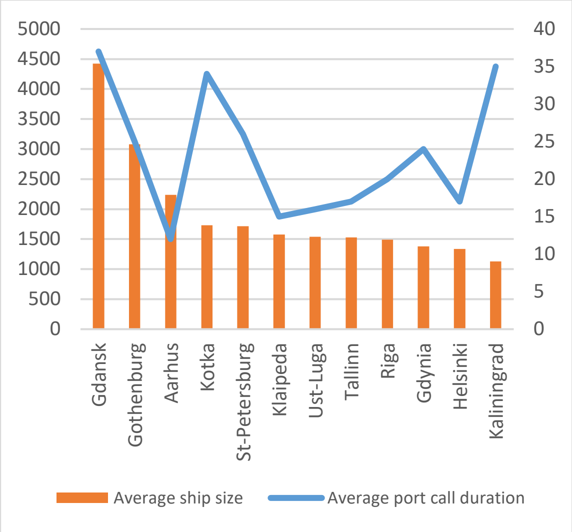
To synthetize, companies have different strategies: global carriers concentrate their flows on some ports like Venice or Gdansk which apparently act as a regional hub when companies specialized in feeder services have a more decentralized network. For instance, we mapped the capacity offered by COSCO in 2016. It is concentrated in the North of the Adriatic Sea principally in the ports of Koper, Trieste, Venice and Rijeka. COSCO uses the ports of Piraeus and Ayios Nikolaos (Greece) like a hub as it is the owner of these ports. Afterward, it transfers the goods to the Adriatic Sea. The behavior of COSCO matches with analyzes on the precedent map and a concentration of the calls is on the ports of the North of Adriatic Sea.

4.3 Network and shipping companies

Nowadays, the question of port competitiveness is crucial for port authorities and operators. In such a scheme, the question of port productivity is central for all the stakeholders. It especially concerns port operation efficiency levels, handling charges, reliability or landside accessibility. Thanks to the AIS data and in relationship with external databases, we determined all container ships that called at a Baltic or Adriatic port in 2019.

In the both peripheral seas, we can analyse port efficiency using the duration of port calls given by AIS data.

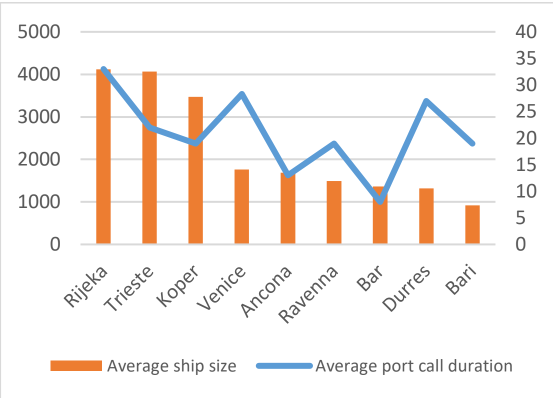
Baltic container ports appear very differently (Figure 6): two ports in particular, namely Gothenburg and Gdansk, are served by ships offering a larger capacity than in the other ports. Combining this analyses to operator’s strategies is also interesting. In the case of Gdansk, the situation is clearly the result of Maersk Line choice to make the polish port its Bal-tic hub (Serry, 2017). AIS data shows that 35% of all port calls are made by Maersk Line, with an average capacity of 4530 TEU.



Source: IHS Maritime, 2020.

Figure 6: container ships' capacity and duration of port call in some Baltic Sea ports in 2019.

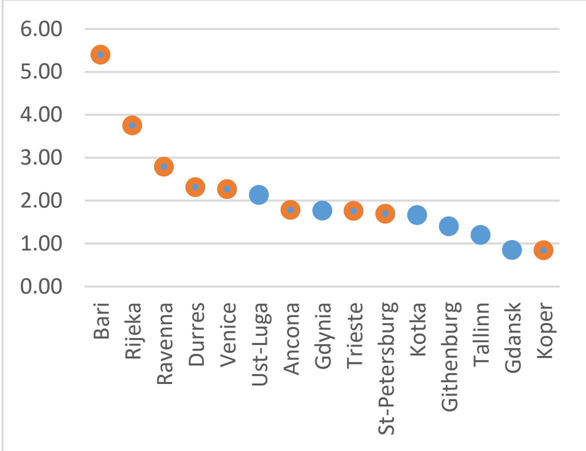
Concerning the Adriatic Sea ports, container ports also appear very heterogeneous (Figure 7): three ports in particular, Koper, Rijeka and Trieste, are served by ships offering a bigger capacity than in the other ports. The graph also shows the dissimilarity between the southern and the northern parts of the Adriatic Sea.



Source: IHS Maritime, 2020.

Figure 7: container ships' capacity and duration of port call in some Adriatic Sea ports in 2019.

By integrating the port traffic in the research process, it is possible to estimate the average length of handling of a TEU in each port. The first result is that Baltic ports seem to be more efficient in container handling speed than the Adriatic ones (Figure 8): average operational speed is 2.17 min per TEU when it is 1.56 in the Baltic sea in the same period. Of course, such analysis could be refined with the number of cranes in each terminal for instance.



Source: IHS Maritime, 2020.

Figure 8: Average speed per TEU (minute).

At least, it also appears that container terminal efficiency is very variable in the Adriatic ports: in the port of Koper, the most efficient one, it takes four times less time than in Rijeka to operate one TEU.

In the BSR container terminal efficiency is also very inconstant: in the port of Gdansk, it takes three times less time than in Kaliningrad to operate one TEU.

5 CONCLUSION

Political and economic mutations have shaped new conditions for development of trade and transport in the Baltic Sea Region and in the Adriatic area. The expansion of international trade has led to an increase in cargo turnover in the ports, primarily due to the active development of consumption markets and at a second level to new transshipment activities.

Competition between ports is evident, as we can see between Gdansk and Gothenburg or between in the BSR or between Trieste and Koper in the Adriatic Sea. This competition between ports consists of ports which can handle container ships and propose distribution of goods to similar markets.

By their connections to the global container-shipping network, the Baltic and the Adriatic Seas have gained in maritime efficiency what they have lost in direct access to the vast world. On the contrary, they have deepened relations with the world ocean as regional hubs emergence prove it.

Despite similarities and comparable challenges due to their location on the European periphery, this comparison has shown that the two seas are differently integrated in the maritime networks especially with container services. Probably because of its proximity to the northern range which dominates and concentrates the containerized flows of the European continent, the Baltic Sea is very heavily feederized. This is evident both in the structure of the marine network and in the strategies of the shipping companies.

The role of feeder ship connections is just as important in the Adriatic Sea, but their organization seems a little different, in particular due to the situation of the Adriatic ports close to the multiple Mediterranean transshipment hubs, but also the contemporary smaller size of the Adriatic market.

From a prospective point of view, recently, northern ports have been favored, especially Hamburg. But the rise of economic centers in the Baltic area and at the coastline of Mediterranean Sea have created opportunities for several multi-port gateway regions to develop transport networks. Furthermore, new opportunities might arise for port systems in the Baltic Sea as well as in the Adriatic Sea. An observation is that countries such as Czech Republic, Poland, Slovenia and Hungary have strong railway networks enabling extension of the hinterlands (Notteboom 2012). Goods from Asia may be reloaded at ports of the Adriatic Sea and further distributed by train to places in East- and Central Europe. A result is shorter distance by sea-transport and saving of time (Lorentzon, 2014).

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WOMEN SEAFARERS ABOARD TRADITIONAL BOATS IN THE MURTER ISLAND AREA

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ABSTRACT

Croatia's island of Murter is one of the rare insular communities where the presence of female workforce on board transport and fishing boats has been considered natural and a maritime and economic conditio sine qua non. Except for the tasks requiring considerable physical strength, the teenage girls and adult women of Murter have participated in all tasks at sea: rowing, handling sails, steering, position fixing, crew management, weather forecasting, small-scale fishing and maintenance of fishing gear. This phenomenon of defying the stereotypes and discrimination against maritime women resumes today. The paper discusses the cultural, economic and maritime circumstances that enabled/forced hundreds of the Murter women to serve on board – as family crewmembers, wage earners or enthusiasts – and allowed them to make a breakthrough from the gender framework, otherwise carefully designed and maintained by the tradition.

Keywords: Murter island, workboats, navigation, seawomen, gender

1 INTRODUCTION

Superstition that women on board bring bad luck has never really taken root in Croatian insular and coastal communities on the eastern side of the Adriatic Sea, at least when it comes to small traditional wooden workboats engaged in coastal navigation and small-scale fishery. In the elaborate list of superstitions, i.e. specific prohibitions of communication, avoidance of certain actions and compulsory performance of some rituals before, during and after fishing in the area of Zadar, there is not even one referring to the presence of women on board (Lulić Štorić, 2015). In the late 19th and the early 20th century, the parish priest of Murter Island made considerable efforts to restrain superstitions among the local population. Again, none of these irrational beliefs referred to women on board.[1]

From the anthropological point of view, Croatia's insular and coastal communities shared the same patriarchal concepts and structures with other communities across the Mediterranean. The gender roles were largely predefined. By default, women were expected to be hard-working, silent, humble and virtuous, in charge of housekeeping, child care, elder care, making clothes, gardening, farming, and the like.[2] However, traditional roles and work distribution on gender basis were less clearly defined on the islands than in coastal communities. Some researches point out that the real patriarchal pressure was never too strong on the islands and that customs were less severe and people more tolerant.[3] When the situation required, the women would set out to sea, the traditional male domain, and assist in navigation and fishing tasks. The islands of Murter, Kaprije, Drvenik, Zlarin and Ugljan are some of Croatia's permanently inhabited islands where the presence of female workforce on board was not just tolerated, but welcome, even appreciated. This was particularly the case when wars, economic crises and other changes heavily shook the established social patterns, resulting in the loss of male workforce. At the beginning of the 20th century, the phylloxera caused catastrophic decay of the vineyards on Croatian islands, including Zlarin. At the same time, there was an essential change in seafaring: sailing ships, which the seafarers of Zlarin used, were superseded by steamships. These events resulted in a crisis of such magnitude that most men from Zlarin were forced to leave the island and seek employment across the ocean. In the absence of men, Zlarin women independently managed their households, raised children, made decisions, and took over a series of

[1] His name was Nikola Plančić (served in Murter from 1891 to 1913), cf. Turčinov, K. (2015), pp. 138-140 and 162-4.

[2] More about gender roles in the Mediterranean culture in: Turčinov, K. (2016), p. 26. See also: Podgorelec & Bara (2014), p. 388.

[3] Podgorelec & Bara (2014), p. 388. See also: Muraj (1996), p. 145.

male jobs, including construction, navigation and fishing (Muraj, 1996).

However, nowhere has the presence of sea-going women been more evident and long-lasting than in the area of Murter Island. For more than 150 years, women on board hundreds of Murter boats have been an everyday sight. The paper discusses the historical, cultural, economic and maritime circumstances that enabled/forced hundreds of the Murter women to serve on board – as family crewmembers, wage earners or enthusiasts – and allowed them to make a breakthrough from the gender framework, otherwise carefully designed and maintained by the tradition.

2 BACKGROUND

The Island of Murter belongs to the North Dalmatian group of islands that lie between the cities of Šibenik and Zadar. Together, these islands represent the densest archipelago in the Adriatic and one of the densest in the Mediterranean. With an area of 19 km^2, Murter Island is the largest in the archipelago. There are four settlements on Murter Island: the little towns of Tisno, Jezera, Betina and Murter. The island is connected to the mainland by a 20 m drawbridge at Tisno. On the other side of the island lies the *Murtersko more* (the Murter Sea), covering the area of 210 km^2. Even though it is not large, the Murter Sea has always presented a challenge to ancient and modern navigators, due to tidal streams and lack of shelter from the NE, NW and SE winds and sudden changes in their force and direction.

In the 15th century, the first 20 families were settled on the island as lease-holders engaged in agriculture and sheep farming. Over the centuries, the population grew steadily. The vicinity of the continent allowed the acquisition of properties in the hinterland of Tisno, the area of Modrave, and the nearby islets, where Murter people gradually turned the rocky soil into vineyards and olive groves. At the same time, some of the islanders were employed as shepherds or lease-holders in the archipelago of Kornati, owned by four noblemen from Zadar. At that time, Murter people showed no interest in any maritime activity. The sea was still considered as the buffer zone against various attackers and looters, and as an area of utmost hazard.

The situation changed when the island's economy reached the limits of sustainability. Overpopulation became unbearable. 60 people die of hunger in 1783 and there were more "hungry years" to follow (Skračić, V., 2004). In the 19th century, when the noblemen from Zadar decided to sell the Kornati Islands, the people of Murter took the opportunity.[4] The colonisation of the islands required extreme efforts as it entailed land reclamation, field work, sheep farming, subdivision of land, building drywalls, shelters, sheds, houses and maritime infrastructure. Despite all the hardship, the acquisition of the islands seemed to be a good decision, as the average lifespan rose from 36 to 55 years.[5]

One of the most prominent changes was the new attitude towards the sea. Most of Murter people had to master a number of new skills associated with navigation because the boat became the essential prerequisite for accessing and maintaining the new properties. In addition, boats required proper berths. A network of quays, slipways and piers was built on both sides of the sea. More new jobs were created in the process.

The boat became top priority and the pivot on which the entire family economy – and existence – depended. While the closest lands were just a few nautical miles away (e.g. Modrave), the most remote properties lay over 20 NM off the Island of Murter, with the 7-8 mile wide Murter Sea offering no shelters from the storms or gusts of NE and SE winds. For instance, one of the largest settlements on Kornati Islands is Vrulje. It was the second home to around 20 families and the port for their boats. Vrulje is around 18 NM from the Bay of Hramina on Murter Island. Today's traditional boats, fitted with engines, make this passage in about 3 hours. In the pre-engine era, the distance required at least 6 hours of sailing or over 10 hours of rowing. These passages could be even longer in case of the wind failing or changing direction. Sometimes the boats were detained overnight in the coves near Opat or Proversa, at the extreme points of the archipelago, waiting for the weather conditions and state of the sea to improve.

Murter families needed boats to make safe passages across the Murter Sea or to the cities of Šibenik and Zadar. In addition, these vessels were expected to navigate in shallow waters and approach various shoreline configurations. They had to be robust and able to transport people, sheep, goats, donkeys, various tools and building materials to their overseas properties, as well as the crops, milk products and fish to the home island. Finally, these boats had to be suitable for fishing, as the seafood became natural part of the menu during lengthy stays on the islands. Basically, what Murter families needed was a multi-purpose vessel.

They were lucky. A hundred years before these events, the village of Betina on Murter Island had become home to the Filipi family from Korčula. The Filipis were boatbuilders. The first and second generation of the family established a number of small boatyards in the area, producing the vessels that combined the designs mastered in Korčula with the needs of the Murter population. The range of boat types included the gajeta, guc, batana and leut, of which the leut and the gajeta, or *betinska gajeta* (gajeta designed in Betina), have proved to be the most popular and commissioned designs to this day.[6] From the structural point of view, the leut and the

[4] Juran (2005), pp. 135-151. See also: Juran (2004), pp. 12-17; Juran (2003), pp. 63-89.

[5] Turčinov, K. (2015), p. 33. In a 2001 research, the life expectancy at birth on North Dalmatian islands stood at 76.7 years. Cf.: Music Milanović, et al (2006), pp. 611-8.

[6] See the detailed description and comparative advantages of these boat designs in: Skračić jr, Tomislav (2015), pp. 423-433.

gajeta are very similar. They have the same round-bottom hull shape with a strong keel to preserve stability and a flared bow to shed spray; they are fitted with several oars and simple lateen sail rigging enabling the speed up to 6 knots. Both are multi-purpose vessels. The key difference lies in their functionality. As a rule, the gajeta is somewhat smaller, typically 6-8 m in length, and less expensive.[7] The leut requires a crew of at least 3 to 4 strong men, whereas a minimal crew, i.e. a family, can operate the gajeta. While sailing in fair weathers, the gajeta requires only one experienced person. When the navigator is assisted by another family member – an elderly person, a child over 10, or a woman, this workboat can operate in almost all weathers.

At that moment, Murter women became seawomen – deckhands, navigators, skippers. Hundreds of boats carried hundreds of women, equally participating in almost all aspects of navigation, transport and fishing.

3 WOMEN IN THE FOREGROUND

The activities of Murter women at sea can roughly fall into two basic categories: sailing and fishing.[8] Sailing tasks included:

- Rowing (one 4 meter wooden oar per person),
- Keeping a lookout,
- Steering (and controlling the mainsheet),
- Sail control: attaching the lateen sail to the boom, furling / unfurling the sail, handling the lines for sail trim and reefing (reducing the sail area),
- Pulling the boat upwind from the shore (when the shoreline configuration allowed; to avoid tacking and save time),
- Loading and unloading cargo: fish, wood, grass, crops, domestic animals, etc.
- Handling mooring lines (and doing anything that was necessary when arriving / leaving the berth),
- Weather forecasting,
- (in modern era) Operating the main engine, navigation lights and other controls.

Fishing activities of women seafarers included:

- Setting and hauling various types of bottom gillnets, fish and lobster traps, and longlines in shallow and deep waters (up to 80 m),
- Catching octopus and calamari, collecting shellfish,
- Predicting fishing grounds with reference to the prevailing or expecting wind force and direction, tidal streams, and depending on the time of day and year,
- Fish cleaning, gutting, cooking and preservation (by salting and drying),
- Making dyes for fishing nets by malleting the myrtle (*myrtus communis*),
- Rinsing and drying nets, and maintenance of fishing tools.

All these activities could be evenly, in any convenient sequence, simultaneously or alternatively, distributed among men and women, but there were situations when women performed all necessary tasks without help from men, including the long and risky passage across the Muter Sea. Here are some of the genuine accounts:[9] Mira Šikić Bortulova (born in 1924) was 10 years old when she assisted her father in deep-sea gillnet fishing; she and her sisters would join a fisherman and operate a small drift net to get some sardines for supper; she used to sail with her female friends, without men, to distant shores to collect grass; when she got married, she went fishing with her husband regularly, except for the times when she was due to give birth and when kids where very young; she also used to row to Šibenik (28 NM) and Zadar (20 NM) to sell fish. Iva Kovačev Božidarova (born 1934) spent the entire life at sea: sailing, rowing, fishing; she knew many a fishing ground and brought cash into the family economy. She had a brother but he was never so successful on board. Until recently, she participated in rowing regattas at Lateen Sail festival that takes place every September. On several occasions, Mira Turčinov Peina (born 1941) and her mother sailed across the Murter Sea alone, with a donkey. Marija Turčinov Stipićeva (born in 1932) showed great navigation skills in heavy weather. She helped her grandfather to save the boat fully loaded with olives in a storm: she handled the sail lines, assisted in repairing the broken boom, rowed and hauled the boat along the shore. On a similar occasion, her skills (reefing the sail) and accurate estimation (rowing through the shallow water between two islands) saved the boat, cargo and the remaining male crewmembers. There were a number of women who the Murter people considered as better navigators and/or fishers than men.

Naturally, the ideal gender equality in work distribution was impossible and unnatural. Women were not engaged in anything that required excessive physical labour such as hauling the boats out of the water, hauling the deep-bottom nets and traps, hoisting the boom and the sail, or handling large anchors. The exceptions were rare.[10] Likewise, they did not take part in some types of drift net fishing, drag net fishing from the coast (beach seining)

[7] The betinska gajeta was a family workboat. The 1857 census counted 1 gajeta per 7.8 residents. The price of a 7-meter gajeta was around 700 litres of olive oil, the latter being the only hard currency at the time, see: Skračić, V. (2004), p. 23.

[8] The list is not necessarily final: it includes the activities that the authors witnessed, or were recorded in photographs or interviews of the very women, See: Turčinov, K. (2015), pp. 202-213.

[9] The real-life examples, accounts and statements that follow can be found in: Turčinov, K. (2015), pp. 160-161, 204-213; and Turčinov, K. (2016), pp. 15-40. See also: Turčinov, B. K. & Skračić, V. (2017), pp. 149-192; Skračić, T. (2004), pp. 180-184.

[10] Mrkonja (2016) states that the women from Kali on Ugljan Island often assisted their husbands in rowing and hauling the boats out of the water in the event of storm, but provides no details (p. 14). The authors of this paper witnessed women doing some heavy manual work, but also learned – empirically – that some hard tasks called for more skill than force.

and other techniques that fall into the category of large-scale fishing. Curiously enough, there was one task that Murter seawomen never performed although they were perfectly capable of – repairing the fishing nets. Until 1960s, the nets were made of cotton and were often damaged by seabed rocks, crabs or large fish. Turčinov, K. (2016) explains that, although repairing was very similar to knitting and sewing, the women deliberately avoided to master this skill, as it would only add to their chores and busy daily schedule (p. 27).

The presence of female workforce was not limited to the family boats: many Murter women earned wages on board commercial fishing boats, mainly the larger designs such as the leuts. Professional fishing operations typically included two or more boats, each having a crew of three or four persons, and lasted from several hours to several days. One woman alone, especially if she was a widow, could not join the crew unless there was a close male relative on board (e.g. a brother, father-in-law). There was no such restriction when two or more women were on board. It is worth noting that the patriarchal code insisted on the appropriate language and body language: women should wear wool skirt and remain obedient and silent, i.e. they were not supposed to talk back or brag about the good catch, but there was no personal provocation nor wage discrimination based on gender.

Mira Šikić Bortulova frequently worked as a deckhand in commercial fishing ventures until she got married. An owner of a boat and gear often asked Iva Kovačev Božidarova and her two female friends to go fishing. He said he preferred them to men because they were skilful, fast in disentangling fish from nets, able to estimate the sea currents accurately, they knew the transits… and he could yell at them when things went wrong. One of them, Mira Dulukina, was exceptionally strong and she was also in charge of hauling the nets for extra pay: while other crewmembers would receive 1 part of the catch, Mira would get 1.25 parts.[11]

4 PRIVATE AND PUBLIC POWER

It seems that the Murter community had no difficulties in accepting the phenomenon of women seafarers and in recognising their skills and contribution. Generally speaking, a patriarchal structure accepts changes much easier if they arise from the necessity than from individualism or enthusiasm.[12] In the times of crises, insisting on clear gender stereotypes and the boundaries between men's and women's roles loses justification and may jeopardise the community. In the case of Zlarin Island, women set off to the sea, the "traditional male domain", and saved the community. In case of Murter, women did the same but on a much larger scale: not only because of the sheer size of the population, area and fleet, but also because the sea was not a "traditional male domain" – the people of Murter were peasants and shepherds before the colonisation of the Kornati Islands. For them, the sea was neither "traditional" nor "male" domain. When they colonised these properties, men and women did it together. The success of this epic venture depended on the contribution of everyone.[13] True, some activities continued to be dominated by women or men, but the gender roles at sea were pragmatic and have remained blurry to this day. The institutions such as the church and the family – the guardians of the tradition and the ideal (patriarchal) order – not only approved of the female active presence on boats, but recognised their maritime skills and their contribution to the economy of the local community.

Meanwhile, in the area of land-based responsibilities, women remained in full charge of the already established tasks: housekeeping, child care, elder care, gardening, farming, etc. Their increased self-awareness, self-esteem and capacity of decision-making were some of the inevitable effects. Considering all this, their position within the community became stronger. The ideal order was shaken but, nevertheless, it persisted and the new circumstances did not eventually result in real gender equality within the community. Reasonably or not, just like on Zlarin Island, the women of Murter chose to use their new position for increasing their private power instead public power. The family remained their stronghold. They left public institutions to be managed by men and controlled the events from behind. Even today, the seawomen of Murter are not inclined to expose their achievements publicly. Vessels, engines, fishing gear, sails and equipment are commissioned by men and most of the boat owners are men, at least nominally. Women massively participate in the annual Lateen Sail regatta but are rarely registered as official skippers.[14] Future research should explore this private / public power policy and all the motives – not only economic and pragmatic – that have been standing behind the presence of women on board Murter boats since 1850s, because the phenomenon of defying the stereotypes resumes – the introduction of engines and the emergence of new technologies, activities (e.g. tourism, boat rentals) and types of vessels (catamarans, speedboats, etc.) have not changed much in this regard.

[11] Deckhands were paid in cash, fish or counter-service.

[12] Turčinov, K. (2015), pp. 19, 143, 154.

[13] It can be rightfully assumed that the first Murter navigators were men, when the acquisition of new lands was taking place in the nearby locations around the home island; however, this cannot be compared with the acquisition and colonization of the Kornati possessions, when the presence of female workforce on board assumed massive proportions.

[14] The exceptions include Ana Jerat, Jelena Belamarić and several other women who proudly own, maintain and use their *gajetas*.

Source: www.latinskoidro.hr

Figure 1: An all-women crew leaves the port of Smokvica at Kornati Islands on a fully loaded gajeta, heading for the 8 NM distant home port of Murter

5 CONCLUSION

There are a number sources confirming that women from Croatia's insular and coastal communities actively served on traditional workboats, thus challenging the assumption that navigation is a male pursuit. However, the presence of female workforce on board and the role the women seafarers have had in the Murter Island area represents a particular phenomenon. It can be explained not only by the sheer size of the population, area and fleet, but also by the fact that the sea – until the 18th century at least – was not a "traditional male domain": the people of Murter were peasants and shepherds before the acquisition of the overseas properties. For them, the sea was neither "traditional" nor "male" domain. There settlement, the "old" Murter, was located on a hill, not by the sea.

From the economic, cultural and social viewpoints, the community of Murter, steadily growing from the 15th to the 18th century, developed structures and values that were not very different from any other small community in the Mediterranean. It was – and perhaps still is – a patriarchal society, with clearly defined gender roles, established and carefully controlled by the church and the family as the most powerful institutions. The situation dramatically changed when the population of the island reached the sustainability limit in the early 19th century. Hunger and the associated effects, illness and high mortality rate, forced the people of Murter to acquire new lands. The acquisitions included the properties on the mainland, the nearby islets and, eventually, the remote Kornati Islands. The colonisation of Kornati assumed mass proportions in terms of investment, people and fleet of workboats that were necessary for accessing, maintaining and exploiting these lands. It also forced Murter people, once predominantly engaged in agriculture and livestock farming, to build maritime infrastructure on both sides of the Murter Sea, and master the new skills of navigation and fishing.

The boatyards in Betina produced several types of vessels that met the new demands. The most common design was the *betinska gajeta*, the 7 m long boat fitted with several oars and a lateen sail, which could be handled by a minimal crew, i.e. a family. At that moment, hundreds of Murter women became deckhands, navigators, skippers and fishers, capable of performing almost all tasks at sea. They rowed, steered, controlled the sail, handled mooring lines, predicted weather conditions and tidal streams, loaded and unloaded cargo, set and hauled various types of bottom gillnets and traps, engaged in fish processing and maintenance of fishing gear. As family members, they were spared from heavy manual labour, but were allowed to join commercial fishing boats with male crew – and were paid equally.

The community not only approved of the female active presence on boats, but also recognised their maritime skills and their contribution to the family economy. Meanwhile, in the area of land-based responsibilities, women remained in full charge of the already established tasks. These events resulted in increased self-awareness and self-esteem, capacity of decision-making and a stronger position of Murter women within the community. Although they did not use the opportunity to expose their achievements publicly, to transform the established institutions and further undermine the patriarchal structures, their increased private power has had lasting effects on the community to this day.

Over the last fifty years, the nautical world has changed considerably. Engines have been installed in traditional workboats; sails and rows are used mainly by enthusiasts; the Kornati archipelago has become a national park; tourism – particularly boating – has created new jobs in chartering, tourist excursions and other branches; the Murter Sea teem with new types of vessels including catamarans, power yachts and inflatable boats. New land-based jobs have allowed women to taste independency better than ever. None of these phenomena has changed the position of the Murter seawomen: their presence aboard various vessels, private or commercial, traditional or modern, is considered natural and is much appreciated.

The paper discusses the historical, economic, cultural and maritime circumstances that enabled, or forced, hundreds of the Murter women to serve on board and allowed them to make a breakthrough from the gender roles. Further research should explore all the motives that have been standing – from 1850s to these days – behind the massive presence of women aboard Murter boats, as well as the full effects of this phenomenon on this community today.

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SOLAR PARKING

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ABSTRACT

Air pollution related to energy consumption has emerged as a significant global problem. One of the possibilities to mitigate the effect of energy consumption is the use of renewable sources of energy, such as solar power. However, as some studies show, solar power currently provides for less than 1% of total electricity consumption.

The world population is growing, and so are their demands and dynamics of life. Consequently, there has never been a larger number of vehicles in use. All this exerts pressure on energy consumption and on the construction of parking spaces. By covering parking spaces with solar panels, both issues would be addressed: parking spaces would become more organised and would provide a part of the required energy. Besides, by providing shadows over parked cars, the users would not need to use as much air conditioning as before, which would result in better fuel efficiency and thus fewer emissions. Some additional features could be added to the system, such as a charging system for e-vehicles.

In the paper, the possibility of implementing solar panels covered parking spaces in Portorož, a tourist resort on the Slovenian coast, will be tested. The objective of the paper is to calculate the costs of solar infrastructure and the potential energy generation to conduct a break-even analysis for a parking location in the proximity of the Faculty of Maritime Studies and Transport.

Keywords: Solar panels, parking spaces, energy generation, costs

1 INTRODUCTION

According to the data of the Statistical Office of the Republic of Slovenia, 1,143,150 personal vehicles were registered in Slovenia in 2018 [1]. This means that the motorisation rate in Slovenia exceeds the average motorisation rate in the European Union. The Slovenian motorisation rate varies between 550 to 650. On the other hand, the average European Union motorisation rate in 2016 was 506 [9]. Furthermore, according to Eurostat, by 2020 Slovenia needs to produce a 25% share of gross final energy consumption from renewable sources. However, between 2015 and 2016 the average value reached 21.6%, which means that Slovenia still did not reach the pre-set goal [8]. The high motorisation rate and insufficient energy produced from renewable sources calls for more organised and eco-friendly parking spaces. A possible solution could be solar parking, specially in cities with high solar potential like Portorož.

To raise the public awareness of solar parking, the possibility of implementation of solar parking at a parking location in the proximity of the Faculty of Maritime Studies and Transport will be tested by calculating the costs of solar infrastructure and potential energy generation at this location.

2 ADVANTAGES AND DISADVANTAGES OF SOLAR PARKING

Most parking lots in cities are made from concrete, so solar canopies would not deteriorate their visual appearance. Even more, parking lots would become visually more organised and solar canopies would provide shadow over the parking spaces. In addition, the electrical energy gained from solar parking can be used for various functions. It can be used for direct charging of electrical vehicles or connected to adjacent buildings and become a part of the electrical energy supply. A great example of such use, where solar panels are providing electrical energy supply for adjacent building, is the Autogrill's station, near the highway in Italy, who offers food and beverage services for travellers. Parking lot covered with solar panels is providing a shadow for its costumers cars and it represents the base for installation of electrical vehicles charging station [12]. If an energy surplus occurs, it can be stored and used in peak hours of energy consumption. Furthermore, stored electrical energy can be used as back-up energy to provide the essential energy in critical situations with power cuts, for example to provide emergency lighting [10].

We should not forget to mention that the gains of an owner of a parking lot with solar canopies would be even greater. Parking lots are usually placed in open areas. For that reason, the electricity that those panels would produce would be greater than the electricity produced on the roofs of buildings because parking lots cover a wider surface. In addition, not all buildings are efficiently orientated.

The biggest disadvantage of solar power is that it is unreliable and variable. Therefore, charging stations which gain their electrical energy from solar power are also unreliable. To make this system reliable for the charging of electrical vehicles, some charging strategies would need to be implemented. There are two types of charging strategies: uncontrolled and controlled [7]. In case of the use of an uncontrolled strategy, the electric vehicle starts charging instantly when it connects to a charger. On the other hand, in a controlled charging strategy the time when the vehicle will be charged is planned in advance. A controlled charging strategy offers more efficient use of produced energy and can minimise the cost of the user with variable tariffs during the day. Moreover, it reduces the costs of the owner because less energy storage is needed if compared to the uncontrolled charging strategy [7]. Overall, these charging stations would support the use of electrical vehicles and make the replacement of internal combustion vehicles more reasonable and feasible.

3 SOLAR PARKING DESIGN

Solar parking requires four main components to work properly: frames, roofs, solar photovoltaic (PV) panels, and foundations [5]. In addition to these inverters, energy storage systems and electrical vehicle chargers are very important elements of solar parking. Without them, the gained energy cannot be put into use.

3.1 Frames and roof types

Canopies can be distinguished by the angle of the roof, the position of the columns, and the number of columns supporting the roof. The frames are divided into V-frames, T-frames and portal frames. V-frames and T-frames can have monopitch roofs or duopitch roofs while portal frames can have barrel-arch roofs and beam roofs [5].

Firstly, in T-frame structures the columns are situated at the centre of the structure. The roof is overhanging the columns. The advantage of T-frame structures is the freedom that they offer to a user while parking their vehicles because the structure itself does not inhibit this action. On the other hand, a disadvantage of this structure is the extra amount of steel which needs to be used to support the overhanging roof and ensure stability. This steel represents additional cost. In Figure 1 we can see a single T-frame form on the left and a double duopitch T-frame on the right [5].

Source: [5]

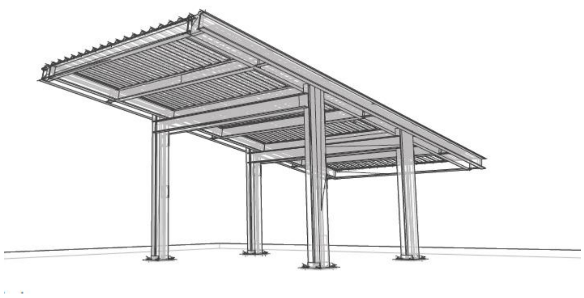
Figure 1: T-frame structures

A V-frame structure is constructed from vertical beams and diagonal struts. This structure provides enough space inside the V-frame for energy converters and other equipment required for charging stations. Furthermore, it ensures the highest business viability for larger parking lots. In Figure 2 we can see a single V-frame form on the left and a double duopitch V-frame form on the right [5].

Source: [5]

Figure 2: V-frame structure

Last but not least, a portal-frame structure has a non-cantilever roof and supporting pillars. It covers a larger surface than other types of frames. In addition to the parking bay it also covers the aisles in front. Consequently, it provides better protection from outside weather effects for the vehicles underneath. Furthermore, it also provides a larger surface for solar panels. However, because of the larger surface more material is required for its construction, which represents additionally costs. A portal-frame structure is shown in figure 3 [5].



Source: [5]

Figure 3: Portal-frame structure

As mentioned, we can divide roofs into monopitch roofs, duopitch roofs, barrel-arch roofs and beam roofs. In this paper only the first two will be discussed because they are the most common. Both monopitch and duopitch systems have roof inclination of 5-10% to ensure a pleasant user experience and self-cleaning [5].

If the monopitch system is orientated south, it operates with higher efficiency than a doupitch system, which will provide only 92.5% of the monopitch system energy. The monopitch system design is flat and can be used in single rows of a parking lot or in double rows of a parking lot. On the other hand, a duopitch roof, because of its distinctive construction in the shape of wings, can only be used in double rows of a parking lot. Choosing the location and right orientation for the duopitch roof is less demanding if compared to the other structures because its annual yield of energy is the same regardless of the orientation. Another benefit of duopitch roofs is that they generate electricity also during dusk and dawn, which is very convenient for supplying electricity to buildings [5].

3.2 Solar PV panel

Since by shape solar parking lots are more demanding than ground or roof solar installations, the industry has developed more flexible, frameless panels to satisfy those requirements. Photovoltaic modules (PV) for V-frame structures and T-frame structures can be mounted on the roof and can be framed or flexible. On the other hand, PV modules on portal frame structures are integrated and can be unframed or made from laminated glass [10]. Most commonly used PV panels are made from monocrystalline, polycrystalline and thin film. Each of these has its own characteristics.

When facing south, monocrystalline and polycrystalline tend to produce more energy per square meter than the thin film. On the other hand, thin film panels are cheaper than monocrystalline and polycrystalline panels. Thus, an owner should weigh what is more important. Panels can be fixed on different materials, which can be flexible and rigid, for example steel sheet, glass, polymer, etc. Solar panels on flexible materials produce less energy per square meter if compared to rigid materials. Because of that, flexible materials are commonly used for special architectural projects [5]. An average size of monocrystalline and polycrystalline module is 1.6 m^2 – 2 m^2. On the other hand, the size of modules of thin film varies between 1.1 m^2 – 2.2 m^2. Most commonly used are monocrystalline and polycrystalline modules framed with aluminium, mainly because of their availability [10].

3.3 Foundation

Foundations depend on the location of solar parking. It is important to differ between surface parking lots covered with solar canopies and solar parking lots on top of multi-floor buildings. While choosing the location for the parking lot covered with solar canopies, it is advisable to consider the advantages and disadvantages of a surface parking lot covered with solar canopies and a parking lot covered with solar canopies on top of a multi-floor building. The owners of a ground parking lot tend to have lower costs with the solar parking installation than the owners of a parking lot on top of a multi-floor building. Thus, ground solar parking installations are more common. A solar parking lot on top of a multi-floor building represents more engineering challenges, which include the determination of the reinforcement elements, which will ensure that the whole structure will be resistant to high forces of the wind, and extra structural components, which will ensure safety [5]. Depending on the type of roof we can determine the appropriate reinforced element. For monopitch roofs screw piles are often used. Screw piles are appropriate for certain types of terrain based on which the size and length of screw piles are determined. Screw piles are installed in the ground and after they reach their life expectancy they can be easily removed. Duopitch roofs need to be supported with concrete piles. Their installation process is similar to that of the screw piles. The only difference is the material of the pile. Furthermore, concrete pads are installed for barrel arch roofs. For this installation, pre-cast concrete or cast-in-place concrete can be used. Which one should be used is determined by the terrain. Last but not least, ballast is used for the reinforcement of beam roofs. Ballast is reinforcing the solar installation with its own weight. For that reason it is often used on rocky terrain where piles cannot be installed [10].

3.4 Inverters

PV modules generate direct current which needs to be converted into alternating current, for instance for the purpose of charging an electrical vehicle. For this reason, we use inverters, which can be divided by installation and connection to PV modules into three types: centralised, string and micro [10]. Centralised inverters are installed on the separate object and are connected to PV modules through PV combiner boxes and PV strings. Furthermore, string inverters are installed on the carport frame, thus directly to PV strings. On the other hand, micro inverters are already installed into PV modules and are connected directly to the PV module [10].

3.5 Energy storage systems

To satisfy the demanded amount of energy at peak hours the system needs to store electrical energy generated from previous hours. For this purpose, centralised batteries or distributed batteries can be used [10]. Distributed batteries need to be set on the solar parking lot infrastructure while centralised batteries can be located away from the solar installation. Storage for electrical energy needs to be adjusted to the service that this energy will provide, for example, providing electricity for a near-by building or direct charging for electrical vehicles. Based on the final point of distribution, the capacity of the energy storage system is determined [10]. Because energy storage systems make solar parking and vehicle charging reliable, governments should support more research and development in this field. Reliable energy systems will support the usage of electrical vehicles and consequently contribute to lower traffic emissions.

3.6 Electrical vehicle chargers

To support the usage of electrical vehicles it is important to provide infrastructure that will correspond to this action. For this purpose, charging stations need to be installed to accommodate our needs. Solar parking could provide some of those facilities. Charging from charging stations at solar parking installation can be slow, fast or rapid [10]. Slow charging provides power up to 7kW and lasts from six to twelve hours. Therefore, this type of charging is appropriate for parking lots close to the buildings in which people work. Fast charging with the power of 7kW to 22kW can take around three to four hours. This is appropriate for parking lots close to schools, universities, etc. Last but not least, rapid charging provides power up to 43kW and charges an electric vehicle in 30 minutes [10].

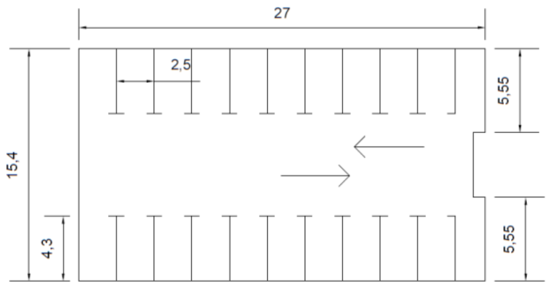
4 CASE STUDY

In the experimental part, calculations of installation costs for a parking lot located near the Faculty of Maritime Studies and Transport will be presented. The parking lot is used by faculty members; thus, it is used constantly during working days. Currently it does not have any extra equipment, which is evident from Figure 4.

Source: Author

Figure 4: Parking lot

The parking lot is 27 meters long and 15.4 meters wide. Considering that the minimal measurements of one parking space in Slovenia are 2.5m by 4.3m, 20 solar parking spaces could fit into this parking lot [6]. The layout of the parking lot is shown in Figure 5.



Source: Author

Figure 5: Layout of the parking lot

For further calculations, modules of the company "Schletter GmbH" under product number 1750000-005 were used. They are used for mono carports. The dimensions of one photovoltaic module are 1,318mm x 990mm. Multiple modules installed in 5 horizontal rows with 2 modules per row constitute the whole. Consequently, the surface of photovoltaic modules installed on one parking space is 13.05m^2, on the other hand the surface of the whole structure is 14.55m^2 [4]. By installing photovoltaic modules onto 20 solar parking spaces, the whole surface of PV modules would be 261m^2 and the surface of the whole structure 291m^2.

$$S_{20\ parking\ spaces} = 13{,}05 \cdot 20 = 261m^2 \tag{1}$$

For further calculations it is necessary to consider that in this case I presume that solar panels are facing 10° south and are aligned with line connecting North and South. After inserting the coordinates of our location and information about solar panels into MathWorks the program displays solar potential of our location which is 1707kWh/m^2 [2]. Solar panels yield varies between 15% an 20% [11]. Because I did not find any information about yield of solar panels used in our case, I decided to presume it is 20%. Consequently, the PV modules on our parking lot will annually produce 89105,4kWh of energy.

$$E_{produced} = 1707\frac{kWh}{m^2} \cdot 261m^2 \cdot 0.2 = 89105{,}4\frac{kWh}{year} \tag{2}$$

An owner of this parking lot could use this electricity to satisfy the demand at peak hours of electricity consumption in the facilities nearby. Another option is to sell the energy to an electricity supply provider or directly to the customer, for instance to enable customers to charge their own electrical vehicles. Selling electrical energy directly to the customer would create a greater income for the owner than selling it to an electricity supply provider.

The average daily driven distance in Slovenia is 13km, which is low compared to other European countries [3]. For example, in Portugal the average daily driven distance is 35km for which an electrical vehicle would require 6kWh of electrical energy per day assuming the consumption of the electrical vehicle is 0.171kWh/km [7]. This would mean that in Slovenia each electrical vehicle would need to charge for approximately 2.23kWh a day. This imaginary installation in Portorož could be complemented with charging stations. If all 20 parking spaces were complemented with electric vehicle charging stations and each day 20 electrical vehicles were charged here, 44.6kWh/day would be consumed.

$$E_{used;day} = 2.23 \cdot 20 = 44.6\frac{kWh}{day} \tag{3}$$

In 2020 there are 262 working days. If on each working day 20 electrical vehicles were charged, they would use 11685.2kWh/year which would leave a surplus of 77420.2 kWh/year.

$$E_{used;year} = 44.6 \cdot 262 = 11685.2\frac{kWh}{year} \tag{4}$$

$$E_{surplus} = 89105{,}4 - 11685.2 = 77420{,}2\frac{kWh}{year} \tag{5}$$

An owner could use this extra energy to provide electricity to a nearby building or sell it to an electricity supply provider, for example the company "Gen-I" who offers 0.05062€/kWh. Selling the surplus would create 3919€/year of profit.

$$\text{Profit} = 77420{,}2 \cdot 0{,}05062 = 3919\frac{€}{\text{year}} \tag{6}$$

Because the costs of implementing solar parking depend on the manufacturer and the price of installed elements, it is not possible to evaluate the exact total cost of infrastructure for this case. However, it is well known that solar parking lots are still not economically attractive. The following approximate calculations are based on data that state that the cost of frames, roofs, foundations and PV systems varies from 900£ to 1,400£ for a 12m^2 and 2kWp power system [5]. Transforming the currency into Euros based on the currency exchange rate of 27 February 2020 (1£ – 1.18€), the price varies from 1,062€ to 1,652€. The mean value of 1,357€ was used in the calculations:

$$Price_{m^2} = \frac{1357€}{12m^2} = 113\ \frac{€}{m^2} \tag{7}$$

$$Cost = 113\ \frac{€}{m^2} \times 291m^2 = 32883€ \tag{8}$$

The payback time of the investment in this case would be approximately 8 and a half years. However, these calculations are based on average values, ideal yield of solar panels and data gained from various resources.

$$Payback\ time = \frac{32991.77€}{3919€/year} = 8.4\ years \tag{9}$$

In addition to already mentioned investment costs, this parking lot would also require concrete foundations and additional equipment, such as charging stations for electric vehicles, energy storage equipment, etc. These costs would increase the payback time. In fact, usual payback time for solar parking is between 17 and 26.5 years [7]. If the presented calculations are accurate, the payback time for this solar parking lot in Portorož would come close to these values. However, in that timeframe most manufacturers provide warranties. Often, they will guarantee the owner that their solar panels will provide 90% power output over the first 10 years and 80% power output in the next 10 to 25 years [10].

4.1 Charging an electrical vehicle

Getting enough energy to fully charge an electrical vehicle may vary between seasons. For further calculations, about the time in which solar panels produce enough energy to fully charge an electrical vehicle, I used meteorological data from Portorož on 29.7.2020, which was a very hot and sunny day. On that day there was approximately 14 hours of sunlight during which the solar potential varied from 14W/m^2 to 869 W/m^2. Every 30 minutes new measurements were taken thus for further calculations I used the average solar potential from that day, which is 501W/m^2 [14]. Consequently, the solar potential on that day was 7.014kWh/m^2.

$$Solar\ potential = 501\frac{W}{m^2} \cdot 14h = 7014\frac{Wh}{m^2} = 7.014\frac{kWh}{m^2} \tag{10}$$

On such days this parking lot, assuming that the yield of the solar panels is 20%, could produce 366.13kWh of energy. This means solar panels from one parking space would produce 18.3kWh/day.

$$E_{produced\ (parking\ lot)} = 7.014\frac{kWh}{m^2} \cdot 261m^2 \cdot 0.2 = 366.13\frac{kWh}{day} \tag{11}$$

$$E_{produced\ (one\ parking\ space)} = \frac{336.13\frac{kWh}{day}}{20} = 18.3\frac{kWh}{day} \tag{12}$$

Reasonably priced electrical car like Opel Corsa-e has battery capacity 45kWh thus when charged fully the range of a car is 275 kilometers [15]. From calculations we can see that solar panels from the parking lot could fully charge 7 electrical cars like Opel Corsa-e with the energy they produce in one day. On the other hand, it would take two and a half days for one parking space covered with solar panels to produce enough energy to fully charge an electrical vehicle like Opel Corsa-e.

$$N_{el.cars} = \frac{336.13\frac{kWh}{day}}{45kWh} = 7.4695 = 7\ electrical\ cars \tag{13}$$

$$T = \frac{45kWh}{18.3kWh} = 2.459\ days \tag{14}$$

More luxurious and efficient electrical car like Tesla Model 3 has battery capacity 72.5kWh thus when charged fully the range of a car is 450 kilometers [16]. From calculations we can see that solar panels on the parking lot could fully charge 4 electrical cars like Tesla Model 3 with the energy they produce in one day. On the other hand, it would take 4 days for one parking space covered with solar panels to produce enough energy to fully charge an electrical vehicle like Tesla Model 3.

$$N_{el.cars} = \frac{336.13\frac{kWh}{day}}{72.5kWh} = 4.63 = 4\ electrical\ cars \tag{15}$$

$$T = \frac{72.5kWh}{18.3kWh} = 3.96\ days \tag{16}$$

Results show that parking lot does not provide enough energy to fully charge 20 vehicles. But we should not forget that currently we are in the transition phase, where electrical vehicles are on the market but the majority still uses vehicles with internal combustion, so probably most parking spaces would not require charging. And because this parking lot is used by faculty members it is full only from Monday to Friday, so the energy produced during Saturday and Sunday is a surplus which can be used in peak hours. Because of this gap during the week where surplus is created and the fact that during winter months these results would probably be lower, a high capacity battery should be installed to balance the energy production through the seasons and days.

5 HOW TO PRODUCE 25% SHARE OF GROSS FINAL ENERGY CONSUMPTION FROM RENEWABLE SOURCES

Like previously mentioned in introduction, Slovenia has a goal to produce a 25% share of gross final energy consumption from renewable sources. However, between 2015 and 2016 the average value reached 21.6%, which means that Slovenia still did not reach the pre-set goal [8]. The total consumption in the year 2016 was 13121GWh [17]. Therefore, Slovenia needs to produce 446.114GWh of energy from renewable sources to reach the pre-set goal.

$$E_{3.4\%} = \frac{13121GWh \cdot 3.4\%}{100\%} = 446.114GWh = 446114000kWh \quad (17)$$

To produce 446114000kWh from renewable sources, Slovenia could install more solar panels on different parking lots, buildings or objects like the one in Coimbatore's VOC park, where the government invested in a solar tree which not only offers shadow for its visitors but also multiple phone charging stations and free Wi-Fi in the range of 350m [13]. But installing only solar panels would not be enough, because to produce 446114000kWh, Slovenia would need to install solar panels on more than 130.67194 hectares because these calculations were made using the data of Portorož city, which has one of the highest solar potential in Slovenia. Therefore, it is important to acknowledge that the result of this calculations would be much higher if the calculations would base on data from any other non-coastline city in Slovenia, because of the fewer sunny days and more diverse relief.

$$E_{produced\ in\ Portorož} = \frac{89105.4kWh}{261m^2} = 341.4\frac{kWh}{m^2} \quad (18)$$

$$S = \frac{446114000kWh}{341.4\frac{kWh}{m^2}} = 1306719.4m^2 = 130.67194ha \quad (19)$$

$$N_{parking\ lots} = \frac{1306719.4m^2}{261m^2} = 5006.58 = 5007 parking\ lots \quad (20)$$

Even tough, it would be difficult to cover more than 5007 parking lots, like the one described in chapter four, with solar panels in Slovenia, I think covering 'park and ride' parking lots around cities like Ljubljana would be a 'step in the right direction'. Shaded parking lots could encourage people even more to leave their personal vehicle on the parking lot and use public transport to their final destination in the city. Furthermore, I believe that covering 650 000m^2 of open storage areas intended for vehicles in Luka Koper will put Slovenia closer to reaching its goal and allow Luka Koper, who has high needs for energy, to have a source of its own [18].

6 CONCLUSION

The aim of this paper was to present solar parking infrastructure, which is still not implemented in Slovenia, and to raise awareness of solar parking and the advantages it brings. While energy consumption increases, Slovenia is searching for solutions which would satisfy the growing demands and preserve the environment, in compliance with the requirements of the European Union. Covering wider surfaces with solar panels represents a partial solution for Slovenia who is trying to reach its goal to produce 25% share of gross final energy consumption from renewable sources. Furthermore, Slovenia is obligated to lower its traffic emissions, which points to the usage of electric vehicles as a substitute to internal combustion vehicles. The biggest problem with electric vehicles is charging. Firstly, they need to be charged almost daily. Because renewable sources of energy are still unreliable, they use the electricity gained from other sources of energy. Parking lots covered with solar panels could represent a partial solution to this problem but for that purpose higher capacity energy storage systems and solar panels with higher yield will need to be developed.

All elements of solar parking infrastructure should be well pre-planned before their installation to ensure the maximum cost efficiency. For that reason, companies often offer counselling on these decisions and provide calculations for various cases. Although in this paper the possibility of implementation was tested, the calculations are based on average values, ideal yield of solar panels and data gained from various resources. However, the results are encouraging so further research and analysis are necessary. Another aspect that needs to be researched before installing solar panels is the aesthetic of the whole. For a touristic city like Portorož it is important that the solar parking does not aesthetically deteriorate but highlight the surroundings. For this reason, a collaboration with landscape designers is recommended.

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COMPARISON OF THE CHARACTERISTICS RELATED TO TRAFFIC ACCIDENTS WITH AND WITHOUT DRIVERS UNDER INFLUENCE OF ALCOHOL IN REPUBLIC OF SERBIA

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ABSTRACT

Driving under the influence of alcohol (DUI) has an effect on the occurrence and severity of traffic accidents. Most researchers in this field linked some characteristics of the traffic accident i.e. type of accident, type of vehicle or time distribution and DUI. This paper presents a comparison of the characteristics related to traffic accidents with noticed DUI and traffic accidents with other drivers (not DUI), which occurred in the Republic of Serbia during 2016. The study dealt with the risk period to occur in traffic accidents related to DUI. The analysis was performed for type and time of traffic accident relation to DUI depend on accidents characteristics and share of total accident. Model of logistic regression was created for research on the prevalence drivers of passengers car of DUI in traffic accidents. The results of this study can be used for further development of the measures for the prevalence of DUI.

Keywords: driving under influence, legal limit, alcohol drinking, involvement in traffic accidents, logistic regression

1 INTRODUCTION

Numerous studies have shown that the presence of alcohol in blood exponentially increases the risk of collision (Asbridge et al., 2004; Borkenstein et al., 1964; Mann et al., 2001). The driver's performances under the influence of alcohol are lowered in comparison to the performances of sober drivers. In their research, Li et al. (2016) examined this by testing 52 Chinese drivers in a simulator, where it was conclude that drivers' performances were highly correlated with alcohol in terms of reaction time and lateral position on the track. With the increase of one unit of alcohol in a driver's breath, the time needed for a reaction becomes slower by 0.3%, i.e. by 0.2% when it comes to the deviation of the lateral position (Li et al., 2016). Smart (1969) noted that the increase of alcohol use and the participation in traffic accidents were related to the lowered driving abilities due to the higher alcohol presence. However, there was less knowledge about the correlation of the collision risk and other factors which accompany alcohol presence.

It is clear that driving under the influence of alcohol increases the risk of traffic accidents. However, the influence of other factors that can be connected with driving under the influence of alcohol is unclear. Various studies have registered a large number of risk factors that connect driving under the influence of alcohol and the involvement in an accident. However, the question is: what are the factors related to driving under the influence of alcohol and what is the factors related to others drivers.

Studies have shown that drivers of different vehicle categories have different sensitivity to alcohol effects (Lin and Kraus, 2009). This is the reason why the initial hypothesis of this research is that various risk factors are correlated to the drivers of different vehicle categories.

The list of the factors' contribution to driving under the influence of alcohol will represent very useful data in the future studies. It will also help to better understand driving under the influence of alcohol for drivers of different vehicle categories and will lead to the improvement of measures for detecting drivers under the influence of alcohol.

1.1 Potential Contributing Factors

In general, most research stated that drivers under the influence of alcohol often did not use seatbelts (Smailovic et al., 2019; NHTSA, 2009; Phillips and Brewer, 2011; Briggs et al., 2008; Sahai et al., 1998). In Norway (Bogstrand et al., 2015) 56.2% of the drivers under the influence of alcohol did not use a seatbelt, while 20.2% of the drivers who used a seatbelt were under the influence of alcohol.

Apart from the seatbelt, the experience of the driver is a very significant risk factor linking the drivers and participation in traffic accidents (Maycock et al., 1991; Copper et al., 1995; Maycock, 2001). Alcohol consumption and accident risk are more often related to young drivers (Christophersen and Gjerde, 2014; Peack et al., 2008) and male drivers (Mann et al., 2010; MacLeod et al., 2015).

Alcohol is related to traffic accidents with fatalities (Evans, 2004). About half of the drivers who were casualties of traffic accidents were under the influence of alcohol in single-vehicle traffic accidents (Christophersen and Gjerde, 2014; Gjerde et al., 2011), while there was a quarter of drivers under the influence of alcohol in multi-vehicle accidents (Gjerde et al., 2011).

Characteristics of the journey itself or the traffic conditions may, as well, be connected to the driver's behaviour. Burgess (2005) based his research on this fact, studying traffic accidents in the US from 1994 until 2003 and came to a conclusion that 42% more accidents occurred on urban than on rural roads. When it comes to fatality accidents, almost 49% more accidents occurred in the urban area (Burgess, 2005). Using the data of some of the biggest car insurance companies in Iran, Soltani et al. (2016) observed damages in traffic accidents, depending on the type of the journey and its characteristics (mandatory vs. non-mandatory journeys). The authors came to a conclusion that when the journey was mandatory (going to and from work), drivers were more often involved in an accident than when their driving was not mandatory (Soltani et al., 2016).

2 METHOD

This study is based on the factors associated with DUI among drivers involved in road traffic accidents in Serbia in 2016, collected from the official police investigation and reports.

The study is based on all drivers involved in traffic accidents in Serbia in 2016. Drivers with fatalities, injured or without injuries were the subject of this study. There were a number of drivers without injuries included in this study, and this is because there were a large number of drivers under the influence of alcohol involved in accidents. Namely, out of 60.666 drivers involved in accidents, about 10% were DUI, while about 8% of DUI were without injuries. In other words 4/5 of DUI survived an accident without injuries.

The variables which were research in this study are:

- Age (number of years);
- Gender (male or female);
- Use of restraint systems (seatbelt or helmet);
- Driver experience (the number of years between obtaining the driver's license until the involvement in a traffic accident);
- Trip/journey purpose (mandatory or non-mandatory);
- Category of the vehicle;
- Area of the accident (urban or rural);
- Type of collision: single-vehicle accident (i.e. involving only one car; commercial motor vehicle; motorcycle; bicycle) or multi-vehicle accident;
- Severity of the injury (fatal, injury or no injury).

Logistic regression was applied for analyzing the association of DUI and risk factors. The logistic regression analysis was carried out to evaluate the correlation between the drivers under the influence of alcohol (dependent variable) and the following variables: gender; age; injury; use of restraint systems; the driver's experience; area; type of accident; journey purpose; and responsibility for the accident. All analyzed drivers were involved in road traffic accidents.

The adjusted odds ratio (OR) and 95% confidence intervals were calculated for all logistic regression models. OR is a statistical measure of the association between an exposure and an outcome. OR represents the odds for a result with certain exposure compared to the odds for the result which occurs with the absence of the exposure (Hosmer and Lemeshow, 2004). The analysis was completed using SPSS Statistics version 20 (Landau and Everitt, 2004).

3 RESULTS

In all groups, motorcyclists were the youngest, 35.7 (SD 12.3), with the shortest driver's experience 9.6 (10.5). Bicyclists were the oldest group of drivers 45.6 (SD 19.2), and car drivers had the longest driver's experience 18.9 (SD 12.4). Bicyclists were the most often involved in accidents under the influence of alcohol 14.8%, followed by motorcyclists (13.6%), car drivers (10.5%), truck drivers (4.7%), and bus drivers (1.5%). The distribution of drivers under the influence of alcohol, in terms of the highest prevalence of bicycle drivers under the influence, is the consequence of alcohol testing of each bicycle driver. Namely, bicycle drivers are rarely alcohol tested and it is even less common to test all bicycle drivers.

About a quarter of the bicyclists were females, as well as 17.4% of car drivers. Women were found in the smallest number among bus drivers 0.4%. In this sample, there were no fatalities among bus drivers, while the biggest ratio of drivers with fatality outcome was noticed among motorcyclists 2.9%. The biggest number of fatality drivers was found among car drivers (51), as seen in Table 1.

Truck drivers used seatbelts in the greatest percent (98.4%); followed by car drivers (98%) and bus drivers (94.8%). 90.1% of motorcyclists and 15.9% of bicyclists used a helmet at the time of an accident.

For all the groups of the driver categories, the greatest number of accidents occurred in urban areas. Truck and motorcycle drivers were most commonly involved in single-vehicle accidents.

Table 1: Analyses of Logistic regression for car drivers

	Car drivers		
	OR	95% CI	
Age	1,003	,996	1,010
Driver experience	0,988**	,980	,997
Gender (ref. = female)	3,702***	3,085	4,441
Injury			
No injury vs. Fatal	7,452***	3,911	14,200
No injury vs. Injury	2,007***	1,788	2,253
Use of restraint systems (ref. = no use)			
Use	0,521***	,406	,669
Area (ref. = rural)			
Urban	1,342***	1,181	1,525
Type of collision (ref. = single vehicle)			
With other vehicles	0,483***	,437	,535
Journey purpose (ref. = mandatory)	***		
Non- mandatory	1,754***	1,592	1,932
Responsibility (mistake) (ref. = others)			
Driver	5,935***	5,200	6,774
Hosmer and Lemeshow test	24.930 (df=8)	p=.002	
Constant	0,018***		

The Logistic regression shows that, where all variables, apart from age, are of wald statistical significance ($p<.05$; or $p<.01$; or $p<.001$). Male drivers are more likely to be under the influence of alcohol (OR=3.702); seven times more likely to be involved in an accident with fatalities and DUI (OR= 7.452), and odds for them to be injured are twice as more likely (OR=2.007).

DUI is more often found in urban areas (OR=1.342). With the increase of a driver's experience, the odds for DUI are insignificantly smaller (OR=0.988). The odds are almost doubled for a DUI without using a seatbelt (OR=0.521, ref. – no use). Also, the odds are almost doubled more for a DUI to be involved in single-vehicle accidents (OR=0.483, ref. single vehicle). DUI is 1.7 times more likely to be recorded on non-mandatory journeys. The driver has around six times higher odds to make a mistake which leads to an accident if he/she is DUI (OR=5.935).

4 DISCUSSION

The results are intuitively clear and confirm that severities of traffic accidents are more serious when involving the drivers under the influence of alcohol. Also severities are correlated with the driver's responsibility. The results of this study show that the two most significant DUI risk factors related to accidents are severity and the driver's mistake.

Most studies which consider the connection between DUI and accidents deal with car drivers mostly and suggest the connection between severity and driving under the influence of alcohol (Smailovic et al., 2019; Pešić et al., 2019; Christophersen and Gjerde, 2014; Gjerde et al., 2011). The results also accentuate that DUI drivers of cars, bicycles and trucks have 90% more likelihood to die in an accident than sober drivers. DUI motorcyclists have a 75% likelihood to die, whereas for bus drivers the likelihood is around 20%. This can be explained by the fact that bus drivers are rarely DUI, which is in accordance with their tasks and job they do – transport of passengers.

5 CONCLUSION

The study is based on the data of real traffic accidents and the official data collected during the accident investigations. Thus, they represent the current risk situation regarding DUI.

The results of this study represent the two most important facts for road traffic safety. The risk factors associated with the driver can be used for creating traffic safety policy and help to detect DUI. The order by importance of risk factors related to DUI and drivers is: drivers' mistakes; non-use of the restraint systems; male drivers; journey purpose; and drivers with short experience. While 70% of the drivers in Serbia use the seatbelt (RTSA, 2015), the likelihood for the drivers under the influence of alcohol to use the seatbelt is 30%. The non-use of seatbelt of drivers represents an important variable for police officers and it suggests that the driver should be alcohol tested. About 80% of motorcycle drivers in Serbia use the helmet, but it is not the case for drivers under the influence of alcohol. About 30% of them use the helmet. This variable helps to detect the driver in the traffic flow who is under the influence of alcohol. If all factors or a majority of those significant factors are present in the driver, such a driver should be alcohol tested.

The results of this study have shown that the driver's mistakes such as: driving without the right of way; overtaking; speeding; misjudgement of the situation; and the use of a cell phone are the most important factors correlated with driving under the influence of alcohol. The available data could not define the effect of each stated driver's mistake, so this can be the subject of future research.

The results of this study will help to better understand the problem of driving under the influence of alcohol among different categories of drivers. DUI is correlated with different risk factors for drivers of specify of vehicle category. The study has shown that for car drivers, all risk factors apart from age are statistically significant.

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UNCERTAINTY AFFECTING SEAPORT-HINTERLAND COORDINATION: THE CASE OF INFORMATION ON CARGO AVAILABILITY

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ABSTRACT

The results of this research enlighten the aspect of uncertainty in seaport-hinterland coordination, especially for the case of containerized import transportation operations. In this domain, hinterland transportation operators need to take decisions on when to pick up specific containers at the seaport terminal while considering customer expectations, costs and operational constraints. An obvious but crucial prerequisite of the latter is cargo availability for onward transportation. Even if a vessel reaches the seaport on time, a number of factors influence the expected cargo availability, such as the unloading sequence or customs activities. For this reason, transportation planning at the seaport-hinterland interface is characterized by great temporal uncertainty. Research indicates that supply chain uncertainty is expected to lead to increasing total costs and thus to lower a systems performance.

The paper discusses the concept of cargo availability predictions as a novel parameter for hinterland transportation planning and examines the question whether it is a suitable instrument to reduce uncertainty for transport operators. The papers' empirical results are based on a qualitative survey with port community actors that has been conducted to identify the reason for uncertainty caused by lacking information on future cargo availability. Furthermore, preliminary results from a quantitative survey are used to identify the need for reduced temporal uncertainty from the perspective of German hinterland transportation providers. Upon these results, the concept of cargo availability predictions is evaluated.

Keywords: Supply Chain Coordination, Supply Chain Uncertainty, Maritime Transport Chains, Port Operations, Hinterland Transportation Planning

1 INTRODUCTION

Business trends and managerial strategies such as the creation of globally dispersed manufacturing networks (Stock, Greis, & Kasarda, 2000), an increasing diversity of products and services as well as outsourcing of non-core activities (Harland, Brenchley, & Walker, 2003) turn modern supply chains into highly complex systems (Arshinder, Kanda, & Deshmukh, 2011; Datta & Christopher, 2011; Raaidi, Bouhaddou, & Benghabrit, 2018). This not only affects the complexity dimensions of multiplicity, variability, speed, size or diversity (Raaidi et al., 2018), but makes uncertainty an inherited and ubiquitous characteristic of logistics and transportation (Flynn, Koufteros, & Lu, 2016; Raaidi et al., 2018). This also holds true for maritime transportation which is a vital part of today's distribution networks with around 80 percent of international trade shipped by sea (UNCTAD, 2020). For this reason, the reduction of uncertainty is an important task of maritime supply chain management (Sys & Vanelslander, 2020). In this paper we will analyze the aspect of uncertainty with regard to the relationship between seaports and hinterland transportation, which we refer to as the seaport-hinterland interface.

The scenario which will be covered relates to the transport planning process for containerized import cargo. In this process, transport companies need to take decisions on when to pick up specific containers at the seaport terminal while considering customer expectations, costs and operational constraints. An obvious but crucial prerequisite of the latter is the physical and administrative availability of the cargo for onward transportation. Uncertainty is expected to arise due to the fact that transport operators do not have any advance information on when specific containers will become available (Elbert & Walter, 2014). For the sake of this uncertainty, planning decisions are expected to be carried out in a reactive manner and thus cause suboptimal capacity utilization and increased cargo dwell times within the terminal. A conceptual approach to reduce this uncertainty was introduced by (Elbert, Oezgen, & Walter, 2010). They argued that providing better predictability by sharing information on when containers are planned to become available could improve coordination between terminals and hinterland transportation. However, the literature lacks in-depth knowledge of how transport operators in fact perceive this scenario (esp. uncertainty related to cargo availability) and whether there actually exists a demand for advance availability information. This paper is supposed to close this gap by presenting insights from the German transport sector.

The remainder of this article is as follows: First, we will outline the current state of supply chain uncertainty research. Next, we will introduce the seaport-hinterland interface as a domain that is highly characterized by uncertainty. In this regard, special emphasis will be given to coordination issues related to containerized import transportation operations. The concept of cargo availability predictions that is expected to reduce uncertainty will be presented as a novel approach for hinterland transportation planning. By evaluating the preliminary results from a qualitative and quantitative survey, we will characterize the need for reduced uncertainty from the perspective of German hinterland transportation providers and will follow the question whether cargo availability predictions could serve as a suitable coordination instrument. After summarizing the results, the paper concludes by outlining avenues for future research.

2 UNCERTAINTY IN SC RESEARCH

The challenges and threats that uncertainty poses to logistics and supply chains have been in the interest of researchers for several decades (Davis, 1993; Mason-Joney & Towill, 1998). Davis for example directly relates uncertainty to variability in a supply system that can be assessed by statistical techniques (Davis, 1993). In contrast, van der Vorst and Beulens provide a managerial view and link uncertainty in the context of SCM "to decision making situations in the supply chain in which the decision maker does not know definitely what to decide as he is indistinct about the objectives; lacks information about (or understanding of) the supply chain or its environment; lacks information processing capacities; is unable to accurately predict the impact of possible control actions on supply chain behavior; or, lacks effective control actions" (van der Vorst & Beulens, 2002, p. 413). This view accounts for the fact, that uncertainty "can arise from either internal or external sources to the supply chain" (Datta & Christopher, 2011).

In the course of our study, we will adapt a differentiating approach introduced by Flynn et al. who describe supply chain uncertainty as a phenomenon that can be mapped on three hierarchical and co-existing levels of a supply chain (Flynn et al., 2016). According to this view, micro-level uncertainty refers to situations in rather repetitive and less complex environments where uncertainty manifests as deviations from previously defined plans. Therefore, micro-level uncertainty corresponds with the concept of uncertainty as "variability" and thus can be considered as statistically measurable. Meso-level uncertainty arises from incomplete information perceived by individual supply chain members. This comes with the assumption that single actors try to manage the information flow in a way that protects their own interest. Therefore, Flynn et al. define it "as the difference between the amount of information needed by a supply chain member and the amount already possessed" (Flynn et al., 2016). On the macro-level, uncertainty originates from far-reaching and suddenly occurring events such as changes in the economic and market conditions that are difficult to anticipate and cause ambiguity (Flynn et al., 2016).

A key motivation to analyze uncertainty in practice as well as in research is its impact on supply chain performance. If not managed adequately, supply chain uncertainty is expected to lead to increasing total costs and to lower the systems performance (Sanchez-Rodrigues, Potter, & Naim, 2010). Inspired by the lean management model, Persson, 1995 denotes that uncertainty fosters decisions that create waste in a logistics system. In practice, such "waste" becomes apparent for example as the creation of excess inventory and safety stocks (Davis, 1993, p. 36), maintaining of overcapacity or planning of buffer times (Persson, 1995, p. 18; van der Vorst & Beulens, 2002, pp. 412–413). For this reason, the reduction or mitigation of uncertainty by means of supply chain coordination and integration represents an important theme in practice and research (Arshinder et al., 2011).

While uncertainty can generally affect all parts of the supply chain, previous works have put an emphasis on manufacturing while considering transport operations rather marginally (Sanchez Rodrigues, Stantchev, Potter, Naim, & Whiteing, 2008). However, as the movement and distribution of goods significantly impacts a supply chains' costs and is vital for flexible responses towards varying customer demands (Sanchez Rodrigues et al., 2008), effective transport operations represent a critical factor for the performance of supply chains (Stank & Goldsby, 2000) and thus an important field to be studied with regards to uncertainty.

3 SEAPORT-HINTERLAND INTERFACE

From a supply chain perspective, efficient interaction between seaports and their hinterland links in terms of reliability, speed as well as flexibility of transshipment and transport activities is crucial for the competitiveness of the superordinated chain (Ducruet, Itoh, & Merk, 2014; Notteboom, 2008). In the course of this work, we will refer to the relationship between seaports and their hinterlands as the seaport-hinterland-interface (Specht & Kotzab, 2020). It represents a segment of a maritime transport chain (Talley, 2014) which covers a main-carriage by ocean transport as well as pre- and on-carriage in the hinterland of the respective port of departure and port of arrival (Schönknecht, 2009).

While the organizational structure within this domain is differentiated and homogeneous (Herz & Flämig, 2014), the subset of actors that are of interest for our study are container terminals and hinterland transport operators. While container terminal are engaged in providing transshipment and storage services for containerized cargo (Talley, 2009), hinterland transport operators carry out transportation services by truck, rail or barge (Schönknecht, 2009). By referencing to the three-level uncertainty framework, uncertainty to the seaport-hinterland nexus can be illustrated as follows:

On the micro-level, operational uncertainty is for example closely linked to the arrivals of transports. Scheduled transport means are often observed to be unpunctual. This not only applies to waterborne transports of ocean vessels and barges but also to trains on the landside. In the case of unscheduled transport means, uncertainty is caused by the fact that arrivals happen without prior notice to the terminal and thus are rather stochastic in nature (Olesen, Dukovska-Popovska, & Hvolby, 2013; van der Horst & de Langen, 2008).

Meso-level uncertainty is likely to appear due to weak integration (Jaffee, 2016) and lack of available process information (Ascencio, González-Ramírez, Bearzotti, Smith, & Camacho-Vallejo, 2014) between seaport terminals and hinterland operators. According to Jaffee, this situation is caused by the operational terminal-hinterland relationship that is often non-contractual (Jaffee, 2016). In fact, the terminals' contractual counterpart are shipping lines, whereas transport operators are usually hired either by freight forwarders and shippers in merchant's haulage or by shipping lines in carrier's haulage mode[1] (European Commission, 1994). For this reason, a "terminal is primarily concerned with meeting the needs of the backward linkage (on the import side) to the shipping lines" (Jaffee, 2016).

As maritime transport chains are part of todays' globally dispersed and complex distribution networks, macro-level uncertainty has a significant effect on operations at the seaport-hinterland interface. This has become especially evident in the events of the COVID-19 pandemic in the year 2020, with drastically decreased vessel calls and operational restrictions that have cause delays in port procedures and disruptions in hinterland transportation (Notteboom & Pallis, 2020).

3.1 The role of cargo availability

In our analysis, we consider the perspective of hinterland transport operators in the import scenario. A problem observed in this context is linked to scheduling/planning decisions that concern the pick-up of one or several containers at the terminal. The procedures differ depending on the respective transport mode: As trucks can usually be served at any time during terminal gate opening hours[2], planning of pickups is carried out rather spontaneously. On the opposite, planning for barges and trains that usually pick up several cargo units at once, follows previously defined schedules. In this case, the transport operator needs to decide which container to pick up with a specific service. Two basic requirements need to be fulfilled in order to release cargo at the terminal:

The first and rather obvious requirement is concerned with the physical availability of the cargo. As servicing container vessels at seaports is a complex and sometimes long-lasting processes, the arrival of the ocean vessel does not represent a suitable indicator for the physical availability of cargo. After the vessel arrives at the berth, containers need to be discharged by a ship-to-shore (STS) crane and stored on the terminal yard (Brinkmann, 2011). Due to the large number of containers that need to be unloaded during one vessel call, variance in physical availability comes in the form of unloading windows that amount to several days. From outside the terminal, a single cargo unit can be expected for unloading at any time within this timespan. An analysis of calls in Hamburg has shown unloading windows lasting up to 90 hours.[3]

Table 1: Analysis of unloading windows at container terminals in Hamburg (in minutes)

				quantile (p=)		
Terminal	avg	std	max	25	50	75
A	643	619	5220	200	390	915
B	812	816	5465	316	525	925
C	470	638	3755	140	255	460
All	689	719	5465	225	425	870

Source: The authors

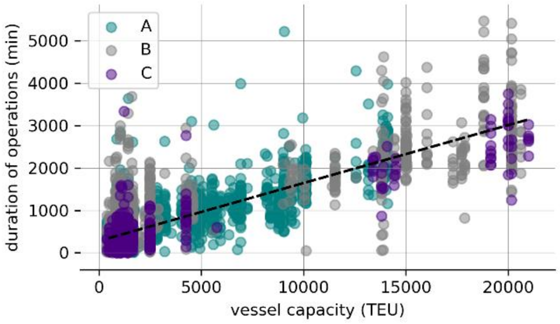
Our observations indicate a positive relationship between the size of the vessel and the duration of unloading operations. While the observed mean unloading window for a small feeder vessel (capacity up to 5000 TEU) amounts to 411 minutes, ultra large container vessels (capacity of >18.000) are observed to stay under

[1]While in carrier's haulage, the shipping line is responsible for organizing the pre- and on-carriage, the shipper or a contracted freight forwarder is responsible in merchant's haulage mode.

[2] Some container terminals have adopted truck appointment systems that can be used to schedule truck arrivals and thereby spread landside workload throughout the day. However, these systems are not adopted as a standard so far (Huynh, Smith, & Harder, 2016).

[3] The analysis has been carried out in the course of this research. An unloading window is defined as the time between the arrival of the vessel at the berth and the end of unloading operations.

unloading service for 2974 minutes on average. Hence, we expect this micro-level uncertainty in regards to the physical availability to intensify in light of increasing vessel sizes (UNCTAD, 2020).



Source: The authors

Figure 1: Relationship between duration of unloading windows in minutes and vessel capacity in TEU

Secondly, the cargo needs to be released on the administrative level. One part of this requirement is fulfilled with the commercial release that is issued by the ocean carrier if all transportation fees are paid (Hofman & Brewster, 2019). Furthermore, cargo needs to be released by customs authorities. In case of doubt, the customs office blocks certain containers for inspections. Uncertainty can arise due to the fact that the occurrence as well as the duration of a container block is not known beforehand (van der Horst & de Langen, 2008).

In modern seaport terminals, external stakeholders are able to trace cargo states via terminal information or port community systems (Heilig, Schwarze, & Voss, 2017). However, these states only refer to the current situation and do not represent future-oriented information, e.g. plans of the unloading process. Thus, the information provided by the terminal has limited value for proactive planning approaches (Olesen et al., 2013).

A concept to reduce uncertainty in the context outlined above is to provide hinterland transport operators with future-oriented information on cargo availability (Elbert et al., 2010). This follows the assumption that it is possible to make adequate predictions, e.g. based on planning information possessed by the actors involved. In the example of the unloading process, this relates to crane planning data such as estimated move times for single containers calculated within the terminal operating system (Navis, 2020).

By means of a simulation analysis, Elbert and Walter have analyzed the effects of such information in the case study of rail on-carriage. Their results show a positive effect of a “container-related ETA” on train capacity utilization (Elbert & Walter, 2014). To the knowledge of the authors, the only practical evaluation of the conceptual approach was conducted at the ITS terminal in Long Beach, USA (Johnson, 2017). However, as this has been a commercial study, no information about technical aspects or results are publicly available.

4 METHODOLOGY

Our research uses data that was collected in the course of a feasibility study for cargo availability predictions at German seaport terminals, with a special focus on the seaports of Bremerhaven and Hamburg. In order to answer our research questions, a two-step approach has been applied:

First, we conducted five semi-structured interviews with experts from a terminal operator (1 expert), a barge operator (3 experts), a trucking company (2 experts), a rail service provider (1 expert) as well as with the German customs authority (1 expert) to get a first overview about the relevant issues and processes. Based on the qualitative results, an online survey was developed and spread by three German transport associations to members that are engaged in hinterland container transport to and from the German seaport container terminals. In total, a sum of 20 surveys has been fully completed and therefore accepted for further analysis. Except of three participants, all respondents hold a managing position within their companies. Half of the respondents have responsibility for a single transport mode (7 for trucking, 2 for barge transport and 1 for rail transport) whereas the other half is responsible for either two or all hinterland modes. In general, it can be stated that all modes were represented in the panel with an emphasis to road transport.

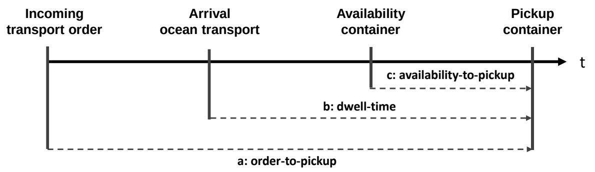
4.1 Results

4.1.1 Customer Expectations

As hinterland transport operators move cargo on behalf of other parties, such as shippers or freight forwarders, it can be assumed that planning procedures need to follow certain customer expectations. In general, the participants within our study reported that transport orders are usually provided without sufficient lead time. At the same time, customers demand a quick pick-up at the terminal. In the case of rail transportation, a dispatcher claimed that this situation leads to a situation where containers are often booked on slots that do not offer sufficient buffer times for process delays. As a consequence, tight tracking of terminal operations becomes necessary for the transport operator in order to avoid empty slots in case that a container will not be available in time. We conclude that transport planning in the import case generally follows demanding customer expectations in terms of the time dimension. This is in line with the observation of the experts that customers react sensibly to delays in the transportation process.

4.1.2 Planning horizon

Given the information about customer expectations, further knowledge about the time dimension is essential in order to investigate the potential benefits of advanced availability information. Therefore, the experts were asked to deliver an estimate based on their practices and perceptions. The most important dates within the planning horizon are the receipt of a transport order coming from the customer, the arrival of the ocean transport which marks the start of terminal operations, the moment when a container reaches the status of "available for transport" as well as the final pick up. Based on the descriptions made by the experts, these dates usually appear in the order visualized in figure 2.



Source: The authors

Figure 2: Generic planning horizon for the import container pickup

Based on our findings, we suspect that the average timespan of the planning process (a) lasts up to a week, in some cases even longer. Surprisingly, 9 respondents reported a fairly short span of 1-2 days. Also, the passage between arrival of the ocean vessel and the final pickup of the container (b) which describes the dwell time of cargo within the terminal does not differ significantly. This observation could be related with the observation that transport orders are issued rather late within the process, hence shortly before the container arrives at the seaport.

Table 2: How would you define the average duration between the following events? (n=19)

	no. of responses		
	a	b	c
Up to 6 hours	0	0	0
7 to 24 hours	0	1	5
1-2 days	8	8	10
3-7 days	9	10	4
> 1 week	2	0	0

Source: The authors

When a container becomes available for onward transportation, it is usually not picked up before at least 7-24 hours. In most cases, containers on average will still stay within the terminal for 1-2 days, according to some respondents between 3-7 days.

4.1.3 Importance of information

As outlined in the previous section, interorganizational information exchange can be considered as a promising way to reduce meso-level uncertainty. Assuming that a decision maker's information demand indicates its perception of different aspects of (meso-level) uncertainty, we have analyzed the importance of various information types that were mentioned within the expert interviews. In accordance with Wiegmans et al. we distinguish between information types in chronological order that are either related to different subjects: the ocean transport, the cargo unit or the terminal (Wiegmans et al., 2018). The importance of the information times was measured based on a 5-point Likert scale within our survey questionnaire.

Table 3: How important do you consider the following information to be for the planning of import container pick-ups? (not important (1) – important (5)) (n=20)

Ref	Historical and static information	avg
vessel	Completed and planned calls at previous ports	2,4
vessel	Size and capacity	2,7
container	Position of container onboard the vessel	3,1
	Current status information	
vessel	Progress of unloading at port of destination	3,9
vessel	Actual time of arrival at port of destination	4,9
vessel	Actual time of departure at port of destination	3,3
container	Status of customs processes	4,6
container	Document status of container	4,4
container	Confirmation about unloading of the container	4,8
container	Information about other blocks (e.g. by carrier)	4,2
container	Transport availability status of container at the terminal	4,9
terminal	Current outages at the terminal	4,8
	Predictions/future-oriented information	
vessel	Estimated time of arrival at port of destination	4,6
vessel	Estimated duration of unloading at port of destination	4,3
container	Estimated time of unloading of the container	4,6
container	Estimated duration of customs inspections	4,3
terminal	Expected outage	4,6

Source: The authors

Except for information on completed and planned calls at previous ports as well as the size and capacity of the ocean vessel, all information types are considered to be at least "rather important" (avg >3). This confirms the relevance of the uncertainty factors mentioned in the expert interviews.

In regard to the chronological classification, information with historical and static context are considered less important than current and future-oriented information types. This observation is consistent for all information subjects. A possible explanation could be the dynamic nature and inherited micro-level uncertainty of operations at the seaport-hinterland interface. Therefore, historic patterns as well as static plans have limited value for transport planning.

The comparison shows that the most important information types relate to current (process) states. Especially the actual time of arrival at port of destination (ATA) and transport availability status of a container at the terminal is considered to be most significant.

What concerns future-oriented information the the estimated time of arrival (ETA) of the ocean vessel is perceived to be as important as the estimated time of unloading. This is surprising given the fact that previous research has put a strong focus on better ETA predictions.

5 SUMMARY AND OUTLOOK

Our research emphasizes the substantial degree of uncertainty that is inherited in the interorganizational and operational environment at the seaport-hinterland interface. The exemplary scenario of import transport planning shows that some of this uncertainty is fostered by weak interorganizational integration between the terminal and hinterland transport operators. As we have illustrated, unloading operations alone account for significant micro-level uncertainty as the time variance in physical availability is dependent on the duration of the unloading window. As a conceptual solution, we have discussed the approach to provide hinterland transport operators with future-oriented information on cargo availability for decision support in transportation planning.

The results of our study highlight that transport operators need to cope with demanding customer expectations in regard to the time factor. At the same time, the comparison of historical/static, current status and future-oriented information types reflects the operational dynamics and the reactive nature of transport planning in the domain. Based on our data we suspect that historic and static data provide less decision support than current information. It becomes obvious that cargo availability is key for planning as information on its status is considered to be most important. We therefore draw the conclusion that there exists a demand for information on future availability of import containers. Therefore, the provision of such information can be considered as a means for terminal operators to make the move from “being gateways, to becoming active players in the supply chain” (Olesen et al., 2013).

However, the preliminary results of our study are not without flaws and should be interpreted with caution: First, the small sample size limits the explanatory power of our data. This is especially true as the number of respondents from each transport mode are fairly low. In addition, some respondents reported that they are engaged in planning for more than one transport mode. Therefore, we were not able to quantify the differences between the transport modes. Moreover, the selection of experts and companies within the study and thus the geographical scope to Germany does not guarantee the applicability of our results to other market environments. As illustrated by Notteboom, the ratio of merchant’s and carrier’s haulage as well as the modal split in hinterland transportation differs on the port and country level (Notteboom, 2008). Therefore, the information flows highlighted in our research might deviate to those in other geographical areas. Further research could therefore be dedicated to other countries and use our results as a means to comparative analyses.

As our study did not specifically assess how future-oriented availability information can be generated, future research should adress the technical aspects that are necessary for predictions that take the physical as well as the administrative factors into account.

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ANALISYS OF INSPECTIONS IN LNG SHIPPING COMPANY

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ABSTRACT

LNG (Liquid Natural Gas) ships, due to their cargo, represent potential source of danger to environment, personnel and property. To avoid potential disaster, high safety standards are introduced to that part of the shipping industry, and all LNG ships are subject to frequent inspections and vettings. Ship inspection control should not be a purpose in itself, but the aim is to eliminate any deficiencies in a quality and timely manner. Frequency of ship inspections should be strictly monitored, too many inspections will have inverse effect on the ship's safety record, i.e. too many inspections will decrease overall safety. This paper analyses the inspection and vetting data of a particular LNG shipping company which is a member of INTERTANKO (the International Association of Independent Tanker Owners), showing that non mandatory inspections promote company overall quality records. The research concludes that the SIRE (Ship Inspection Report Program) is a unique tool for risk evaluation and for conducting inspections by the CDI (Chemical Distribution Institute) which helps LNG shipping companies to reach the set standards and legal frameworks.. The satisfactory results of the inspections also stimulate progress in a safety system and environmental protection without neglecting the need to achieve the company's goals.

Keywords: LNG ship, inspection, statistics, risk evaluation, INTERTANKO.

1 INTRODUCTION

The characteristic of the world maritime market is constant growth and frequent changes in business. Technological advances have a significant impact on the maritime shipping market, introducing modern forms of sea freight transport such as containerization, barge transport, transport of liquid gas by tankers and other directly affect supply structure and the whole market [1]. After oil and product tankers, liquefied gas tankers have the highest tonnage growth in the overall tanker fleet, indicating their significant presence in the maritime market [2]. Liquefied natural gas (LNG) ships are twin-bottom ships classified according to the type of tanks specially designed to store natural gas cooled below -160° C, i.e. below methane boiling point [3]. Natural liquefied gas (LNG) is mix of methane (CH_4) with smaller part of the ethane (C_2H_6) and other gases (propane C_3H_8 and butane C_4H_{10}) [3] in very low quantities or in traces. The main characteristic of the liquefied gas is high flammability, which must be taken into account when designing and operating these types of ships, especially from a safety point of view. Numerous laws, rules, standards and guidelines seek to minimize the potential damage that can be caused by LNG vessels. These regulations apply to the creation, construction, operation and maintenance of LNG facilities and LNG vessels [4].

Every maritime accident results in some consequence, which can be loss of life, endangering the environment or causing the pollution, damaging or losing the ship, cargo or the infrastructure. These accidents create great material damage, huge costs and a bad reputation for the company. Negative reputation is bad for business and LNG shipping companies tend to implement firm in-house standards of inspections on their vessels. This, additional standards usually will satisfy more than the legal framework and eventually will achieve a more secure system.

With the signing of the Paris Memorandum of Understanding (MOU) in 1982 The European Community has made strides in controlling the safety of ships and maintaining the cleanliness of the sea. Since then, the MOU has undergone a number of changes with intention to increase responsibilities of State Port Control (PSC) together with the increase of the number of States signatories to the Memorandum [5]. The Paris Memorandum (MOU) is an official document in which 27 maritime authorities confirm that they will implement a harmonized national port control system [6]. The confirmation represents significant progress on shipping safety and surveillance. The progress made has not bypassed the LNG shipping companies either.

This paper presents the result of a survey of inspections and vettings performed during 2017 in one LNG company. The company supplied the data under NO

DISCLOSURE condition, therefore, in this paper there will be no names and data leading to recognize the company.

2 ROLE OF INSPECTION IN LNG SHIPPING COMPANIES

Transport of liquid cargo, such as oil, petroleum products or liquefied natural gas is a high-risk activity on board ships which can cause a maritime accident with catastrophic consequences. Therefore, it is important that all stakeholders have a high level of awareness of this problem and that all of them treat these problems appropriately. In recent decades a significant increase in public awareness have been seen which has also created some positive pressure. Ships are subjected to numerous controls and inspections with the intention that the results of all controls and inspections should be more visible and harmonized. That can be achieved only through stronger international and institutional co-operation [7].

Inspection of the ship should not be a purpose in itself, but the tool to eliminate any deficiencies in a propper and timely manner. Frequency of ship inspections should be strictly monitored, too many inspections will have inverse effect on the ship's safety record, too many inspections will decrease overall safety (Fig 1).

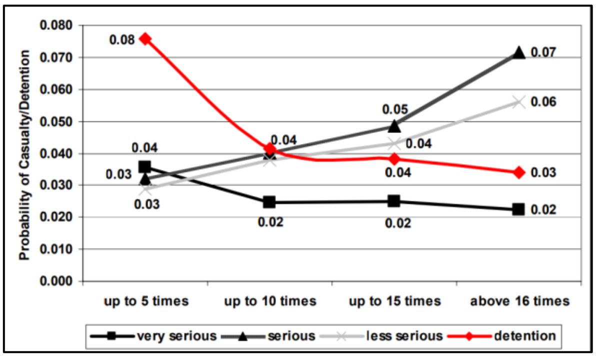

Figure 1: Probability of Casualty per Frequency of Inspection [8]

The requirements of each region or state are not the same, so ship-owners often resort to flags that are less demanding in their regulations. This could only be prevented by harmonizing all rules at the international level. With increased transparency and control of elimination of possible deficiencies, the system overall becomes safer and more efficient. Otherwise the inspections are often overlapped and excessive and ineffective supervision can occur [9].

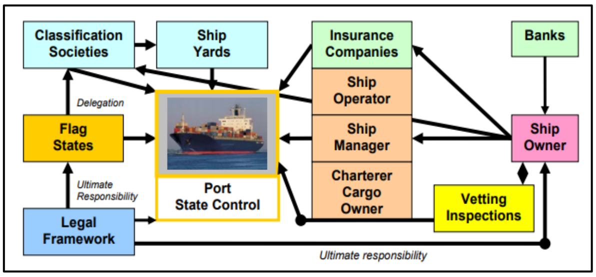

Figure 2: Players of the Safety Regime in General [10]

Inspections due to various legal requirements are included into supervising the ship since her beginning in the shipyard, and it will continue throughout her life. During this period all stakeholders are in a certain interdependence as shown in Figure 2.

Considering that inspections are costly and demanding and that reduction of inspections would reduce the costs they cause, thus decreasing the number of the inspections would be a relief to shipping companies. At the same time, increasing the number of the inspections would decrease ship detention and serious malfunctions which are (or can be) more expensive and more damaging than inspection costs will cause. Therefore, the frequency of different inspections and vettings varies. There is an educated estimate of 11 inspections annually for tankers, 6 for dry cargo vessels and 5 for all other types of vessels [10]. Various researches show that the ships of higher-earning companies have fewer detected deficiencies and those ships also eliminate discovered deficiencies more effectively [7].

It can be concluded that there is a direct correlation between inspection and the profitability of the shipping company, profitable companies are performing more internal inspections, which will eventually discover some of deficiencies which will otherwise remain undetected. This effect is not negligible, since the main goal of the shipping company is profit, so investing in inspections will apparently decrease profit margin and the over-inspecting will create an unfavorable atmosphere in the industry. It means that it is necessary to carry out inspections in order to maximize the level of security, but with the obligation to strike a balance between all those who carry out the inspections so that they do not recur. Figure 1 depicts how the change of frequency of inspections effects number of causalities and detentions.

Although LNG ships are inspected by different institutions, the biggest responsibility and obligation for keeping ships up to standards is on the shipping company. It is therefore required that each shipping company develop an internal system for checking ships, including setting minimum safety standards, collecting appropriate data and adequately assessing them at all stages of the ship's life. Accident statistics and inspection results show that non-compliant vessels are still present in the industry, that such vessels still carry cargo. That is a direct threat and a poor industry reference, and this phenomenon must be curbed.

3 LNG COMPANY INTERNAL INSPECTION PROGRAM

As a response to a number of tanker accidents with serious consequences is public awareness and concern, and with this comes increased scrutiny. LNG shipping companies are engaged in the supply and transportation of natural liquefied gas (LNG) and, due to the nature of their business, are subject to constant inspections in order to maintain high standards of transport. Inspections carried out by different institutions are an obligation that shippers must fulfil, but in order to raise the level of safety in all segments, the most important element are internal inspections carried out by the company itself.

The two most represented inspection systems are: the Ship Inspection Report Program (SIRE), developed by OCIMF (The Oil Companies International Marine Forum), a voluntary association of oil companies having an interest in the shipment and terminalling of crude oil gas and their products and an inspection system within the Chemical Distribution Institute (CDI) [11].

The introduction of SIRE is optional, but most of respectable LNG companies implements this program. According to SIRE, the inspection should be carried out every 6 months and the inspection should be carried out by an inspector who must have the appropriate knowledge and skills and be appointed by OCIMF. The SIRE program requires a unique inspection protocol implemented by the following tools [12]:

- Vessel Inspection Questionnaire (VIQ)
- Barges Inspection Questionnaire (BIQ)
- Uniform SIRE Inspection Report
- Vessels Particulars Questionnaire (VPQ)
- Barge Particulars Questionnaire (BPQ).

Inspection reports are part of the SIRE database and are available to all OCIMF members. OCIMF collaborates with all important institutions such as the International Maritime Organization, the Paris Memorandum of Understanding, the UK Marine and Coastguard Agency, the Australian Maritime Safety Agency and other Port State Control Administrations [12] with the intention to eliminate substandard (inadequate) ships.

CDI, on the other hand, is a non-profit foundation that inspects and audits the complete supply chain for the transportation and storage of bulk and packaged chemicals. CDI was created by the chemical industry to develop an effective risk assessment system [13]. This system enables LNG companies to create a balance between corporate social responsibility, environmental protection and economic values.

3.1 Analysis of the non-mandatory inspections in the LNG company

For the purpose of researching the subject matter, the data of a specific LNG company, a member of INTERTANKO, was collected and analyzed. INTERTANKO (International Association of Independent Tanker Owners) is a trade association of independent tanker owners founded in 1970 and actively supports its members in various operational, technical, legal and commercial issues affecting tanker owners and operators worldwide [14].

The selected company is under all mandatory surveys and inspections, but it also uses the SIRE program as well as CDI monitoring. The results of the SIRE inspections for 2017 are shown in Table 1.

Table 1: Results of SIRE inspections in the company

SIRE inspections	2017
Ships that have not passed the SIRE inspection	0
Number of SIRE inspections	19
Number of deficiencies	35
Average number of deficiencies per SIRE inspection	1.84
Average safety management deficiencies (SIRE Ch.5) per inspetion	0.32
Average navigational deficiencies (SIRE Ch.4) per inspetion	0.37
Average mechanical/steering deficiencies (SIRE Ch.11) per inspetion	0.37

The results are further processed and compared with the results of previous quarters in order to regularly monitor changes. SIRE's 2017 annual performance for the LNG observed is shown in Figure 2.

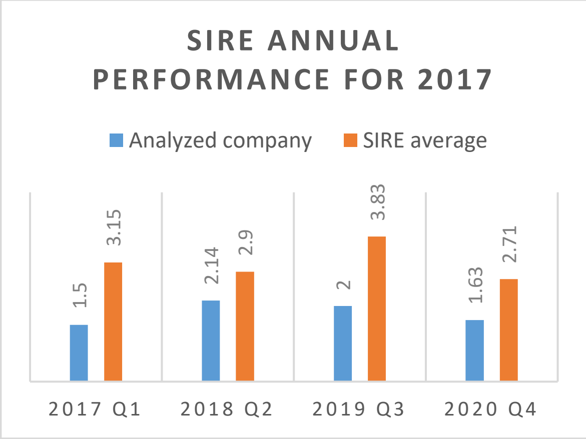

Figure 3: SIRE inspections performance for 2017

The conclusion visible in Figure 3 is that the number of deficiencies on the ships of the analyzed company during 2017 through all 4 quarters was below the average of all SIRE inspections. Considering the above, the overall result is satisfactory.

The deficiencies recorded during the year were analyzed according to the Vessel Inspection Questionnaire (VIQ) as shown in Figure 4. The report is taken from Q88.com database [15].

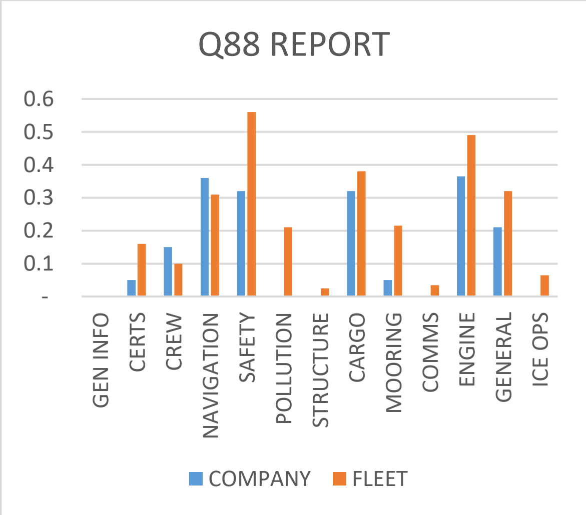

Figure 4: The deficiencies analyzed according VIQ [15]

From the Figure 4 it is visible that the company results are better than average in all fields except in crew and navigation. In the area of safety, positive trends are emphasized, the result is almost twice better than average.

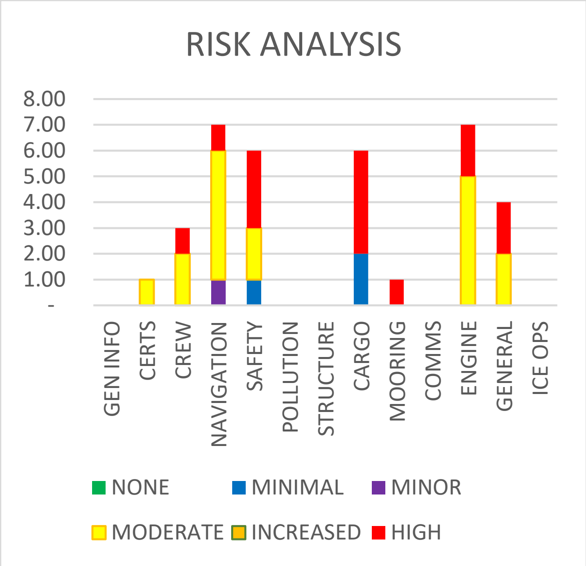

Figure 5: Risk analysis

Q88 report can be divided according to the risk factor. Risk factors analysis for 2017 for the observed LNG shipping company is shown in Figure 5.

Figure 5 concludes that the deficiencies with most pronounced risks are present in the chapters of cargo and safety, while the majority of deficiencies in navigation and crew area are moderate risks.

Ongoing inspections and vettings provide insight into the ship and company condition. They provide conclusions from which to draw further action in order to achieve the best possible results. Each shipping company regularly monitors all its ships and compares them with each other both in terms of safety and other segments. Figure 6 shows an overview of the average number of SIRE deficiencies per vessel of the analyzed LNG company.

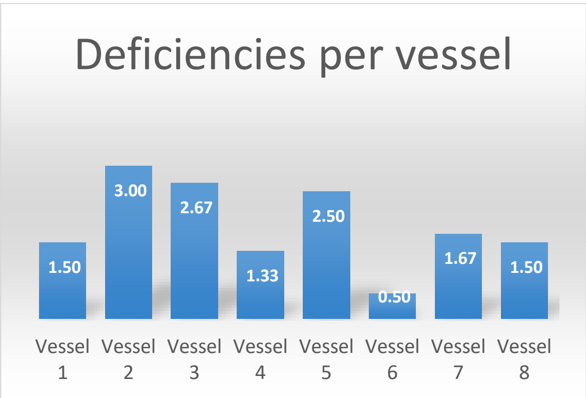

Figure 6: SIRE deficiencies per vessel

Figure 6 shows that the average number of deficiencies is in the range of 0.5 to 3.0 per ship. That indicates the tendency of shipping companies to maintain a very high standard of safety and to achieve enviable results during inspections and vettings, even though this is a very young fleet.

Considering that the analyzed company is a member of the INTERTANKO [14] association, the results of the inspections are compared among the members. INTERTANKO is a renowned association of ship owners for the transportation of oil, derivatives and gas. The members of the association actively promote the quality of business and take care of positioning themselves on the market, taking into account good reputation. Arranging and supervision of ship's inspections and vettings, then acting on the results obtained, especially with the necessary elimination of the deficiencies, is in direct relation with the image of the INTERTANKO and associated companies to achieve overall goal. Overall goal of all in the LNG industry is obtaining good records and maintaining good safety standards [16].

Figure 7 shows the analyzed company Q88 results compared to the average results of the INTERTANKO database.

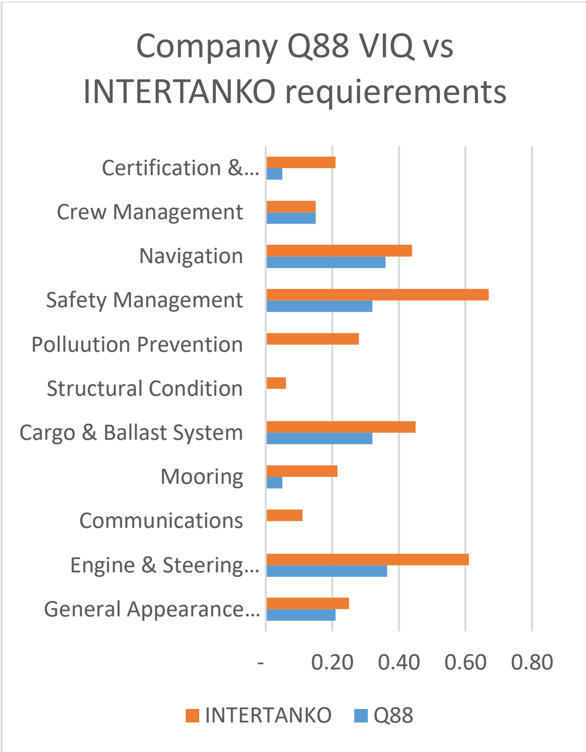

Figure 7: Deficiencies comparison

By analyzing Figure 7, it can be seen that during 2017 the LNG shipping company achieved results that are better than prescribed standards of the International Union of Independent Owners of Tankers (INTERTANKO) in all areas of inspection [14].

4 CONCLUSION

The presence of liquefied gas tankers in the overall tanker fleet is steadily increasing. The main feature of LNG (Liquid Natural Gas) ships is that their purpose is the transport of highly flammable cargo. Due to that characteristic those vessels are subject to regular inspections and vettings with the intention to ensure high safety standards. A series of laws, rules, standards and guidelines try to minimize possible damage, so stringent legal regulations apply from the construction of the ship until its final exploitation. Although there are numerous inspections scheduled by various and numerous institutions, the biggest responsibility for the safety of the ship, crew, cargo and environment is within the shipping company. Therefore, in addition to the mandatory inspections and vettings, LNG companies also arrange non-mandatory inspections that the companies carry out by their own decision.

The inspection regimes described in the paper are: the Ship Inspection Report Program (SIRE), developed by the International Marine Forum Oil Company (OCIMF), and the inspection system within the Chemical Distribution Institute (CDI). The introduction of SIRE inspections as well as membership in the INTERTANKO association is optional, but every respectable LNG company implements SIRE program and every respectable LNG company is a member of INTERTANKO (International Association of Independent Tanker Owners).

With intention to check how SIRE data can describe the quality of the company, the data for 2017 were collected and analyzed. The selected company is fulfill all mandatory inspections and vettings, but it also uses the SIRE program as well as CDI monitoring. All reports are processed and presented in this paper, showing that the company has above average results in most of the inspected areas. Those results are in accordance with the prescribed standards of INTERTANKO.

Non-mandatory inspections discovered significant number of deficiencies and pinpointed some areas where improvement is possible. By comparison of the non-mandatory inspection data, it is possible to determine the quality of the company.

Non-mandatory inspection programs, described in the paper help to promote positive competition in the industry in order to eliminate substandard companies and vessels, creating the whole industry much better and safer.

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EDUCATION SYSTEM CONTRIBUTING TO THE ART OF COMMAND AND LEADERSHIP OF THE CROATIAN NAVAL UNITS

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ABSTRACT

Naval officers when carrying out command duties at all levels represent a crucial element in commanding and leading naval units. They are a part of a highly formalized military system. Developed command, leadership and managerial skills as essential excellence factors which commanders have to possess are indispensable for timely planning of processes and supervision of the execution of planned activities. The goal of this paper is to research and analyze characteristics required for command duties in the Croatian Navy's naval units. The expected outcome of this paper is to point out the fact that completed naval/civilian studies, followed by advanced military education and experience acquired on naval vessels are a basis for promotion to highest officer duties in the Croatian Navy.

Keywords: Naval unit, the Navy, leading, commanding

1 INTRODUCTION

The art of command, management and successful leadership within a wide range of human activities has always been an inexhaustible subject which, even today, presents a challenge to many authors who by using different approaches and aspects are trying to display complexity of the topic.

Making a profit as a must and a basic goal of social profitable activities has generated a need for the most essential factor necessary for accomplishing this goal – shaping of a successful leader.

If we analyse the role of a leader and successful management in a hierarchically organised military system of the Republic of Croatia (hereinafter referred to as RC), which is what this paper is about, we come to the realisation that in order to create leaders and develop their capabilities, it is necessary to additionally and systematically invest in education and training.

In the military education in the RC, current models and projects of education enable all the members of the Croatian Armed Forces (hereinafter referred to as CAF) to acquire academic and military knowledge, skills and capabilities necessary for command duties, both in the national and international military environment, and for contributing to civilian structures of the society.

Answers to the questions about the process of creating quality leadership and management in the CAF can be found in methodology and examples of educational experiences used in the RC military system so far. In the text below, affirmation of leaders among naval officers in the naval units of the Croatian Navy (hereinafter referred to as CN) will also be taken into consideration.

2 DEFINITION OF COMMANDING

But firstly, it is necessary to define leadership and commanding in the RC military system as an art of making decisions, leading and motivating subordinates in the execution of tasks with the least possible undesirable consequences [1].

To make a quality and in many cases quick decision, to lead and motivate subordinates or units without making mistakes is a combination of different factors which form the profile of a successful commander.

Demanding years-long education, knowledge and education, positive personal features and capability to use different leadership styles present some of the most crucial factors for quality execution of military tasks and for being called a successful commander.

3 SPECIFICITY OF LEADING AND COMMANDING IN A MILITARY STRUCTURE

So, the military leadership model recognizes commanding as a skill of an individual who, by applying more commanding styles, in accordance with circumstances, carries out complex processes in operations with the purpose of overpowering the enemy.

In its structure, the military model has particularities which make it different from civilian leadership models. Commanding and managing in armed forces, contrary to civilian leadership models, applies solely the principles of single leadership and subordination **[2]**. The military model recognises one and only and clear chain-of-command under one commander.

Commanders and their staff, as the creators of complex processes of making a military decision in the course of planning and preparation of a task, enable a subordinated commander to decide in which way (how?) to carry out its execution.

However, the other elements of a task, which give answers to the questions who?, what?, where?, and when? are defined in an order, and subordinated commanders, except under special and justified circumstances, have no possibility to change the above mentioned elements, or the superior officer's decisions.

The very structure of the system of single leadership and subordination in a military model may also cause negative effects in the leadership process. For example, the process of making military decisions can be affected by greater centralisation, rigidity and suppression of the subordinates' initiative.

Effects of work and relationship with subordinates in a military system are measureable and they indicate how successful and efficient a commander is. Successful commanders in a subordinated system communicate, direct and delegate with trust, with a clear realisation that the delegation system does not release them from their responsibilities [2].

The efficient functioning of all the military systems, and the same goes for the CAF, is based on issuing and carrying out of clear and executable orders [3] along with two-way communication and control of execution.

The joint concept for operating within the framework of the North Atlantic Treaty Organisation (hereinafter referred to as NATO), of which the CAF are part, points out the importance of command and control, where by organising staff, assets, infrastructure and procedures a common goal is achieved.

The complexity of leadership and command is especially evident in military models of smaller countries, such as the RC, where the integration of the military within the society is of the utmost importance, especially in cases of undesirable circumstances or threats.

An example of the abovementioned we can find in the synergy of the naval forces for the protection of Croatian interests at sea. Responsibility for the maritime area of the RC, which covers an area larger than its mainland area and which is strategically exceptionally important for the sustainability of the country, represent one of national priorities.

In the future, complex situations can be expected on the Croatian blue border, which is a European Union border as well, and in the whole area of the territorial sea of the RC. They have to be responded in a proper way by engaging all the available national resources and through application of the integration principle. Tasks referring to the implementation of maritime acts, search and rescue, removal of consequences of environmental incidents, possible migration crises, etc., demand and prove the need to integrate the military system with other state bodies and relevant institutions.

On these grounds, it is necessary to harmonise educational and training activities of future commanders with the needs of national social movements so that they could acquire not only military knowledge and skills but also academic knowledge and skills indispensable for the benefit and development of a stable society. For example, a ship commander educated through old-fashioned classical military training methods, where solely military knowledge and skills for traditional maritime combat tasks are acquired, will not be fully qualified for all the assignments within the framework of his/her unit's mission.

Hence, creators of military education and training curricula, if we perceive it in a long-term and visionary way, should strive towards the continued development and modernisation of education of attendees of military studies, schools and courses.

The importance of developing the CAF, and, consequently, military education and training as an essential factor in the development of future commanders and leaders in the CAF, is of crucial importance and the Armed Forces of the Republic of Croatia are going in this direction. The document "Educational Concept for the Needs of the CAF of 2017" as an umbrella operational concept is being built on the National Security Strategy and the Military Strategy of the RC. It describes the goals which should be obtained through the educational system for the needs of the CAF and it stresses the necessity of creating strategic leaders, leaders at the operational level of command and the necessity of developing experts in specific professional fields [5].

In the text below, we will observe in a more detailed the way of creating leaders at the operational level of command in the Croatian naval units. These units carry out their demanding peace-time duties in the specific maritime environment and protect the national integrity and sovereignty of the RC.

Specific peace-time duties, which include civilian structures, both national and international ones, demand high professional competences of those who carry them out, and especially of their leaders.

The military education system in the RC has been developing since the Homeland War. Nowadays, it is carried out by the Dr. Franjo Tuđman Croatian Defence Academy (hereinafter referred to as CDA) [6] in line with the curricula and instructions and schedules of the training of CAF headquarters, units and institutions.

Different education cycles at the CDA are attended annually by approximately one thousand attendees consisting of attendees from other ministries and state administration bodies and attendees from foreign militaries [6].

Non-commissioned officers (hereinafter referred to as NCOs) go through a leadership development process through the Basic and Advanced NCO Course and Sergeant Major Course, whereas officers attend the Basic and Advanced Officer Course and Command and Staff School.

The War College, as the highest stage of the military education, offers the level of education and preparation for the highest command duties in the national or international environment.

A lot of CAF members work in different missions in the international military environment, therefore, the active knowledge of foreign languages has become mandatory. A quality and systematic three-month long course of the most represented foreign languages is carried out in the Foreign Language Centre, organisational unit of the CDA.

Furthermore, in cooperation with the academic community, a development of university study programmes, specially designed for the needs of the Ministry of Defence and the CAF, started in 2014. Since then, undergraduate and graduate university studies of Military Leadership Management and Military Engineering [7] and undergraduate and graduate university study programme of aeronautics have been carried out. An integrated undergraduate and graduate university study programme of Naval Studies [8] was commenced in 2018, and a postgraduate specialist study is being launched in 2020.

4 DEVELOPMENT PROCEDURE OF CROATIAN NAVY OFFICERS

The university integrated undergraduate and graduate university study programme of Naval Studies was developed as a result of the cooperation between the Dr. Franjo Tuđman Croatian Defence Academy and the University of Split [9]. The purpose is to acquire necessary knowledge and qualifications corresponding to maritime standards of professions in both the military and civilian environment. This study programme is supported by the faculties which can in term of the content contribute to appropriate academic education of future naval officers of the CAF.

For example, the CN naval officers, especially officers form the Coast Guard of the RC (hereinafter referred to as CGRC) as a component of the CN, participate actively and continuously, in cooperation with other competent ministries, in the protection of Croatian rights and interests at sea, with the tendency of an increasing number of activities. Hence, this study programme of the Naval Studies, as it was primarily conceived, will to a great extent fulfil the expectations and solve the problem of the deficit of quality naval officers as future commanders on responsible and complex duties.

By meeting criteria to enrol at the Integrated undergraduate and graduate university study programme of Naval Studies, a student begins with the study programme lasting for five years of ten semesters, and is carried out as a full-time study according to the programme specially harmonised by the University of Split and the Croatian Defence Academy. The programme respects NATO standards and standards imposed by the Convention on Standards of Training, Certification and Watchkeeping for Seafarers.

In the course of the study, it is also planned to implement different courses such as a combat rescue swimmer course, alpine climbing course, parachuting course, sailing course, etc. This kind of education enables students to acquire additional capabilities that will help them successfully solve their units' tasks.

Training through a military expertise and on board practice is an integral part of the study. In the course of the military expertise practice, students will learn about the skills of leadership, command and control, handling personal weapons, firing and maintaining weapons and spatial and environmental orientation. In the course of the on board practice they will meet with the specificity of work and life on board a ship by taking an active part in training and all the other daily shipboard activities.

General competences that students acquire after graduating from the study programme of the Naval Studies are equal to those acquired at the other maritime faculties in the RC. In addition to the general knowledge, they will also acquire knowledge of specific capabilities on the basis of which they will be authorised to perform duties within the scope of the CGRC.

Students receive scholarships from the Ministry of Defence, Ministry of Interior and Ministry of Sea, Transport and Infrastructure.

After graduating from the study programme of the Naval Studies, students will receive the degree of the master of naval studies in the field of naval nautical study and in the field of naval marine engineering, After graduating from the study programme, the Ministry of Defence students will be commissioned to the first officer rank, ensign, and they will be posted to first officer's duties on board a ship.

5 SPECIFICITY OF SHIP ORGANISATION

On the grounds of the Act on Service in the Armed Forces of the Republic of Croatia, ordinances in force prescribe the organisation of life and work on board a ship and the ways of training of its crew, sailors, NCOs and officers. The Ordinance on Service on Vessels of the CAF and the Ordinance on Qualification and Professional Exams of Seafarers in the CN define each member of a crew an obligation to take a three-part exam on the ship called the Exam of autonomous performance of the assigned duty/Qualifications Exam [10], [11].

The autonomous performance of the assigned duty (hereinafter referred to as APAD) on CN ships presumes that members of the CN, that is members of the crew, are capable of living and working on board a ship on the duty they are posted to. The first step towards being qualified for the autonomous performance is to acquire knowledge and take an exam in the Basic Safety Training Course which has been designed to meet requirements of STCW95 (Including Amendments) section VI/1, based on IMO model courses 1.19, 1.20, 1.21, 1.22 - D2 [12], [13]. After that, a seafarer takes an exam in Knowledge of the Ship and Ship Organisation (this exam is taken a month after the embarkation). After six months of training activities and education on board the ship a seafarer, mentored by a more experienced officer or NCO from the crew, takes the Professional Exam before three-member examination commission from the superior headquarters.

After the qualifications exam is passed, every crew member becomes an active part of the ship organisation within a ship section or division and they maintain and upgrade the level of their skills and knowledge through daily autonomous or group training.

Commanders of sections and divisions are responsible for the training and activities within their section or division. Professionalism, capacity to lead and manage, desire for self-development, quality personal traits and consistency and reliability, are basic principles active military persons on command duties should strive to attain. These traits are essential in the process of electing candidates for command duties.

The role of COs is of a great importance. By applying the aforementioned principles, they create smaller, vocationally different, quality teams that the executive officer and CO through their leadership and managerial skills join into a whole.

Actually, the basic COs' role is to harmonise the work of all the divisions and sections of the ship in line with ship schedules and to optimally manage available human and material resources that they are entrusted with.

6 DECK WATCH OFFICER (DWO) EXAM

In addition to the aforementioned exams, naval officers shall also pass a Deck Watch Officer Exam in order to autonomously and successfully command the deck watch at sea and at anchor. The contents of the exam is harmonised with the deck watch officer exam in the merchant navy. it is an integral part of naval officer training process in the CN and it is taken after the APAD exam. It is a compulsory exam ad it may be taken by naval officers with at least 12 months of seagoing service on CN vessels, sailing as apprentice deck watch officers.

7 EXAM FOR THE COMMANDING OFFICER OF A CROATIAN NAVY VESSEL

In their professional development to the position of the commanding officer of the ship (hereinafter referred to as CO), CN naval officers shall acquire certain experiences and qualifications. They obtain it through work and practice when sailing on ships as a member of the crew at lower organisational officer's duties. With several years of experience on such duties professional knowledge and experience is acquired, seamanship skills are improved and leadership and managerial capabilities are developed.

In cases when naval officers excel in their work and effort and show commanding abilities, at the proposal of the CO and the superior headquarters, they become eligible for the posting of the CO. This is followed by an intensive training in this direction.

The process of training a naval officer to become a CO is a complex procedure which in the course of several months demands maximum engagement of each crew member. The work and training are under constant command and control of the ship commander who as a mentor directs and trains the future commander in all the activities, procedures and ship manoeuvres Results of the work and training are monitored by the superior headquarters of the naval unit the ship is a part of.

The final stage of the training for the CO, which precedes a Qualification Tactical Exercise (hereinafter referred to as QTE) consists of periodical execution of a several-day sailing with the ship through at least two Demo Tactical Exercises (hereinafter referred to as DTE). In addition to the crew, members of the commission from a one-level higher headquarters are present at the both exercises. After two or more DTEs are carried out successfully, the commission issues a certificate that the ship and the crew are ready for a QTE.

The QTE is controlled by the commission from a two-level higher headquarters. After the QTE is carried out successfully, the naval officer is qualified for the duty of the CO.

8 COMMANDER OF A NAVAL UNIT

After successfully performing the duty of a CO, naval officers are posted to higher command duties or head of staff duties. It is a principle that they are posted to command duties in the same naval unit. Their experience, acquired knowledge and leadership capabilities in the role of the CO will be demonstrated to a full extent in the more demanding role of the second-in-command or commander of the naval unit. Duties of the naval unit commander, who is responsible for several ships and crews thereof, comprise managing and coordinating training processes, logistic support, and solving of human resource issues. Demands deriving from the task description of a naval unit impose upon the commander or the second-in-command high leadership and managerial capabilities. Responsibility for assets and people, professional and organised leading and managing of people and all the training activities, successful execution of tasks are only some of the demands which the person performing the duty of the second-in-command or the commander of a naval units is supposed to fulfil.

9 CONCLUSION

The art of management and leadership, as the most important factor for the success of all organised systems is also a key to the success in the specific military environment, such as the CN, the bearer of the maritime security of the RC.

In line with challenges it meets and the role it is entrusted with, the CN, systematically at all the levels, creates leaders and commanders who will, at national and international plans, contribute significantly to the development of the CAF with their knowledge, expertise and personal traits.

High technological achievement in naval-maritime industry and development of maritime transport and other sea-related activities require from naval officers, along with expertise and adaptability, resourcefulness to overcome organisational and technical procedures in different social structures. Elements having an impact on performance of all the navies are levels of competence and training of naval officers, NCOs and sailors.

Investing in in projects of educating and training of naval NCOs and officers for future commanders at tactical and strategic level presents a key to the success and development of CN naval units, CAF and overall community.

Today's intentions of responsible state bodies and current model of the military education in the RC represent a quality way in accomplishing goals oriented towards achieving the continuous development of successful leaders and commanders who will be able to respond to challenges lying ahead of the CN, and the overall CAF.

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STUDENTS ' ATTITUDES TOWARD A FUTURE CAREER IN SHIPPING: PROACTIVE BEHAVIOR AND PLANNING

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ABSTRACT

Contemporary shipping is characterized by the growing development of technology which implies a reduction in the number of ship crew members. This situation requires examining the attitudes of maritime students about the planning of the future career, as well as the activities they proactively undertake to be able to embark in a shorter period after graduation, which is the basic goal of the paper.

The profile of the students and their attitudes regarding career planning and proactive behavior will be graphically presented, as the key results of primary research performed. The sample includes 150 students of bachelor studies in the field of nautical and maritime transport, ship engineering, and marine electrical engineering.

Keywords: student, shipping, career planning, proactive behavior, attitudes

1 INTRODUCTION

Today, the European Union has about 220,000 seafarers, which is about 18% of the total number of seafarers globally. Flexible tax treatment of seafarers' salaries aims at encouraging European shipowners to employ European seafarers. It is also aimed to increase the competitiveness of the European seafarers in the international maritime market [13].

Maritime crew-related issues can be attributed to technological progress and automation of ship systems because modern technologies require more complex and advanced skills of the maritime workforce, but also a smaller number of crew members [13]. Therefore, this research is important to determine the proactive behavior of students and assess their awareness of the challenges of the future profession. This paper raises many questions related to the personality of the students, individual preferences, social intelligence, and coping in building a network of contacts even before embarkation on the ship. Therefore, we used here the well-known career engagement scale that directly targets the mentioned issues [8].

To explain this complex matter, the authors started from the definition of the research question: How do students plan their future careers during studies and what exactly do they undertake?

At the first level of analysis, we explained the sample and defined the characteristics of the respondents. In the second one, we presented the specific results of the questionnaire conducted to respond to the research question.

An overview of the relevant literature, a description of the methodology and profile of the respondents, and the results with discussion and conclusions are presented in the continuation of the paper.

2 LITERATURE REVIEW

The dynamism of the maritime labor market indicates the need for future seafarers to plan their careers. The career planning process can be viewed from two aspects of responsibility: individual and organizational [2]. In today's highly competitive environment, the responsibility for career management is increasingly in the hands of the individuals, and the planning process itself focuses on individual skills, abilities, needs, and aspirations. It is therefore extremely important for maritime students to act proactively and develop professional career planning skills before graduation. It has been proven that proactive planning influences success during the first years of career-building [4]. In maritime affairs, the authors have addressed this issue very limitedly [7; 11; 12; 1].

In the more recent reviews of the literature it has been found a model for developing professional career planning skills for maritime students [11]. The authors pointed out that the skills for successful future career planning in the maritime industry are: skills of labor world cognition, adjustment to work, self-cognition and self-development skills, social and lifelong learning skills. Finally, the result of the model are the stages in the maritime career planning process [11]:

Phase I: self-assessment - recognizing one's personality traits, competencies, interests, and goals that are important for a maritime career;

Phase II: career development opportunities research - refers to the collection and research of relevant information in a career at sea, global trends in the development of the sector, employment and learning opportunities;

Phase III: professional career decision-making - making a long-term decision with the ability to assess and control the impact of external factors, and,

Phase IV: preparation of a career plan - implies the skills of defining a career vision, knowing the structure, stages, and content of a career plan to form the structure of the plan.

The criteria for choosing a maritime career are the location of the home (coastal areas are traditionally known by seafaring), family influence (young people are more likely to make choice if their family members are seafarers), good career prospects (salary, profession status, the early taking of responsibility, opportunity, and promotion), long-term interest in the sea, and less influential travel factor [5].

Taking into account the fact that the interest in developing a career at sea is decreasing worldwide, some studies show the attitudes of young people towards a career at sea and the impact of promotion campaigns in the maritime sector [7]. It was found that the possibility of travel and international work is often emphasized in promotional campaigns. According to the opinion of young people, this aspect is ranked as less important for employment, while the periods away from home are rated as the most negative aspect of a maritime career. The authors concluded that, when promoting a career at sea, the possibilities of working ashore after several years of seafaring should be emphasized.

This is often because of family pressure, accidents, difficult social conditions on board (cultural differences, stress, and workload), and the lack of company culture [5]. For example, the results of the survey at Kalmar Maritime Academy show that the main factors of employment on board are: salary (89.2%), professional training (41.2%), availability of the internet and other communication channels (38.4%), rank promotion (36.4%), free time onboard (36.4%), well-functioning relieving system (34%), employment security (30.8%), work less than 6 weeks (28.8%), number operating hours (28.4%) and 24% depends on the shipowner and his reputation [6].

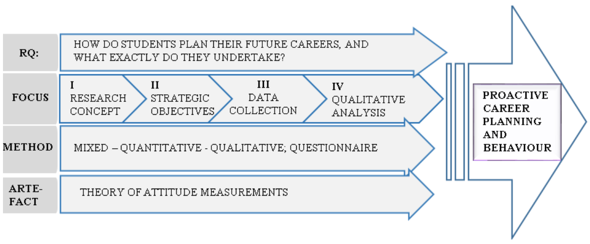
Career plans differ according to the levels of study [12]. Namely, postgraduate students in Hong Kong are significantly less oriented towards further studies compared to undergraduate students. Half of the postgraduate students are interested in finding a job in the maritime business (and, in some cases, logistics), but undergraduate students often planned to seek professional life in other industries [12]. Specifically, more than half of postgraduate students want to work in a shipbuilding industry (56%), then in the (general) transport industry (53%), port and coast guards (49%), tourism (40%), while the least prefer working in public administration (21%) [12]. Shipping stands out as a promising professional path within the complex system of maritime affairs [15]. Students show interest in containers (45%), dry bulk (14%), tankers (11.6%), and a few would like to work for cruise or coastal shipping companies. In this survey, no postgraduate students had any professional sea-going experience [12]. It was also found that educational institutions and the tourism industry should cooperate more efficiently to establish a platform for students to gain more experience, positive and realistic perceptions of occupation, and to motivate them to build a future career in this sector after graduation [16].

Career planning depends on professional and personal status, age, family circumstances, financial goals, and lifestyle preferred [2]. The quality of an individual's education is related to the possibilities of employment and faster promotion onboard [3]. For instance, Filipino maritime students perceive positive relations between good grades and easier employment [1]. It will be very interesting for future research to consult the representatives of the maritime companies who recruit future seafarers to respond to the question about relations between good grades and easier employment since there is no common attitude about the matter. They also strive to reach the highest rank on board in the future, regardless of the efforts they need to invest at a given moment. Research has shown that students' determination is influenced by the years of study and education of the mother. Older students showed a higher degree of determination to achieve goals than younger ones. Students whose mothers have a higher level of education are also more determined to succeed. Thus, a higher level of parental education indicates a lower chance for children to become "hibernating" students [1].

The results of the study from Lithuania showed that maritime students rarely consult with professors on professional career planning [11]. A significant proportion of lecturers are willing to provide relevant information, especially the ones having a marine rank and experience. The success of a student's professional career depends on professional competencies (theoretical and practical knowledge and skills); general skills of professional and personal development (teamwork, leadership, effective problem solving, knowledge of other cultures, organizing and planning work, etc.), and career planning skills.

3 METHODOLOGY

Figure 1 presents graphically all the steps in the process of defining the objectives, research questions, methods, as well as the results expected.



Source: Author

Figure 1: Framework of the Paper

The author based the research on the theory of attitudes applying the mixed quantitative-qualitative method, and statistical processing of primary data. The survey was initiated by the basic research question RQ1, while the focus is on qualitative analysis of results. The outcomes are defined as a review of career planning and proactive behavior: Faculty of Maritime Studies Kotor students' case study.

The survey is performed among students during their four years of marine engineering, nautical, and electrical engineering studies at the Faculty of Maritime Studies Kotor.

A questionnaire technique was conducted with the questions given as follows in Table 1. Section 1 describes the characteristics of the respondents. Section 2 specifies career planning and proactive behavior where a 5-point Likert scale: (1) almost never, (2) occasionally, (3) moderate, (4) quite often, (5) very often is used for measuring students' attitudes.

Table 1: Career engagement scale

CAREER ENGAGEMENT SCALE
Section 1: Characteristics of the students
Q1.1 Where were you born?
Q1.2 What is your class?
Q1.3 Which secondary school did you graduate from?
Q1.4 Have you completed training onboard?
Q1.5 How many years are you planning to work at sea?
Q1.6 Which type of ship are you planning to work on?
Section 2: Attitudes and perceptions related to career planning
Q2.1 Actively seek to design professional future career
Q2.2 Undertaken activities to achieve career goals
Q2.3 Cared for the development of career
Q2.4 Developed plans and goals for future career
Q2.5 Seriously thought about personal values, interests, abilities and weaknesses
Q2.6 Collected information about employers, professional development opportunities or the job market in desired area
Q2.7 Established or maintained contacts with people who can help professionally
Q2.8 Voluntarily participated in further education, training or other events to support career
Q2.9 Assumed duties or positions that will help progress professionally

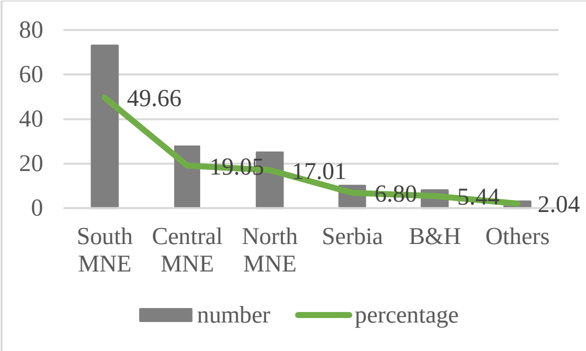
Source: Author according to [8]

4 RESULTS AND DISCUSSION

4.1 Students' profile and characteristics

When it comes to students' characteristics, we analyzed: a) regional distribution, b) year of study (class), c) previous secondary school education, d) training onboard, e) knowledge about ships and affinity for a specific type, f) duration of the future career.

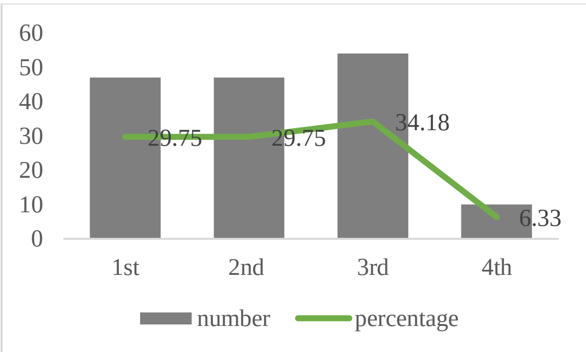
Graph 1 shows that the majority of the respondents are from the South of Montenegro.



Source: Author according to primary research results

Graph 1: Regional distribution of the students

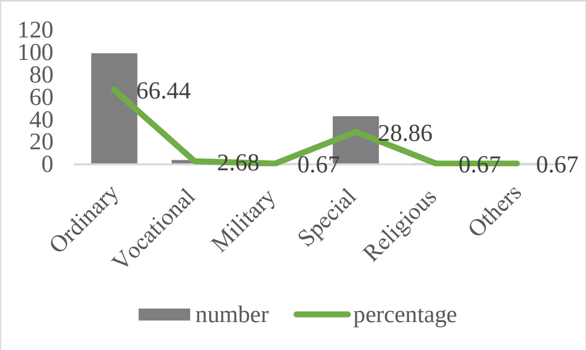
Then, students come from the Central and North part of Montenegro. When it comes to the wider region, most students come from Serbia, then Bosnia and Herzegovina, as well as from other neighboring countries. This confirms the dominance of students located near the coastline, where there is a tradition of seafaring in the family and the nearest environment. This could include demographic and economic analysis. Namely, there is a significant frequency of students who come from the central and north part of Montenegro, which confirms the attractiveness of maritime studies for these students. This could be explained by the economic situation and internal migration (i.e. lack of possibilities for employment ashore). In demographic terms, in 2019 in the northern region, a negative migration balance was recorded and amounted to 1,670 people. A positive migration balance was recorded in the other two Montenegrin regions, with it being higher in the central and amounting to 898 people, while in the coastal region it is 772 persons [14]. When comparing salaries, e.g. the average salary (gross) in January 2020 in Montenegro was 787 euros, while the average salary without taxes and contributions (net) was 524 euros [14]. When the ship's salary is in question, the ILO minimum basic wage for an able seafarer was the US $ 618 as of 1 July 2019, US $ 625 as of 1 January 2020, and the US $ 641 as of 1 January 2021 [9].



Source: Author according to primary research results

Graph 2: Class

When it comes to the class, most respondents study bachelor's (first cycle) level of studies, while also there are specialist students (Graph 2).

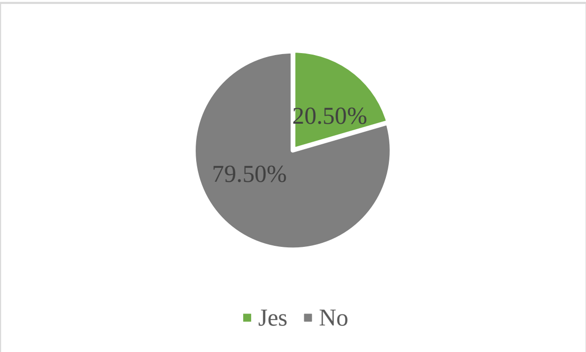


Source: Author according to primary research results

Graph 3: Previous education of the students

Since 2017 at the University of Montenegro all study programs have been reorganized according to the system of academic studies (3 years of bachelor, 2 years of master, and 3 years of Ph.D. studies). The newly accredited programs of master and doctoral studies are available for the academic year of 2020-21.

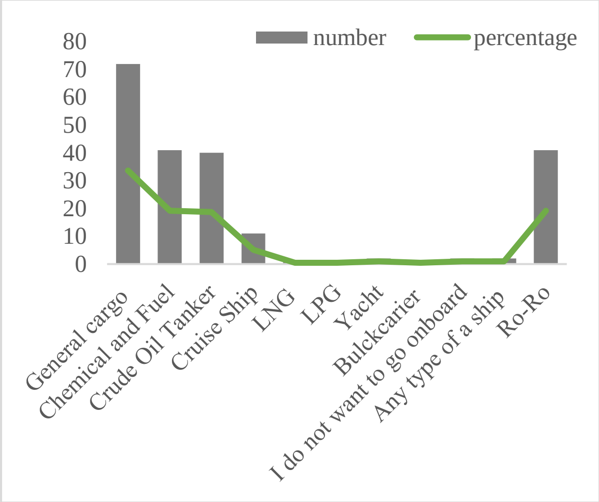
Graph 3 shows the predominance of students who graduated from an ordinary secondary school. A very few graduated from vocational, military, and religious schools. Recently, the Faculty of Maritime Studies Kotor recorded the increase in the number of students who have the highest grades (scores) acquired at secondary school [10].



Source: Author according to primary research results

Graph 4: Training onboard

Graph 4 shows that 20.5% of the students finished on-board training. This situation is due to the lack of financial resources to ensure that all students can participate in navigation practice, which is the case at some faculties that possess their own training vessels.

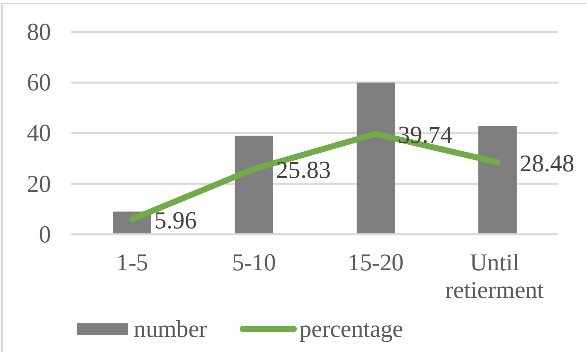


Source: Author according to primary research results

Graph 5: Vessel types preferred

As shown in Graph 5, 33.64% of student respondents said they preferred mostly general cargo type. It is also interesting to students to start career on chemicals and fuel, crude oil and Ro – Ro vessel types. Students also chose cargo ships over passenger ships. This is because there are more opportunities to get a job on cargo vessels, since there is a great interest in passenger vessels, as well as the stronger competition. Minor is the number of those who have no idea about future vessel types, as well as those ones who do not want to go onboard.

When it comes to the years planned for a seafaring life, students think about the option of the next 15-20 years, and also until retirement. It can be said that future seafarers have a strong motive for seafaring life, as well as to make plans about the time dimension of the navigation (Graph 6).



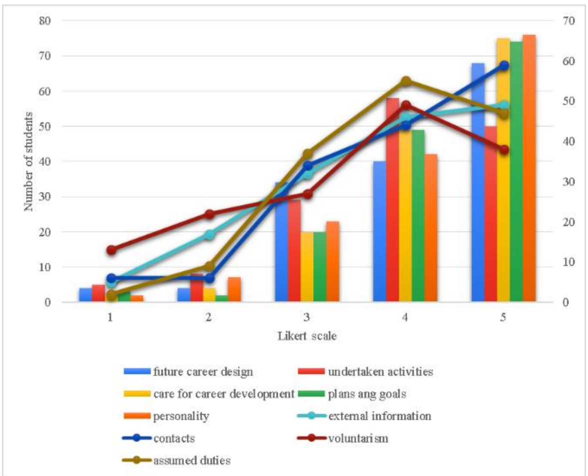
Source: Author according to primary research results

Graph 6: Plan about navigation

A few respondents seek a temporary career (5.96%). Most of them understand the complexity of seafaring life, and assess it as a long term professional option for themselves.

4.2 Career planning and proactive behavior

Upon application of the career engagement scale, it was confirmed that the majority of respondents act proactively and positively in regards to career planning (Graph 7).



Source: Author based on primary research results

Graph 7: Maritime career engagement scale

Namely, students rated all of the elements of proactive behavior highly, choosing value 4 and/or 5 of the 5-point Likert scale.

The analysis of the results confirms that 76 out of 150 students seriously considered personal values, interests, abilities, and weaknesses. It means that they are very aware of their strengths and the abilities to develop themselves as maritime professionals. Also, many students care about their future careers (75 out of 150), while on the other hand, they undertake a lot of effort to create clear plans and goals for the future career (74 out of 150), but also do concrete activities (68 out of 150) such as preparation for the selection interviews, collection of the information about documentation needed for the first embarkation, etc. Thus, students ranked all the categories mentioned with the highest value (5).

It is very important for students to achieve stable and maintained contacts with people who can help them professionally. It is also interesting that students have rarely (almost never) voluntarily participated in further education, training or other events to support their careers (13 out of 150, Graph 7).

This can be a recommendation to establish the support service for students to create networks with future employees, especially for the purpose of providing the first embarkation. This kind of students' service should be more encouraged and practiced at the maritime education institutions.

5 CONCLUSIONS

It is argued at the beginning of this paper that the leading problem of human resources in maritime industry is the recruitment and retention of seafarers, as well as the impact of technology on reducing the number of crew members. This research is a contribution to discovering how students perceive their careers before starting work onboard.

In this paper we confirmed previous results that the other authors published in the relevant literature, but besides it the paper defines: a) the main characteristics of the students, b) concrete attitudes about planning of the future career and proactive behavior. It was found that the students mostly come from the coast, plan to work onboard ship in a long period, and that they prefer cargo rather than passenger vessels. This trend could be very interesting for future research. They are also aware of personal values, interests, abilities, and weaknesses, and they care about future career taking many activities before graduation.

This paper contributes not only to the student population, but to the management of institutions to consider needs of students, especially in the direction of providing training onboard, investing in volunteer actions and increasing awareness of engagement in early career development.

It would be fruitful to pursue further research in directions to have larger sample size. Comparing attitudes of maritime students with other students who have intentions to start on-shore career would also be useful.

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MACHINE LEARNING IN LOGISTICS

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ABSTRACT

As in other business areas, logistics is faced with the problem of relying on large amounts of structured and unstructured data that must be processed and analyzed in the shortest possible time in order to provide companies with broad and deep insight into their business and improve their decision-making capabilities. With classical computer and software systems that require human intelligence, it is completely impossible to do this satisfactorily enough. Therefore, new technologies, including Artificial Intelligence and Machine Learning, which enable machines to learn automatically and improve from experience without being explicitly programmed, must be combined with already existing platforms. In view of the popularity and necessity of these methods in the logistics sector, we would like to verify the interest of researchers in these methods in the field of logistics. In order to show how often Machine Learning has been considered for the solution of logistics problems and for which aspects of logistics it has been applied among academic researchers, we conducted a literature review of the research and review scientific articles. The results show that the interest of researchers is not as great as in the profession, but the number of works has increased significantly in recent years.

Keywords: machine learning, artificial intelligence, logistics

1 INTRODUCTION

In the age of Industry 4.0 and the Big Data phenomenon, all sectors must adapt to the development and integration of new technologies, in order to remain competitive. In logistics, there is a large amount of structured and unstructured data that needs to be processed and analyzed in a short period of time to provide high quality and timely information to support decision making. Since time and cost are two of the most important indicators of how efficient and effective the company is, the need for new technologies that enable machines to speed up the processing and analysis of data is essential. Planning and scheduling, predicting and forecasting and other logistics activities, especially where many and complex rules have to be taken into account, can be significantly optimized using artificial intelligence (AI) and machine learning (ML), which are currently among the most promising. AI and ML are already incorporated in many software solutions used in logistics and supply chains. According to Gartner, "by 2023, AI techniques will be an embedded or augmented component across 25% of all installed supply chain technology solutions" (Logility, 2020).

One of the main advantages of Machine Learning is therefore that it can learn from previous data. This allows us to use past experience to successfully predict future trends and developments. Furthermore, AI and ML offers the possibility to automate processes, shorten execution times and accelerate decision-making processes with less human interaction. The task of AI-supported digital platforms is to solve the complex problems that contain ambiguity and uncertainty.

Machine learning is already used in practice in various sub-areas of logistics, e.g. for the detection of product or process anomalies, predictive maintenance of equipment and means of transport, forecasting and prediction of events and trends (demand forecasting), natural language processing, voice agents, automatic extraction of information from text (text categorization, text clustering, document summarization, opinion mining), automatic planning and scheduling, anticipatory (predictive) logistics, smart (intelligent) logistics assets, inventory optimization, warehouse navigation, automation of warehouses, distribution centers, and product delivery and others (Wlodarczak, 2020), (Krmac, 2019), (Daugherty & Wilson, 2018).

Given the popularity and necessity of AI and, ML methods in particular in the logistics industry, i.e. in practice, we would like to review the interest of researchers in these methods in the field of logistics. In order to show how often Machine Learning it has been considered for the solution of logistics problems and for which aspects of logistics it has been applied among researchers, we conducted a literature review of the research and review scientific articles. Therefore, this article aims to give an overview of machine learning techniques in logistics and to present their application in this field in a general way. Obviously, there is much more interest in the application of machine learning in practice than among scientists. From the overview it can be concluded, that many different problems in logistics can benefit from machine learning, from shipping to routing and packaging and many others. The aim of all of them is to speed up the processes through fast and high quality decision-making as well as to minimize the costs and the techniques of machine learning are well suited for this kind of problems. The main contributions of this article are: (1) it provides a systematic description of machine learning and methods, (2) it examines the applications of machine learning in the logistics field and (3) it presents and analyzes current research on the application of machine learning in solving logistic problems.

2 ARTIFICIAL INTELLIGENCE

Artificial intelligence (AI) is usually defined as machine behavior that would be considered intelligent if displayed by humans. It includes planning, learning, reasoning and problem solving to name a few. The most prominent subfields are robotics, computer vision, speech recognition and natural language processing. (Kaplan, 2016)

AI is able to analyze huge amounts of data in short time, which is ever more important in modern technology. While it provides better accuracy, flexibility and personalization of processes, it is also subject to certain negative perception, most notably the fear that intelligent machines will replace (and outsmart) humans. These fears are largely unfounded and it is far more likely that AI will benefit and assist humans in a wide range of areas of expertise, from medicine to all types of industries.

AI applications in logistics and supply chain were described in details in (Krmac, 2019).

3 MACHINE LEARNING

Machine learning (ML) is a sub-area of artificial intelligence and stands for any number of algorithms that need not be explicitly (or manually) told all the rules but can learn them from data themselves (Wlodarczak, 2020). This is useful when the rules are not known beforehand or there are too many of them to program manually, the most famous example probably being the game of chess. Machine learning is used to find patterns in data or to make predictions from input data.

One of the basic aspects of machine learning is that whereas humans learn from experience, machines learn from data. It is therefore crucial to operate with large enough amounts of quality data. It is unlikely that raw data is suitable as input for machine learning, as it is usually not in the suitable format. Moreover, it is noisy, contains irrelevant data and can be too large. Thus the first step is always data preprocessing, which can be time consuming and is done manually (Wlodarczak, 2020). First, distinctive properties of the input data have to be determined. These are called features and the process is feature extraction. Other steps include sampling, that is selecting a subset of data representative of the full data distribution, duplicates removal and outlier removal. Outliers are data that are considerably different from other instances. After the data is preprocessed, learning takes place.

There are three main types of machine learning: supervised, unsupervised and semi-supervised learning. They are briefly described in the following.

3.1 Supervised learning

Supervised learning uses labelled data as input for training. Training examples consist of (x, y) pairs, where x stands for input and y stands for output. The goal is to find the decision (or prediction) function that maps input to output and is then able to work with examples that are different from training data (Wlodarczak, 2020).

Supervised learning is divided roughly into two categories: classification and regression. The goal of classification is assigning data (or observations) to different categories and its output is discrete. Regression has continuous output and is used to predict the relationship between different variables. There are several algorithms that are used in machine learning and fall under either of the two categories. Classification methods are presented in Table 1 while regression methods are described in Table 2.

Table 1: Description of classification methods in supervised learning

Classification method	Description
Artificial neural network (ANN)	Based on the human nervous system it imitates neurons in the human brain and their interactions. It imitates strengthening and weakening of synaptic connections by assigning weights to input data and linearly combining them. It has three layers: input layer, hidden layer and output layer. The role of the hidden layer is to determine the function to map input to output. If there are more than one hidden layers present, it is called Deep learning.
Bayesian models	Based on Bayes' theorem, these are basically probabilistic models. They use prior probabilities and a likelihood to predict posterior probability.
Decision tree	The main operating point are the attributes. Tree-like structure is constructed with the root node representing the first attribute and intermediate nodes representing subsequent attributes. Branches represent possible outcomes on attributes and leaf nodes hold a class label. Decision trees can be combined, for example into a Random forest, which utilizes many individual trees.
Support vector machine (SVM)	Binary linear classifier where the main idea is to find a hyperplane in an n-dimensional space to separate data points into two classes. The goal is to find a maximum margin hyperplane that is one with the

Classification method	Description
	largest distance from the nearest training points.
k-nearest neighbor (k-NN)	It uses distance between data points in feature space and assigns the point the class that the k nearest neighbours belong to (k is a positive integer and is usually small). It is an example of instance-based learning where the learner waits for new instances and compares them to the previous ones.

Source: Summarized from (Wlodarczak, 2020)

Table 2: Description of regression methods in supervised learning.

Regression method	Description
Linear regression	Studies the relationship between two variables and assumes a linear dependence, using the well-known equation $y = ax + b$ where x and y are the independent and dependent variables, respectively, a is the slope and b is the offset. The coefficients a and b are determined from fitting. The most common method for fitting is the least squares method.
Polynomial regression	Polynomial regression is used when the dependence between variables is not linear. The model is then described as $y = \sum_{i=1}^{n} a_i x^i$ where the coefficients a_i are determined from the fit.
Logistic regression	It is used when the dependent variable is binary and calculates the probability of each outcome. It is based on the logistic function $L(x) = \frac{1}{1+e^{-x}}$

Source: Summarized from (Wlodarczak, 2020)

3.2 Unsupervised learning

Unsupervised learning is used when the input data is not labelled. Thus, there is no reference to compare to. It is used for discerning the underlying structure of the data and the most common method is clustering (Wlodarczak, 2020). It separates data points based on some similarity measure and can as such often be subjective.

The most common clustering method is the so-called k-means clustering. It is a partitional clustering algorithm, meaning that each instance is assigned only to one cluster and none of the instances remains unassigned. In k-means clustering there are k disjoint clusters, where k is predefined and must be selected carefully. Centroids, arithmetical means, of the clusters are determined, and an instance is assigned to the cluster with the nearest centroid. The centroid need not be a data point. It is an iterative method as clusters are modified in each step with every new instance assigned to them. A similar method is k-medoids clustering, where the centroid is the most representative data point in the cluster, instead of the mean.

3.3 Semi-supervised learning

Semi-supervised learning is a hybrid method and usually includes small amount of labelled data and large amounts of unlabeled data. It begins the training on labelled data, the results of which are used to label the originally unlabeled data. This data is then called pseudo-labelled.

4 LITERATURE REVIEW

As already pointed out, this article does not aim to be a comprehensive review of the area, but rather intends to show different uses of machine learning in different subareas of logistics.

4.1 The methodology of literature review

The review of full-text freely accessible English-written scientific articles without time limit was carried out in June 2020. For the review the ScienceDirect database was searched with two different keywords: 1. “machine learning” AND “logistics” and 2. “machine learning” AND “logistics” AND “transportation”. The search was focused on titles, keywords, and abstracts. After the first reading of titles and abstracts, 17 scientific and 3 review articles remained. After the full-text reading the 17 scientific articles entered the classification process (see Table 3). The publication year of these selected articles ranges from 2016 to 2020, with the majority of articles published in 2019 and 2020.

4.2 Results of the scientific literature review of machine learning techniques in logistics

For the present article, 17 research and 3 review articles on machine learning in logistics were analyzed.

Focusing on logistics and Machine Learning, three (3) review articles were found. The limitations of classical applications of control engineering in production and logistics, as well a survey of various distributed approaches and technologies of control engineering and ICT that “can support the realization of cooperative structures from the resource level to the level of networked enterprises”, including cooperative ML approaches that were already applied to production and logistics problems, were highlighted by (Monostori et al., 2015). The systematic literature review of event processing in supply chain management from 2005 until 2018 was undertaken in (Konovalenko & Ludwig, 2019). They conclude that “tapping into big data and machine learning techniques could unleash potential systems with high volumes of event data” and in this way interface with existing Decision Support Systems in use.

Villalobos et al. (Villalobos, Soto-Silva, González-Araya, & González–Ramirez, 2019) provided an overview of “the state of the art, challenges, and opportunities” that rise from “the integration of sensing data and information into decision support systems for the supply chain of fresh fruits and vegetables”. They presented the use of machine learning component to “solve the tactical version of the planning and coordination problem” in the fresh produce supply chain.

The findings derived from the 17 scientific papers are summarized in Table 3, in which the article, type of ML (supervised or unsupervised), the ML algorithm used, and year of publication are presented. A more detailed analysis of the findings can be found in the next section.

5 DISCUSSION AND CONCLUSIONS

As can be seen from the previous section and Table 3, there are many possible applications of ML in numerous sub-areas of logistics, such as distribution, packaging, routing and delivery, to name a few.

The number of articles analyzed is not particularly high, which shows that academic interest in this area is relatively low compared to the already widespread use of ML in industry. However, it is clear from Figure 1 that the number of articles published has increased significantly over the last five years (taking into account that at the time of writing this article, only half of 2020 has passed and therefore more articles are expected in 2020).

The majority of the examples (14 out of 17) use supervised learning, while unsupervised learning was used in only three cases. This is probably to be expected, as we usually want to predict behavior based on previous results, and is consistent with other areas of industry where supervised learning also dominates. In those cases where supervised learning was used, there is no clear preference for any of the algorithms, as they are rather uniformly distributed over the examples.

Table 3: Examples of ML methods in different subareas of logistics.

Article	ML type	ML algorithm	Logistics sub-area	Year of publication
(Cavalcante, Frazzon, Forcellini, & Ivanov, 2019)	supervised	k-nearest neighbour, logistic regression	supplier selection	2019
(Piendl, Matteis, & Liedtke, 2019)	supervised	Bayesian classifier	shipment	2018
(Guo, Cheng, & Wang, 2017)	supervised	ANN	facility location problem	2016
(Hughes, Moreno, Yushimito, & Huerta-Cánepa, 2019)	supervised	-	delivery	2019
(Barua, Zou, & Zhou, 2020)	supervised	ANN, SVM	freight transport	2020
(Zhang, Guan, Yuan, Chen, & Wu, 2020)	supervised	decision tree	reallocation	2020
(Tarallo, Akabane, Shimabukuro, Mello, & Amancio, 2019)	supervised	SVM, ANN	distribution, delivery	2019
(Göçmen & Erol, 2019)	unsupervised	k-means	routing	2019
(Liu, Liu, Hansen, Pozdnukhov, & Zhang, 2019)	supervised	SVM, decision tree, logistic regression	traffic management	2019
(Tarapata, Nowicki, Antkiewicz, Dudzinski, & Janik, 2020)	supervised	-	distribution	2020
(Knoll, Neumeier, Prüglmeier, & Reinhart, 2019)	supervised	decision tree	packaging	2019
(Becker & Intoyoad, 2017)	unsupervised	k-medoids	logistics processes	2017
(Knoll, Prüglmeier, & Reinhart, 2016)	supervised	-	logistics processes	2016
(Snoeck, Merchán, & Winkenbach, 2020)	supervised	Bayesian network	routing	2020
(Tufano, Accorsi, & Manzini, 2020)	unsupervised	k-means	3PL	2020
(Nagahara, Sprock, & Helu, 2019)	supervised	ANN	production	2019
(Aguilar-Chinea, Rodriguez, Expósito, Melian-Batista, & Moreno-Vega, 2019)	supervised	decision tree	shipment	2019

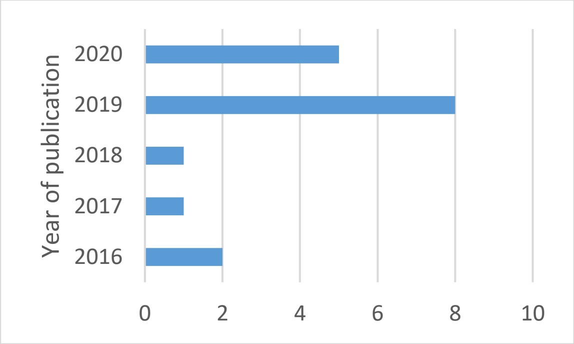

Figure 1: Number of published scientific articles on ML in logistics by year of publication.

There are also a small number of literature reviews or surveys on use of ML in logistics. The most intuitive justification for this would probably be the fact that logistics is in many cases treated as a part of the supply chain that was not covered by our search term.

Limiting the search process to scientific articles and reviews, excluding conference papers, books and other reports, and using only the term "logistics" in the search phrase instead of "supply chain" are the main limitations of this article. These are also the main reasons why the number of articles found is relatively small, which may raise questions about the reliability of the results.

The scope of our research was to conduct an initial review of the scientific articles on machine learning in logistics, in order to give the scientific community the opportunity to find out which gaps can be filled with their future research and thus to contribute to the future research agenda.

It can be firmly concluded that Machine learning is gaining in importance in numerous sub-areas of logistics and is expected to play an even greater role in the future. Academic research in this area is relatively new, but is increasing in scope. There are many problems in logistics that are very suited for ML, among other things routing and (a)location planning of facility, which has already been investigated in some articles, but there is much more to learn.

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CHARACTERISTICS OF NON-MOTORIZED PARTICIPANTS IN THE CITY OF ZAGREB

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ABSTRACT

Non-motorized road users in urban areas involve two main groups: pedestrians and cyclists. Pedestrians and cyclists, in contrast to motorized forms of traffic, have much greater opportunities in choosing movements and routes. The City of Zagreb, as the largest urban area in the Republic of Croatia, is a quality area in terms of researching the personal characteristics of pedestrians and cyclists. The research of personal characteristics of pedestrians and cyclists in the area of the City of Zagreb was conducted in a representative sample and can be considered relevant. The characteristics of pedestrians and cyclists are the first step by which further research can be undertaken in terms of travel habits and level of safety. The characteristics of pedestrians and cyclists allow the assessment of parameters in different individuals that influence the making of certain decisions and conditions. Based on the obtained parameters, qualitative conclusions can be made about the level of safety of non-motorized traffic in urban areas. The conducted research will show the aggregation of certain characteristics of pedestrians and cyclists that can help create a better picture of mobility and safety of non-motorized traffic in the City of Zagreb. The paper consists of an introductory part, existing research on the subject, data collection methodology, presentation of results, and research-based discussion and conclusions.

Keywords: non-motorized, modal split, pedestrian, cyclist, Zagreb

1 INTRODUCTION

Pedestrians and cyclists are considered to be major components of non-motorized traffic in urban areas. By increasing the share of non-motorized traffic in mode distributions across different urban areas, the risk of their casualties also increases. As part of the project "Sustainable safety of non-motorized transport in urban areas" funded by the Swiss-Croatian Cooperation Program, the Department of Urban Transport of the Faculty of Transport and Traffic Sciences as a leading partner and the of Cyclists Union conducted a survey of characteristics and behaviour of non-motorized participants in Zagreb.

The characteristics of non-motorized road users are the first step in detecting the state of mobility in urban areas. The state of mobility can then help to assess the general safety situation of non-motorized traffic. A survey of the characteristics of non-motorized participants (pedestrians and cyclists) was conducted through determining the general characteristics of pedestrians and cyclists.

Determining the general characteristics of pedestrians and cyclists was determined through the age distribution of respondents, gender distribution of respondents, possession of a driver's license and the distribution of work status of respondents. Through this data, it can be assessed which groups most often choose walking or cycling as a form of travel. In addition, the modal split of the respondents was examined in order to obtain a general view of the state of mobility, and to draw certain conclusions from the analysed.

2 LITERATURE OVERVIEW

Various studies and scientific work have demonstrated the impact of certain characteristics of residents on the number of traffic accidents with pedestrians and cyclists. The impact of demographic and socio-economic characteristics on the number of traffic accidents of pedestrians and cyclists is visible through the scientific literature [1][2][3]. The paper [2] shows how social characteristics such as ethnicity and the level of education in the suburbs affect the severity of pedestrian accidents.

A set of different papers investigated the possible impact of general characteristics of the population on the number of traffic accidents with pedestrians and cyclists.

The paper [4] studies the role of objective and observable characteristics of pedestrian areas in relation to models of recreational walking in two neighbourhoods with opposite socio-economic statuses of residents. Research has shown that recreational walking can take place outside the proposed neighbourhood, when objective and particularly observed features of pedestrian areas are suitable.

The aim of the paper [5] was to investigate the relationship between pedestrian injuries and the socioeconomic characteristics of the population. Research has shown that pedestrian accidents are 4 times more common in low-income neighbourhoods, and that neither the age of the population, the level of education, the knowledge of the English language, nor the population density explain such a result.

The aim of the paper [6] was to investigate the importance of socio-economic factors, road characteristics and other factors in explaining the probability that a pedestrian will be fatally injured after participating in a traffic accident. Although the paper does not prove that the socio-economic environment at the neighbourhood level plays a statistically significant role, many other attributes play a statistically and numerically significant role in increasing the chances of pedestrians being seriously injured or fatally injured when hit by a motor vehicle.

A study conducted in [7] through cognitive-psychological variables, such as risk assessment, self-efficacy, and demographic variables, compared the attitudes and behaviour of older pedestrians in a city with higher socioeconomic opportunities (Tel Aviv) with a city with lower socioeconomic opportunities (Beer Sheva).

Pedestrians in a city with higher socioeconomic opportunities demonstrate safer road crossing patterns than in a city with lower socioeconomic opportunities. Also, elderly pedestrians have safer crossing patterns than younger pedestrians. The interaction of location and age was found due to a larger gap of safe behaviour of elder and young pedestrians in a city with higher standards than in a city with a lower one. In Tel Aviv, the elderly follow the rules much more than the young, while in Beer Sheva, the elderly and the young are almost similar in their patterns when moving across pedestrian crossings. Additional research has shown that older people in Tel Aviv have a greater awareness of road risk factors and their limitations as older people. Moreover, older pedestrians in Beer Sheva, compared to those in Tel Aviv, estimated a greater ability of their own to cross the streets safely.

The paper [8] assesses the role of socio-economic factors and the environment in the safety of children in road traffic. The paper used logistic regression for data analysis (socio-economic and social characteristics of children and parents) to identify characteristics associated with a particular type of accident.

Paper [9] presents the development and evaluation of a model for estimating pedestrian flow based on pedestrian activities (high and low). The results, in general, show that the size of the pedestrian flow varied depending on the level of activity. Estimates from the model could be used in transportation planning, safety, and operational analysis.

The purpose of paper [10] was to analyse the characteristics of pedestrian accidents in Clark County, NV, and to determine whether there is a significant association between pedestrian accidents and socioeconomic magnitudes. Significant predictors of pedestrian accidents by neighbourhoods were, percentage of Hispanics, middle age, median household income, and population density. The general conclusion of the paper is that pedestrian traffic accidents are an obstacle to physical activity, and efforts need to be made to reduce them. Solutions can positively affect physical activity and mobility.

A methodology for pedestrian traffic accident analysis that combines Geographic Information System (GIS) methods and statistical analysis to study the impact of socioeconomic and demographic factors on the frequency of traffic accidents is presented in [11]. Calculations derived from traffic accident density and statistical modelling are relatively identical in the sense that the possibility of owning a personal vehicle in the household was a factor influencing the frequency of pedestrian accidents. The results of this paper can help implement proactive strategies to increase pedestrian safety.

The paper [12] developed a new and easily calculated measure of pedestrian friendliness for urban neighbourhoods that makes the best use of available data, and also addresses issues concerning other models used. The results fully coincide with the expectation of pedestrian friendliness in different parts of the city. Possible extensions are also listed, and the measure could be improved if more types of data are available.

3 METHODOLOGY OF DATA PREPARATION

The data collection methodology consisted of three components. The first component was the determination of a representative sample. A representative sample was determined through the number of inhabitants of the City of Zagreb who use walking or cycling on a daily basis. In accordance with the available data on the modal split for the area of the City of Zagreb, the number of 300,000 inhabitants who walk or cycle on a daily basis is estimated.

The sample size was determined with a confidence level of 95% and a confidence interval of 6%. By further calculation, a minimum number of 267 subjects was obtained. The data collected by field research and their processing in the software tool MS Excel served as a basis for determining the general characteristics of the respondents.

Data collection was performed in two ways:

- Field survey research;
- Online survey form.

Data collected by field research were collected in city centres at several selected locations. The locations of the survey research were selected based on the research, and the assessment of the main attractors of walking and biking trips. Data collection was carried out throughout the day, in several different time periods, with a focus on peak hours (morning, afternoon).

Source: Authors

Figure 1: Example of a survey questionnaire

The selection of respondents was done by random selection, respecting the rule of the largest possible distribution of respondents. The survey was conducted by members of the Department of Urban Transport of the Faculty of Transport and Traffic Sciences together with colleagues from the association "Cyclists' Union". An example of the cover page of an online form is shown in Figure 1.

The interviewers would randomly approach pedestrians and cyclists and conduct a survey through a pleasant conversation. The respondents were selected according to the normal distribution in order to include as many people with different characteristics (gender, age) as possible, but with the retention of the largest group of respondents.

Data collection using an online form was done through social networks, various media, sharing with various available stakeholders (depending on the city), and personal contacts and acquaintances. The involvement of several different stakeholders in the cities made it possible to fill in the online form for the wider population.

Through field survey research and filling out online forms, 277 completed valid survey questionnaires were collected and distributed equally according to the collection locations. The survey was conducted from June 2019 to February 2020. Such a long period of time made it possible to cover the tourist and school seasons. By comparing the calculated minimum required sample of 267 and the collected surveys of 277, it can be concluded that the relevant sample was met.

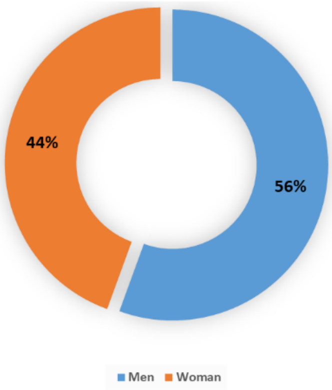
Data processing was performed in the MS Excel software tool for each individual question from the survey questionnaire. The data seen in the next section in the graphs are shown in relative terms.

4 RESEARCH RESULTS

General Characteristics of the respondents were determined through a survey. During the research, the following categories of respondents were identified in accordance with their general characteristics:

1. Gender of respondents;
2. Age structure of respondents;
3. Possession of the driving license;
4. Occupation of the respondents;
5. Used forms of travel;
6. Frequency of using a particular travel mode.

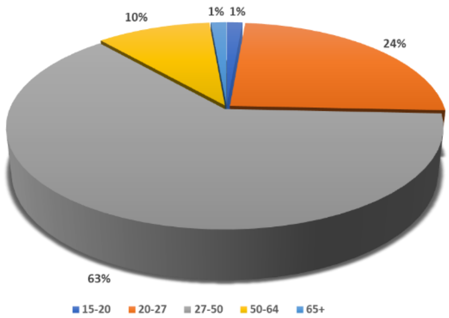
The first four describe the general characteristics of the respondents, while the last two refers to the used mode of travel (during a typical working day) and demonstrates the impact of general characteristics on the mobility of the respondents.



Source: Authors

Figure 2: Distribution of respondents by gender

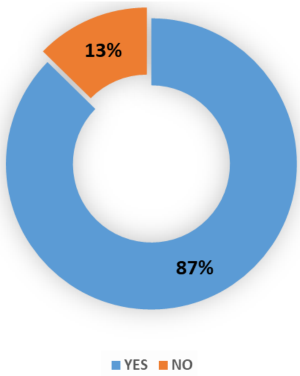
Figure 2 shows the gender distribution of respondents of whom males are represented with a slightly larger sample (56%). Such a relationship shows an almost equal distribution of males and females thus reducing the possibility of influencing the end results. Also, such a distribution shows that a slightly larger number of men walk or cycle, but again there is no significant difference that would demonstrate a certain impact.



Source: Authors

Figure 3: Distribution of respondents by age

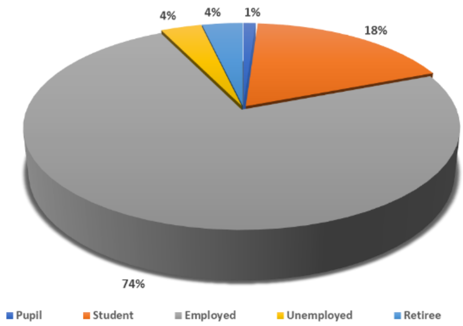
Figure 3 shows the distribution of respondents according to age structure. It can be seen from the presentation that the largest number of respondents is between 27 - 50 years of age, while of the other age structures, the most represented are the age groups of 50 - 65 and 20 - 27 years of age. Such representation of the age structure corresponds to the general age structure of the population. Additional reasons for such distribution is that the most represented group has the largest age interval, and this group includes people who travel the most experientially (equal number of obligatory and voluntary activities).



Source: Authors

Figure 4: Possession of a valid driver's license

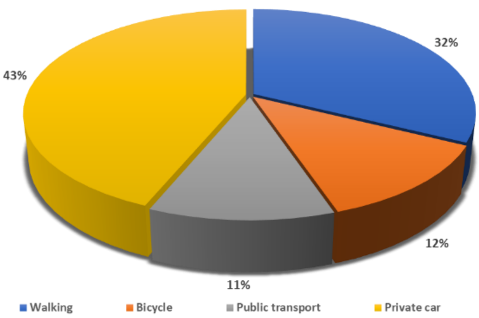
Figure 4. shows the possession of a valid driver’s license by the respondents. If we consider the comparison with the age structure, where 5% of respondents are under 20 and 21% under 27 years of age, it can be concluded that the vast majority of respondents have a valid driver's license and should be fully aware of this. with traffic rules and regulations.



Source: Authors

Figure 5: Distribution of respondents by occupation

Figure 5 shows the structure of respondents by occupation. The representation of employed respondents of 70%, and students of 15%, shows that the largest number of pedestrians and cyclists are persons who have a higher number of activities, compared to persons without compulsory activities.



Source: Authors

Figure 6: Modal split distribution of respondents

Figure 6 shows the frequency of using a particular form of travel mode. Large percentages of infrequent or no use of trains, ferries, motorcycles and e-scooters can be justified through research sites in city centres where short-distance travel is more dominant. Also, a small share of e-scooters is implied due to the relatively new form of micro-transport that has not yet expanded. The high representation of approximately 44% of pedestrians and cyclists in everyday travel is understandable through the very essence of the research and the focus on non-motorized road users. However, a large share of passenger car travel (43%) is visible, as well as a very low share (11%) of the use of public transport in the area of the centre of the City of Zagreb.

From the above, it can be established that there is a very high dependence of residents on car travel, especially because the respondents were pedestrians or cyclists during the survey. The share of non-motorized forms of travel of 44%, and the share of public transport of 11% shows a negative situation in terms of the use of sustainable forms of transport. Such a modal split roughly corresponds to the existing research on modal distribution both in the city of Zagreb and in other cities of the Republic of Croatia.

5 DISCUSSION

Determining the general characteristics of non-motorized traffic in the City of Zagreb through a representative sample showed the following data. Pedestrians and cyclists who travel through the area of the centre of the city of Zagreb, correspond to the general structure of the population according to age distribution, distribution of employment and possession of a driver's license. Age distribution, and distribution by occupation, show that the largest number of pedestrians and cyclists belong to the category of younger and middle age groups. These groups are characterized by the largest number of obligations, but also opportunities for social and / or recreational activities.

Regarding the possession of a driver's license, 87% of respondents stated that they do own one. If the influence of persons under the age of 20 is deducted from this number, it can be concluded that over 90% of respondents have basic knowledge of safety, regulations and behaviour in traffic. A larger number of male respondents can be justified by several reasons that were not part of the study, but the difference between respondents by gender is not significant. From the above, it is possible to conclude that there is a slightly higher proportion of men than women who travel by non-motorized forms of transport.

Modal split, characteristic of one typical working day obtained by the research, shows similar results to those of the existing research. Also, the modal split shows how people who walk or cycle use a personal car as their primary means of transportation, while they choose walking or cycling as an alternative form of travel. General characteristics demonstrate an increase in the use of non-motorized traffic (walking and / or cycling) only in the case of inability to use a car as the primary means of transport.

If a car is available to people, in most cases the person will choose a car as the primary means of transport.

6 CONCUSION

A study of the characteristics and modal distribution of non-motorized road users has shown results that greatly affect the safety of pedestrians and cyclists. The survey was conducted in the area of the centre of the City of Zagreb, where a relevant sample of respondents was collected. The relevant sample of respondents according to the processed data and demonstrated distributions shows a great similarity with the distributions of the general population. The structure of the respondents corresponded to the general population where the majority of respondents were between 20 - 50 years of age, with 70% of respondents being employed.

Analysis of travel mode selection data showed a significant share of passenger car use (43%), with a share of public passenger transport of 11%, regardless of the fact that the respondents were pedestrians and cyclists at the time. The influence of the general characteristics of the respondents is manifested through the possibility or impossibility of using a personal car. If a person has the opportunity to use a personal car through the possession of a driver's license, health or secured financial income, the person will in most cases choose a personal car as a means of travel.

If a person does not have the option of choosing a personal car, if his health, distance to the destination of the trip, and weather conditions allow walking or cycling, the person will travel as a participant in non-motorized traffic.

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RETURN FLOWS IN HOME DELIVERY

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ABSTRACT

Due to the development of e-commerce, the number of home deliveries, as well as the return flows of goods, packaging and logistics units, is increasing. Return flows require complex organization, high costs and affect the volume of transport and harmful emissions. Also, the realization of return flows affects the level of service, customer satisfaction and loyalty, choice of retailer, sales of goods and competitiveness in the market. Therefore, designing efficient return flow processes is very important. This paper describes the factors that affect the characteristics of the return flows of goods, and performs the structuring and classification of flows according to different criteria. The basic characteristics of the return flows of packaging and logistics units used in home delivery will also be described.

Keywords: Return flows, home delivery, e-commerce, characteristics, structuring

1 INTRODUCTION

In recent decades, the number of e-retailers has been growing, and traditional retailers are increasingly expanding their business to an online channel, developing the concept of "click & mortar" retailers, multichannel and omnichannel (Hübner et al., 2016b). The development of the Internet and e-commerce has significantly affected the relationship between companies and customers, so more and more companies offer home delivery service (Morganti et al., 2014; Gevaers et al., 2009). Home delivery is the delivery of goods to a home address or other location of the customer's choice, made by companies rather than by customer (Browne et al., 2001). The growth of delivery services is transforming the supply of households, as well as the structure and characteristics of flows, primarily in urban areas and their residential areas.

With the expansion of e-commerce and delivery services, the number of returns, i.e. flows of goods, packaging and logistics units that take place in the reverse direction, is growing (JDA & Centiro, 2017). Return flows of goods are primarily related to the delivery of non-food goods, and return flows of packaging and logistics units for the delivery of food goods. Like delivery, return flows at the end of the supply chain require complex organization and generate high costs (Vanelslander et al., 2013), which can disturb the economic viability of e-commerce (Agatz et al., 2008). Also, the realization of return flows contributes to the increase in the volume of transport and harmful emissions (Edwards et al., 2009). On the other hand, return policy affects the level of service (Gevaers et al., 2009), customer satisfaction and loyalty (Ramanathan, 2011), choosing the right retailer and selling goods and is considered an important factor of market competitiveness (Mukhopadhyay & Setoputro, 2004). According to research, the number of customers satisfied with the realization of return flows (about 67%) is less than the number of customers satisfied with delivery (87.7%), but changes year in year out (IMRG, 2019). Also, a large number of customers change retailers due to bad experiences with the realization of return flows (JDA & Centiro, 2017). Therefore, designing efficient return flow processes is extremely important (Min et al., 2006).

In the context of goods return flows, returnability refers to the ease of returning goods with which customers are not satisfied and the network's ability to process such returns (Chopra, 2003). When ordering online, the customer does not have a complete and direct insight into the characteristics of the goods, so he can be delivered goods that do not match the type, quality or quantity of the ordered goods, which causes his dissatisfaction. The rate of return of goods ordered online is significantly higher than in the case of in-store sales (Vlachos & Dekker, 2003; Fernie & McKinnon, 2009) and can reach as much as 75% (Mostard & Teunter, 2006). In addition to dissatisfaction and the customer's decision to return the product, return flows can be generated by unsuccessful delivery due to the customer's absence and inability to make unattended delivery (using mailbox, reception box, delivery to the neighbor's household, etc.).

In addition to the goods returned from the place of consumption, i.e. the home address, the return flows may consist of packaging and logistics units. These return flows are usually integrated with regular scheduled food deliveries. In the past, milk deliveries have generated return flows of reusable packaging, and in recent years an increasing number of supermarkets have been delivering groceries, which also generate return flows of packaging and delivery boxes.

In recent decades, return logistics has attracted the attention of a large number of researchers. Two key themes of the papers are network optimization (Niknejad & Petrovic, 2014; Alumur et al., 2012; Min et al., 2006) and return flow management processes (Genchev et al., 2011; Stock & Mulki, 2009; Mollenkopf et al., 2007). Return flows in e-commerce have been analyzed in numerous papers (Mukhopadhyay & Setoputro, 2004; XiaoYan et al., 2012; Bernon et al., 2016). Several papers deal with the application of a new crowdsourcing concept in the realization of return flows in e-commerce (Pan et al., 2015). Although goods ordered via e-commerce are often delivered to the home address, they can also be delivered by the customer ("click & collect"), which affects the characteristics of return flows. Therefore, these papers do not always explicitly address the characteristics of return flows generated by home delivery. On the other hand, return flows are analyzed in the literature on home delivery, but in insufficient detail and only within research of wider coverage (Morganti et al., 2014; Browne et al., 2001), and papers that are fully dedicated to this topic does not yet exist.

This paper contains an analysis of the basic characteristics of return flows of goods delivered to the home address and the factors that affect their realization, and the structuring and classification of flows according to different criteria. Also, the characteristics of the return flows of packaging and logistics units used in home delivery will be described. The main goal and contribution of the paper is to get acquainted with the characteristics of return flows generated by home deliveries, as well as to create a basis for future research in this area, which is insufficiently researched.

The paper is organized as follows. After the introduction, the second chapter will describe the basic characteristics and dependence of return flows in delivery on various factors. In the third chapter, the structuring and classification of return flows according to different criteria will be performed. The fourth chapter will analyze the return flows of packaging and logistics units used in home delivery. Finally, conclusions and directions of future research are given.

2 FACTORS INFLUENCING THE CHARACTERISTICS OF THE RETURN FLOWS OF GOODS

Characteristics, complexity of return flow organization and return rate depend on ordering system and sales channel, delivery characteristics (starting and end point, reception method, safety, delivery time and speed, additional services, etc.), type and characteristics of goods, cost of return, etc. In the following, the dependence of the characteristics of the return flows on the mentioned factors will be analyzed.

Ordering goods for home delivery can be done in person or remotely (Browne et al., 2001). Nowadays, the dominant system of ordering goods for delivery is online ordering, and a significantly lower percentage of deliveries are generated by other forms of remote ordering (ordering by mail, telephone, fax, etc.) and in-person ordering. The ordering system is interconnected with ***sales channels***. With the development of the Internet, an increasing number of retailers are realizing exclusively online sales, and traditional retailers are expanding their business from a physical to an online channel. In this way, the concepts of multichannel and omnichannel are developed. Multichannel involves the parallel operation of logistics systems for physical and online channels, without mutual operational coordination, exchange of goods or other forms of channel integration (Beck & Rygl, 2015; Hübner et al., 2016b). In this case, the customer can order goods for delivery only online, and on the physical channel he personally picks and delivers the goods to the household. With channel integration, the multichannel evolves into a new form of sales channel organization called the omnichannel (Piotrowicz & Cuthbertson, 2014). In omnichannel sales, neither the customer nor the retailer distinguishes between channels (Verhoef et al., 2015) and channels represent a unique structure that allows online orders to be processed in physical stores, as well as goods ordered in store to be delivered to the customer's location. (Hübner et al., 2016b). Sales channel and the ordering system affect the characteristics of realization of return flows and return rate. Online and multichannel retailers have a higher number of returns, because customers do not have a direct and complete insight into the characteristics of goods when ordering remotely (Bernon et al., 2016; Agatz et al., 2008; Wood, 2001). Therefore, some e-retailers are opening facilities where users can get information about the goods or test/try them, and where no sales are made (Visser et al., 2014). This practice is called "offline to online" and can reduce the number of returns. The number of returns can also be reduced by applying omnichannel sales (Bernon et al., 2016). Also, the concept of omnichannel enables the sale of returned goods on the physical channel.

Delivery characteristics significantly affect the realization of return flows. The distribution infrastructure for deliveries is most often used for the realization of return flows, so the end point of the return flow usually coincides with the starting point of delivery (store, logistics center, location of the manufacturer). As the distance of the customer from the end point of the return flow increases, the complexity and costs of realization increase, due to which the number of returns decreases (Lim et al., 2018). The goods are rarely returned directly to the manufacturer, because they are usually the furthest from the customer. On the other hand, the return rate is highest with retailers with a dense network of stores or collection and delivery points (CDPs) that accept returned goods. Also, the end point of delivery and the method of receipt of goods affect return rate, time and way of realization of return flows. The end point of delivery can be home address, neighbor's household, customer's workplace, CDP, etc. Receipt of goods can be realized in the presence (attended delivery) or without the presence of the customer (unattended delivery, using a mailbox, receiving box, accessing to the facility etc.). When the goods are delivered to the home address in the presence of the customer, he can check the characteristics and correctness of the goods and make any complaints to the supplier, which usually simplifies the realization of return flows (Hübner et al., 2016a). On the other hand, the customer does not have insight into the characteristics of the goods at the time of delivery to other points (neighbor's household, workplace, CDP, etc.) and unattended delivery, which affects the time and complexity of return flows. The safety of the goods in delivery is crucial for preserving their quality, correctness and integrity and reducing returns due to damage. Therefore, it is necessary to ensure adequate handling, packaging and transport of goods. Delivery time and speed have an impact on the return rate, as delivery delays increase the likelihood of returns (Xing & Grant, 2006). Additional services provided by some suppliers may also affect return rate (Agatz et al., 2008). Thus, the services of assembling and locating furniture in the customer's home and installing electronic products can reduce the number of returns.

The type of goods is one of the key factors influencing the level of return rate and the characteristics of return flows. Some types of goods, due to their characteristics, are very rarely or never returned to the retailer (perishable, time-sensitive, goods produced according to the customer's wishes, etc.) (Browne et al., 2001). According to research, return rate of food products delivered to a home address is less than 1% (Hübner et al., 2016a). The return rate is significantly higher for non-food goods (usually 25-30%; Edwards et al., 2009), but it depends on the type, dimensions and value of the goods. Furniture, white goods and other goods of large dimensions and value have the lowest return rate, because they are most often ordered in person in stores (Visser et al., 2014), where the customer has a complete insight into the characteristics of the goods. Also, the specific logistical demands that generate the physical characteristics of the goods affect the complexity of the realization of flows and increase costs, which can deter customers from returning. Goods of smaller dimensions and value (books, clothes, shoes, etc.) are returned to the retailer much more often (Browne et al., 2001). The return rate is highest when delivering clothes. On average, it is twice as high as the return rate in traditional retail (Bernon et al., 2016), and can reach as much as 45% (Agatz et al., 2008).

The cost of return also affects the massiveness of return flows. When returns are free, customers often order more clothes than they need to try them on (Morganti et al., 2014), which increases the number of returns and the complexity of their organization. For these reasons, traders are increasingly charging for returns (Bernon et al., 2016).

3 STRUCTURING RETURN FLOWS OF GOODS

Return flows of goods delivered to the home address can be structured according to different criteria: cause and time of realization, executor, integration with deliveries, end point, etc. (Figure 1). Although they have not been the subject of research so far, these criteria and their interdependence have a decisive influence on the way of realization of return flows and comprehensively represent their heterogeneity and complexity. Therefore, the classifications of return flows according to these criteria will be described below.

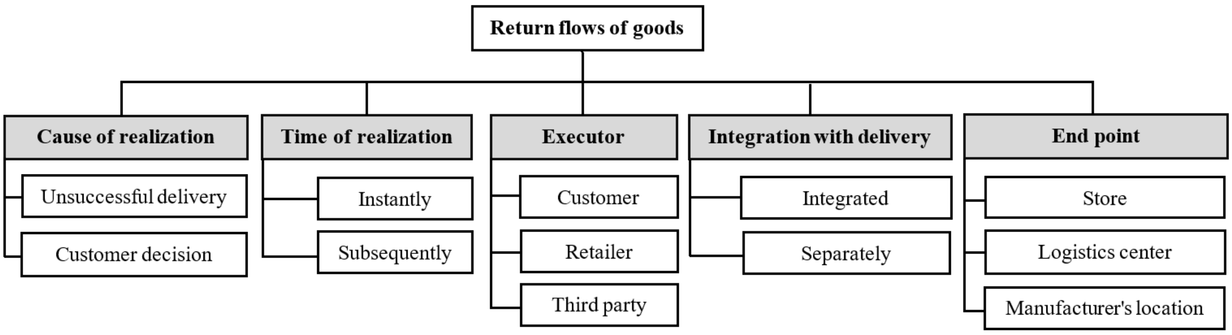

Figure 1: Structuring return flows in home delivery

The causes of the realization of return flows can be different. They are realized due to the unsuccessful delivery or the customer decision to return the goods. Unsuccessful delivery is most often caused by the absence of the customer (“not at home” syndrome) and the inability to receive goods without presence (unattended reception). If the customer is not at the home address at the time of delivery, and it is not possible to realize any form of unattended delivery (using reception box, accessing to the facility, delivery to a neighbor or CDP, etc.; McKinnon & Tallam, 2003) delivery must be canceled or delayed, which generates return flows. Also, the customer can decide to return the received goods. As reasons for the return of goods, customers state the following: goods do not meet expectations (43%), damage to goods (27%), change of customer's decision (the customer bought the goods, but in the meantime decided not to receive them; 7.5%) and rejection of inappropriate alternatives (customer orders several alternatives with the intention of returning inappropriate ones; 15%) (JDA & Centiro, 2017).

Return flows also differ from the aspect of ***realization time***. There are instant and subsequent returns. In the first case, the customer is absent or refuses to receive the goods, so the supplier realizes a return with the same vehicle immediately after delivery. In the second case, the customer receives the goods and subsequently makes a decision to return the goods. The time, but also the complexity of the organization and return rate depend on the type of goods, the end point of delivery and the method of receipt. Food deliveries very rarely generate returns, which are most often instant (Hübner et al., 2016a), while non-food items generate instant and subsequent returns much more often. When delivered to the home address in the presence of the customer, instant returns are usually realized, because the customer can check the characteristics and correctness of the goods and make complaints to the supplier. On the other hand, deliveries to other points (neighbor's household, workplace, CDP, etc.) or unattended deliveries generate a smaller number of current (Fernie & McKinnon, 2009), but a larger number of subsequent returns. The deadline within which the return can be made is usually determined by the retailers, but it can also be defined by law (Browne et al., 2001).

Return flows can be realized by customers, retailers or a third party (logistics service provider, crowd-worker). The choice of the ***return flow executor*** depends on the cause and time of realization, service and infrastructure of the retailer, contractual obligations of the retailer and the customer, integration with delivery, delivery executor, etc. The largest number of returns in e-commerce is realized by the customer, delivering products to store or dedicated return facilities (Bernon et al., 2016). However, this does not only include the returns of goods delivered to the home address, but also those that the customer delivered independently ("click & collect"). In the contract with the retailer, the customer can undertake to independently make a possible return of the goods or pay its costs (Browne et al., 2001). The customer usually realizes subsequent returns, due to dissatisfaction, damage to the goods, changes in the purchase decision, etc. The key factors for the successful realization of return flows for customers are the ease of return and the number of points at which they can be realized (Bernon et al., 2016). Therefore, the realization of return flows by the customer is particularly suitable for "click & mortar" retailers, who have an extensive network of stores near customers (Edwards et al., 2009). Also, customers can return the goods to the CDP, from where the retailer ship them to the end point of the return flow. Some retailers include a complete return flow organization in the delivery service, which is free or paid for by the customer (Browne et al., 2001). Retailers realize instant and subsequent returns, trying to integrate them with deliveries. This concept is very attractive to customers, but requires higher costs than returning goods to stores by customers (Chopra, 2003). The customer or retailer can also hire a logistics service provider (courier, express and parcel services - CEP, postal operators, etc.) (Hübner et al., 2016a) or a crowd-worker (Pan et al., 2015) to realize the return flows. According to research, when choosing a logistics provider, half of the customers opt for CEP and half for postal operators (Edwards et al., 2009). CEPs are the most common executors of return flows of non-food goods, and their engagement for the return of food goods is most often limited by law due to specific logistical demands (Hübner et al., 2016a). Postal operators are also engaged in the return of non-food goods, usually small in size. The lack of the postal operator service is the impossibility of tracking and visibility of goods in the system due to the lack of integration of the system of the operator and the retailer (Bernon et al., 2016). Crowdsourcing is a new concept in logistics, which implies outsourcing logistics tasks to individuals, who perform them with the help of their own resources (means of transport, household storage space, transshipment resources, etc.) (Tadić & Veljović, 2020; Carbone et al., 2017). Crowd-workers can also be engaged in the realization of return flows, which can significantly affect the reduction of negative economic, environmental and social impacts caused by the traditional way of realization of returns (Pan et al., 2015). Also, retailers often use a hybrid strategy to offer customers a wider choice. Thus, some companies allow that customers return goods in stores, but also through CEP and postal operators (Bernon et al., 2016). In these companies, about half of the returns are realized by the customers themselves, delivering the goods to the stores, and the rest is realized through logistics service providers (Edwards et al., 2009).

The realization of return flows largely depends on the ***integration with delivery***. Return flows can be integrated with deliveries or realized separately. Suppliers strive to integrate return flows with deliveries, as separate realization negatively affects the customer experience and the organization of return logistics (Bernon et al., 2016). CEPs are also increasingly integrating deliveries and return flows (Edwards et al., 2009). Return of goods is associated with its delivery (instant return) or other deliveries (subsequent return). Integration reduces the distance traveled and the number of empty journeys.

The distribution structure for deliveries is most often used for the realization of return flows. Therefore, the distribution network must be adapted to the realization of return flows. ***The end point*** of the return flow is the point where the returned goods are processed and usually coincides with the starting point of delivery, i.e. the location where the stocks are located. These can be the locations of the retailer (stores, logistics centers) or the manufacturer (De Koster, 2002). Return of goods to the end point can be realized directly or through CDPs. Retailers use CDPs to accelerate return handling (Yrjölä, 2001; Lim et al., 2018). Customers deliver goods to nearby CDPs, where they are grouped together, allowing for more efficient return flow to the end point. There are two types of CDPs, attended and unattended (Lim et al., 2018; Visser et al., 2014; McKinnon & Tallam, 2003). Shops with long working hours are most often used as attended CDPs (Gevaers et al., 2009). Retailers may use their own or third party facilities. Retailers with a small number of stores often use the stores of other retailers to accept returned goods, because they cover a much larger area (Bernon et al., 2016). However, in this way, the retailer can increase the turnover of competing companies at his own expense. Unattended CDPs are also used for returns (Vakulenko et al., 2018). Unattended CDPs are locations where automated receipt and storage of goods is performed until the moment the customer picks it up, using the order reference code.

The retailer can use stores or logistics centers to process the returned goods. Stores are most commonly used by "click & mortar" retailers, reducing infrastructure investment and return flow management costs (Agatz et al., 2008). Also, returned goods can be sold in the stores after processing. This concept is very suitable for customers (Johnson et al., 2005), but also for retailers, given the ease of realization of return flows. On the other hand, problems may arise in the acceptance and processing of returned goods, as stores are not designed and equipped for these operations (Chopra, 2003). Also, there may be an imbalance in inventory management due to the large amount of returned goods that the retailer cannot resell (Bernon et al., 2016). Listed disadvantages but also the advantages of this concept are not present in the application of logistics centers for the realization of returns. Retailer's logistics center from which the goods are delivered or a dedicated return logistics center can be the return end point (Morganti et al., 2014).

Analogous to the drop shipping concept used in delivery, the end point of return flows can be the location of the manufacturer or retailer's supplier/wholesaler. This concept is not efficient in most cases, requires high costs and complex flow coordination (Chopra, 2003), which is why it is rarely applied (Lim et al., 2018).

4 RETURN FLOWS OF PACKAGING AND LOGISTICS UNITS

In addition to goods, return flows in home deliveries may consist of packaging and logistics units. The deliveries can use reusable packaging made of glass, aluminum and stainless steel. Different logistics units can be used for home delivery, but since the quantity and volume of goods in delivery are usually small (Visser et al., 2014), pallets are used on rare occasions (delivery of furniture, construction materials, etc.), while miniload units are used much more often. The delivery/thermo box is a particularly important miniload unit for home delivery. It is an insulated secured box, which is equipped with a docking mechanism (Punakivi et al., 2001). Return flows are most often integrated with regular scheduled deliveries of consumer goods (mostly food). The supplier fills the packaging in his premises, packs it in a delivery box, which he delivers and hands over to the customer, or attaches it to the outer wall in case of customer absence (McKinnon & Tallam, 2003). On that occasion, he takes over the box from the previous delivery and realizes its return. In this way, milk delivery and packaging return flows have been realized in the past, and in recent years supermarkets have increasingly used delivery boxes for regular scheduled food delivery.

5 CONCLUSION

Return flows of goods generated by home deliveries can be realized for various reasons (unsuccessful delivery, customer dissatisfaction with the goods, etc.), and their characteristics, complexity of the organization and return rate depend on various factors (sales channels, delivery characteristics, type of goods, etc.). The efficiency of the realization of return flows is very important for the satisfaction and loyalty of customers and the competitiveness of retailers.

In addition to goods, return flows can consist of packaging and logistics units. Of particular importance are reusable packaging and delivery boxes used for regular scheduled food deliveries. In order to reduce costs and the number of empty journeys, these return flows are usually integrated with deliveries.

This paper contains an analysis of the basic characteristics of return flows of goods generated by home delivery and the factors that affect their realization, and the structuring and classification of flows according to different criteria. Also, the characteristics of the return flows of packaging and logistics units used in home delivery are described. This achieved the basic goal and contribution of the paper. In addition, the contribution of the paper is to create a basis for future research in this area, which is insufficiently researched. In future research, attention should be paid to certain processes that take place during or after the return of goods (transport, acceptance and processing, storage, etc.) and options for managing returned goods (recycling, destruction, resale, etc.). Methods of reducing the return rate may also be the subject of future research. Also, the focus of the researcher's attention may be on the possibilities of integrating returns with other flows realized by retailers and customers.

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REVENUE AND COSTS ALLOCATION FOR COMMUNAL AND OTHER SERVICES – CASE STUDY OF THE CITY OF SUBOTICA

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ABSTRACT

The past three decades have witnessed many different regulatory and institutional reforms in urban public transport (UPT) systems. The main goal of these changes was to deliver a higher level of quality of transport services, through ensuring cost-efficient service delivery, reducing subsidies and minimizing negative environmental impacts. To successfully achieve this goal it is necessary to specify thoroughly all of the obligations, rights and risks that can be produced within and outside the system. The City of Subotica is one of the few municipalities in the Republic of Serbia with a model of regulated monopoly in UPT. In 2014, all urban and suburban transport services were entrusted to the public transport company within a public service contract, for a period of 6 years. This is a typical gross cost contract, i.e. the revenue risk is born by the authority and the production risk is allocated to the operator. However, the operator bears a certain level of difference between the total contracted cost of production of the transport service and the realized revenue, which varied between 50% - 20% as defined by the annexes to the contract. Moreover, the public transport company operates other services (mainly intercity lines) and suburban passengers may use these lines for their suburban trips.
This paper presents a modified gross cost contract in UPT which includes transport work for suburban passengers on other lines in the total contracted transport service. The authors defined an original model for cost allocation for communal and other services for the public transport company. To calculate subsidies, the total revenue for the communal services includes all types of suburban fares that are realized on other lines.

Keywords: Urban Public Transport, Public service contract, Risk allocation, Cost allocation.

1 INTRODUCTION

The public transport system represents one of the most significant city subsystems and one of the most important communal activities. In order to organize the system, it is requisite to clearly define the rights, obligations and risks of each of contracting parties, i.e. the city as the transport market owner and the operator.

Based on the payment model, there are two most important types of fixed-price contracts: gross cost contracts and net cost contracts. In the Gross cost contract model, the entire fare revenue is collected by the city authority and the operator(s) is paid a specified amount to provide the specified service for a certain period. Under the Net Cost model the operator has two sources of income: the commercial revenue from the service usage and a fixed transfer from the regulator. This means that any change in transport demand affects the operator's profit [1].

The choice of the contract type depends on the system structure (i.e. network characteristics), its performance and costs on the one hand, and on the other side on the division of risk between the parties, as well as the possible need for additional incentives that would help achieving the system target function [1]. Other studies are based on the assumption that the type of contract is exogenous [2-5]. Furthermore, Gagnepain and Ivaldi stated that the type of contract was often determined by political motives, rather than economic ones [6]. This could be said to be a common practice in Serbian cities, as a result of their public monopoly contracts' origins and unstable transport market.

One should not overlook the fact that under a net-cost contract the operator has to forecast his cost, revenue and risk over the entire concession period [7]. The main motive for using a net cost contract would therefore be that it incentivises the operator to contribute to marketing and to generate additional passengers [8]. However, it is hard to find these contract types in a completely "clean" form, because they are usually modified to better comply with the system needs.

The subject of this paper is the public transport system in the city of Subotica, i.e. models for cost allocation and revenue collection within this system.

The aim of the paper is to present models for cost allocation and revenue collection, i.e. cost and revenue allocation and distribution to communal and other activities.

The paper consist of the following chapters: the first chapter presents the main characteristics of the public transport system in Subotica, i.e. the characteristics of the transportation network, vehicles, number of transported passengers and transport work. The second chapter contains the cost allocation model with the aim of determining the participation ratio of the communal service and calculating its value. The third chapter provides the revenue collection model with the calculation of the unit costs of the production of transport work. Finally, concluding remarks are provided at the end of the paper.

2 THE DESCRIPTION OF THE SYSTEM

The public transport system in Subotica is represented by one operator, the public company JP "SUBOTICA-TRANS". In 2014, the city entrusted all passenger transport services to this company on the basis of the "Contract on regulating rights and obligations of the city of Subotica and JP "SUBOTICA-TRANS" in performing the communal service of the urban and suburban public transport in the area of the city of Subotica". The contract is classified as a gross cost contract on the production of gross transport service according to which the risk of the production of the transport service is borne by the operator (JP "SUBOTICA-TRANS"), while the revenue risk is allocated to the city of Subotica. The contract was signed for the period of 6 years. In addition to managing the urban and suburban public transport, JP "SUBOTICA-TRANS" also operates as an intercity transport company, which is defined as an economic activity by regulatory acts [9].

Table 1 shows the main indicators of the urban and suburban (communal activity) and intercity public transport. It should be underlined that out of 35 intercity lines maintained by JP "SUBOTICA-TRANS", as many as 26 lines (approximately 74%) contain the sections where the communal service of suburban transport is conducted.

Table 1: The main indicators of the public transport system

Indicator	Communal service		Intercity transport
	Urban transport	Suburban transport	
Operational length of lines (km)	217.8	5,236	N/A
Number of lines (-)	11	12	35
Number of departures (-)	422	245	110
Inventory number of vehicles (vehicles)	34	26	31
Number of transported passengers (passenger/year)	4,064,840	1,748,295	589,494
Gross transport work (vehicle km/year)	1,620,896	1,998,401	1,373,064

In 2012 the urban and suburban public transport system started to apply an electronic fare collection system which applies non-contact smart cards (non-personalized smart cards (the so-called electronic wallet) and personalized smart cards (personalized cards for passengers and other categories)) and paper cards. The income and expenditure analysis of the system determined that the business revenue structure is typical of the transport service with the subsidy share of around 14%. Notations used in paper are presented in Table 2.

Table 2: Some notations used in this paper

TRW_{com} - transport work for the communal activity
TRW_{oth} - transport work for other activities
$NTW_{p,l}$ – the net transport work for the transportation of suburban passengers (p) on the line (l)
Hr_{com} - total working hours for the communal activity
Hr_{oth} - total working hours for other activities
δ_{TRW} - the percentage share of the communal activity in the total planned vehicle kilometres
δ_{Hr} - the percentage share of the communal activity in the total working hours
α - weighted utility participation ratio of the communal activity
β - weighted utility participation ratio of other activities
Cd – direct cost
Ci –indirect cost
Cd_j - direct cost type j,
Ci_k – indirect cost type k,
τ - unit cost of the production of transport work
m – number of cost types
r – cost type
Rts – the operator's revenue from ticket selling
TR – total guaranteed revenue of the operator
Psu_l – number of transported suburban passengers on the line (l)

3 COST ALLOCATION MODEL

In order to create a basis for management and allocation of costs, it is requisite to conduct their classification. Most commonly, costs are divided into fixed, variable and additional (follow-on) costs. Fixed costs are not directly related to the volume of the vehicle operation and they involve the expenses of possessing a vehicle (depreciation, insurance), money costs, administrative expenses, employee earnings, costs of electricity, heating, licences, taxes, etc. Variable costs are directly related to the intensity of the vehicle operation. These are the costs of the driving energy, tyres, maintenance, etc.

Although the above-mentioned classification is coherent and related to the origin of costs, division of costs and revenues according to the activity type does not represent a simple task in the complex organizational and technological systems where resources (primarily vehicles and drivers, maintenance workers, other transportation personnel, logistics, energy) are used for performing the activities which are technologically very similar (urban, suburban and intercity passenger transport), but are differently regulated by legislation. Therefore, these models classify costs according to their place of origin into direct and indirect costs. Direct costs occur directly on vehicles and can be directly correlated with them. The direct costs included in the model are: the costs of basic materials – spare parts, tyre costs, fuel costs and depreciation costs. In order to correlate indirect costs with vehicles, certain number of allocation parameters is required. The model includes the total number of 47 indirect costs, with the costs related to the employee earnings being the most significant.

However, in the business systems with a large number of products and services, using only one of the parameters (e.g. total working hours) can lead to the error in cost allocation. Almost all costs originate from performing both activity types and require the allocation to the communal activity (urban and suburban public transport subsystems) and other activities. It is true that the total realized working hours represent the basic cause of most costs. However, certain costs, primarily costs of the driving energy, tyres, maintenance and similar, are predominantly caused by the realized transport work.

Therefore, the authors concluded that the cost allocation model had to be flexible in order to involve the minimum of two allocation parameters, as well as to allow its application for different time periods (day, month, year, etc). On the other hand, the model had to be simple to implement and adaptable to the changes in cost structure.

The proposed cost allocation model for communal and other activities consists of two parts – initial cost allocation and final cost allocation.

3.1 Initial cost allocation

The input data for the model are all costs of the business system, i.e. all realized costs borne by the system. The fist allocation is performed immediately after making the cost entries.

In the first step, for each cost C_r the allocation is conducted to communal and other activities. The allocation parameters are the total working hours (for communal and other activities) and total transport work expressed in vehicle kilometres (for communal and other activities). The percentage share of the activity in the total working hours and percentage share of the communal activity in the total planned vehicle kilometres are obtained according to the models:

$$\delta_{Hr} = \frac{Hr_{com}}{Hr_{com}+Hr_{oth}} \cdot 100\% \quad (1)$$

$$\delta_{TRW} = \frac{TRW_{com}}{TRW_{com}+TRW_{oth}} \cdot 100\% \quad (2)$$

The cost allocation uses the weighted utility participation ratio of the communal activity, which is obtained as the arithmetic mean of the previous ratios:

$$\alpha = \frac{\delta_{Hr}+\delta_{TRW}}{2} \quad (3)$$

The share of other activities is calculated by means of the weighted ratio:

$$\beta = 1 - \alpha \quad (4)$$

In the second step, the costs per each activity are calculated, using the weighted utility participation ratios. For a specific cost r the models are as follows:

$$C_{r,com} = C_r \cdot \alpha \ [EUR] \quad (5)$$

$$C_{r,oth} = C_r \cdot \beta \ [EUR] \quad (6)$$

The third step includes the calculation of the initial costs of the communal activity and the initial costs of other activities, according to the following models:

$$C_{com,in} = \sum_{r=1}^{m} C_{r,com} \ [EUR] \quad (7)$$

$$C_{oth,in} = \sum_{r=1}^{m} C_{r,oth} \ [EUR] \quad (8)$$

3.2 Final cost allocation

At the end of each month, cost allocation is repeated on the basis of the realization. The model is presented in the following figure.

In the first step, the costs are allocated to direct and indirect costs, while:

$$C = \sum_{r=1}^{m} C_r = Cd + Ci = \sum_{j=1}^{md} Cd_j + \sum_{k=1}^{mi} Ci_k \ [EUR] \quad (9)$$

In the second step, each of the direct costs is allocated according to its origin, i.e. the vehicle:

$$Cd_j = Cd_j^{UR} + Cd_j^{SU} + Cd_j^{OT} + Cd_j^{MIX} \ [EUR] \quad (10)$$

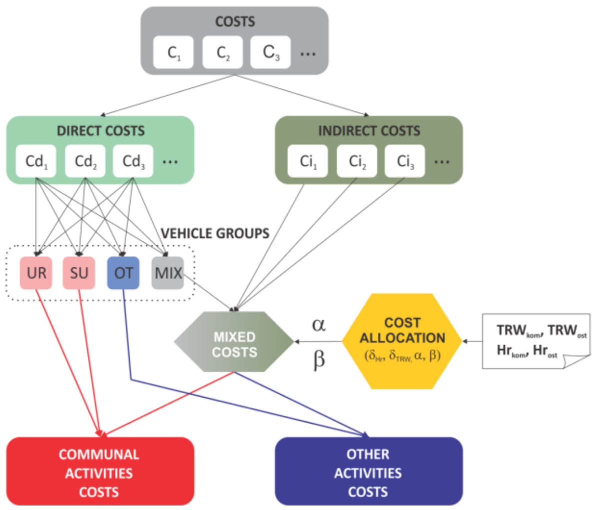

Figure 1: Cost allocation model – a graphic presentation

Vehicles are divided into groups according to the activity within which they operated during the observed time period for which the allocation is conducted. There are four vehicle types in JP "SUBOTICA-TRANS": vehicles which operated only in the urban subsystem (UR), vehicles which operated only in the suburban subsystem (SU), vehicles which operated only in other subsystems – activities (OT), and vehicles which operated in both communal and other services (MIX). The last vehicle group is the only group for which the direct cost allocation to communal and other activities has to be conducted by means of the cost allocation model. The remaining three costs can be allocated within the corresponding activity in which they were realized.

The third step includes the allocation of all indirect costs (C_{i_k}), as well as direct costs (Cd_j^{MIX}), for the group of vehicles which operated within both the communal and other activities (MIX). For a particular indirect cost of type k the models are as follows:

$$Ci_{k,kom} = Ci_k \cdot \alpha \ [EUR] \quad (11)$$

$$Ci_{k,ost} = Ci_k \cdot \beta \ [EUR] \quad (12)$$

Where α and β are weighted utility participation ratios for communal and other activities, respectively. If the observed month witnesses significant differences between the realized and planned values of the input calculation parameters (Hr_{com}, Hr_{oth}, TRW_{com} and TRW_{oth}), the calculation of the parameters α and β has to be repeated according to the pre-defined model.

The models for direct costs for the MIX group vehicles are similar:

$$Cd_{j,com}^{MIX} = Cd_j^{MIX} \cdot \alpha \ [EUR] \quad (13)$$

$$Cd_{j,oth}^{MIX} = Cd_j^{MIX} \cdot \beta \ [EUR] \quad (14)$$

The fifth step includes the final calculation of the total costs of the communal activities and the total costs of other activities according to the following models:

$$C_{com} = \sum_{k=1}^{mi} Ci_{k,com} + \sum_{j=1}^{md} Cd_{j,com}^{MIX} \ [EUR] \quad (15)$$

$$C_{oth} = \sum_{k=1}^{mi} Ci_{k,oth} + \sum_{j=1}^{md} Cd_{j,oth}^{MIX} \ [EUR] \quad (16)$$

Using the sample of available data for the year of 2018, the initial parameters of cost allocation were calculated. The input data for the calculations were: costs/expenses, gross transport work in vehicle kilometres in the communal and other activities and the effective and total working hours in the communal and other activities. The calculation results are provided in the following table.

Table 3: Initial input parameters for allocation

Parameter	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
$\boldsymbol{\delta_{Hr}}$	84.53	83.85	83.80	84.40	83.81	84.45	85.75	85.68	83.81	83.70	83.47	84.36	84.29
$\boldsymbol{\delta_{TRW}}$	69.35	66.64	66.99	62.95	61.07	63.52	69.32	65.98	66.04	65.38	67.29	69.51	66.05
$\boldsymbol{\alpha}$	76.94	75.24	75.40	73.67	72.44	73.98	77.54	75.83	74.93	74.54	75.38	76.94	75.17

The analysis of the obtained data about the actual system operation proposes the initial value of the parameter α=75.17% for the first allocation following the model introduction.

4 REVENUE COLLECTION MODEL

The total guaranteed revenue of the operator consists of selling all ticket types, collected penalty fares for passengers without a valid ticket and subsidies from the City budget (according to the contract on performing communal services of the urban and suburban passenger transport in the area of the city of Subotica).

The main reason for creating the model is dividing the revenue into the revenue realized by communal activities and the total revenue and defining their share. The revenue from ticket selling in communal services is realized by selling all types of tickets in the urban and suburban public transport subsystems. However, on certain suburban sections, passengers are transported using other lines, mostly the intercity ones. Therefore, the revenue from ticket selling in communal services should also include the revenue realized by selling all ticket types for the suburban transport on other lines, as well as the subsidies necessary for this type of communal service. The following text contains an improved model for calculating the guaranteed revenue of the operator from the communal activity. The structure of the model is presented in Figure 2.

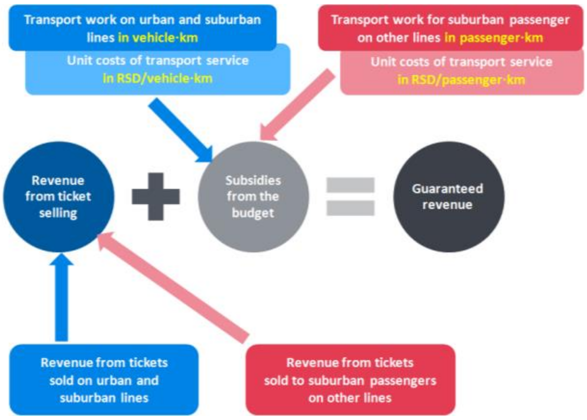

Figure 2: Structure of the revenue collection model

The total revenue of the operator from ticket selling is the sum of the income from selling all ticket types in the urban and suburban public transport system and the income from selling all ticket types in the suburban public transport realized on other lines:

$$Rts_{total} = Rts_{UT\&SU} + Rts_{SU/OTH}[EUR] \quad (17)$$

The total revenue from selling all ticket types in the suburban passenger transport realized on other lines is obtained as the sum of the revenue (price) of each ticket $PR_{p,l}$ sold to a passenger (p) on a suburban line (l), according to the model:

$$Rts_{SU/OTH} = \sum_{l=1}^{m} \sum_{p=1}^{Psu_l} PR_{p,l}, [EUR] \quad (18)$$

In order to calculate the subsidies of the City, the model for calculating the guaranteed revenue per realized gross transport work expressed in vehicle kilometres was used for the lines in the urban and suburban public transport, based on the valid timetable, according to the following model:

$$R_{UR\&SU} = \tau_{UR} \cdot TRW_{UR} + \tau_{SU} \cdot TRW_{SU}, [EUR] \quad (19)$$

The calculation of the unit costs of transport work (τ) was conducted for the characteristic line per each subsystem. The calculation was conducted on the basis of the analysis of the complete system and available data (transport work, vehicle fleet, timetables, economic and operational indicators). The estimated unit costs of the production of transport work for the urban and suburban public transport system in Subotica amount to:

- for the characteristic line of the urban transport subsystem – 1.38 EUR/km,
- for the characteristic line of the suburban transport subsystem – 1.26 EUR/km.

The realized transport work for transporting suburban passengers on other lines was balanced according to the realized net transport work expressed in passenger·km. The total realized transport work for transporting suburban passengers on other lines is obtained as the sum of the transport work for each suburban passenger (p) on the line (l), according to the model:

$$NTW_{SU/OTH} = \sum_{l=1}^{m} \sum_{p=1}^{Psu_l} NTW_{p,l}, [passenger \cdot km] \quad (20)$$

The unit costs of the production of transport work for transporting suburban passengers on other lines ($\tau_{SU/OTH}$) according to passenger·km equal the ratio of revenue and total net transport work on all suburban lines:

$$\tau_{SU/OTH} = \frac{R_{SU}}{NTW_{SU}}, [\frac{EUR}{passenger \cdot km}] \quad (21)$$

The unit costs of the production of transport work for transporting suburban passengers on other lines ($\tau_{SU/OTH}$) were calculated on the basis of the following input data: number of transported passengers in the system in 2018, the realized gross transport work in the system in 2018, the proposed (new) unit cost of the production of the transport service and the mean driving length in the suburban transport (the research was conducted in 2009).

The obtained value was:

$$\tau_{SU/OTH} = 0.087 \frac{EUR}{passenger \cdot km}.$$

The total operator's revenue from the production of transport work for transporting suburban passengers on other lines ($R_{SU/OTH}$) is obtained as the multiplication product of the unit cost of the transportation of suburban passengers on other lines ($\tau_{SU/OTH}$) and the net realized transport work ($NTW_{SU/OTH}$), according to the equation:

$$R_{SU/OTH} = \tau_{SU/OTH} \cdot NTW_{SU/OTH,}[EUR] \quad (22)$$

The total guaranteed revenue of the operator is the sum of the revenue of the main activity on urban and suburban lines and the revenue of the operator from the production of transport work for transporting suburban passengers on other lines:

$$TR = R_{UR\&SU} + R_{SU/OTH}\ [EUR] \quad (23)$$

5 CONCLUSIONS

The paper presents the models for the revenue and cost allocation to communal and other activities in the public transport system in Subotica. The application of the cost allocation model, which consists of the initial and final cost allocation, provided the share of the communal activity in the total costs, based on the defined indicators and input parameters. This share amounts to 75.17%.

The application of the model for the allocation and calculation of the guaranteed revenue of the operator determined the most significant elements for the revenue allocation and distribution to communal and other activities. The estimated unit costs of the production of transport work was calculated to amount to 1.38 EUR/km for the characteristic urban line and 1.26 EUR/km for the characteristic suburban line. The unit costs of the production of the transport work for transporting suburban passengers on other lines were also calculated and they amount to 0.087 EUR/(passenger·km).

The presented models can be applied in all public transport systems, regardless of the system's size, with the aim of cost and revenue allocation, i.e. their division to communal and other activities.

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THE ROLE OF THE NAVIGATION SAFETY SYSTEM IN SERBIA

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ABSTRACT

Navigation safety jobs are administrative, inspection, technical and other professional activities determined in the Republic of Serbia by the Law on navigation and harbors in inland waters and regulations adopted on the basis of this Law, ensuring the safety of navigation. These tasks are the responsibility of the ministry in charge of transport, port authorities, Directorate for determination of seaworthiness, the Directorate for Inland Waterways, Agency for the Ports Management, authorized legal person for the technical maintenance of state waterways and authorized legal person for the technical maintenance of the state waterways on the territory of the autonomous province.
In the period from 2009 to 2013 on the rivers Danube and Sava were implemented the most modern river information services (RIS). The continuous development of RIS involves making the other regulations on the organization and establishing RIS in the Republic of Serbia in accordance with the European standards. The coastal network of base stations (15 on the Danube River and three on the Sava River), which fully covered by the signal the flow of these rivers is established. River Information Services (RIS) are established on the waterways of at least class IV and higher, as well as in the ports opened for international traffic.
Convention on the Suppression of Unlawful Acts against the Safety of Maritime Navigation is adopted in our country in March 2004 with the adoption of the Decree promulgating the Law on Ratification of the Convention on the Suppression of Unlawful Acts against the Safety of Maritime Navigation.

Keywords: navigation, safety, regulation, Serbia

1 INTRODUCTION

The first maritime safety rules served navigational requirements. In ancient times the only such rules were those prescribing the display of certain lights when sailing in close proximity to other vessels. From the 16th century the rule that a white light had to be exibited at a ship's uppermost point was universally recognized.

The rules and regulations on giving way and on the lights to be exhibited by ships, after 1840. were issued by Great Britain, France, Prussia and Netherlanda, but also Hamburg. These rules and regulations were not yet universally binding, nor were they codified or harmonized on an international level.

Navigation safety jobs are administrative, inspection, technical and other professional activities determined in the Republic of Serbia by the Law on navigation and harbors in inland waters and regulations adopted on the basis of this Law, ensuring the safety of navigation. These tasks are the responsibility of the ministry in charge of transport, port authorities, Directorate for determination of seaworthiness, the Directorate for Inland Waterways, Agency for the Ports Management, authorized legal person for the technical maintenance of state waterways and authorized legal person for the technical maintenance of the state water ways on the territory of the autonomous province.[1]

2 NAVIGATION SAFETY AND EXPERENCE OF THE REPUBLIC OF SERBIA

Waterways must be organized, navigability on them must be maintained and navigation safety facilities installed and conditions for safe navigation provided in accordance with the established category of the waterway. Navigation safety and navigability of waterways according to the established category is provided by technical maintenance.2 Works of technical maintenance3 of all international waterways in accordance with the established category, as well as navigation safety facilities on them, are entrusted to the Directorate for Inland Waterways, while the operations of technical maintenance of state waterways, as well as maintenance of navigation safety facilities on them, which are located at Vojvodina are entrusted to "Waters of Vojvodina".

Waterways in the Republic of Serbia on the whole are in jurisdiction of the Ministry of Construction, Transport

[1] Article 7. of the Law on navigation and harbors in inland waters, "Official Gazette of the Republic of Serbia", no. 73/10, 121/12, 18/15, 96/15, 92/16, 104/16, 113/17, 41/18, 95/18.
[2] Article 12, paragraph 2 and 3. of the Law on navigation and harbors in inland waters.
[3] Regulation on the technical maintenance of international and interstate waterways ("Official Gazette of the Republic of Serbia", no. 93/15.) prescribes the manner of performing technical maintenance of international and interstate waterways.

and Infrastructure, and the maintenance and development of international and interstate waterways is entrusted to the Directorate for Inland Waterways. All activities related to water transport is regulated by the Law on navigation and harbors in inland waters[4], the Law on maritime navigation[5] and the Law on the Transport of Dangerous Goods[6] and are the responsibility of the following government agencies and organizations: - Ministry of Construction, Transport and Infrastructure - Department for water traffic and navigation safety in which normative, research and analytical, administrative and professional activities in the field of maritime and inland navigation are performed;[7] - Directorate for Inland Waterways, established as a body within the Ministry mainly for performance of professional and technical tasks of maintenance, labeling and development of waterways with international status (Danube, Sava, Tisa), as well as for the establishment, maintenance and development of River Information Services (RIS) in compliance with EU directives and regulations; - Authority for Determination of the Seaworthiness as an administrative body within the Ministry that performs primarily professional and technical services, or activities of technical control which verifies if the ship satisfies the requirements of technical rules for for determination of the seaworthiness and - Port Governance Agency that is a Government regulatory body established to carry out strategic and administrative management of ports and harbors, regardless of their ownership status, i.e. regulatory, professional and development activities with aim at continuous and undisturbed business activities in the port area.

River information services (RIS) established by Directorate for Inland Waterways offer services that provide information on navigation and traffic, transport management, statistics, for the purpose of customs and police authorities, accidents, the port and other fees and other information. In the period from 2009 to 2013 on the rivers Danube and Sava were implemented the most modern river information services (RIS). The continuous development of RIS involves making the other regulations on the organization and establishing RIS in the Republic of Serbia in accordance with the European standards. The coastal network of base stations (15 on the Danube River and three on the Sava River), which fully covered by the signal the flow of these rivers is established. River Information Services (RIS) are established on the waterways of at least class IV and higher, as well as in the ports opened for international traffic.[8]

Decree on the types of services of River Information Services (RIS) and the beginning of their mandatory application[9], regulates the types of services River Information Services (RIS) and the deadline for its mandatory application. The types of services that all inland waterways vessels, other than boats, floating bodies and floating objects, navigating the waterways of at least class IV and higher, as well as in ports open to international traffic (RIS area), are obliged to use in accordance with the law are : 1) locating and tracking of ships using the Automatic Identification system (AIS) [10]; 2) an electronic reporting from the vessel (ERI); 3) information obtained through the Electronic Navigational Charts (ENC); 4) Electronic communications for shipping. [11]

The commander is responsible for the accuracy of data on vessel and voyage when communicating the identity and position to RIS center. These data are stored in the RIS center for at least three years and can serve as evidence in the process of dispute resolution in case of shipping accidents, and in the case of shipping accidents involving loss of life and great damage to property RIS data are kept indefinitely. Data obtained from the RIS - a can serve as the rebuttable evidence in court. [12]

A vessel traffic *service* (*VTS*) is a standard adopted by the United Nations Economic Commission for Europe and represents service for the provision of services in order to improve the safety and efficiency of marine transport and environmental protection, capable of establishing communication with the participants in traffic and to respond traffic needs in the area of mandatory application of VTS.[13] System for information and ship traffic control (VTS) is a system that can affect traffic and taking measures in order to solve traffic

[4] "Official Gazette of the Republic of Serbia", no. 73/10, 121/12, 18/15, 96/15, 92/16, 104/16, 113/17, 41/18, 95/18.
[5] "Official Gazette of the Republic of Serbia", no. 87/11, 104/13, 18/15, 113/17, 83/18.
[6] "Official Gazette of the Republic of Serbia", no. 104/16, 83/18, 95/18.
[7] Activities within the scope of this Sector are carried out at the Ministry headquarters and in branch offices for the territory of several municipalities and for the towns area- port authorities and their branch offices (Prahovo, Kladovo, Veliko Gradište, Smederevo, Pancevo, Belgrade, Sremska Mitrovica, Titel, Bač, Novi Sad, Apatin, Bezdan); Harbor Authority is a unit of the Ministry, which performs administrative, technical, inspection and other professional activities that ensure the safety of navigation within its jurisdiction. Administrative tasks in the jurisdiction of the Harbor Authority are as follows: 1) maintenance of the register of ships and other vessels; 2) keeping the official records of the performed registration; 3) the issuance of prescribed books and documents; 4) issuing personal and other documents for the crew members of the vessel; 5) and other administrative tasks confided to them by this law or other regulations. (Articles 166. and 169. of the Law on navigation and harbors in inland waters, "Official Gazette of the Republic of Serbia", no. 73/10, 121/12, 18/15, 96/15, 92/16, 104/16, 113/17, 41 / 18, 95/18.
[8] Article 177. of the Law on navigation and harbors in inland waters.
[9] "Official Gazette of the Republic of Serbia", no. 63/13.
[10] As of January 1, 2014 the obligation of locating and tracking of ships using AIS system was introduced, as well as the issuance of electronic communications for shipping. Other services, such as electronic reporting from vessels (ERI) and the use of information obtained through Electronic Navigational Charts (ENC) are obligatory as of 1 January 2015.
[11] Article 2, paragraph 1.of the Decree on the types of services of River Information Services (RIS) and the beginning of their mandatory application
[12] Article 187. of the Law on navigation and harbors in inland waters, "Official Gazette of the Republic of Serbia", no. 73/10, 121/12, 18/15, 96/15, 92/16, 104/16, 113/17, 41/18, 95/18.
[13] Article 4, paragraph 1, point 54. of the Law on navigation and harbors in inland waters.

situations that occur in areas designated by coastal states. In accordance with the Regulation on vessel traffic *service (VTS)*[14] Ministry in charge of transport is managing the vessel traffic *service* (VTS) in accordance with the law regulating the safety of inland navigation.[15] Information about events, facts, identity and position of the vessel and electronic reports from the vessels are kept in electronic form for at least three years in order to compile the current and the strategic traffic situation using RIS applications. These data can be used for the reconstruction and analysis of the traffic situation in the case of endangering navigation safety, shipping accidents or suspicion that there was an environmental pollution from vessels.[16]

Electronic Navigational Charts (ENC) are provided for the entire flow of the Danube, Sava and Tisa through Serbia.

The national system "SafeSeaNet" is established and used in accordance with the technical requirements laid down by the European Commission, and kept in electronic form making possible the receiving of data on domestic ships continuously 24 hours a day.[17]

Domestic boat[18] must be equipped with Automatic Identification system (AIS), in accordance with the standards prescribed by the International Maritime Organization (IMO), which must be permanently switched on, except when international agreements, regulations and standards regulate the navigation data protection.[19] Domestic boat must have a Navigation Data Recording System (VDR), which fulfills the characteristics prescribed by IMO Resolution A.861 (20), with subsequent amendments and standards of testing prescribed by the International Commission for electronics (IEC).

The ship with its own drive, technical vessel and river-sea ship must have a radio station[20] and are obliged to organize watch service during navigation, in accordance with regulations organizing radio traffic.[21] Inland waterway vessels that have a radio device must have a call sign by the regulations on international radio traffic, while naval vessels that have a radio device must have a call sign or MMSI number[22] in accordance with the regulations on international radio traffic.[23] The provisions of Radio regulations, adopted by the International Telecommunication Union, are applied on the manner and conditions of work of radio service for the navigation safety of domestic ships, as well as on the conditions to be met by the ship's radio station. [24]

The issue of navigation safety is actual today in the Republic of Serbia. After 76 years, the removal of 23 German vessels from the Second World War from the Danube starts near Prahovo.

We still remeber that during 1944 as many as 30 German vessels were sunk in the Romanian part of the Danube. In the first phase, one million and five hundred thousand euros were provided for the removal of 23 German vessels from the Second World War from the Danube. We will finally have the Danube, which will be navigable by entire course throughout Serbia.

3 SHIPPING ACCIDENTS AND SUPPRESION OF UNLAWFUL ACTS AGAINST THE NAVIGATION SAFETY

Great Britain in the general interest took the initiative and drafted, in cooperation with France, the first set of **Regulations for Preventing Collisions at Sea** and these regulations came into force on June 1st,1863. In 1894. they were incorporated into the **British Merchant Shipping Act**. Subsequently, all European seafaring nations as well as the United States issued legislation with substantially the same content.

In 1914 at the International Conference in London, the **Convention for the Safety of Life at Sea (**June 20, 1914**)** was concluded**,** but that Convention did not become effective, because of the outbreak of the First World War and the fact that only few States ratified it.

Convention on the Suppression of Unlawful Acts against the Safety of Maritime Navigation is adopted in our country in March 2004 with the adoption of the Decree promulgating the Law on Ratification of the Convention on the Suppression of Unlawful Acts

[14] "Official Gazette" no. 76/17.
[15] Article 2. of the Regulation on vessel traffic *service* (VTS), "Official Gazette" no. 76/17.
[16] Article 8. of the Regulation on vessel traffic *service* (VTS).
[17] Article 134. of the Law on maritime navigation, “Official Gazette of the Republic of Serbia”, no. 87/11, 104/13, 18/15, 113/17, 83/18.
[18] The ship, with the exception of the naval ship, must use the Automatic Identification system (AIS) using AIS device for inland navigation that meets the requirements prescribed by the regulations on the River Information Services (RIS). (Article 71, paragraph 1 of the Decree on conditions for navigation and rules of navigation on inland waterways, "Official Gazette" No. 96/14).
[19] Article 132. of the Law on maritime navigation.
[20] Using VHF and UHF radio stations is permitted only for the purpose of ensuring of navigation safety, as well as for communication with the relevant port authorities, Port Governance Agency and shippers. In the exercise of these radio services, port authority is obliged to organize a watch service. Radio stations can only work on the assigned frequencies, except in the case of broadcasting distress calls, messages and announcements to be broadcasted in the event of danger for the vessel, as well as in case of natural disasters, saving human lives, and in other similar cases where the utilization of other frequencies is also allowed on the condition that it is in a way that is best suited for radio station to accomplish a task related to the elimination of hazards. On the manner and conditions of work of radio service for the navigation safety on ships, as well as the conditions to be met by the ship's radio station, are applied the provisions of "Regional Arrangement concerning the radiotelephone service on inland waterways" - "RAINWAT" and Radio rules adopted by the International Telecommunication Union. (Article 29 of the Law on navigation and harbors in inland waters, "Official Gazette" No. 73/10, 121/12, 18/15, 96/15, 92/16, 104/16, 113/17, 41/18, 95/18).
[21] Article 28. of the Law on navigation and harbors in inland waters, “Official Gazette of the Republic of Serbia”, no. 73/10, 121/12, 18/15, 96/15, 92/16, 104/16, 113/17, 41/18, 95/18.
[22] MMSI number (Maritime Mobile Service Identity Number) is international maritime radiocommunication identification number. (Article 3, paragraph 1, item 19. of the Law on nationality and registration of vessels, "Official Gazette" No. 10/13, 18/15, 83/18).
[23] Article 13. of the Law on nationality and registration of vessels.
[24] Article 9. of the Law on maritime navigation, “Official Gazette of the Republic of Serbia”, no. 87/11, 104/13, 18/15, 113/17, 83/18.

against the Safety of Maritime Navigation.[25] By this act the state parties have confirmed their wish to monitor rules and standards related to the prevention and control of unlawful acts against ships and persons on board ships, in order, to update them if necessary.

In the sense of the suppression of unlawful Acts against the Maritime Navigation Safety, it is prohibited to the commander and another member of the crew, passenger or other person on a domestic ship to: 1) by force or threat or any other form of intimidation seize or take over the control over a ship; 2) perform an act of violence against a person on board the ship if that act is likely to endanger the safe navigation of the ship; 3) destroy or cause larger damage to the vessel ship or its cargo, which can jeopardize the safety of the vessel; 4) place or allow placing on the domestic ship, by any means, device or substance which is likely to destroy the ship, or cause damage to the ship or load; 5) destroy or seriously damage maritime navigation installations or seriously interfere with their operation, if such action may endanger the navigation safety[26]; 6) transmit false informations, thereby endangering the safe navigation of the ship; 7) threaten in order to compel a physical or juristic person to do or abstain from doing any act, if that threat is likely to endanger the safe navigation of the ship. [27]

Domestic passenger vessels, including fast passenger ships and cargo ships, including tankers for transportation of oil, gas and chemicals, cargo ships for the transportation of bulk cargo, as well as fast cargo ships of 500 GT and above, facilities for research and exploitation of the seabed as well as shipyards where naval ships are built, must have: 1) approved safety evaluation of the ship, i.e. shipyard; 2) International certificate for the safety of the ship, i.e. shipyard or temporary international certificate for the safety of the ship, i.e. shipyard; 3) officer responsible for the ship safety, i.e. shipyard safety; 4) record on permanent inspection; 5) The ship security alert system.[28] The owner or company, for the operated ship makes the ship security plan, based on the ship safety evaluation from article 164, paragraph 1. of the Law on maritime navigation. [29]

The ministry responsible for transport, in cooperation with the ministry responsible for internal affairs, shall determine the appropriate safety level that shipyards or domestic vessels when sailing into the ports of Member States of the SOLAS Convention must apply. [30]

Non-contractual liability of the carrier, ie. ship refers to the so-called maritime accidents or navigation incidents not preceded by a contractual relationship, the most often it is a collision of ships, stranding, sinking or shipwreck. Accidents are resulting from natural causes during the maritime navigation or human factor.

If on board happens an event which endangers the ship or navigation safety, or if an extraordinary event to the ship, passengers, other persons or property on board appears, or if any immediate danger to the safety of navigation, pollution with dangerous or harmful substances on the waterway is noticed, commander is required to describe the event, i.e. enter in the logbook immediately the note on remarked immediate danger or pollution of the waterway. The commander is obliged to inform on the event immediately by radio communication other participants in navigation and the nearest Harbor Authority, and on arrival at the first port, i.e. dock, submit a report to the Port Authority, together with a excerpt from the logbook. If this event occurred during the sailing abroad, the commander shall, after arrival at the first port,i.e. dock submit a report on the event, together with a excerpt from the logbook, to a diplomatic or consular mission of the Republic of Serbia. [31]

Search and rescue of domestic ships and endangered items of local juristic and physical persons is compulsory, on condition that it does not endanger the safety of persons, the safety of a boat, a yacht, boat or other vessel or other devices that perform the search, i.e. the rescue. Search and rescue of endangered items in foreign ownership is obligatory if these prevent or eliminate damage that can occur or that remove the threat to the navigation safety.[32]

Damaged, stranded or sunk vessel or object lost from the vessel which disturbs or endangers the navigation safety or the utilization of natural resources in the waterway or presents a risk of contamination, must be removed by the order of the port authority. If the owner or operator of a vessel does not remove the vessel or the object as required, port authority shall order the Directorate, i.e. the authorized legal person for the technical maintenance of state waterways, i.e. authorized legal person for the technical maintenance of state waterways on the territory of the autonomous region, the removal of the vessel or objects from the waterway that disturb or endanger the navigation safety, at the expense of that person. [33]

Part of the German ships sunk in September 1944 on the Danube from Brza Palanka to Prahovo should finally be pulled to the shore from the bottom of the river after seven decades. The first step was contract on the

[25] "Official Gazette of SCG - International treaties", no. 2/04, "Official Gazette of RS - International treaties", no. 1/10.

[26] Navigation safety means conditions, regulations and technical rules and measures to be met by a vessel and its crew, waterways, ports and harbors that ensure safe navigation.

[27] Article 172. of the Law on maritime navigation, “Official Gazette of the Republic of Serbia”, no. 87/11, 104/13, 18/15, 113/17, 83/18.

[28] Article 164. of the Law on maritime navigation.

[29] Article 168, paragraph 1. Law on maritime navigation.

[30] Article 165. of the Law on maritime navigation.

[31] Article 148. of the Law on navigation and harbors in inland waters, “Official Gazette of the Republic of Serbia”, no. 73/10, 121/12, 18/15, 96/15, 92/16, 104/16, 113/17, 41/18, 95/18.

[32] Article 124. of the Law on maritime navigation, “Official Gazette of the Republic of Serbia”, no. 87/11, 104/13, 18/15, 113/17, 83/18. and article 71. Law on navigation and harbors in inland waters, “Official Gazette of the Republic of Serbia”, no. 73/10, 121/12, 18/15, 96/15, 92/16, 104/16, 113/17, 41/18, 95/18.

[33] Article 55, paragraph 2 and 3. Law on navigation and harbors in inland waters.

preparation of a technical report on the presence of unexploded ordnances on sunk ships, signed on the 27th of May 2020. By this agreement the action that we have been waiting for years will start, for the Danube to be finally all the way navigable throughout Serbia. The realization of this project begins after 2 years of preparation, and the goal of the project is to provide a full profile of the waterway (180-meters) by removing 23 sunk ships near Prahovo, which is narrowed to only 100 meters due to the presence of these ships. This would achieve a significant increase in the flow of the Danube in that sector, but also better conditions for the safe flow of water traffic, especially in periods of the year with low water levels.

4 CONCLUSION

As population grows and industrial and tourist activity development contiues, the global warming, rising sea level and risks of severe sea storms endanger the world and experts think about costal protection and organize monitoring.

If you come to Serbia you are in one of the most bio-diverse countries where the water and other factors are healthy.

Traffic accidents belong to a group of the most frequent causes of death in the world, and a man largely contributes to the occurrence of traffic accidents. Keeping this fact in mind, the developing awareness of significance of participants' in traffic safe behavior is the basis for the successful traffic safety management.

In addition to education, punitive measures are also very important for the realization of safe navigation.

At present, maritime safety regulations are the subject of several international conventions and IMO resolutions which fall within the following categories: prevention of collisions at sea, safety of seagoing vessels, supporting services and installations of costal States.

The aim of this study was to show importance of the navigation safety and explain its role in the Republic of Serbia. The factors that could be considered of influence for the topic are definitely multi-use of ports and marinas, information systems, financial and legal aspects, systems of loading and unloading of a ship.

Despite the numerous efforts of researchers around the world, having in mind the importance of the rivers and sea and resources that they offer, accidents and endangering of safety in water traffic happen and we should be aware of their serious consequences.

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APPLICATION OF DRONES FOR DETECTING AND IMPROVING THE QUALITY OF ROAD SIGNS AND MARKINGS

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ABSTRACT

Over the years the rapid development of technology has shaped the entire transport system and all its elements. Technological advancements modify people's needs, i.e. their traffic demands, which consequently leads to changes in the traffic and transport system. The development of V2V, V2I, V2P, V2X technologies, 5G network, autonomous vehicles, IoT, and similar, opens up unlimited possibilities and offers new potential for improving the existing situation. A special group of new technologies is represented by drones, whose use is increasingly becoming an integral part of modern life. Their application in traffic is still being tested and examined. Currently, drones are most commonly used to detect traffic disruptions, but can also be used to record pavement conditions, collect real-time traffic flow data, exchange and deliver goods, etc. Due to their characteristics such as dimensions, speed, remote control, easy airspace manoeuvring, drones can have multiple benefits. This paper will analyze the possibility of using drones to detect the characteristics and condition of traffic signalization, with the aim of simplifying and improving network quality management and control. Also, the paper will outline the main advantages and the limitations that can be a major obstacle to the mass use of drones for these purposes.

Keywords: drones, traffic signalization, modern technologies, road quality management

1 INTRODUCTION

The past ten years have witnessed a significant expansion of drone use primarily due to their characteristics such as dimensions, remote control, speed, easy airspace manoeuvring, etc. Consequently, drones are increasingly becoming a vital element of modern society. So far drones have been mainly used for military purposes. However, the development of technology and commercialization has expanded their field of use. Today drones are most frequently used for the environment recording, spatial mapping, environmental monitoring, delivery, while they also have an important role in agriculture (Zhang, Cao, Xu, & Gulliver, 2018). Drones were first implemented in traffic with the aim of monitoring and detecting the traffic flow parameters – most commonly traffic volume and speed (Bruin & Booysen, 2015). Their use was promptly expanded to include traffic control, identification of congestion, incidents, hazardous points, first aid provision, rescuing, etc. (Gharibi, Boutaba, & Waslander, 2016).

The development and implementation of autonomous vehicles have additionally changed the requirements regarding the infrastructure, traffic signalization and equipment. The latest degree of autonomy presumes the total exclusion of the human factor from the vehicle's driving control system and replacement of the human factor with a set of smart sensors and cameras. This means that a computer will take the role of a human and perform all important actions while driving: detecting specific objects (other vehicles, traffic signalization, obstacles on the road, etc.), detecting non-motorized traffic participants, identifying the detected elements, decision-making and reacting, i.e. implementing the decision. Each of the mentioned actions requires the constant communication between the vehicle and the surroundings (The Future of Transportation, 2018, 2019).

Traffic signalization is very significant for the driver's orientation and supply of the required information while driving. Its role is additionally emphasized when implementing autonomous vehicles. Some of the characteristics of traffic signalization which might have a negative impact on traffic are the following: damaged signs and markings, faded signalization, poor levels of retroreflection, traffic signs showing incorrect directions, inexistence of traffic signalization, etc. Therefore, it is extremely significant to establish the appropriate control system, i.e. the analysis of the condition and quality of traffic signalization, in order to fulfil the requirements imposed by the implementation of autonomous vehicles.

A document issued by the International Standardization Organization defines quality as *the sum of features and characteristics of a product or a service which have an* *ability to satisfy the stated or implied needs* (International Standardization Organization (ISO), 1994). This means that each traffic sign or marking have to satisfy all standardized quality norms in order to be applied or used in traffic.

Generally, during the control and analysis of the condition and quality of traffic signalization, several problems arise. First, technology (i.e. the measurement method) can differ significantly depending on the measured feature. The traditional method of collecting, measuring and analyzing traffic signalization characteristics involves field research during which the condition is determined mainly visually. For example, the characteristics such as damage, faded signs and markings, incorrectly directed traffic signs, leaning poles and similar can be determined visually. However, the measurement of retroreflection, colour quality and skid resistance is conducted by means of specific devices. In some situations, the measurement of retroreflection and colour quality requires additional laboratory analyses. This approach evidently requires significant time resources, which has led to the development of mobile devices for the quality control of particular features. For instance, the 2018 "Measure Across America Project" analyzed the differences between the manual and mobile recording of the condition and quality of horizontal signalization. The recording was conducted in five states in America, including the total length of 1860 kilometres of horizontal markings. The analysis by means of manual recording lasted for 759 days, while the same measurement by means of a mobile device took 25 hours (RoadVista, 2018).

An additional problem is related to the number of signs and markings, as well as the number of the measured characteristics. In case of less favourable weather conditions or unsuitable terrain characteristics, the measurement time and required resources are significantly increased.

For now, there are still no studies or projects that have dealt with the use of drones for these purposes, which gave us the encouragement to present this idea and examine the implementation possibilities.

The aim of this paper is to examine the possibility of drone application for collecting and analyzing the characteristics of traffic signalization on the rural network. The application of drones considerably automates this process, which accelerates and simplifies the collection and analysis of data. The main idea of this paper is based on integrating or equipping drones with the necessary sensors and cameras which would detect and photo-document specific characteristics of traffic signalization.

The paper consists of five chapters, while the analysis of drone application is conducted in two separate sections: the chapter on the analysis of condition and quality of vertical signalization and the chapter on the analysis of condition and quality of horizontal signalization. Finally, the paper contains a comparative analysis of the characteristics of the two selected drones and a proposed model which, with minor modifications, can be applied for the measurements described in this paper.

2 APPLICATION OF DRONES FOR ANALYZING THE CONDITION AND QUALITY OF TRAFFIC SIGNS

In the cadastre of the Republic of Serbia the quality of traffic signalization is observed through the series of characteristics presented in Table 1. The largest number of the presented characteristics can be determined by means of simple visual observation – the traffic sign pole quality, the pole damage, sheet metal damage, colour damage, a leaning pole, an incorrectly directed sign or the wrong order of signs on the pole. However, certain characteristics, such as the measurement of retroreflection and colorimetry, require the use of specific devices, which will be explained further in the paper.

The characteristics presented in Table 1 are divided into five groups, and the defined order creates a hierarchical structure. In the process of analyzing the condition and quality of traffic signalization, this hierarchical structure enables ceasing of further analysis if one of the criteria has unsatisfactory results. In this case, necessary interventions and urgent elimination of irregularities are demanded.

Table 1: Characteristics of traffic signs

No.	**Traffic signs characteristic**	Group
1.	Name of the street (area)	I
2.	Serial number of the traffic sign	II
3.	Serial number of the pole	
4.	Traffic sign category	
5.	Traffic sign code	
6.	Traffic sign height	III
7.	Traffic sign dimensions	
8.	Quality of the traffic sign pole	
9.	Damage of the traffic sign pole	
10.	Damaged sheet metal of the traffic sign	
11.	Damaged traffic sign colour	
12.	Leaning traffic sign pole	IV
13.	Incorrectly directed traffic sign	
14.	Incorrect order of traffic signs on the pole	
15.	Quality of the traffic sign colour	V
16.	Traffic sign retroreflection	

Source: Traffic Signalization Cadastre of Serbia

In this case, one of the main roles of drones is photo-documenting the traffic sign characteristics presented in Table 1, as explained in the following text.

The first presented information refers to a characteristic from Group I – the name of the street – which is used for defining the micro-location of the traffic sign. This information can be obtained by means of GPS and a receiver which are constituent parts of every drone.

Information in Groups II, III and IV is obtained by means of a simple analysis of the photo-documentation collected by drones. For instance, the photo-documentation of the traffic sign's label, code and stamp can provide all the basic data related to the specific traffic sign: serial number, production year, manufacturer, number and date of the standard according to which it was produced, the class of retroreflective performance, etc.

The dimensions and height of the traffic sign can be obtained by the GIS databases which contain the implemented area maps. The mapping itself is performed using drones. Figure 1 shows an example of checking the objects' dimension in the GIS application service. The same procedure can be used for measuring the height and dimensions of traffic signs. Additionally, by comparing the dimensions of unchangeable objects, such as buildings, traffic signs height and dimensions can be calculated. This procedure can be also used for verification, bearing in mind that the dimensions of traffic signs are conditioned by the road category.

Currently, the quality and damage of the traffic sign pole, damage of the sheet metal and sign colour, a leaning pole, an incorrectly directed traffic sign and incorrect order of the signs on the pole are visualy analyzed by researchers in the field. All mentioned sign characteristics can also be post analized through drone collected photo-documentation, which can avoid coslty field research. Here it is important to emphasize the suitability of drones for photo-documenting the traffic sign from all angles (360^0), which ensures additional operational flexibility. This procedure can be characterized as semi-automatic traffic sign quality control.

Figure 1: Checking the objects' dimensions after mapping

The collection of data from Group V is conducted by means of a retroreflectometer[1] which measures the traffic sign's retroreflection and the spectrophotometer/colorimeter[2] which measures the traffic sign's colour quality. The mentioned devices are shown in Figure 2. In this situation, drones can be used for the transportation of these devices. In other words, in addition or instead of a camera, drones would be connected to the retroreflectometer and colorimeter. In this case, the processes of starting, measuring and turning the device off should be completely automated at the moment when the drone approaches the traffic sign.

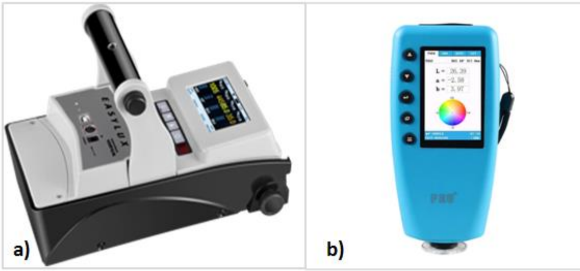


Figure 2: a) Retroreflectometer, b) Spectrophotometer

The visibility of traffic signs in night-time driving conditions represents a significant feature. However, this characteristic has to be examined and measured during night. In January 2020 the Regulation on Unmanned Aerial Vehicles was amended to allow the use of drones at night with the approval of the Civil Aviation Directorate of the Republic of Serbia and previous registration onto the unmanned aerial vehicle register (Regulation on Unmanned Aerial Vehicles, 2020). Thus, one of the main obstacles to applying drones for analyzing the condition and quality of traffic signalization was removed.

In general, the entire previously described procedure of applying drones refers only to data collection, while the condition and quality analysis would be conducted by an expert team on the basis of the obtained data and photo-documentation.

Due to the technology development, the data analysis can be automated and conducted without the presence of people. Cosequently, the human role would solely be to control the mentioned process.

The application of artificial intelligence, primarily neural networks, enables the simplification of the analysis of the condition and quality of traffic signalization. In the previous years, their application has significantly contributed to the development of automatic recognition and "reading" of traffic signs and markings (Figure 3). This step has enabled faster testing and development of autonomous vehicles.

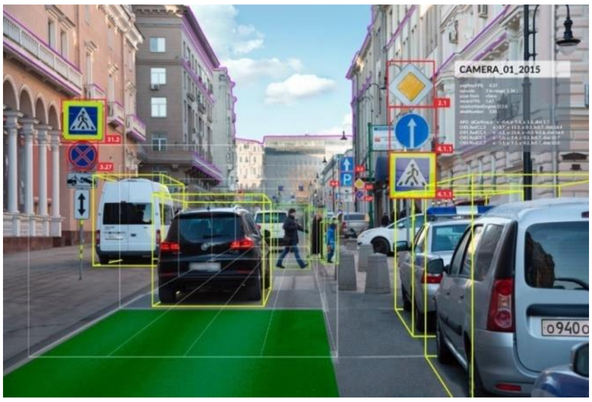
In this specific case, the characteristics such as the traffic sign pole quality, damage of the pole, damage of the sign's sheet metal and damage of the colour, can be collected and analyzed in the following manner:

- The first step involves collecting data about the defined characteristics of the traffic sign itself. Photo-documentation is collected by means of drones.

[1] The dimensions of standard hand retroreflectometer are: 290x115x325 (mm), with weight of 2.7kg. The retroreflectometer shown in the Figure 2a) has the dimensions of: 255x160x220 (mm), with weight less than 2.1kg.

[2] The characteristics of spectrophotometer also varies depending on the device. The spectrophotometer shown in the Figure 2b), has the dimensions of: 77x86x210 (mm), and weight of 550g

- The second step includes the creation of integrated databases about the characteristics of traffic signalization.
- The third step involves the analysis of the traffic sign condition and quality using a system of algorithms based on the neural network principle.



Source: https://sudonull.com/

Figure 3: Feature identification and recognition by means of artificial intelligence

In order to simplify the process, the initial control process can be observed as a binary system. Each damage or irregularity on the traffic sign can be assigned the code zero (0), while the traffic sign without damage can be coded one (1). In this manner, all the observed irregularities in any step would mean that the traffic sign is damaged and that certain interventions are required, which stops any further analysis.

3 APPLICATION OF DRONEs FOR ANALYZING THE CONDITION AND QUALITY OF CARRIAGEWAY MARKINGS

The cadastre of the Republic of Serbia defines the specific set of characteristics of markings which have to be examined in order to determine the condition and quality of the markings. The characteristics shown in Table 2 are divided into three hierarchically ordered groups, similarly to the grouping of traffic sign characteristics presented in the previous chapter.

It should be highlighted that the analysis of the marking quality is most commonly conducted by means of inspections and visually, since the damages are easily perceivable. However, a more objective quality analysis requires the quantification and measurement of a certain number of the condition indicators. In this case, drones can be applied for collecting and photo-documenting the characteristics presented in Table 2.

The Group I elements are related to general characteristics of the markings, including the following: the micro-location of the marking, marking code and marking dimensions. The data on the micro-location are obtained by GPS devices incorporated in drones. The markings can be determined on the basis of photo-documentation and classification of the road where the marking is located, while its dimensions are calculated based on the area maps in the GIS application service.

The marking damage includes the absence of colour or a particular part of the horizontal marking. These data can be documented, i.e. collected by recording the markings and creating specific documentation by means of drones.

Table 2: Characteristics of markings

No.	Marking characteristic	Group
1.	Street, area or section name	I
2.	Marking code	
3.	Marking dimensions	
4.	Marking damage	II
5.	Marking durability	
6.	Faded marking	
7.	Marking retroreflection	III
8.	Skid resistance	

Source: Traffic Signalization Cadastre of Serbia

The marking durability is expressed by the ratio of the damaged surfaces and the initial (undamaged) surface of the marking. The age of the marking and traffic load should be taken into consideration when calculating this feature. The damaged area can be easily calculated using specifically prepared photo-documentation, while the data on new (undamaged) markings are provided in the producer's specifications.

A faded marking (discoloration) is most frequently determined by means of comparison and visual tests using the etalon with the same material.

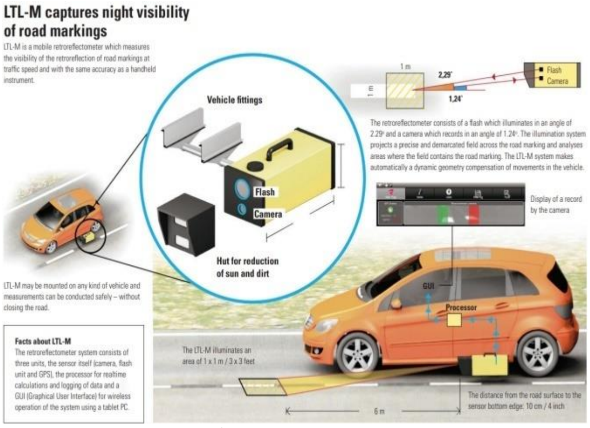
Certain difficulties or limitations are related to collecting data regarding the retroreflection and skid resistance of markings, due to the fact that these characteristics are measured by special devices[3]. The traditional measurement of retroreflection involves placing the device on the horizontal marking, which is followed by reading. Today, a large number of companies use mobile retroreflectometers, which can measure retroreflection at different vehicle speeds with the identical precision as in the manual measurement. Figure 4 shows an example of a mobile retroreflectometer for measuring retroreflection in night-time conditions.

This paper proposes a similar concept while using drones instead of vehicles. The main limitations of the mentioned idea are: the drone's payload capacity, i.e. the weight of the retroreflectometer and the potential endangering of road traffic safety, since the retroreflectometer has to be placed at the 10-cm distance from the carriageway surface.

It should be emphasized that this type of examination asks for timely informing of traffic participants in order

[3] Retroreflection is measured by means of a retroreflectometer, while skid resistance is measured using the British Pendulum (SRT – Skid Resistance Tester)

to avoid negative impact on the participants' safety. In this situation, participants can be informed by means of variable message signs. Also, the real time information could be given by mobile phones, the internet, radio and similar, which could directly prevent the mentioned problem. The most rigorous measure would certainly be the closure of the road section during field measurements, as a last preventive measure.



Source: Illustration from the Danish engineering magazine Ingeniøren

Figure 4: Mobile retroreflectometer

A similar problem arises when measuring skid resistance. The measuring device (the British Pendulum) has to be placed on the carriageway, i.e. on the horizontal marking. This measurement method can have a negative impact on traffic safety, particularly on rural sections where vehicles drive at high speeds. Negative consequences can be prevented by the appropriate management measures and timely informing of users about the field measurements. However, it should be emphasized that the possibilities of examining traffic signalization are considerably limited by technical characteristics of the available measuring instruments, as previously mentioned regarding the SRT device.

4 TECHNICAL CHARACTERISTICS OF DRONES FOR ANALYZING TRAFFIC SIGNALIZATION

Based on the previous analysis, Table 3 shows basic characteristics of the selected drone models which, with minor modifications, can be applied for the analysis of the condition and quality of traffic signalization.

The following models were selected: DJI – Inspire 2 and WingtraOne. Both models meet the requirements of mapping and terrain visualization and contain the characteristics suitable for recording the condition and quality of traffic signalization. It should be mentioned that both models are primarily produced for the purpose of mapping, so the characteristics of cameras and sensors are adapted to these requirements. Although both models are highly accurate, certain modifications would be required regarding the characteristics of sensors and recording cameras.

The possibility of replacing a camera or a lens is a significant advantage of certain models and both selected models have this possibility. For example, the DJI – Inspire 2 drone uses a Zenmuse X5 or X7 camera which has the possibility of optical zooming and camera lens replacement. These features enable taking remarkably detailed photographs of the objects at different distances.

Table 3: Characteristics of the selected drone models

Model	Characteristics	Value
DJI – Inspire 2	Weight	4,250 g
	Maximum speed	up to 94 km/h
	Maximum wind speed	10 m/s
	Maximum flight time	up to 27 min.
	Vertical positioning	+/- 10 cm
	Horizontal positioning	+/- 30 cm
	Maximum flight altitude	5,000 m
WingtraOne	Weight	3,700 g
	Maximum speed	up to 64 km/h
	Maximum wind speed	up to 12 m/s
	Maximum flight time	up to 55 min.
	Vertical positioning	+/- 23 mm
	Horizontal positioning	+/- 13 mm
	Maximum flight altitude	5,000 m

Source: WingtraOne User Manual, Inspire 2 Series User Manual

On the other hand, under optimal conditions the WingtraOne model with the 42 MP camera has the absolute accuracy at the level of 1 cm (Wingtra AG, 2018), while the standard error value is added to this value.

A significant advantage of the DJI – Inspire 2 model is perceived in the application of artificial intelligence. Namely, this drone possesses the following systems:

- The Obstacle Sensing and Avoiding system contains optical sensors for detecting objects in the range of 30 m. This feature is significant in terms of safety, since it enables detecting objects in the vicinity of the drone such as buildings, bridges, etc.
- The Active Track system involves the possibility of following the selected object using modern algorithms for the recognition of photographs. In this specific case, it is possible to follow or detect a defined traffic sign or a specified marking.
- The Tap Fly system provides the user with the possibility of setting the final location or a destination where the drone has to land or which it has to reach. By setting this location, the software calculates its optimum route while considering the possible obstacles on the flight route.

An additional feature of this model is the flight speed reaching 94 km/h. It should be underlined that this is the maximum flight speed reached under optimal conditions, while drones usually fly at lower speeds. However, the flight speed parameter can be significant in the situations when continuous recording is required, such as the recording of the horizontal signalization markings: edge lines, centre lines, etc. On the other hand, the WingtraOne model possesses slightly slower maximum flight speed (64 km/h) but can encompass a larger recording area.

A significant advantage of the WingtraOne model in comparison to the DJI – Inspire 2 model is the flight length. It can be seen in Table 3 that the WingtraOne model can remain in the air for up to 55 minutes, which significantly increases the effective flight time. Thus, the process of analyzing the condition and quality of traffic signalization is facilitated and accelerated, particularly if the battery recharge time is taken into account.

The limitation of this model is its construction which makes it more robust and less mobile than the DJI - Inspire 2 model. This feature is particularly important when analyzing traffic signs and additional obstacles, facilities or equipment in the surroundings. Owing to its manoeuvring possibilities, the DJI – Inspire 2 drone model provides simple and easy photo-documentation of the traffic sign from all directions and angles (360^0).

Generally speaking, technical characteristics of drones provide significant advantages in comparison to manual measurement methods, particularly in case of inaccessible terrain configuration and different positions of traffic signs in the profile. The process of manual analysis and measurement is particularly difficult on the roads where traffic signs are set on portals, i.e. above the carriageway. In these situations, drones represent an efficient solution and their application simplifies all necessary measurement. In addition, the basic idea and advantage of drone application is the possibility of simultaneous data collection about the horizontal and vertical signalization, which significantly reduces the collection time. Figure 5 shows an example of detecting and photo-documenting traffic signs and markings. In this situation drones would have to be equipped with a larger number of smart sensors and cameras than it is currently the case.

Figure 5:An example of simultaneous collection of data about the characteristics of traffic signs and markings

One of the limitations typical of the largest number of commercial drones is their sensitivity to various weather conditions: strong wind, rain, snow, etc. Table 1 shows the maximum wind speed values at which the model can be managed. For DJI drones these values range from 8 to 10 m/s (Hall, 2020). On the other hand, the producers of the WingtraOne model rose this limit to 12 m/s, with the safety recommendation for the drone to be used at the wind speeds up to 10 m/s (Wingtra AG, 2018).

Despite several significant advantages of the WingtraOne model, a serious disadvantage of this drone model is its price which is almost ten times higher than the price of the DJI – Inspire 2 model.

The limitation of both models refers to their payload capacity. For instance, the WingtraOne model can carry the additional payload weight of 800 g, which represents a significant limitation considering the research described in this paper. Generally, this is the limitation of the largest number of commercial and widely available drones. The models specifically designed for carrying large cargo are mostly used for military and industrial purposes.

The analysis of the technical characteristics of drones shows certain limitations which prevent a comprehensive examination of the mentioned features of traffic signalization. However, with minor modifications, the presented DJI – Inspire 2 model can be applied for the needs of the analysis presented in this paper.

5 CONCLUSION

Current tendencies and directions of the traffic system development, which envisage the complete automation and correlation of all users, require significant structural changes and improvement of all traffic subsystems. This step is particularly significant when it comes to the implementation of autonomous vehicles which require continuous communication with the environment, appropriate infrastructure and high quality level of traffic signalization. Therefore, the aim of this paper was to examine the possibilities of drone application for controlling the condition and quality of traffic signalization on the rural network. The paper provides the basic characteristics of traffic signs and markings which should be examined, as well as the measurement method by means of drones. Finally, the paper contains the comparison of two selected models and the proposed drone with technical characteristics which, with minor modifications, can be used for needs of the research in this paper.

The analysis of the photo-documentation collected by drones provides the following characteristics of traffic signs and markings: quality of the traffic sign pole, damage of the pole, sheet metal, colour, a leaning pole, an incorrectly directed sign and the number of signs on the pole, damaged markings and faded markings. The characteristics of traffic signs and markings related to their dimensions can be obtained on the basis of the area maps using the GIS application service. The characteristics such as retroreflection, colorimetry and skid resistance require certain drone modifications, which primarily refer to the number, types of sensors and cameras and the drone payload capacity.

Therefore, the paper presents two drone models whose technical characteristics best correspond to the requirements of the research described in this paper. On the basis of the conducted analysis, it can be concluded that with minor modifications the DJI – Inspire 2 model can be used for examining the condition and quality of traffic signalization.

The main advantage of the application of drones in comparison to traditional measurement methods described in this paper refers to the potential time savings. Drones significantly facilitate the access to certain locations, i.e. to traffic signs mounted on portals, in tunnels, on bridges, etc. Due to the fact that drones use air space, potential congestion in the network can be easily avoided.

Another advantage of drones is the possibility of the simultaneous collection of data on both horizontal and vertical signalization. The integration of artificial intelligence can additionally automate the entire process of data collection and analysis, which significantly reduces the required time and personnel resources.

The limitation of drone application in the Republic of Serbia used to be the impossibility of using drones for night-time measurements. However, the Regulation on Unmanned Aerial Vehicles was amended to overcome the mentioned obstacle, which significantly increased a wider use of drones.

Another aspect of drone application is related to the regulation of their use in field measurements. In these situations, it is required to establish the appropriate system of informing drivers about the ongoing measurements and to standardize the appearance of drones and equipment in order to ensure their visibility in all weather conditions. The aim of these activities is to prevent a negative impact on road traffic safety.

Generally speaking, although the use of drones is still in its testing phase, their application can provide multiple benefits, particularly in terms of the possible integration with other traffic subsystems.

Bearing in mind the significant attainable advantages, the authors of this paper presented one of the potential roles of drones in traffic and thus pointed to the additional possibilities of their wider use. The subject of the authors' future research will be the above-mentioned aspect of integration and more extensive drone use. The aim of the future research will be the creation of an efficient traffic system which will be able to respond to future demands and continuous technological improvement.

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ASSESSMENT OF NAUTICAL TOURISM CAPACITY IN SPLIT AND DALMATIA COUNTY THROUGH PRISM OF SPATIAL AND TRANSPORT PLANNING

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ABSTRACT

The goal of this paper is to show the existing relations between spatial and maritime spatial planning, with particular emphasis on maritime transport. The coastal and marine space is naturally limited, and controlled exploitation is a necessary condition for achieving sustainable development. The paper highlights the importance of spatial planning, as well as through the analysis of the parts of spatial plans of Split-Dalmatia County brings estimation of county capacity in terms of port infrastructure and the space that is in the purpose of nautical tourism. An analysis demonstrate that through spatial and transport planning solutions for non-harmonized relationships in the operation of individual transport sectors could be offered, especially in the planning of the relationship between supply and demand for transport infrastructure.

Keywords: spatial planning; maritime spatial planning; nautical tourism; Spatial plan of Split and Dalmatia County.

1 INTRODUCTION

In recent decades, increased human and economic activities with accompanying tourist activities "consumed" large amounts of space and led to the transformation of the entire regions. Following the trends of development, there is no doubt that demand for space will continue to grow. It is undeniable that tourism in all aspects can contribute to social and economic development, as well as the reconstruction of a particular area, but without specific instruments, such as regional plans, outlined future plans for tourism development will hardly be sustainable. Given the strong intensity of the use of space and the coast for the purpose of tourism, it is necessary to set up barriers and "control" or tie tourism development with zoning. Furthermore, the development of tourism, especially nautical tourism is closely linked to the coastal zone and marine space. Furthermore, the intensive use of shore requires planning of the sea use, i.e. zones for various human activities which are involving maritime, offshore, aquaculture must be defined. In this segment Maritime spatial planning (MSP) is of genuine importance. Determination of such zones, and identification of key stakeholders in the three-dimensional maritime area certainly lead to effective management of maritime activities, as well as the sustainable use of marine and coastal resources. [1] An important factor in maritime spatial planning is the influence of human activities on the marine environment. MSP is determined by environmental measures on land and sea, providing free access to the coast, but also the preservation of endangered areas.

2 BACKGROUND RESEARCH

A review of relevant literature point out that there are numerous studies dealing with spatial planning, spatial and transport planning and maritime spatial planning separately, but very few of them put in correlation spatial and transport planning with shipping, or spatial-transport planning and nautical tourism. On the other hand, there are numerous studies that correlate spatial planning and tourism [1, 2, 3] and a certain part of the information can be transmitted to the sector of nautical tourism. Looking at the correlation of spatial planning and tourism, experience in Croatia shows how urban planning can have a positive impact on the development of tourism, especially if mutual relationship is clearly and comprehensively defined. Furthermore, tourist activities transform the entire region, and it is crucial to plan and control tourism development. Linking tourism with spatial planning and with the development plans of other sectors is of vital importance. [2]

Maritime spatial planning (MSP) is discussed a lot in recent years. In order to resolve a number of disputes over the use of the marine space and coastal areas there is a need for creating a common methodology that will establish new interrelationships between users of space and natural resources. [4] The fact is that the process of coastal belt planning, especially the sea surface and the seabed itself is very complex. Through regulatory framework, the standardization and direct activities for spatial planners in the space of protected coastal area are strictly determined, but practice often reveals many uncertainties related to the planning of specific functions that must be on the shore (littoral functions), as well as all kind of ports, moorings and anchorages, industrial capacity, tourist buildings and complexes which besides accommodation include a number of other, supporting facilities, etc. In MSP problems also occurs due to non-compliance of regulations and different interpretation of certain terms in the various regulations. [5]

In order to perform a nautical tourism services in all kind of ports, moorings and anchorages as well as accompanying tourist facilities are crucial. The development of nautical tourism through its specific activity and the need for space around the coastline, among other things, emphasizes the problems of protection of the coastal and marine environment. Mindful of the potential problems and counting on the preservation of the natural environment, nautical tourism, as an economic and tourism branch should be developed within the limits of acceptable loads and recognizable features of space. [6] Integrated planning of nautical port should be based on a systematic approach that combines economic, social, spatial, environmental and infrastructure aspects. [7] The model of spatial development of nautical tourism has to include environmental guidelines that will enable their effective development in accordance with the area and its capacity. [6]

3 SIGNIFICANCE AND ROLE OF EXISTING REGULATIONS IN SPATIAL PLANNING OF REPUBLIC OF CROATIA FROM THE POINT OF MARITIME SPATIAL PLANNING

The rapid economic development, and objectives that are facing the growth of the economy have largely contributed to the unplanned and uncontrolled exploitation of the space. Institutional structure governing the issue of space and its sustainability, environmental concern and raising awareness of the importance of spatial planning represent a key factors which lead to regulated and controlled relationships of spatial development.

The basic legislative framework for the system of spatial planning is The Physical Planning Act (NN 153/13, 65/17, 114/18, 39/19). On the basis of the said Act, spatial planning as an interdisciplinary activity represents institutional and technical form of management spatial dimension of sustainability, which is based on the assessment of development opportunities, within the retention personality space requirements to protect the area and the preservation of environmental quality and nature, determines the allocation of space / surface, conditions for development activities and infrastructure, their deployment in space, conditions for urban transformation and urban rehabilitation of built-up areas and conditions for realization of the planned activities in the space. [8] After the dispensation of the facilities and contents in the area, the adoption and implementation of spatial plan occur. [4] The Act stipulates the adoption of the plans at national, regional and local level.

Maritime spatial planning represents a process of planning and organization of human activities in the marine area, taking into account the planned development and the need to preserve marine ecosystems in order to achieve ecological, economic and social objectives. [8.10] MSP is therefore a tool which attempts to mitigate conflicts arising from human interaction and exploitation of the marine environment. MSP is often associated with the concept of the Blue economy, in which the importance of economic and social aspects of sustainable growth are emphasized.

Maritime spatial planning in Croatia is governed by The Physical Planning Act (Article 49a), and the sea area is planned within [8]:

- National Plan of spatial development,
- Regional Plan of the protected ecological and fishing areas,
- Spatial plan of the continental shelf of the Republic of Croatian,
- physical plans of national parks and nature parks covering sea area,
- spatial plans of counties that comprise the sea area and spatial plans of towns or municipalities within their borders specified in accordance with special regulations and shown in the Register of spatial units is conducted on the basis of specific regulations governing state survey and real estate cadastre,
- general city planning and urban spatial plans which include marine area.

The key document, Directive 2014/89/EU of the European Parliament and of the Council of 23 July 2014 establishing a framework for maritime spatial planning which recognized the need for an integrated approach to planning and management due to a series of multiple pressures on coastal resources (plants for the production of energy from renewable sources, exploration and exploitation of oil and gas, maritime and fishing activities, etc.) has been transposed into Croatian law. The planned uses of the sea are now displayed in the Physical Planning Strategy of the Republic of Croatian in 1997 (NN 76/13) and the Program of Physical Planning of the Republic of Croatian (NN 50/99 and 84/13) and the physical plans of counties and local government units (the main maritime paths, areas for exploration and exploitation of hydrocarbons, port state and county importance, mariculture, nautical tourism and its sea and in others.). Within the transposed Directive 201/89/EU, at national level, sea will be planned with National plan of spatial development and regional plans within the limits of the continental shelf of Croatia. On the regional and local level, the use of sea will be planned within spatial plans of counties that include sea and spatial plans of towns or municipalities within their borders. [9]

In developing and adopting regional plans covering the sea area the appropriate attention to the specifics of the marine areas, significant current and future activities, the purpose and methods of use of marine areas and their impacts on the environment and safety of navigation is devoted. Creation of spatial plans should be geared towards sustainable development of tourism, maritime transport, fishing and mariculture industries, and energy sector within area.

The main assumptions underlying the development of coastal and marine space are stated in the objectives of the spatial development, and they include [4]: raise the general level of development and an increase in living standards, employment and quality of life, the establishment of economic and demographic balance of growth and development in coastal and marine zone, insurance of concordance of space and transport corridors to significant coastal and sea routes, the space development and planning on the principles of sustainable development, the protection of the marine and coastal environment on the principles of integrated approach, and the prevention of environmental pollution.

Considering Croatia's membership in the European Union and the transposition of applicable laws and regulations into national legislation, monitoring of EU trends and guidelines represent a critical step in the process of maritime spatial planning. The issue of MSP has been discussed by the European Commission a lot, and crucial year was 2013, considering the adopted Directive on Maritime Spatial Planning (2014/89/EU), which pointed out that Member States bordering marine waters shall cooperate with the aim of ensuring that maritime spatial plans are coherent and coordinated across the marine region. [12] When establishing and implementing maritime spatial plans, Member States shall identify and take into account the spatial and temporal distribution of relevant existing and future activities and uses in their marine waters. Possible activities are: for example: installations for energy and renewable energy production, location and infrastructure for pumping oil and gas, maritime transport routs and traffic flows, submarine cables and pipelines, fishing areas, aquaculture, protected natural areas, tourism, etc. [4]

Considering the broad scope of the sectors in which MSP spatial has a direct or indirect impact, it is clear maritime spatial planning can solve many of the current problems and their interactions among sectors (such as production of renewable energy and maritime navigation).

4 INTERRELATIONS OF NAUTICAL TOURISM AND SPATIAL AND TRANSPORT PLANNING

Increased need for movement of people and goods has developed a need for transport planning. By analyzing the existing transport problems with predicting future requirements and needs of the transport system an effective (economic and transport) transport and transfer of people, goods and information is defined. The basic goal of the transport system development is harmonization of relations between traffic supply and demand in the transport system as a whole, at the level of city, county, region and even on the country level, through the fulfillment of the internal, the original traffic direction and transit of goods and passengers.

The primarily goal of transport planning is to meet traffic demand. Further individual transport solutions can be implemented in order to reduce the adverse effects on people and the environment, or because they are cheaper and faster than previously offered. Looking at all developed models of transport planning, spatial and transport planning in urban areas represents the most complex problem due to the density of life, as well as the city's numerous activities.

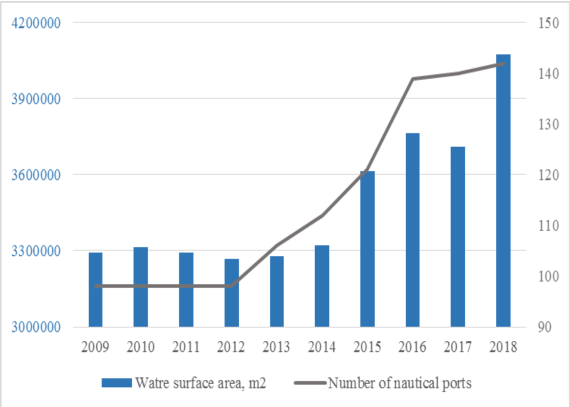
Spatial and transport planning is crucial and in realization of nautical – tourist services, given that for the realization of the same, the key interactions of several sectors is crucial. Nautical tourism is certainly one of the phenomena in terms of rapid growth and development of the past few years. Considering tourism in general, the impact on transport is reflected in the constant requirement of growing and diversified transport capacities, as well as in increased transport services quality. The fact is that just the quantity and quality of transport and communications infrastructure known to have a decisive influence on the choice of the country or the place where tourists will stay. Seasonality of total tourism demand together with mode of transport which is used by tourists define the structure of the transport demand on market. In this way, the transport sector is faced with an enormous challenge of meeting and balancing seasonal and sectoral distortion of transport supply and demand. Transport needs to effectively respond to the challenges that are upon it, otherwise it distorts the segment of the tourist offer, or the product itself.

The Republic of Croatia has shown great potential nautical tourism development. The realized income of nautical ports in 2018 amounted to 857 million, which is 2.7% higher revenue compared to 2017. [14]

The key factor in nautical tourism development are the nautical tourism ports, as well as their capacity. The growth and development of nautical tourism directly affects the increased demand for the number of berths, and accordingly the space intended for the fulfillment of nautical services is "spent". Lack of space and substandard functions of port leads to creation of congestion and transport conflicts in the rush hour. [15]

In the coastal towns, transport problems further intensify during the season, and it is necessary to promptly respond to them. Furthermore, the additional pressure on the sea (the sea area) is evident from available data.

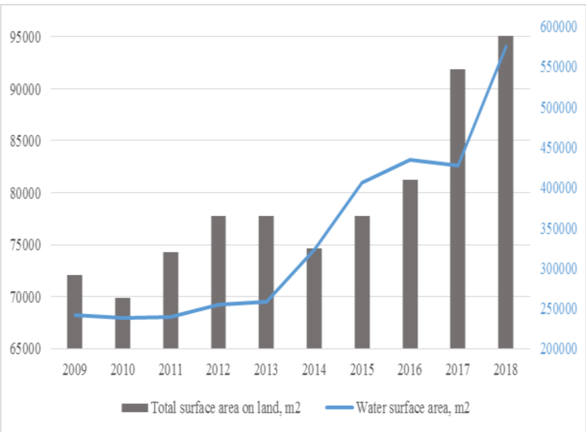
Figure 1 show the increment in terms of the space which is used in the purpose of nautical tourism, but also the increment of number of nautical tourism ports for 10 year period (2009 – 2018).



Source: Made by authors using Croatian Bureau of Statistics Reports [14]

Figure 1: Overview of nautical tourism ports and water surface area used for period 2009-2018

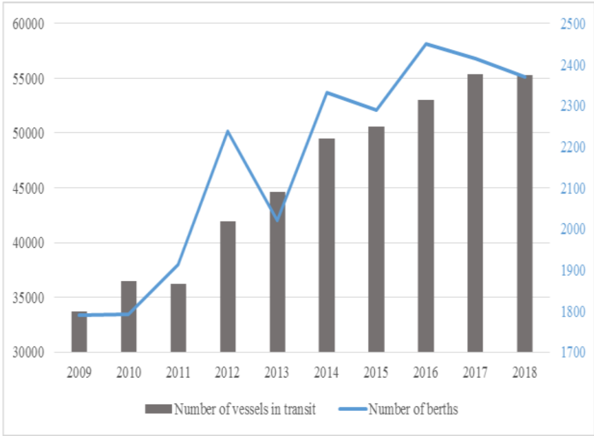
Figure 2 shows data for the area of Split and Dalmatia County, including surface which is occupied for the purpose of nautical tourism, as well as the total surface area that is needed on land. It is evident that form 2014 – 2018 water surface drastically increased. Similarly, the total surface area on land has increased for 20 000 m^2. Additionally, the increase occurred also in the number of berths on the mainland, which grow to 753 in 2018. (Figure 3)



Source: Made by authors using Croatian Bureau of Statistics Reports [14]

Figure 2: Overview of total area (on sea and land used for nautical tourism purpose for period 2009-2018

Figure 3 is directly connected with space which is used for the purpose of nautical tourism. The figure 3 puts in relation number of berth and vessels in transit for 10 year period. From figure 3 variations in number of berth can be observed, while the number of vessels in transit steadily increased for the observed period.



Source: Made by authors using Croatian Bureau of Statistics Reports [14]

Figure 3: Overview of number of berths and vessels in transit for period 2009-2018

5 ANALYSIS OF EXISTING SPLIT AND DALMATIA COUNTY SPATIAL PLAN WITH SPECIAL FOCUS ON NAUTICAL TOURISM

Split and Dalmatia county occupies 14106.40 km^2, of which the 9576.40 km^2 is sea area, and 4523.64 km^2 the land area. County encompasses 16 cities and 39 municipalities, i.e. 55 local governments. There are 74 islands and 57 islets and reefs in Split and Dalmatia county, from which regarding size and population 5 islands stand out, namely Čiovo, Šolta, Brač, Hvar and Vis. [16]

Split-Dalmatia County Spatial Plan (hereinafter referred as Plan) was adopted in October 2002, followed by another five amendments to the plan, with the last amendment in October 2013.

Including physical, physics-chemical and biological characteristics the Split-Dalmatia sea area is delimited to [17]:

- semi-enclosed bays (Kaštela bay, Marina bay, Trogir bay),
- channels (Split, Brač, Hvar, Vis), and
- open waters of Middle Adriatic.

Within the Plan, the maritime delimitations is carried out through allocation for: traffic activities, fishing, aquaculture, tourism, recreation and other activities. Sea surface intended for transport activities delimit the waterways, ports, moorings and anchorages.

Plan also identifies the category of naval construction, and includes following: Shipyards (Kastel Sucurac - Brižine, Sumartin and Solin - Vranjic); nautical tourism ports (marinas with a capacity of 200 berths); industrial ports: Pučišća-Veselje. [17]

5.1 Status of sea ports

The Plan harmonized codes and a list of ports open to public traffic in the county with the applicable regulations and decisions. According to elaborated local government requirements five new ports open for public traffic are planned. [17]

Table 1: List of ports in Split and Dalmatia County

Ports of special international economic interest	Ports of county interest
Split	Brač – Bol, Milna, Sumartin, Supetar
Hvar	Dugi Rat - Krilo Jesenice
Komiža	Gradac – Drvenik
Stari Grad	Hvar – Hvar, Jelsa, Sućuraj, Stari Grad
Vis	Kaštela - Kaštel Štafilić – Resnik
	Makarska – Makarska
	Omiš – Omiš
	Šolta – Rogač, Stomorska, Nečujam, Livka
	Trogir – Divulje, Trogir, Ćiovo, Drvenik Veli
	Vis - Parja – Rogačić

Source: Made by authors using Split and Dalmatia County Spatial Plan [17]

Criteria for the construction of ports for special purpose - nautical tourism ports are coordinated with changes of laws for the area. In addition, according to the elaborated requirements of local governments new nautical tourism ports are planned, some were closed, and the capacity for some already planned ports were modified. Furthermore, general Croatian Plans defined regimes for space exploitation where the capacity of commercial nautical centres berths limits to a maximum of 1.000 berths while the smallest capacity is determined with 200 berths. [18] Likewise, the number of berths in nautical tourism ports is determined according to the use of sea surface. The minimum capacity is the margin at which the effectiveness of utility use and technical-sanitary facilities and devices is reached, while the optimum capacity comprises limit above which economic, functional and ecological criteria collapse.

Though analysis and comparison of the Action Plan for the development of nautical tourism in Split and Dalmatia County from 2013, and amended County Spatial Plan (2013), the following can be concluded:

1. According to the Action Plan which included an analysis of the planned port in the Spatial plan applicable at that time (2007), in the area of Split-Dalmatia county the locations of nautical port were determined with total capacity:
   - Existing: 1,735 berths
   - Planned capacity: 6,422 berths
   - Total: 8,157 berths
2. Amendments to the Split and Dalmatia Spatial plan shows that in the period from 2007-2013 the capacity intended for nautical tourism greatly changed. The total capacity of newly planned nautical tourism ports is 1960 berths, and the total capacity after the development and expansion of the planned port should be 10 198. [17,18]

Table 2: List of sea ports according the existing Split and Dalmatia county Spatial Plan

newly planned nautical tourism ports	closed nautical tourism ports	an increase of the capacity in ports
Brela (Brela) – Soline	Bol (Bol) – Račić	Trogir (Trogir) – Brodotrogir
Dugi Rat (Krilo Jesenice) – Bajnice – Mutogras	Hvar (Hvar) – Križna Luka	Trogir (Drvenik Veliki) – Zirona
Marina (Vinišće) – Vinišće	Hvar (Vela Garška) – Vela Garška	Tučepi (Tučepi) – Tučep
Milna (Milna) – Kanarija	Hvar (Hvar) – Gradska luka	
Okrug (Okrug Gornji) – Saldun	Podgora (Živogošće) – Blato	
Okrug (Okrug Gornji) – Široka		
Okrug (Okrug Gornji) – Toć		
Podgora (Živogošće) – Živogošće		
Podgora (Podgora) – Podgora		
Pučišća (Pučišća) – Stipanska luka		
Split (Split) – Gradska luka		
Supetar (Supetar) – Malačnica		
Sutivan (Sutivan) – Sutivan		

Source: Made by authors using Split and Dalmatia County Spatial Plan [17]

Spatial plan of Split and Dalmatia County define that during the construction of nautical tourism ports, as far as possible is it necessary to preserve the current quality of the coast and the sea, i.e. greater changes of coastline through filling and shore excavation are not allowed. Nautical tourism complexes shouldn't be enclosed in a way which prevent access to the coast, only the approaches from shore on berths and piers can be enclosed.

6 CONCLUSION

This paper highlights the importance of spatial planning; especially planning in terms of the maritime resources exploitation, with a special emphasis on nautical tourism as one of the aspects of the use of the sea. Activities related to nautical tourism are very specific in terms of the need for space, both in the mainland and the coastal area. Besides the elaboration of plans on the space use, the issues related to the protection of the coastal and marine environment are also emphasized. Foundation for management of textremely valuable coastal area is well developed spatial plan, whereby it has to be agreed between all the relevant stakeholders which are involved and take care of the coastal area, and all current and potential users of the area. [5] While managing sea resources, except effectively and rationally managed coastal zone, it is of genuine importance that plans subordinate not only protection, but also the improvement of the marine environment.

In order to meet the growing needs of nautical tourism market in Republic of Croatia, strong efforts and investments in the development of port and nautical infrastructure are noted. Analysis of nautical tourism traffic for the period 2009-2018, shows the growing number of nautical tourism ports, which also affects the growing need for space that is in his purpose. Furthermore, comparison of the existing Spatial Plan of Split-Dalmatia County from 2013, with the previous plan from 2007, as well as comparison with the Action Plan of development of nautical tourism Split-Dalmatia County from 2013 showed that in the period 2007-2013 the capacity that is in use of nautical tourism greatly changed. In 2007, the total capacity (existing and planned then) was 8,157 berths, while in the currently valid Spatial Plan the capacity of newly planned nautical tourism ports is 1960, and the total capacity after the development and expansion of the planned ports should be 10, 198. Likewise, analysis of infrastructure for reception of vessels in Split-Dalmatia County show that there are location that have been identified in existing plans, but also there are locations that shall be included in the new spatial plans or shall be closed. It has been observed that in certain areas of the county additional requirements and demand for berths are noted and the stated requirements have been included in the spatial plans of municipalities or county.

Furthermore, during the construction and planning of new marinas, it is very important to respect the segment of environmental protection. While building new ports, the inappropriate places (e.g. natural parks) shall be avoided, and increase in reception capacity shall be done through the revitalization, rehabilitation and reconstruction of the existing ports. Apart from the devastating effect on the natural environment, inappropriate constructed nautical tourism ports, due to the dislocation of the points of supply and the lack of infrastructure, may have difficulties in the supply chain and cause problems in the preservation of the natural environment. [6, 19] Likewise, it is of great importance, which is in line with the set strategic goals within the Strategy for the development of nautical tourism 2009-2019, that the spatial planning system is constantly improved. The decision to build new capacity of nautical tourism ports shall be brought through determination of the carrying capacity of the area and the limits of reception capacity growth in a given period, with the aim of preventing their abrupt construction. [19] At the very least, it is indisputable that during the development of new activities, and use of marine resources for different purposes including the purpose of nautical tourism the component of spatial planning, with the aim of achieving sustainable and effective development should be included.

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MOORED AND PASSING SHIPS ASSESSMENT IN PORT

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ABSTRACT

Accidents in port areas are generally relatively minor given the lesser speeds prevailing, but dangerous cargo terminals located in the vicinity of populated areas present some risk of accidents with catastrophic consequences. The maritime risk assessment frameworks have been developed in many ports, but few include studies incorporating collisions between sailing and moored ships. The paper presents the risk assessment framework for such accidents. Moreover, it presents the important role of harbour regulations in navigation risk management process within the port area. Today's port regulations are created mostly based on the good practice of pilots and other experts, whereas quantitative methods are used less frequently. The intention of the presented case study was to demonstrate how quantitative risk assessment may be used in port policy development, which is why the method created is general and may be used in any terminal with dangerous cargo. The risk assessment of marine liquid gas terminals in the vicinity of waterways under navigational and operational safety considerations is an example of a port accident with extremely low probability and catastrophic consequences. The multi-stage method consists of several steps that make up a complex methodology, consisting of expert study, real-time simulation - a simulation of a collision in port is presented - and analytical-empirical calculations for consequence assessment. The case studies of the developed method are presented based on two real accidents, one in the Police Port along the Świnoujście-Szczecin waterway, and the second in the Port of Koper in Slovenia. The results of this study could be used as the framework for risk assessment of collisions in a port area, particularly when dealing with dangerous cargo or sensitive vessels like cruise ships.

Keywords: Port accidents, risk assessment, terminal safety, harbour regulations, mooring, collision energy

1 INTRODUCTION

Due to the nature of their business activity and complexity ports are highly challenging in regard to the development and implementation of a Port Safety Management System (PSMS). Moreover, the interests of groups with opposing goals need to co-exist in ports. The Harbour Master plays the crucial role, being responsible for overall port safety, implementation of safety regulations and PSMS, information exchange, the environment, and security within the ports. Unfortunately, there is a lack of global regulation in this area. There have been several attempts and case studies made to attempt to create such regulations (1), but there are serious obstructions, in particular because such a framework must satisfy global, regional, local, and industrial regulations.

The most comprehensive and elaborated legal framework for PSMS is the UK Port Marine Safety Code (2), which introduced a formal risk assessment including the ALARP (As Low As Reasonably Practicable) concept. A similar comprehensive concept has been implemented in New Zealand and is applied in other countries like the U.S., Canada, and the Netherlands. The risk management procedure applied according to this standard is based on the following steps: data gathering and familiarisation, hazard identification, risk analysis, risk assessment, and risk control. Several attempts have been made to link IMO (International Maritime Organization) FSA (Formal Safety Assessment) (3), (4), (5) with PSMS, but serious limitations have been observed, such as the influence of different standards of operation, especially for dangerous cargo handling terminals; the influence of constantly changing port infrastructure; that serious maritime accidents in ports are rare events; the belief of decision makers that due to low energies and ship speed reduction in ports the risk is lower than typically calculated; and that ship traffic influence and the significant influence of a human factor must be taken into account.

Port regulations (port bylaws) have a significant role in the safety management process as a major implementer of Risk Control Options (RCO). Additionally, several relevant documents exist in ports: terminal safety procedures, terminal operational procedures and procedures of accidents consequences mitigation (such as contingency planning). Port regulations are often created based on expert opinions (pilots, Harbour Master) using specific local knowledge. The dangerous cargo terminals (oil, gas or chemical) usually operate under an international industrial legal framework created by organizations such as OCIMF (Oil Companies International Marine Forum) or ICS (International Chamber of Shipping).

The paper first presents the need of a port to assess the risk between the approaching and a moored ship. The risk is defined as a potential loss of property and the risk criteria are related to the revenue of the analysed port and the cost of an average accident. According to the risk calculation the probability of accidents is calculated for two different ports according to the specifics of the approaching channels and piloting procedures. Next the consequences are analysed with the energy collision model supported by the kinematic model of mooring ropes. The result is the evaluation of the limit velocity of the ship approaching the terminal to keep consequences of a collision within a reasonable limit. The last is the evaluation of the risk applying the event tree approach considering the likelihood of the collision events and their consequences estimated in costs. The risk is presented with the F-N function comparing the two analysed ports.

1.1 Addressing risk

Again, accidents in port areas are rare events, especially those with significant consequences. This may be problematic in creating proper methodologies of their analyses and could lead to poor policy decisions (6). The risk assessment in port areas is a process wherein all possible hazards should be taken into account (7), (8). Several complex methodologies of risk assessment have indeed been developed (9), (10), but there is no detailed solution for risk assessment in regard to mooring ships with dangerous cargo, except for problems related with excessive waves generated by passing ships (11). The studies made by (12) show that port infrastructure facilities significantly affect vessel exposure to risk. Also, studies made by (13) and an earlier one, made by (14), stressed this problem and reveal that FSA methodology might be insufficient given constantly changing port infrastructure. Moreover, the authors demonstrate in this paper that the problem has a complicated spatiotemporal nature due to variability in quay occupation, which makes the situation even more complex.

In the presented study, the so-called Potentially Catastrophic Scenario (PCS) has been introduced to find the risk of a ship colliding with a moored ship due to technical failure. The PCS has been developed here by the combination of several analytical methods involving simulation of the impact energy. There is a potential possibility of a scenario with even higher negative outcomes, but the probability of such accidents in port has been assessed as extremely low, because of low approaching speeds and it is not taken into consideration (15).

Two accidents are described in this paper, neither of which caused significant consequences, but are used to demonstrate the ability of the proposed methodology to evaluate the risk of in-port manoeuvring operations. The first is a collision between the ship *Altamar* and the bunker ship Palica, moored side by side, into the 250 passengers Ro-Pax ferry *Baltivia* in Świnoujscie Ferry Terminal, Poland. The second is the collision between the container ship UASC MADINAH and the cruise ship Thomson Spirit Valletta in the port of Koper, Slovenia. Even though these accidents occurred between different types of ships and in different ports, the risk evaluation approach may be the same and the implementation of the RCOs transferred from one country or port to another.

Luckily, neither leakage of bunker liquids nor fire resulted from these accidents. The damage to the Palica tanker was around half of a square meter located on the forecastle a safe distance from the bunker ship tanks. The case of the container ship colliding with the cruiser caused more damage to the hull, but the load line area was not damaged.

Figure 1a: View of two collision events in a port of Police

Figure 1b: View of two collision events in a port of Koper

2 RISK ASSESSMENT FRAMEWORK

The consequence of the concept applied in this study is related to the accident energy released and with the depth of the moored ship hull penetration (h_d). In the presented cases, there is a safety barrier: the ballast tank located on the ship's side denoted by d_b. For the purpose of this study when the Potentially Catastrophic Scenario is taken into account, the risk is calculated as a product of probability and consequences only when the depth of penetration could reach a tank with fuel.

Acceptable risk is not specified in Polish or Slovenian legislation for such maritime systems (7), (16). Moreover, there is not enough operation time of such vessels in the studied area to develop acceptable risk standards based on statistical data as described by Kristiansen (10). The risk acceptance criteria are therefore calculated based on the potential loss of property (17). The risk of losing part or all of the port revenue and costs of ship damage or total loss is an economic risk that primarily influences the company policy. The world fleet statistics show that the number of accidents is increasing with the increase in the number of ships sailing. On the other hand, the consequences of accidents are less severe thanks to the continuous maritime standards improvements for ship construction, electronic navigation control, shore vessel traffic services, and more.

The risk of property loss is here calculated as:

$$PLP_A = r_P \cdot EV \tag{1}$$

Where EV is the average revenue of the port per ship year and r_P is the loss of property per accident per average port revenue per year.

$$r_P = (C_{a\_c}/rev_{a\_y}) \tag{2}$$

where,
C_{a_c} – is the average collision cost per ship year and

rev_{a_y} – the average revenue of the port per year

The unit for PLP_A is the ratio of property loss in M€/ship year M€ business economic value. Further, the frequency of property loss is calculated with eq. 3, where N_u is the cost of a total loss depending on ship type. An average value of $\sum_{N=1}^{N_u} \frac{1}{N}$ for Panamax size is 4.5, where N is 1 to the maximum property loss in M€.

$$\boldsymbol{F} = \frac{\boldsymbol{PLP_A}}{\sum_{\boldsymbol{N=1}}^{\boldsymbol{N_u}} \frac{\boldsymbol{1}}{\boldsymbol{N}}}, \tag{3}$$

For the year 2018, the tolerable damage cost F is calculated $1.34 \cdot 10^{-3}$ property lost M€/ship year (18). The acceptable area around this value is defined by factor 0.1 and 10, respectively, for the low and high sides.

Following are the results for the traffic analysed for the complete area presented for the traffic lane calling at the Świnoujście and the Port of Koper traffic waterways.

The probability of collision is further calculated where the most important factor is the hourly probability of rudder failure (P_t), which stands for rudder system failure. This value was determined by Gucma and Gralak (28) using a database of more than 77 ships of the Polish owner Polsteam over 7 years of operation. The expected value during ship passage is $4.8 \cdot 10^{-4}$ per hour of ships operation. For realistic traffic and input data for Police Port: I_w = 300 ship/year, I_t =40 ships/year, t_t =24h, t_w =0.5min, and P_r = 0.05 (starboard 30 deg.), we obtain the probability of collision due to technical failure of the rudder estimated as $8.9 \cdot 10^{-6}$ yearly.

For the Port of Koper the expected frequency of collision is calculated from *eq.1*, according to the simulated traffic flow from *eq.2* and *eq.3*. The result is $8.3 \cdot 10^{-4}$ per ship year with large spill consequence for 800 ships/year. The frequency of contact with lesser consequences is evaluated for 15 years of statistics and is $1.8 \cdot 10^{-3}$ per ship year.

3 DETERMINING THE CONSEQUENCES OF AN ACCIDENTS

Several methods for assessing ship damage resultant from collision have been developed. The comprehensive study of today's methodology of ship collision consequences is presented in (19), (20), (21). These methods in terms of the number of input parameters can be divided into dedicated methods (numerical methods; e.g., FEM), general methods requiring only general parameters (analytical), and combined methods (22). The method presented in this paper belongs to the second class and includes some simplifications so that it can be applied easily with only general assumptions about the parameters of the ships involved in the collision. The procedure for determining the consequences of collisions comprises the following steps:

- determine the collision scenario;
- determine the energy released during the collision considering rigid body dynamics;
- identify the material damaged in a collision;
- determine the expected maximum distance of penetration of the hull;

- determine whether the acceptable risk was exceeded - i.e., that the cargo tank may have been damaged.

3.1 Energy released during collision (external dynamics)

The energy is determined separately from the standpoint of movement before and after the collision assuming that the movement of the ship can be described by following equations of motion (33):

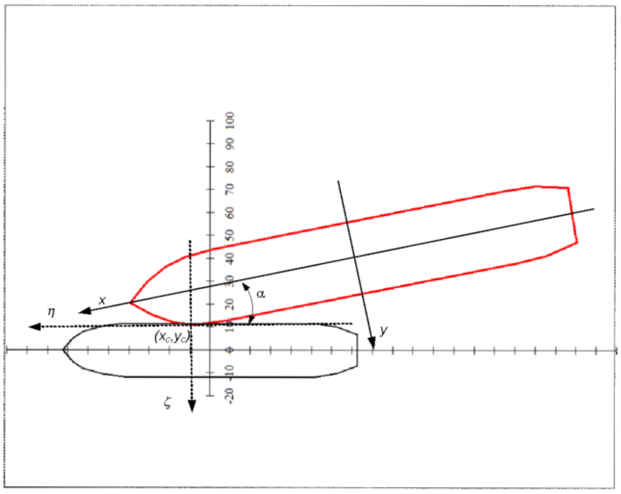

Figure 2: The xy and ζη coordinate system (collision with α=10 deg. angle).

The situation and coordinate system are presented in Figure . A further step according to the formulas of (23): the energy is calculated considering two cases, with sliding of the colliding vessel alongside the moored ship and with no sliding. The coefficient of friction (μ_0) and restitution coefficient (e) are part of the model. The energy loss is expressed as in (24):

$$E_\zeta = \int_0^{\zeta \max} F_\zeta d\zeta$$
$$E_\eta = \int_0^{\eta \max} F_\eta d\eta \tag{4}$$

where:

E_ζ and E_η – energy lost in ζ and η direction.

The detailed formulas in both cases are presented in (25). Additionally, the total energy of the striking vessel (E_0) is calculated as:

$$E_0 = 0.5 m_{ux} v^2 \tag{5}$$

In the literature, one can find information (23) as to how much energy is absorbed by the part of the bow of the colliding ship (due to the stiffness and construction of the bow part the values are given from 0 to 20%). In the presented calculations, it was set as 0% as a conservative value, which means the bow of the colliding vessel is not damaged at all. The results of calculations are presented in Table 1. The energy, damaged material, and depth of penetration hd are shown. The colours indicating exceeding of critical limit and the possibility of damage to the tank are marked according to the following ranges of hd:

- Red – exceeded the value of hd, certain damage to the tank i.e. hd>=1.5m,
- Orange – likely damage to the tank, dangerous values: i.e., 1m<hd<1.5m,
- Yellow – possible damage to the tank, values close to dangerous ones: i.e., 0.5m<hd<1,0m,
- Green – minor damage hd<0.5m.

The energies released during the collision for the relatively slow surge speed of a cruise ship of 2m/s is presented in Figure 3. It can be observed that when the collision angle is higher than 60°, there is no sliding of ships. The ratio of initial energy (E0=0.5mxv2) to energy dispatched during the collision is presented in Figure 3. It could be found that almost 90% of initial energy is released when the angle is higher than 40°.

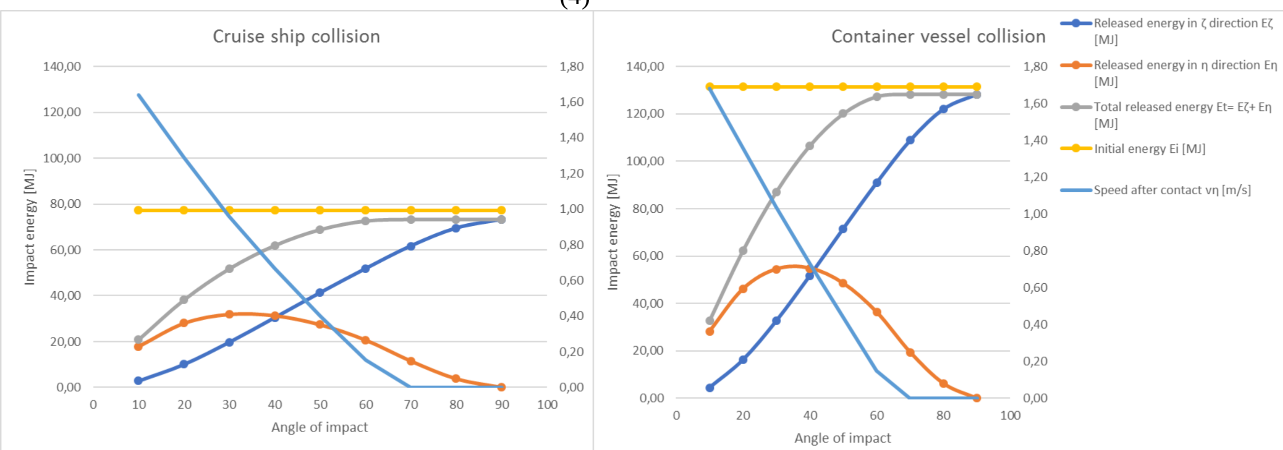

Figure 3: Energy release in ζ and η directions for initial surge speed vx=2m/s (Cruise ship and Container vessel)

Table 1: Energy released, damaged material and the depth of penetration h_d for chemical ammonia tanker struck in the side by a cruise ship with different parameters and speed

Energy [MJ]	Speed [m/s]				Depth of penetration [m]			
speed/ angle	1	2	3	4	1	2	3	4
10	6.89	32.72	62.04	110.29	0.35	0.6	0.75	0.9
20	13.57	62.31	122.17	217.20	0.45	0.75	0.95	1.15
30	19.67	87.15	177.02	314.70	0.5	0.85	1.1	1.3
40	24.87	106.57	223.82	397.90	0.55	0.9	1.2	1.45
50	28.86	120.08	259.72	461.72	0.55	0.95	1.25	1.5
60	31.26	127.28	281.38	500.23	0.6	0.95	1.25	1.6
70	31.78	128.27	286.00	508.45	0.6	0.95	1.3	1.6
80	31.78	128.27	286.00	508.45	0.6	0.95	1.3	1.6

Table 1 indicates that a ship at 4m/s speed could penetrate the tanks of a moored ship with 70 degrees angle between the colliding ships. The maximum angle that is physically possible due to traffic distribution and hydrodynamic characteristics of colliding ships is estimated at about 50 degrees.

4 CONSEQUENCES OF COLLISION ON A MOORED SHIP

The force exerted on a ship during a collision not only causes damage to the hull, but the impulse of that force is also transmitted to the ship itself, which moves. The energy that the mooring ship takes over is transferred to the mooring ropes, which must limit the movement. The movement of the moored ship is contained as long as the mooring lines are intact; when they break the ship would float freely, causing additional risk. Particularly critical is the movement during cargo operations. An excessive movement of the ship could cause damage to a loading crane on a bulk carrier or a pipe breaking on a tanker ship or extensive damage to a cargo ramp on a Ro-Ro ship, etc. The model presented limits the permissible displacement of 4 m in the longitudinal direction. The model is based on a formulation of the static force equilibrium oriented to the collision point.

$$\sum F_i x = 0$$

$$\sum F_i y = 0 \tag{6}$$

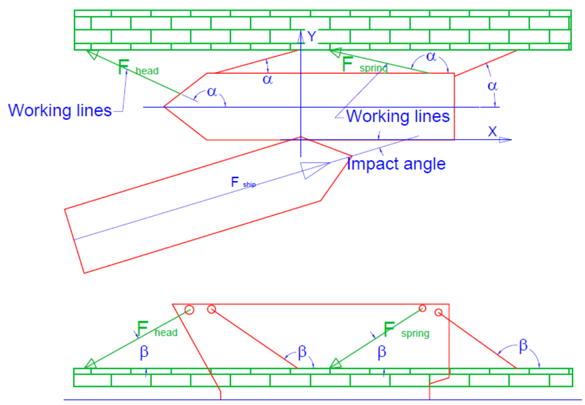

Figure 4: Mooring configuration and rope angles

The resulting forces in mooring lines are F_{head} and F_{spring}, calculated considering the horizontal and vertical position of the lines. According to the mooring configuration and the collision direction, the force of the collision is transferred to the mooring lines but also to the fenders on the banking side of the ship. In fact, part of the moving energy is converted to friction between the ship hull and fenders. The presented mooring model also considers the friction force resulting from the impact force in *y* direction and the friction coefficient (0.5).

Table 2: Mooring lines positions and length for the lateral collision model

	Length	Alpha	Beta	No.	
Head l.	60	140	20	2	in use
Stern l.	45	150	15	2	not in use
Breast l. FW	55	120	15	2	not in use
Breast l. ST	38	160	15	2	not in use
Spring l. FW	42	170	15	1	not in use
Spring l. ST	90	170	10	2	in use

Table 2 shows the length of engaged mooring lines and their angles according to the ship mooring plan at the port terminal. The number of lines could vary and depends on the weather condition, but for steady conditions the mooring configuration is as presented. The longitudinal force transferred from the colliding to the struck ship is transferred to the two headlines and two spring lines.

According to the force equilibrium equations the tension on the engaged ropes is calculated considering the collision speed and angle. Most of the force is transferred to the spring line as its angle is almost in line with that of the pier.

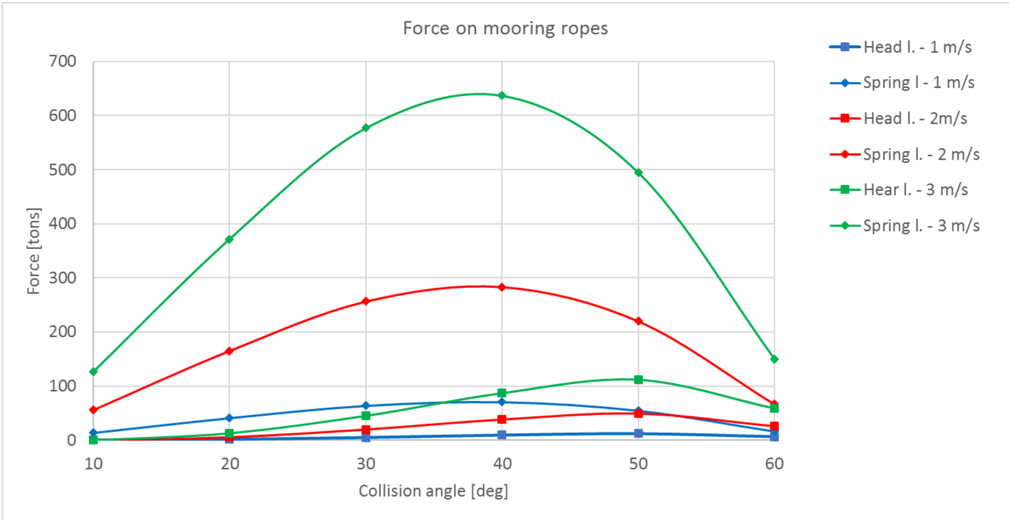

Figure 5: Force on mooring ropes caused by the collision

Figure 5 shows the calculated forces on headlines and spring lines that take on the impact force.

Further, the calculation of mooring ropes is performed. According to the equipment number each ship applies specific mooring equipment, which includes the working load of mooring ropes and their size. As the market offers different types of mooring ropes, made from different materials, the model below assumes two type of ropes. The first is a high tensile aramid rope with a diameter of 50 mm and a breaking load of 180 tons, the second is polypropylene rope with a diameter of 80 mm and a breaking load of 105 tons. The maximum allowable elongation of each rope presented in Table 3 is used to calculate the extension of the rope under load condition and to determine when the extension overcomes the maximum allowable ship movement. As observed in the table the aramid ropes are more likely to break in excessive load condition. The polypropylene ropes work with more elasticity and could not keep the moored ship in position even in low speed collisions or contacts.

Values in Table represent the lengths of ropes under collision load conditions. When the calculated length of the rope exceeds the allowable elongation percent it is indicated as “Max movement” and when the calculated load on a rope exceeds the breaking load it is indicated as “Break”.

Table 3: Calculation of forces in mooring lines, extensions, and tear points

Rope elongation d=50mm, Mooring line (Aramid) [m]			
Max load [ton]	**180**		
Elongation [%]	**5%**		
angle/speed	1	2	3
Head l./ Spring l. ST	**Aramid line**		
Head l. 10°	60.00	60.00	60.00
Spring l.	90.18	90.70	91.58
20°	60.01	60.05	60.11
	90.52	92.07	Break
30°	60.04	60.17	60.38
	90.80	93.21	Break
40°	60.08	60.32	60.73
	90.89	93.54	Break
50°	60.10	60.42	60.94
	90.69	92.75	Break
60°	60.06	60.22	60.49
	90.21	90.83	91.87

Rope elongation d=80mm. Mooring line (Polypropilene)[m]			
Max load [ton]	**105**		
Elongation [%]	**18%**		
angle/speed	1	2	3
Head l. Spring l. ST	**Polyester line**		
Head l. 10°	60.00	60.00	60.00
Spring l.	91.08	Max movement	Max movement
20°	60.08	60.30	60.67
	93.19	Max movement	Break
30°	60.26	61.04	62.33
	Max movement	Break	Break
40°	60.50	62.00	Max movement
	Max movement	Break	Break
50°	60.64	62.56	Max movement
	Max movement	Break	Break
60°	60.34	61.35	63.04
	91.28	Max movement	Max movement

According to the calculated consequences in this analysis, the following risk control options (RCO) are considered as follows:

- Speed reduction while passing near the berth of a moored ship;
- Restrictions or prohibiting bunkering or liquid cargo operation during passage of large passenger ship;
- Speed limit or prohibition of passages near a moored chemical ship;
- Special navigational markings;
- Mandatory tugboat requirements.

5 RISK EVALUATION

The risk evaluation applies the event tree for the collision event. The basic structure of the event tree is based on the MEPC report (18) and is used is used for the calculation of PLP.

The main branches of the collision event tree have four main levels. At the first the ship is considered as moored or sailing (stuck or striking), the second is the area of the accident (terminal area, congested waters, open waters, or limited waters), the third is the loading condition (loaded or in ballast), and next is the accident magnitude where the hull could be breached or not. Double hull penetration or not is also considered. The probability of each branch is partially obtained from the MEPC report but modified with the statistical data from the Port of Koper and the police port. The initial collision probabilities for two ports have been previously calculated and used in the event tree. The final probabilities of each branch and the risk are calculated and further used for the design of the risk curve. The collision risk is here presented with the F-N curve for a panamax ship. The PLP risk for larger ships could exceed the tolerable risk mainly because of higher ship value, which is why the average ship size is considered.

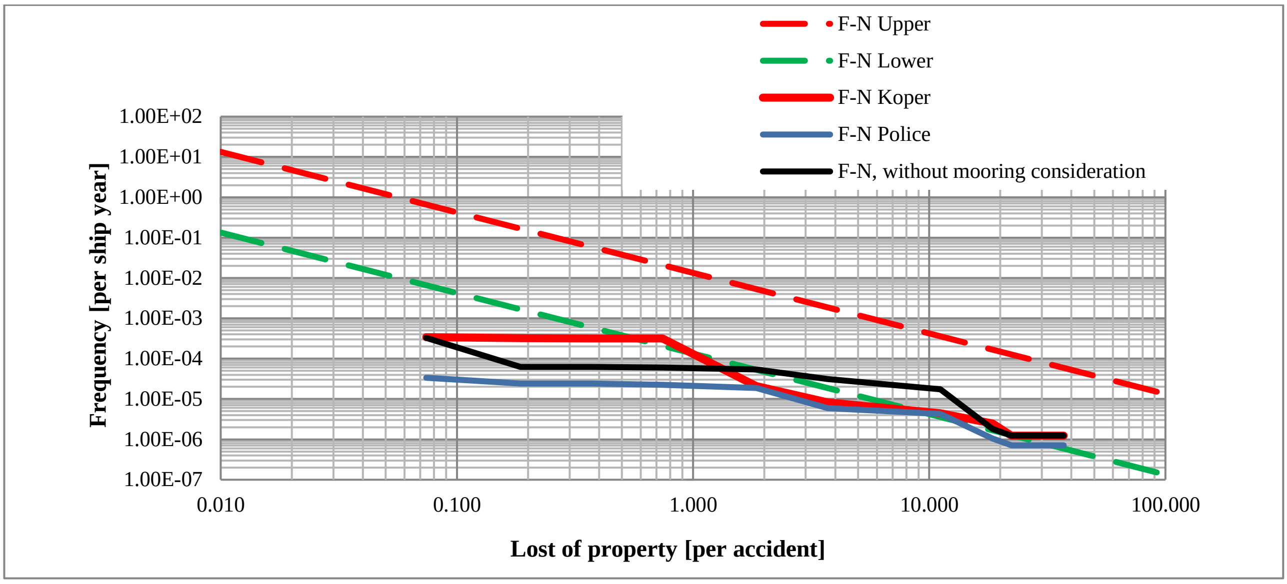

Figure 6: Collective risk level for an average ship size in port for collision event

Figure 6 shows the economic aspect of the risk where the PLP graph above shows that the property losses, due to collision accidents, do no produce relevant economic risk to the port. It should be noted that risks should be considered together, especially those which are directly related with the cost benefit. The second is the risk curve for the police port that is lower than the Port of Koper only because the initial probability is lower than calculated for the Port of Koper. Considering that the probability of mooring failure during the collision in port influences the risk curve in the range of 0.1 to 10 M€ damage, the findings mean that the mooring break of a ship should be considered in the risk assessment although in the analysed port the risk in both cases is within the acceptable area. The presented results quantitatively suggest the importance of a proper mooring arrangement assuming the probability of a collision in a terminal area.

Considering the findings from section 0, the approaching speed to a terminal basin should be about 2 to 3 knots and the approaching angle towards a moored ship not more than 30°. Exceeding these values the moored ship would break the mooring ropes and move from its mooring position. The F-N curve where the mooring failure is not considered shows that the accident with same probability of collision could result in property loss that is 8 M€ higher than when the mooring failure is considered.

6 CONCLUSIONS

The problem of the coexistence of dangerous cargo terminals with ship traffic requires assured acceptable risk levels in port areas. The aim of the presented method is to provide decision makers a methodological framework for calculating the risk along with practical actions that should be taken to minimize this risk to an acceptable level. Such actions could be implemented as port regulations.

The method and framework presented in the paper is aimed at determining the risk of a possible collision between a passing ship and a moored ship. It should be noted that the simulation method was used to determine the maximum physically possible speed and angle of contact in a PCS (Potentially Catastrophic Scenario) accident. Usually, in restricted port areas, there is no possibility of achieving such high energies and angles of impact; in such a case, there is no need to carry on such extensive investigations. The consequences model was applied by changing input parameters. The maximum acceptable speed of a passing ship is calculated based on the consequences to the moored ship and its break from the moored position. According to the calculated probability of collision and consequences the risk is evaluated. The event tree approach is applied where the risk is presented with the F-N curve. The event tree is found to be the most appropriate approach as the methodology framework, as it can be constantly upgraded with new events and the probabilities of branch events may be modified on monthly or yearly basis according to port statistics. The paper demonstrates that considering the mooring characteristics in a risk assessment of the port could reduce the risk through acknowledging that a collision accident would not result in extremely high consequences for ships and structures. The cost of a stronger mooring arrangement is minimal while the savings could be considered in millions for a single accident.

The paper demonstrates that previously developed frameworks for maritime risk analysis did not fully cover the accident type presented here (collision). The presented work and framework can be used for port policy making. As the engineering conclusion from the case study, which was used as an example, the large ships reducing speed is the most economical solution along with navigating with caution when a sensitive ship is moored in the passageway of the approaching ship.

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OVERCOMING GROWTH BARRIERS IN REGIONAL PORT DEVELOPMENT

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ABSTRACT

Ports are complex systems that have a crucial role in the transportation of freight and unquestionable importance for economies worldwide. The functioning of the ports requires a lot of resources, and their performance depends on many factors.

The focus of the paper is on the Port of Koper and Port of Gdansk. Two ports, located in the countries with a similar history that joined the EU in 2004, are connected by the Baltic-Adriatic corridor. The authors analyse the development of these ports in the recent period and identify the key measures that boosted their progress. In the final part of the paper, the authors analyse the transferability of identified measures between the ports.

Keywords: seaport, Poland, Slovenia, port development factors, comparative analysis

1 INTRODUCTION

Ports are complex systems that have a crucial role in the transportation of freight, as around 11 billion tonnes of goods are transported by sea annually. From 80 to 90% of international trade expressed in ton-miles is done by the sea. International maritime trade is expected to grow, with an average annual growth rate of 3.5 % over the period from 2019 to 2024 (UNCTAD, 2019) further. This will put even more pressure on the ports and their hinterland links as ever bigger ships with ever-higher quantities of cargo call to the ports.

Ports are facilitators of trade, and they create a substantial value added by direct, indirect, and induced impacts in the region. Ports directly provide jobs to the local population, but this is rather marginal in comparison with the broader regional economic implications. Many factors influence the importance and position of the port in a global context. These factors are (e.g., Slack (1985), Tongzoon (2002) or Wu (2011)): port's infrastructure and equipment, port's efficiency, sea access, location of the port, port's hinterland accessibility, port charges and the costs of auxiliary services, the reputation of the port, etc.

The ports analysed in this paper belong to the two countries with similar histories; both were rather closed and centrally developed before the 1990s, and both joined the EU at the same time. Yet they are also different in many aspects.

The authors analyse the development of the Port of Koper and Port of Gdansk in the recent period and identify the key measures that boosted their progress. In the final part of the paper, the authors analyse the potential transferability of identified measures between the ports.

2 THE ANALYSED PORTS

Ports are essential for the European economy, as about 74% of EU international trade and about 37% of EU internal trade is done by sea (Pastori, 2015). Around 1.5 million workers are employed in European ports directly and a similar number in accompanying activities. The general perception of ports is thus that they are engines of socio-economic development for the regions they serve (e.g., Danielis & Gregori, 2013; Valantasis-Kanellos & Song, 2015; Jouili, 2016).

In total, European ports handle around 4 billion tonnes of cargo annually. According to the European Sea Ports Organization (ESPO), approximately 1,200 ports in 23 EU member states carry out around 90% of this traffic. Among these ports are also the port of Koper and the port of Gdansk.

2.1 The Port of Koper

The Port of Koper is the only Slovenian international cargo port. In 60 years of operation, it developed from a single berth port to a port with 12 specialized terminals, with 3,300m of the quayside and 26 berths. Seventy kilometres of roads and thirty kilometres of rail lines connect all the terminals to the public transport infrastructure. Annually around 2,000 ships call to the port, and in 2019 the port handled roughly 23 million tons of cargo and almost 960,000 TEUs.

The port, managed by the public limited company Luka Koper, currently covers 280 hectares of area. Luka Koper is planning a significant expansion of the port area and, consequently, an increase in the throughput; by 2030, it should be between 27.4 and 35.1 million tons (Luka Koper, 2015).

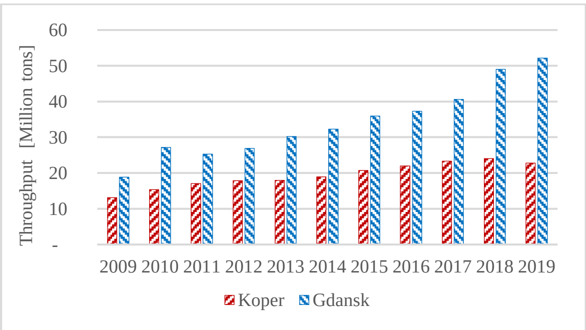
2.2 The Port of Gdansk

Poland has several international cargo ports, among which Gdańsk, Gdynia, Szczecin, and Świnoujście are the most important. All Polish ports reached 100 million tons of traffic for the first time in 2018.

The Port of Gdańsk is the largest Polish port with the share in total throughput, reaching 46% in 2016 (up from 39% in 2009). The port spreads on more than 1,065 hectares of the area divided into two sectors, inner port, and outer port. This landlord port was called by around 2,500 ships and handled more than 52 million tons of various types of cargo in 2019. The plan is to double this volume by 2030.

3 COMPARISON BETWEEN THE PORT OF KOPER AND PORT OF GDANSK

In the period from 2009 to 2019, the Port of Koper increased its throughput by almost 74%, while Port of Gdansk recorded an increase of nearly 177% or in other words, the average annual growth rate (AAGR) was 5.8% in Koper and 11.4% in Gdansk. What are the reasons for the booming that Gdansk is recording, and what can Koper learn from Gdansk experience? To identify the answers, it is necessary to check the development of the port in a longer period.

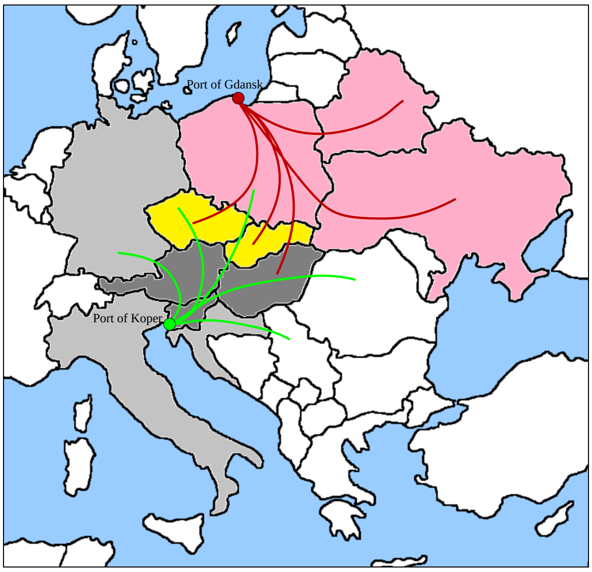


Source: authors, based on (Luka Koper, 2020); (Port of Gdansk, 2020a)

Figure 1: The throughput of the Port of Koper and Port of Gdansk

3.1 The port hinterland

The construction of the commercial port of Koper commenced in the 1950s when it became clear that Trieste and its port would not belong to Yugoslavia. In the same period also the port of Gdansk was rebuilt, following the devastation during World War II. The Port of Gdansk became the leading industrial and shipping center of the Polish People's Republic and mainly served the large Polish and Soviet economy until the beginning of the 1990s. Port of Koper, on the other hand, helped the economy of Yugoslavia together with the port of Rijeka in its initial years of operation, but already by the mid-1970s, transit represented more than 50% of the total throughput (Sadar, 1999). Later, this share declined slightly; however, since Slovenia's independence, foreign markets represent about two-thirds of the port's traffic. With independence, the port of Koper lost the Yugoslav market and had to focus on the demands of Central Europe. Today, the hinterland of the port of Koper comprises Austria, Hungary, Czechia, Slovakia, Croatia, northern Italy, and even southern Germany and Poland. Similarly, the port of Gdansk lost the once profitable and reliable (regardless of occasionally turbulent relationship) markets of the Soviet Union when the state disintegrated. The hinterland of the port of Gdansk now consists of the Czechia, Slovakia, Ukraine, Belarus, and Poland. As can be seen from the following figure, two countries are of the particular interest of both ports, namely Czechia and Slovakia.



Source: authors, based on ports' documents

Figure 2: The (overlapping) hinterlands of Port of Koper and port of Gdansk

The hinterlands of both ports have a tremendous economic potential, which will be further emphasized with the movement of "blue banana" – Europe's industrial heartland towards the east, where the labour force is cheaper. This gives the ports the reason to be optimistic as the cargo concentration in the hinterland will rise.

3.2 The port administration

The Port of Gdansk Authority SA was established in 1998. This company is the sole entity managing the port in Gdansk. It is owned by the State Treasury, the Municipality of Gdansk, and the entitled employees. The Port of Gdansk is a landlord port, where the Port Authority manages the properties and port infrastructure, plans the port development, acquires properties for port development needs, constructs, develops, maintains, and upgrades the port infrastructure, assures the access to port facilities, etc. The Port Authority seeks to recover all port-infrastructure related costs, generate cash flow, and attract outside investments and private capital. The port's infrastructure is leased to 19 operators that provide cargo handling services; in some of them, also public money is present.

Contrarily, the Port of Koper has a unique administration model. There is no Port Authority in Slovenia. Instead, Luka Koper, the public limited company with the 51% state ownership, governs and manages the development of the Port of Koper and, at the same time, provides cargo handling operations and other value-added services on all terminals. Luka Koper is hence at the same time the Port Authority and the only concessionaire in the port. So, Koper is not a standard service port, nor is it a corporatized port. Still, it has some of the weaknesses of these two models, mainly the mix of public and private objectives, the inefficiency due to the lack of internal competition, limited access to federal funds, and less problem-solving capability and flexibility in case of labor problems.

3.3 Main cargo types

In the analysed period, Gdansk turned from bulk port to the universal port handling more than 65% of the traffic of the container in all Polish ports in 2016; since than, this share has increased. Yet other cargo types have not been neglected either. Liquid fuels, general cargo, coal, and grain have the highest percentage in the throughput of the Port of Gdansk; however, all cargo types are handled in the port. The throughput diversity guarantees that the port is not much affected by turbulences in individual cargo groups. Recently, this was proven when the grain market was in crisis; however, the port's throughput was not affected.

The Port of Gdansk is the fastest growing port in Europe, and the deep-water container terminal (DCT) contributes largely to this success. Its unique location, in the ice-free zone of the southern Baltic Sea, makes it the ideal gateway port for the Central and Eastern Europe and transhipment hub for the Baltic.

Following the idea from the late 1990s, the Gdansk Port Authority leased port premises to build the first deepwater container terminal in Poland in 2004 to the DCT Gdansk. This decision changed the course of the history of the Port of Gdansk and initiated a change in the transport geography of the Baltic Sea (Port of Gdansk, 2016). The first direct weekly link to Asia was established in 2010. The DCT terminal exceeded the first million containers already in 2013. The new quay was finished by the end of 2016, and the yearly capacity of the terminal increased to 2.8 million TEU. The terminal that has 1,300 m of the quay is currently equipped with 11 post-Panamax ship-to-shore (STS) container cranes and can accommodate the largest container ships. DCT Gdansk has been transferred to Singaporean state port operator PSA International, the Polish Development Fund (PFR), and the IFM Global Infrastructure Fund in 2019.

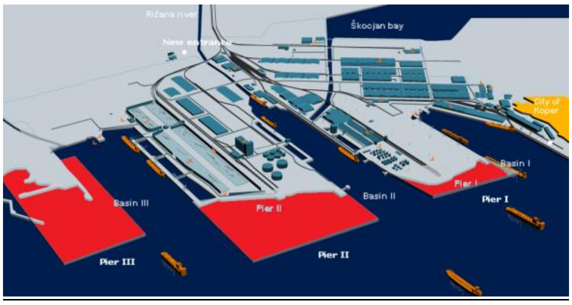
In the same period, the Port of Koper has focused on containers and new cars; the Port of Koper is the leading container port in the North Adriatic and the second biggest car-port in the Mediterranean region. The port's car terminal is working with all major car manufacturers, and in 2019 they handled almost 706 thousand cars. This was 50 thousand less than a year before. In terms of container manipulation, the Port of Koper is not demonstrating any essential advantages to other north Adriatic ports but has until 2019 been doing better than the rest.

Such specialization can be very risky; both segments are profitable, but for the containers, the competition is very harsh as there are five large ports located in the radius of around 100 km. At the same time, the car market is very volatile, which was pretty evident in 2009 when the port handled 45% fewer cars than in 2008.

3.4 Port expansion

The port of Koper is about to reach its maximum throughput capacity. In more than a decade, the port's area has not been expanded while the cargo throughput doubled. The ambitious expansion plans of Luka Koper can be seen in Figure 3. Slovenia's National Spatial Plan confirmed those plans in June 2011; however, the projects are delayed, and some, like the construction of pier III is on hold for the moment. Nevertheless, Luka Koper plans around EUR 700 million EUR of investments in infrastructure and superstructure in the port area for the period 2016-2030, 300 million in the period until 2020, and an additional 400 million until 2030. These investments include (summarized from Luka Koper, 2015): extension of Pier I and Pier II, extra storage areas (including covered storages for liquid, bulk, and general cargos as well as covered storage areas intended for container stripping and stuffing and additional vehicle storage facilities) as well as provision of rail tracks, improved road accesses, seabed dredging, and sediment disposal sites.

The extension of Pier I started in 2019. It will add around 100 m of quay to the existing container terminal. The entire investment, which is expected to be completed in 2021, will result in the increased capacity of the container terminal to at least 1.5 million TEUs annually. The total value of the investment made by Luka Koper in the modernization of container terminal (equipment) and quayside is approximated to EUR 235 million.



Source: (Luka Koper, 2012)

Figure 3: Expansion plans for the port of Koper

Although the current capacity of Port of Gdansk surpasses 99 million tons, the expansion plans are massive; a three-stage EUR 2.8 billion terminal complex of a new Central Port should include 19 km of new quays, 8.5 km of breakwaters, nine terminals for a variety of cargo, four turning basins and three approach fairways (Safety4sea, 2019). The terminals will be used for containers, passengers, offshore operations, LNG operations, and shipbuilding, the selection of the priorities will be market-driven.

Source: (Poland at Sea, 2019)

Figure 4: Visualisation of the Gdansk Central Port

3.5 The hinterland connections

The favourable geostrategic position of the Port of Koper has been emphasized for more than 20 years; Koper and other North Adriatic ports provide the shortest sea-route from the East to Europe. Yet, not much has been done regarding the port's access to land transport infrastructure and hinterland infrastructure itself, in particular rail infrastructure, that would further enhance the position of the port.

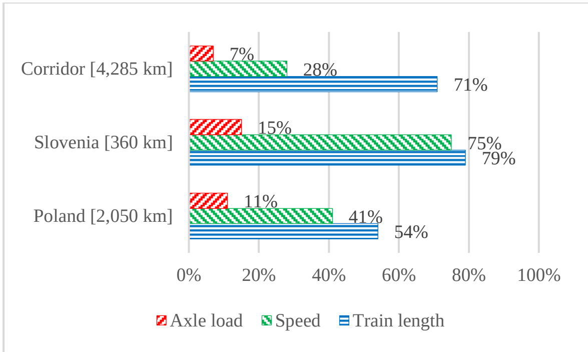
The highway system of Slovenia has been completed, and the port got a new entrance after a long period of negotiations. However, it is still not fully operable and has not relieved the congestion in the city. Around 1,000 trucks transit to the port daily.

The existing one-track electrified railway line between Koper and Divača is the only railway connection of the port of Koper to the hinterland. The capacity of the line is limited due to its technical characteristics (electrification system, significant inclination), and potential traffic is additionally affected by different emergencies and works on the line. The utilization level of the track is at the maximum. In general, rail infrastructure in Slovenia is outdated and limits the performance of rail transport; nevertheless, around 60% of the port's throughput (transshipment excluded) is done by rails. The new track with a length of 27 km is to be completed by 2026 at the cost of around 1.3 billion EUR.

Neither Slovenian nor Polish railways fit the requirements of the Baltic-Adriatic Corridor. The Baltic-Adriatic Corridor is one of the most critical trans-European road and railway axes in Central Europe. It connects the ports in Adriatic with the ports of the Baltic Sea. The port of Koper and the port of Gdansk are positioned on this corridor and are listed among the 328 core TEN-T ports.

The Baltic-Adriatic Corridor includes 3,600 km of road and 4,285 km of rail infrastructure. While the road infrastructure is satisfying almost along the entire corridor, the rail infrastructure is not.

Rail infrastructure portfolio of the Baltic Adriatic Corridor consists of 20 Connecting Europe Facility (CEF) Actions, eight of them are located on the Polish part of the corridor. They are worth EUR 936 million of CEF Transport funding. Another five are on the Slovenian part of the corridor and are worth EUR 212 million of CEF funding (EC, 2018).



Source: authors, based on (Bodewig, 2018)

Figure 5: Extent of non-compliant rail freight infrastructure in 2017

Poland has an aspirant plan to improve its railway network, and consequently fully realise its growing importance as a transit country. Poland plans to invest around EUR 15.9 billion in the railway network by 2023. By 2019, around 60% of the National Railway Programme has been either completed or in progress, totaling in investments of around EUR 9 billion (RailwayPro, 2019).

The Port of Gdansk is well connected to its national transport networks. In 2016, the tunnel below the Martwa Wisla came into service. The tunnel connects the left-bank side of the Port of Gdansk with the national road and motorway network. The investor was the Gdansk Municipality, and the project was co-financed from the European funds. The value of the investment amounted to EUR 210 million (Port of Gdansk, 2020b). Together with other rods sections, the tunnel allows getting to the

Port of Gdansk from the A1 motorway without encountering any traffic lights or traffic jams.

The modernisation of the railway line linking the port and the construction of a new railway bridge. The EUR 123 million investment, which included the laying of more than 30 km of new railway tracks, and the construction of 5 flyovers and bridges as well as the local rail traffic control centre, increased the rail traffic capacity of the junction six-fold (Port of Gdansk, 2020b).

4 DISCUSSION AND CONCLUSIONS

In 2019, the throughput of the Port of Koper decreased for the first time in more than a decade. The decrease of more than 5% was mostly geared by the reduction of general and dry bulk cargo by more than 16 and 17%, respectively. The number of handled containers dropped by 3%. When the throughput declined in 2009, it was a global phenomenon due to the global economic crisis, but the decline in 2019 is somewhat specific, as global maritime trade increased by 2.6% (UNCTAD, 2019), notwithstanding the trade war between US and China. The throughput in other North Adriatic ports also decreased, but the structure of their throughput suggests the shift of cargo among the ports existed, and that the port of Koper lost the most. The Port of Gdansk continued to increase the throughput also in 2019.

Nowadays, ports no longer compete only with the offer on the seaside, e.g., by investing in terminals and improving their efficiency, or by assuring better maritime connections, but also on landside, with logistics chains, IT services, and door-to-door connectivity. Studies (e.g., OECD/ITF, 2008; de Langen, 2008; Meersman et al., 2009 or Tongzon, 2009) show that the quality of service and thus the competitiveness of a port diminish when the port or its hinterland links are approaching the maximum capacity utilization. In such cases, the time required for the goods to leave or reach the port increases, and this results in higher costs and also reduces the reliability of the service. The Port of Gdansk is the only port on the Baltic capable of receiving the largest container vessels. It has been supported by local and national authorities, while the administration model allows it to attract private capital. Recently, the connection of the Port of Gdansk to the national transport networks has been improved, and the port can further develop without hampering the development of the city or weakening the positive relationship between the port and the local community. Also, Poland is the fastest growing and seventh-largest economy in the EU, with a total GDP of EUR 524 billion. With its 40 million inhabitants and well-developed industry, it is alone the important market for the national ports, and the relatively good hinterland connections link it to a market of 120 million people.

Port of Koper has limited expansion possibilities; the port is surrounded by settlements on two sides and by a nature reserve on the third one. Furthermore, the unique administration model of the Port of Koper limits the capabilities of its investment while the state doesn't seem to support the port's development eagerly; the fortunate geostrategic position of the port and country has been highlighted since Slovenia became an independent state. EU recognized this position back in 1993, but Slovenia delayed with the construction of the national transport network and especially neglected the railway system. The inability to determine the shares of equity in a Luka Koper company makes the restructuring impossible at the moment. However, fresh capital is inevitable if the Port of Koper wants to maintain its position among the north Adriatic ports.

The two analysed ports have a shared hinterland in the form of two land-locked countries, namely Slovakia and Czechia. The Slovenian Port of Koper has the advantage of providing the shortest route from East (Asian countries are important trading partners for both countries). At the same time, the Port of Gdansk can already accept the largest ships. Besides, Poland is currently putting more effort into restructuring its railway infrastructure than Slovenia.

The characteristics of the railway infrastructure have a significant impact on the utilization of rolling stock and, consequently, on the economy, competitiveness, and reliability of rail transport. Railway transport in Slovenia does not manage to achieve the competitive advantages that railways can otherwise offer. Train lengths are limited primarily for operational, organizational, and safety reasons (e. g., train crossing or station lengths), and the weight of trains and wagons is limited primarily for technical reasons.

Slovenia is considered a high-income country, but the economy is small, and transport-related projects are costly due to dynamic terrain. The second track connecting the Port of Koper to its hinterland is finally under construction, but there are many other deficiencies on the Slovenia railway network. If they are not to be eliminated soon, the cargo might divert to other north Adriatic ports as Italy has good railway infrastructure, and Austria is investing EUR 9.5 billion in its southern rail infrastructure. Another alternative is the Port of Gdansk with longer transit time but lower transport costs.

Port of Koper cannot reach the volumes of Port of Gdansk (if for nothing, then for the limited expansion possibilities), but can improve its position in the north Adriatic area by systematically following the steps the that Port of Gdansk took. Simultaneously the state of Slovenia needs to understand the value of the port for the national economy. The Port of Koper is an important source of employment; the estimates show that every million tons of throughput in the port generates 820 working places, and the Port of Koper contributes around 2% to Slovenian GDP (Luka Koper, 2018).

In this paper, the authors analysed the elements influencing the port operation and the possibility of the Port of Koper to implement certain measures. The analysis is not supported by quantification. In future research, the authors will analyse the time series for both, or selected, port to identify the effects of the measures on the performance of the port. Several indicators will be created and compared.

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FORMATION OF THE MODEL OF CONTRAILER TRANSPORTATION MANAGEMENT IN THE CONDITIONS OF INFORMATION ECONOMY

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ABSTRACT

An important strategic direction in the development of the administration and management of contrailer transportation, increasing its productivity, competitiveness and quality of transport services in the sphere of information economy is the transformation of such transportation and logistics systems into new models. Formation which is possible by application of principles and methods of digitization of transport services, consolidation of independent subjects of the existing transport-production process, geographically distributed and interacting in the integrated information-economic space.
The publication focuses on the search for an effective way to improve and implement the resources of the transport system in the space of interaction of several modes of transport in the segment of contrailer transportation, the idea of which is to assess the ability of enterprises to participate in such transportation, as well as in the integration of information systems, as operating subjects of the transportation process, and the future.
In this paper we present the model of counter carriage management in the information economy, which was developed and passed state registration in the Russian Federation. The developed model automates the accounting, analysis and ranking of correspondence of technical equipment of railway stations and transport and logistic terminals for the assessment of their possibilities of planning and organization of contrailer transportation on directions. It analyzes and selects the optimal complex measures for technical retrofitting of subjects of piggyback traffic. Carries out the control of the contrailer cargo traffic by the railway transport, records and registers the influence on the fulfillment of the schedule standard of the contrailer cargo traffic as a part of the road trains, records the influence of the freight participants on the fulfillment of the road train traffic standard at all stages of freight transportation.
Introduction of the information model of the contrailer transportation management, consolidates the information systems of the contrailer cargo transportation subjects and increases the information exchange in the information and economic space, as regards the execution of the transportation documents and applications for cargo transportation, the choice of economically rational conditions of loading, unloading and transportation, the choice of the optimal mode of transportation at all stages of cargo transportation.

Keywords: model, contrailer transport, information system, information economy

1 INTRODUCTION

Scientists and engineers of many countries solve problems of cargo transportation optimization, taking into account many aspects of the transport system functioning, its problematic (non-productive) sections and attractiveness of different segments of the transport services market, including the costs of transport infrastructure development and safety provision.

The article is devoted to the problem of development of transport potential of Russia in the segment of intermodal (contrailer) transportations. The basic attention is directed on search of an effective way of perfection and realization of resources of transport branch in space of multimodal transport interaction, and also development of its transit potential at the organization of intermodal (contreiler) transportations. The idea is to assess the capacity of enterprises to participate in such cargo transportation, as well as the integration of information systems, both existing subjects of the transportation process and future.

One of the important strategic directions in the development and improvement of the systems of piggyback shipment, increasing their competitiveness and productivity, is the transformation of these transport and logistics systems into qualitatively new, formed on the principles and methods of digitalization of transport services, consolidation of independent entities of the existing transport industry, geographically distributed and interacting in the integrated information and economic space.

The ongoing scientific research and world practice determine the following prerequisites for the development and improvement of intermodal (piggyback) transportation in the Russian Federation:

- a large share of freight on roads from export-import cargo transportation;
- regional restrictions on road freight transportation during off-season periods;
- difficult (adverse) climatic conditions;
- highly developed transport infrastructure of the railway system;
- perfect infrastructure of the railway industry information complex;
- availability of automated corporate transportation management systems;
- global trend of development of environmentally safe modes of transport and cargo transportation methods;
- increased market share of transport services in international intermodal (piggyback) traffic.
- organization of unified international transport and logistics services.

The basis of formation of the given intermodal cargo transportation in Russia, is integration of system of intermodal (piggyback) cargo transportations of the country in integral world transport and information environment and perfection of resource possibilities of transport branch in a segment of transit cargo transportations. Realization of the given perspective in the conditions of information economy, is possible by qualitative interaction of two types of transport (railway and automobile), construction of the integrated information environment of management of processes of manufacture and transportation in a global information content, perfection of types of transport services and ways of their granting.

2 SYSTEM DESIGN PRINCIPLES AND TECHNIQUES

At present, in the Russian Federation, the organization of intermodal (piggyback) transportation using the railway industry is at the stage of development, so one of the largest operators of railway rolling stock Joint Stock Company "Federal Freight Company" (JSC "FGC"), developed and passed state registration, the model of specialized railway rolling stock (piggyback platform) and a multi-turn means of fastening vehicles. The Open Joint Stock Company Russian Railways (JSC Russian Railways), the only company transporting railway industry, has organized a survey of railway directions for the possibility of intermodal (piggyback) cargo transportation. The next stage envisages the inspection of transport and logistics terminals for the organization of such cargo transportation.

The publication focuses on the search for an effective way to improve and implement the resources of the transport system in the information economy, in the space of interaction of several modes of transport in the segment of contrailer transportation [1]. The idea is to assess the ability of enterprises to participate in such cargo transportation, as well as the integration of information systems, as the existing subjects of the transportation process, and future [2].

In the given work the developed model of information system "Automated control system of complex transport service in a segment contrailer transportations" (ACS CTS CT) is presented. The model is designed to automate the accounting, analysis and ranking of correspondence of technical equipment of railway stations and transport and logistic terminals to assess their ability to plan and organize contrailer traffic on the directions. The model of the information system analyses and selects the optimal complex measures for technical retrofitting of the interested subjects of intermodal (piggyback) transportation. It carries out the control of counterflow of goods by the railway transport, records and registers the exposure of the participants of cargo transportation to completion of the graphical standard of counterflow of goods by the road trains, records the stakeholder influence of cargo transportation standard implementation of counterflow by the road trains at the whole stage of cargo transportation.

The model of information system of ACS CTS CT functions in the uniform transport and information environment, being based on information streams received from subjects of transportation and from a control system of a global database, and also electronic systems of normative-legal and normative-reference information [3]. Data interchange flows is carried out according to the approved regulations.

The model implements information and control functions and provides automation of the following processes:

- taking into account information and technical and technological equipment of train station, manufacturing facilities, transport and logistics terminals and shipments handling locations to assess their ability to plan and organize contrailer traffic on the directions;
- registration, analysis and ranking of the correspondences of the technical and technological equipment of railway stations, production facilities, transport and logistics terminals and cargo transshipment sites [4];
- analysis and selection of optimal complex measures for technical-technological and information equipment of interested subjects of piggyback transport;
- visualisation of the performance of transport services by the subjects of transportation, with the registration (evaluation) of the reasons for noncompliance or poor quality performance of the contractual requirements of cargo transportation [5];

- control of correspondence of piggyback consignments, accounting, processing, analysis, registration of fulfillment of the contractual requirements for graphic follow up and delivery of piggyback cargo by railway transport [6];
- accounting, analysis and registration of the influence of the participants of the freight traffic on the fulfillment of the road-train traffic regulations at the whole stage of the freight transportation;
- execution of an electronic application according to the approved form for the organization of the counterpoint shipment;
- calculation of the term of delivery of consignments and the cost of cargo transportation;
- search and visualization of regulatory and reference materials regulating intermodal transportation.

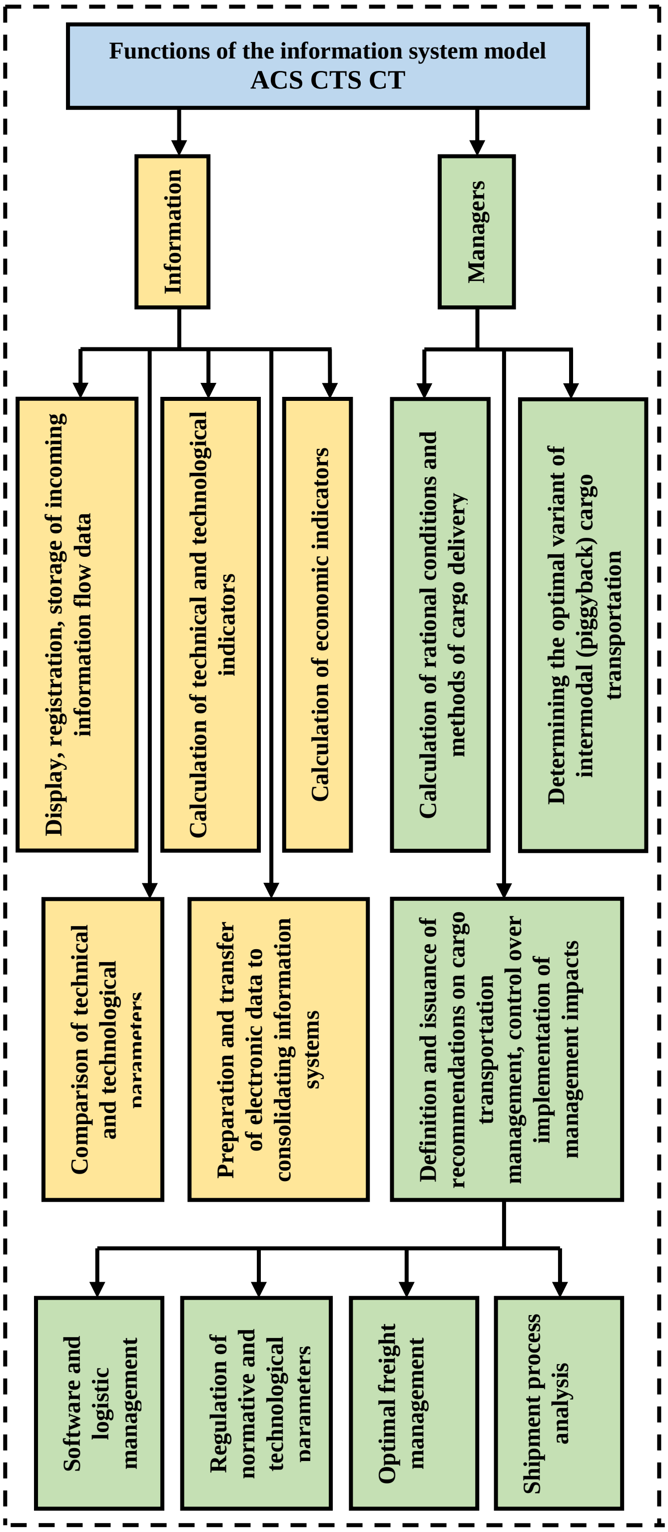

Figure 1: The general functionally dependent schema of the information system model ACS CTS CT.

Figure 1 shows the general functionally dependent scheme of the model of information system of the ACS CTS CT.

On the basis of job duties of system administrators and requests of system users for their automated places, the following access rights are approved by the regulations:

- an automated workplace of the system user, submission of an electronic application of the approved form for the organization of piggyback shipment, ranking of production facilities, calculation of the term of delivery of consignments and the cost of cargo transportation, control of transport services and control of intermodal correspondence [7];
- an automated workplace of the system administrator, control and correction of registration of an electronic application for sending, control of ranking of production facilities, control and correction of calculation of the term of delivery of consignments and the cost of cargo transportation, input of information data into the system under conditions of change or addition of normative-legal and reference materials [7, 8].

The system database is formed, including incoming information from system users (requests for selection parameters and recommendations).

A key element of the model ACS CTS CT, is a virtual cognitive system that integrates transport subsystems, affecting the intellectuals of the transport environment, as a result has a major impact on the process of determining and choosing the optimal solution system.

The stratified scheme of the virtual cognitive system of ACS CTS CT is shown in Figure 2.

As shown in Fig. 2:

- the lower stratum, reflects the subsystem of users, includes the objects of production, terminals and handling resources used in intermodal (piggyback) transportation, including a network of sensors located on vehicles, ground objects of transport infrastructure and executive equipment and mechanisms that ensure the collection of data on the current state, as the transport infrastructure of the subjects of transportation, rolling stock, production and transportation processes, as well as on the implementation of the following mechanisms [8];
- stratum of the telecommunications subsystem, includes devices directly to the network, which provide high-quality interaction in the exchange of information flows about the organization and management of countertranslair shipments, as well as information flows of skills and knowledge of the system integrators [8, 9];
- the information subsystem's stratum includes devices and processes that ensure collection, processing, analysis, accounting of information and control of trains on the railway infrastructure, displays accounting and registration of the influence of intermodal transport subjects on the quality of production and transportation processes at all stages of implementation;
- stratum of cognitive subsystem, carries out transformation and structuring of subprocesses of processing, operational monitoring, deep analysis, accounting and registration of infrastructure, available resources of proposed production facilities, with a view to their correlation with the requirements for the organization of intermodal transportation;
- - the application subsystem stratum, displays the process of using the structured knowledge and skills, as well as forms the management solutions.

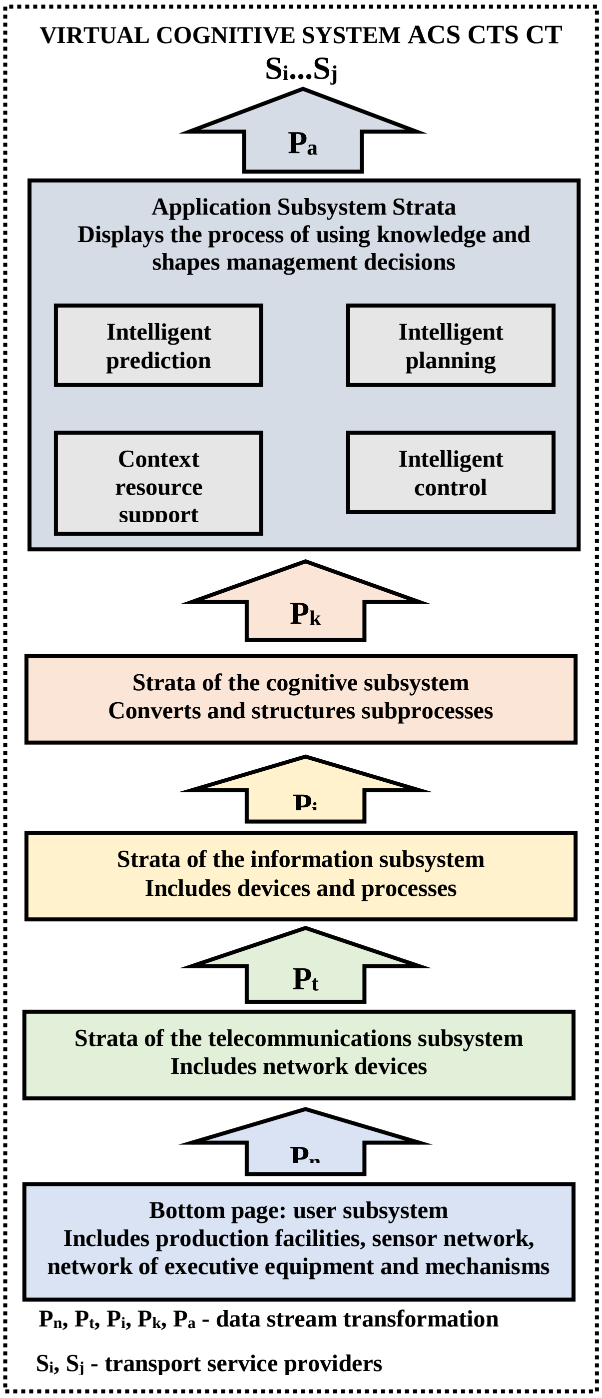

Figure 2: Stratified virtual cognitive system ACS CTS CT

For the automated calculation of priorities in accounting, analysis and ranking of the correspondence of the technical equipment of the railway stations and transport and logistic terminals for the evaluation of their possibilities of planning and organization of the contrailer traffic on the directions by the authors, the theory of decision-making in the conditions of certainty, in particular, the method of analysis of hierarchies, which provides the definition of the numerical scale of preferences for the probable variant solutions [10, 11].

The virtual control system, differs from others that has the built in intellectual architecture - cognitive subsystem which forms knowledge, as a whole about uniform information system, the global transport and information environment and organizational and technological management on the basis of information streams [11, 12]. The formation of knowledge and skills is provided by the results of information data processing system positions, which come from system subjects and integrators [13].

When programming the KTU KP virtual cognitive system, the languages JavaScript, Java, html, DB2, postgreSQL are used. KTU KP control system is used in the operating environment (compatible) Windows 7, 8, 10. It occupies the volume of 15728000 bytes. The software is located on the server; as a result, no other or additional software is required at the user stations [13, 14].

3 RESULTS

The model is a software product. For use of the given model the complex of normative and legal documents, including normative and technical instructions of integrators of system, and also methodical recommendations necessary for introduction of the given software product is developed.

Model, in the Russian Federation has passed the state inspection and registration.

The information system model is visualized by digital layers:

- ranking of inspected transport and production facilities for compliance with the requirements for intermodal transportation organization (data input by system users) [13, 14];
- evaluation of production facilities based on the ranking results (evaluation and ranking is performed by the system, which assigns a rank from 1 to 5 in accordance with the approved protocol, then the system issues recommendations to the user on possible retrofitting of facilities or gives an opinion on possible implementation of intermodal (piggyback) transportation) [15];
- electronic application form for piggyback shipment;
- control of the intermodal (piggyback) shipment (performed by the order number);
- control of organization of transport and production processes carried out with intermodal (piggyback) consignments;
- the list of electronic documents regulating the organization of intermodal (piggyback) transportation.

The ACS model of the KTU KP is currently used by JSC «FGC» during the inspection of transport and logistics terminals for the possibility of intermodal (piggyback) cargo transportation.

Fragments of visual display of the ACS CTS CT model are shown in Figures 3, 4, 5.

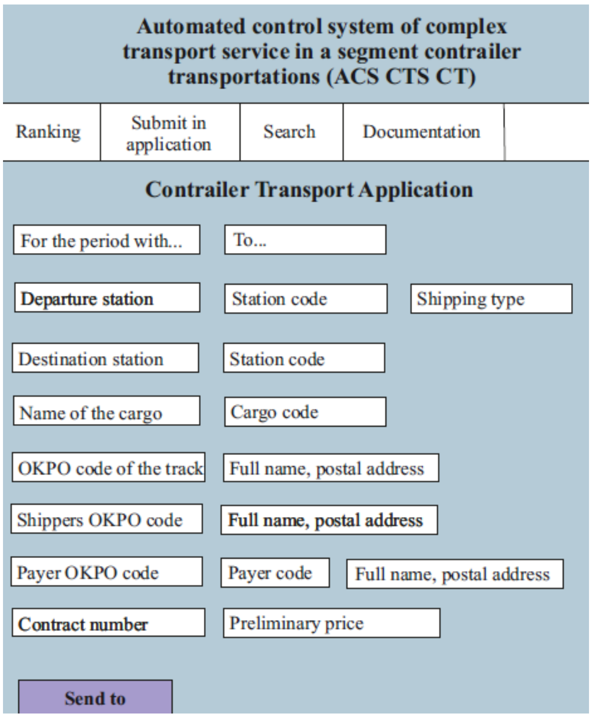

Figure 3: Electronic Contrailer Request Form

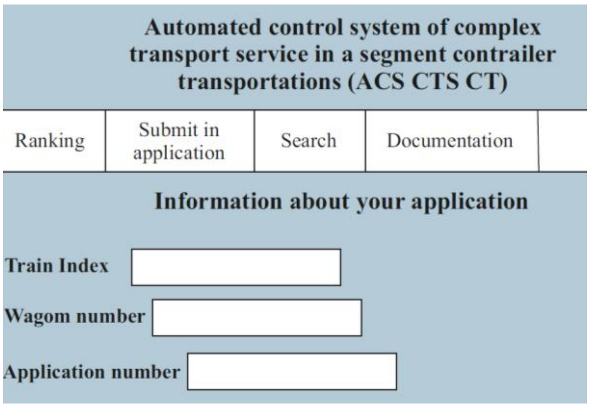

Figure 4: Search Form for Controlling Contrailer Sending Followup

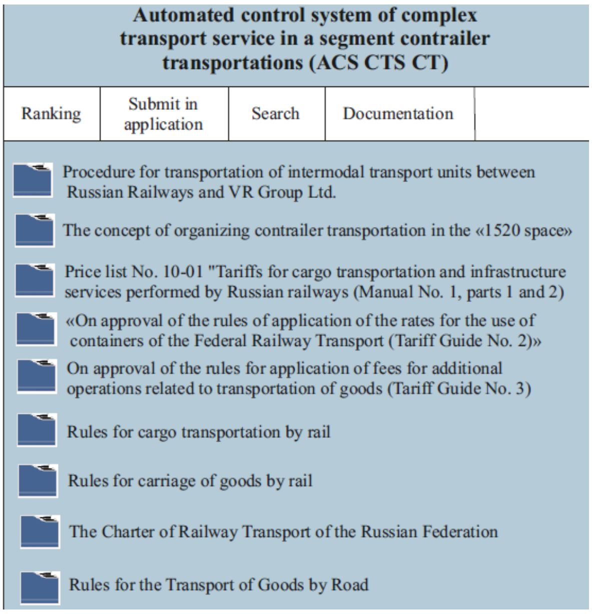

Figure 5: List of electronic documents regulating the organization of intermodal transport

4 CONCLUSIONS

Thus, the model of information system of ACS CTS CT forms conditions in which there is a union of information streams of users of a network and information streams of the networks applied in the uniform transport and information environment (as agreed) that provides consolidation of information systems of subjects of intermodal (contreiler) cargo transportation and raises an information exchange in information and economic space, concerning registration of transport documents and demands for cargo transportation, a choice of economically rational hearing.

The model allows interested subjects of intermodal (piggyback) cargo transportation to estimate resource possibilities of transport and logistic terminals planned for participation in such cargo transportation and to receive corrective decisions on their retrofitting.

Carried out researches and results of use of model of ACS CTS CT show that the given model of information system creates conditions for formation of uniform technological process of delivery of cargoes by intermodal (contreiler) transportations which assume a constancy and uniformity of process of cargo transportation on all its life cycle. It provides qualitative interaction of modes of transport (automobile, railway) and interested subjects of cargo transportation. Improves the potential of the railway transport in the integration of the Russian transport industry into the global transport and information content and develops the transit resource potential of the country.

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THE EXPERIMENTAL DESIGN TO DETERMINE THE WORKLOAD OF THE OFFICER ON WATCH

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ABSTRACT

Human error as the cause of maritime accidents causes a considerable number of accidents in the merchant navy, despite modern navigational aids. A heavy workload, due to the processing of information from various nautical instruments, causes potentially dangerous human erroneous action, which leads investigators to classify the accident as being caused by human factor. The aim of this paper is to propose a set of measurements which, according to the available literature study, should evaluate the workload of the person in the full-mission simulator during the collision avoidance maneuver.

Keywords: Workload, human factor, human erroneous action, marine simulator, disturbing factor.

1 INTRODUCTION

The aim of this paper is to propose the quantification of the officers on watch (OOW) workload measurement design. During collision avoidance OOW brings critical decisions for the safe navigation. At OOWs' high workload, caused by hard navigational conditions or various disturbing factors, human erroneous action (HEA) typically occurs, which causes, in a worst-case scenario, a marine accident [1]. In the EMSA marine accident report for the year 2019, despite modern navigational equipment, human error contributing 75% of all accidents [2], thus OOW workload assessment is an important parameter for understanding HEA which consequently affects the safety of navigation. The workload is typically observed during an experimental scenario in the safe environment of the marine simulator, exposing participants to potentially dangerous collision situations. The workload is induced with forced weather conditions (e.g. strong wind, waves, rain), raise of traffic density, disturbing factor (e.g. navigational equipment alarms, checking social media sites), or with additional cognitive tasks, (e.g. n-back test) [3]. In available maritime literature [4], [5], authors typically conclude the correlation between workload and OOWs' working experience factor, which is known from psychology [6], where the workload is estimated from the way information is processed in the working memory.

Table 1: Biometrical data collecting

Direct approach	Indirect approach
Brain waves intensity	Heart rate
Stress hormone rate	Electro-Dermal Activity
	Pupil diameter
	Body acceleration

Portable biometric sensors are used to identify and assess the high workload (Table 1), typically using two approaches. The advantage of the direct approach is the direct observation of the cognitive load, e.g. by measuring the intensity of brain waves in the working memory-brain area. An obvious advantage of the indirect approach is its lower invasiveness, which in most cases is less disturbing for the participants and therefore has less influence on the biometric value of the participant during the given task.

2 ASSESSMENT OF WORKLOAD

A comparison of the methods for assessing the workload of OOWs in the available literature is difficult due to the different objectives of the specific experiment. In most cases, the experimental scenario consists of two phases: easy navigation (low workload) and hard navigation (high workload). Statistical methods for data mining show a difference in biometrics between each phase with significant accuracy, which implies the state of workload of the OOWs. However, the common denominator of the available studies is that too invasive a data collection method and/or too complex a scenario typically has such a negative impact on the participant that the biometric results show a high workload in both phases of the experiment [4]. Exposure to invasive measuring devices affects the biometric readings of the participant, and if the simulation is switched from easy (low workload) to heavy (high workload), the significant rate of change in the biometric parameters is not readable due to over-excitation of the biometric parameters in the low workload phase, especially if the participants are less experienced. The assumption that the workload is high due to disturbing factors is mentioned in several studies [3], [4], so that the search for an optimal experimental design is an important task in the preparation phase. The data acquisition in the realistic environment [3], [7] shows the challenge of controlling the disturbances (e.g. traffic, weather, telephone calls) in comparison to the simulated experimental environment [4], [5], [7], [8], in which the disturbances are controlled and repeatable. From this point of view, a full-mission simulator is an optimal test environment for biometric data acquisition of OOWs to assess the workload during a given experimental task.

The typical experimental design used in the available studies consists of two experimental parts, easy and hard navigation. Biometric observational data are statistically extracted to assess the workload (Figure 1).

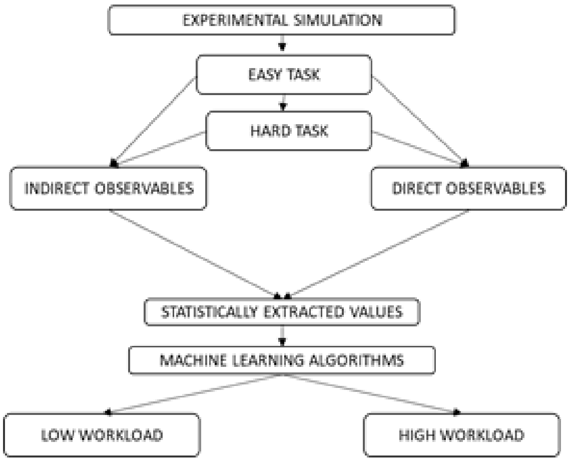

Figure 1: Typical experimental algorithm

The correlation between maritime safety at sea and the workload of OOWs shows that the primary task performance of OOWs decreases with increasing workload [5], [7]. The common observable of this correlation is the extension of the processing time in the working memory [6] due to disturbing factors that affect the workload of the OOWs and thus the HEA. The processing time in the working memory depends on the reaction time of the OOWs during the collision avoidance maneuver (Figure 2).

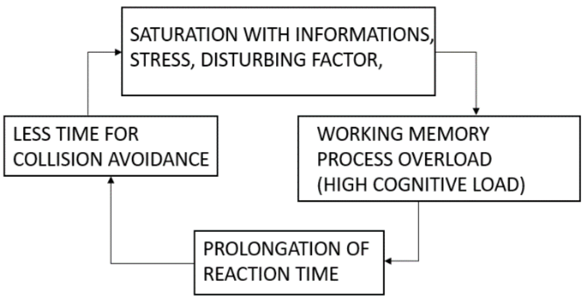

Figure 2: Cognitive process saturation

The extension of the reaction time during the hard part of the experimental task implies a high workload [5]. During biometric data acquisition in the control phase (easy task), OOWs are confronted with conditions similar to those in real navigation. The disturbing factor in the experimental phase (bad weather conditions, alarms, checking social media sites...) induces a typical biometric response, which is observed and recorded by EDA, heart rate, pupil diameter, etc.

2.1 Experimental proposal

There are several methods and sensors developed to assess the workload of OOWs. The indirect assessment method typically does not require a high financial and technical effort, which was one of the reasons why we use it. The other reason was that indirect data collection, e.g. eye tracking method, EDA and heart rate, is well known and typically used by cognitive load research in other traffic areas, e.g. road and air traffic. The above methods are well validated and proven reliable if the experiment is well designed. Under this assumption, we are preparing several experimental scenarios in the full-mission simulator (Transas Navi-Trainer 5000), in which the participants are confronted with bad voyage conditions during the collision avoidance task by a considerably realistic approach. Biometric markers will be acquired using Pupil-Labs eye-tracking glasses and Empatica's E4 medical-grade wearable wristband with EDA, heart rate, temperature sensor and an accelerometer.

2.2 The aim of the experiment

The aim of the experiment is to determine the influence of the disturbing factor on the workload of OOWs by comparing the biometric markers during a light and a heavy task. Assuming that the disturbing factor induces a high workload of the working memory and thus of the HEA, four different tasks are prepared for the participants. The tasks will be divided according to the difficulty of the collision avoidance maneuver and the disturbance factor involved (Figure 3).

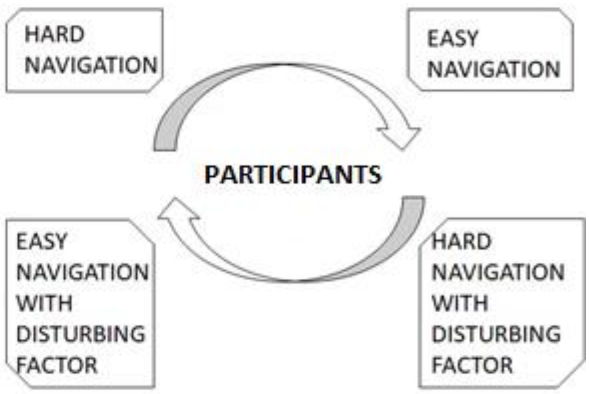

Figure 3: Proposed experimental design

For each task, the biometric parameters of the OOWs (e.g. EDA, heart rate, blood pressure) are recorded together with the ship parameters (e.g. rudder angle, speed). The correlation between the biomarkers and the difficulty of the task (without disturbing factor), implies the average workload of the OOWs during the specific maneuver (control phase). The values are compared with the data collected during the disturbing factor task (experimental phase), whereupon the effects of the disturbing factor effect are evaluated (Figure 4).

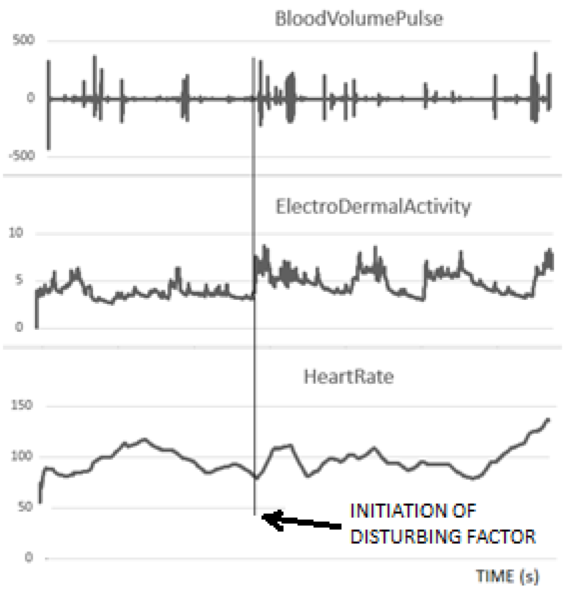

Figure 4: Biometric parameters during the simulation and the moment when disturbing factor occur

For data extraction, statistical tools are used, based on regression analysis and machine learning classifiers, e.g. decision tree or neural networks.

3 CONCLUSION

In the available literature, indirect and direct approaches are used to assess the workload of OOWs during simulated tasks in the nautical training simulator (Table 1). A comparison of the approaches shows that both methods have several advantages, so that a direct comparison is difficult. Biometric observations in the available literature typically include heart rate, EEG intensity, galvanic skin response, blood pressure, stress hormone levels and pupil diameter. In the experimental proposal, OOWs are observed during the collision avoidance maneuver in the modern Transas Navi-Trainer full-mission simulator, equipped with wearable biometrical sensors such as pupil diameter, heart rate and EDA sensors, where the raw values are recorded. Statistically extracted parameters acquired from the experimental task indicate the utilization level of the OOW with significant accuracy. Statistical tools for extracting values are further developed by models for estimating workload based on machine learning algorithms. We expect the experiment to be performed in October 2020.

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