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Table of Contents

G. Kukec, N. Štefanić — 6
Application of digitalization and automation in production and services – „paperless office"

D. Poljak — 13
Identification of Lean and Green wastes in a water supply organization and their impact on water losses in water supply systems

R. Obraz, V. Mudronja — 22
Improvement of incoming quality control by applying PDCA cycle

A. M. Kovač & A. Kovač — 30
Outsourcing design - the leaner approach

A. Belošević, J. Stepanić, B. Runje, A. Horvatić Novak — 37
Smart dimensional measurements in high-series automotive industry

A. Marić — 43
Impact of socio-technical systems used in project management on project success

N. Štefanić, M. Hegedić, M. Gudlin, P. Greguric — 48
Implementing Lean digital strategy to improve competitiveness of Croatian manufacturing industry

P. Gregurić, D. Liović, A. Štefanić — 58
VSM implementation as part of digital transformation strategy

D. Liović, P. Gregurić, A. Štefanić — 68
Impact of digitalization and Industry 4.0 on different industries

A. Marić — 76
Comparison of personality type tools and their relationship with project success

A. Marić — 83
Effects of problem-solving methods on project success

G. Kukec — 89
Robotic process automation – a journey through digital transformation

V. Uran, D. Radović, M. Rob — 94
The impact of palletization on the flexibility in manufacturing systems

A. Štefanić, P. Gregurić, D. Liović — 104
Digital Lean in Smart Factory

N. Štefanić, T. Brnadić, I. Veža — 108
Digital transformation of industry in Croatia

B. Gajšek, H. Cajner, M. Butlewski, G. Đukić — 113
Towards Balanced Productivity and Ergonomics in the pursuit of Lean Warehousing

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APPLICATION OF DIGITALIZATION AND AUTOMATION IN PRODUCTION AND SERVICES

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Abstract

When talking about company performance, whether service or a production company, it depends on a detailed understanding of its structure to survive the competition. This paper deals with the conversion continuum in the so-called "paperless" and process automation that are common to companies in both manufacturing and services. Furthermore, it gives an insight into the impact of environmental paper usage and other recommendations on the parallel implementation of digital transformation and the introduction of new IT technologies within the company. The results of this scientific approach have shown that there is a wide-open field for research on the subject.

Keywords: Automation, Digital transformation, Paperless, Lean, Industry 4.0

1. INTRODUCTION

In search to increase efficiency, most companies already undergo a digital transformation. In many companies, a lot of processes are handled paperless and it is not defined what data should be digitized and what should be archived in paper form - in a traditional way.

The so-called paperless office concept, or just "Paperless", is known since the 1970s. By 2000 there was a paradigm that the amount of paper within the office environment would be significantly reduced or even entirely disappeared by the arrival of new technologies and platforms such as e-mail, e-data storage, and the web. In the contrary, the amount of paper drastically increased. For this reason, instead of completely switching to "paperless", concepts are also explored - how to use less paper.

Paper leads to increased waste in the process, which is the opposite effect to Lean methodology. Increasing the amount of paper imposes the use of recorders, storage and archiving in the physical sense, the need for digitization and digital archives, creating the need for using IT technology and resources and additional human resources to work on that part. This can lead to the company's financial impact and eliminating the positive impact on other projects.

Prior to digitizing and switching to "paperless", a company should have a clearly defined strategy - whether it wants to digitize or switch to "paperless". In addition to increasing efficiency, in the sense of Lean management and transformation of the company, there is also an important strategic role for Green management. Conversion of traditional processes to "paperless" can improve operational efficiency.

The very idea of digitization is the use of e-components in a certain part of the process. At the same time, paper can be used in other parts of the process. In paperless, paper as a means is not part of the process.

2. RESEARCH

Initial aim of this study was to research benefits of implementing paperless concept. The research questions are:

Q1: What are the issues in paper usage?

Q2: What are the benefits of the electronic document and how can technology help?

Data collection was made through literature review and implementation of cognitive solution process (invoice-scanning process pilot in a finance sector company). The data analysis integrated inductive and deductive approaches. Hypothesis for the experiment (pilot in a finance sector company):

Data-driven process with cognitive solutions and machine learning technology is more efficient than process-driven approach.

Further research would have to be carried out in a wider variety of settings in order to confirm the initial findings and include comparative research on process-driven vs. data-driven technologies.

3. DISCUSSION

3.1.Why paper usage is an issue?

Everyday tons of trees are cut just to satisfy man's never-ending need for paper. In the meantime, environmental degradation has emerged as a major global concern for human survival. According to [1], about 400 mil. tons of paper are produced per year globally with predicted growth of 1,6% till 2025. Figure 1 shows that global average annual paper consumption is 108,2 kg per capita.

Approx. 324 l of water is used to produce 1 kg of paper [2]. This means that global average water consumption needed just for paper production is 3.5056,8 l per capita. The paper manufacturing industry the largest industrial consumer of water per kg of finished product. [2]. Paper is also one of the biggest solid waste components. According to [1], 90% of paper files will end up to waste because only 10% of paper documents are really valuable. While decomposing, paper releases methane. This greenhouse gas is 23 times more potent than carbon dioxide [1]. The paper and pulp industry are the fourth largest emitter of greenhouse gases in the manufacturing sector. Therefore, going for Paperless is also the need of today for conservation of natural environment and should be a part of Green movement. Paper handling is also expensive and takes space.

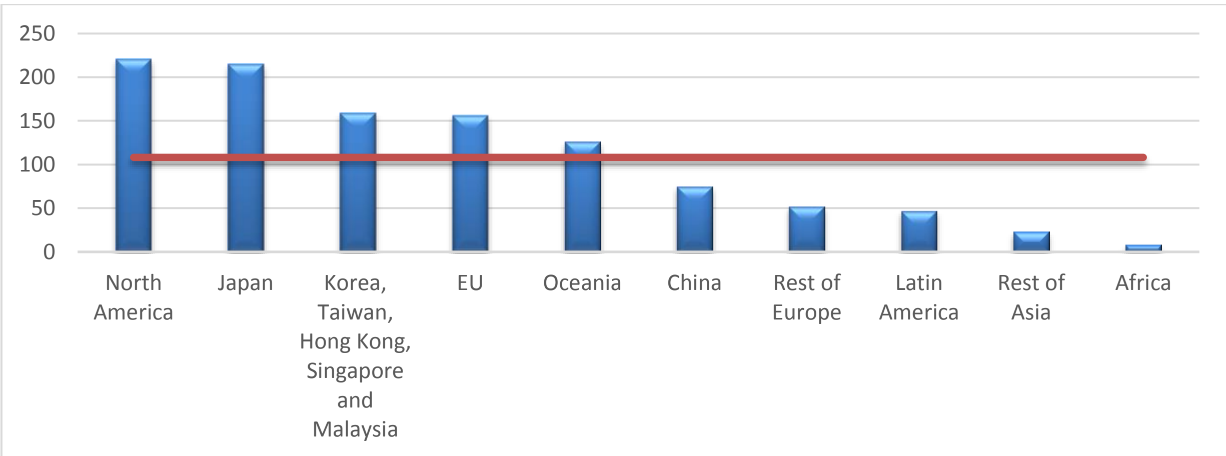

Figure 1 – Global paper consumption by region in 2013 in kg/capita, proportionate to population in each country/region [1]

In 1946, ENIAC - the first electronic computer, was announced to the public. It started the transformation of our society - from being mechanical to electronic based. Since then, society is being re-shaped by reshaping how information is shared. In 1978, University of Illinois, prof. Lancaster wrote an academic paper suggesting that, by the dawn of the 21st century, developed nations like the United States and Canada would be living in a "paperless society," in which electronic delivery and sharing of documents would be the norm [4]. As stated, exactly the opposite - paper production is increasing due to the global demands and the highest paper consumption is in North America (Figure 1).

In today's competition, virtually all professions require methods to improve efficiency. Employees need access information 24/7/365, anywhere-anytime. Technology drives every aspect of what we do in our profession today. Good way to make the process more efficient is to apply Lean methodology. Main target of lean is to eliminate waste and to concentrate on the value-added activities. The old "paper" process should be converted to digital and files and documents should be stored in a way that allows an easy-any time access.

3.2.What are the benefits of an electronic document?

Electronic documents can be traced as well as the access to them can be fully logged. Document management system software were created in the effort to introduce "paperless" offices [2]. It is an electronically organized database with retrieval of documents by providing secure access.

There is also ability to easily encrypt data which is stored electronically. Simply put, ability to protect the confidentiality of electronically stored files than those stored in hard copy is much greater. Electronic data is searchable, and a document management system can be more easily used which also has a benefit to find your document in a easier and probably less-time consuming way. There are a lot of indirect benefits using the electronic documents. Electronic data interchange allows two or more parties to interchange documents and interact between. This can be basically explained in terms what is the benefit of e-mail instead of traditional letter? It provides both security and efficiency, as electronic document cannot be stolen easily as hard copies [3]. According to [4], main benefit in implementing paperless processes is the reduction in storage space for paper documents by 64,25 % (Figure 2). Although paper storage takes about 15% office space [5], paper handling takes additional space, thus employees need more space. Electronic files take up virtually no space and multiple copies can be made with theoretically no additional space needed. Hardware also takes space, but storage can be obtained on a cloud-based infrastructure in which case only a workstation is needed to access the files (which would probably be needed any way-if paper is used).

Storage used for "converted paper" documents or documents which replace the paper can also be used for storing different records – i.e. – audio files and video files. Some of the companies are changing their products by changing the processes to go paperless. Paperless work instructions on assembly lines with set of different languages are used [3].

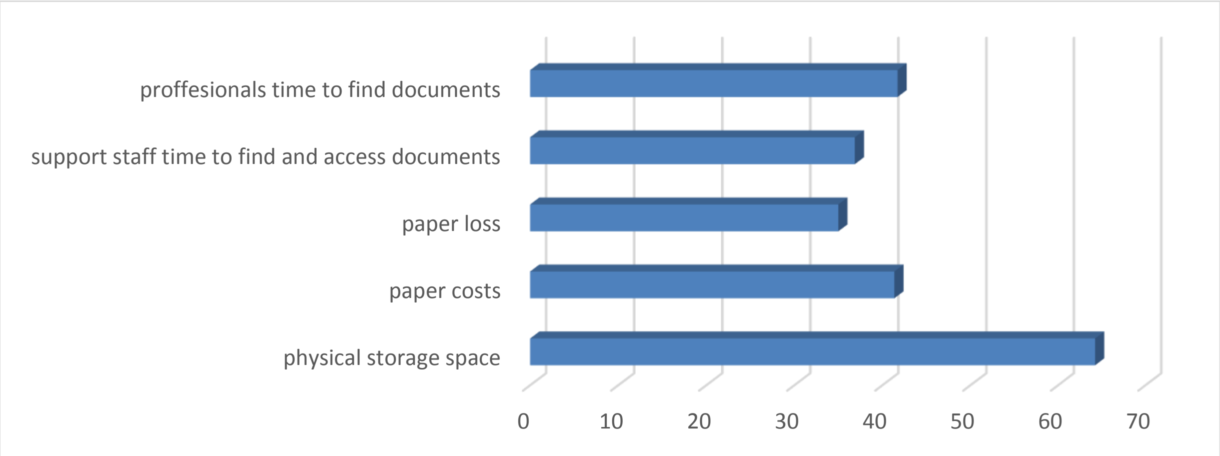

Figure 2 – Estimated cost reduction change percentages reported by the partners of implementing firms [4]

Application of electronic documents not only automates manual and semi-manual processes and paper transactions, but also enables and helps different organizations in moving to a fully electronic environment. This changes the way they operate. Paperless exchange of information is possible using Electronic Data Interchange (EDI), Electronic Bulletin Boards (EBB), Electronic Funds Transfer (EFT) and other network-based technologies. It enables different e-commerce and e-services between different organisations s.e. business to business (B2B) or government to business (G2B) or even business and end-customer (B2C), e-marketing etc. Application of paperless concept is already present in the society and addresses virtually every aspect of the global society from the largest organisation to the single person.

3.3.Paperless challenge – data over paper

The major obstacle to a paperless office is a resistance to re-engineering of processes [6], and there is obviously a learning curve in using the new technologies and re-defining the processes to go paperless. Special care should be taken when considering the measures to ensure the expected availability, accessibility and security of the data.

Validation of the software goes beyond requirements and implementation and should be defined on a life cycle level. According to [7], a very clear software lifecycle management (SLC) documentation that contains software development process from cradle to grave should be done.

Transition to paperless is not easy and it takes a lot of commitment to overcome the natural inertia of any office [7]. Besides that, the possible obstacles are the costs. Costs depend on the size of the company (Figure 3). Basically, small companies will probably use lower-level, self-installing software and there will be no need for additional implementation services, Mid-sized and larger companies will include implementation services, which could be more expensive than the software as it will probably include more locations.

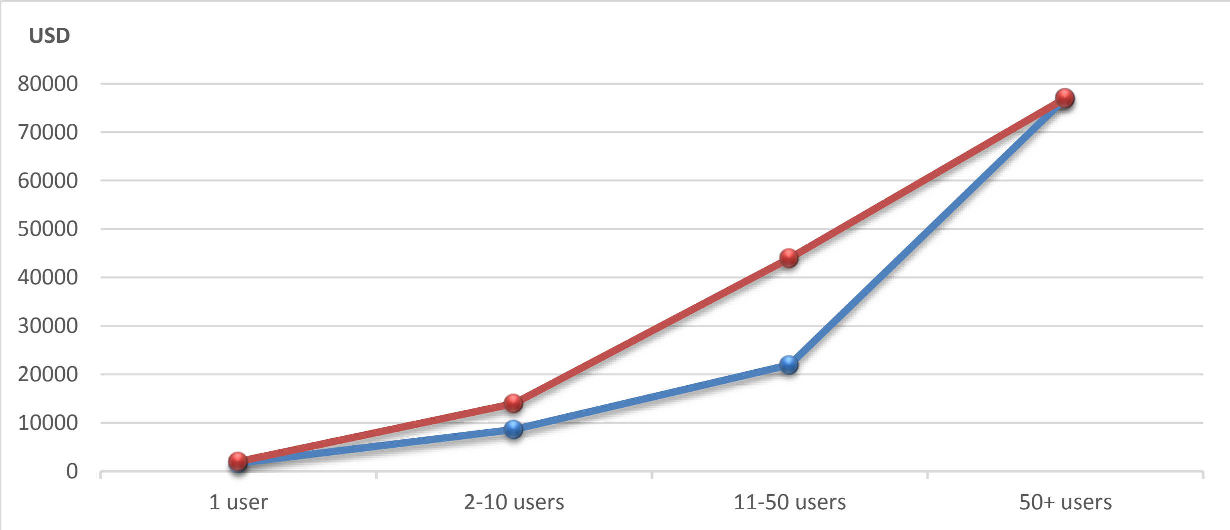

Figure 3 – Costs of Paperless System Software depending on the size of organization [7]

Due information is stored electronically, there is always a chance that the information will not be available or even lost. Availability, redundancy and maintenance of IT systems costs. For some company's significant start-up costs can appear. A drop in ICT equipment prices makes a paperless conversion more attractive [6], but separate business cases must be analysed to ensure optimal solution is applied.

Another aspect of this issue are malicious software. Any malicious software can cause problem, no matter which protection technology is used. Maybe the biggest problem with the malicious software today is that they can embed in files for a long period before they are released or 3rd parties can steal data in a shadow for a long time before it is noticed. Probably with today cybercriminal, there should not be such thing as "too small" or "not important". Zero trust principle must be applied when defending data.

3.4.Paperless conversion possibility and possible threats – cognitive solutions

To reduce paper consumption, paper handling, office space/physical storage needs files must be organized electronically. Moving to electronic organization is about changing the strategy and realizing that a hard copy of every piece of information is not really needed.

Moving to a paperless environment does not mean that all records will be paperless, or that all electronic records are equal. It simply means that the technology is used to use less paper. When data is digitally generated (using a software), the result is a file which is a searchable and editable document. Its content is easily accessible for individual or collective use, even collaboration on the same document. In addition, these documents can be easily imported into document management system and workflow systems from which one could, i.e. search and access information about specific details.

If a document is a hard copy (i.e. invoice) or even a digital image (i.e. contract which was scanned as a photo and sent via e-mail), integration of this kind of data with all the features of the electronically generated document into the paperless workflow can be difficult to accomplish. Relatively widely used technology for this purpose is scanning to searchable electronic records using optical character recognition (OCR). About 33% of accounting practices already use the OCR technology [7]. The remaining question with the OCR technology is how to define the meaning of the recognized characters or fields?

Relatively new resolution is to combine process-driven tasks with the data-driven tasks and operations. This is commonly known as the cognitive solutions. Going straight to the cognitive solution process, it can be divided to process-driven and data-driven tasks. While process driven tasks and operations follow the processes the data-driven tasks are making the processes by using and processing the data which is inputted or stored. Process driven tasks are easily manageable and visible whether there are manual, semi-automated or fully automated. Methodologies for process analysis and improvement can be applied there. But there are also some relatively new technologies s.e. Robotic Process Automation (RPA) for automating the process-driven tasks and there are already some publications on obstacles, threats and implementation concerns regarding this technology. Special care should be considered when taking in consideration data-driven tasks and new process definition by Artificial Intelligence (AI) as well as managing them, as those are the new technologies which are rapidly growing and emerging into the market and yet there are not many user cases or statistical data. Process-driven tasks can be observed as a tip of an iceberg as we still cannot tell what lies under (Figure 4).

Non-negligible are the costs. While small firms may benefit the most from using less paper it should be taken in consideration separate business cases whether it is profitable to invest in such technology or not due surveys show that computer costs increased by 39% only after implementation of paperless processes [4].

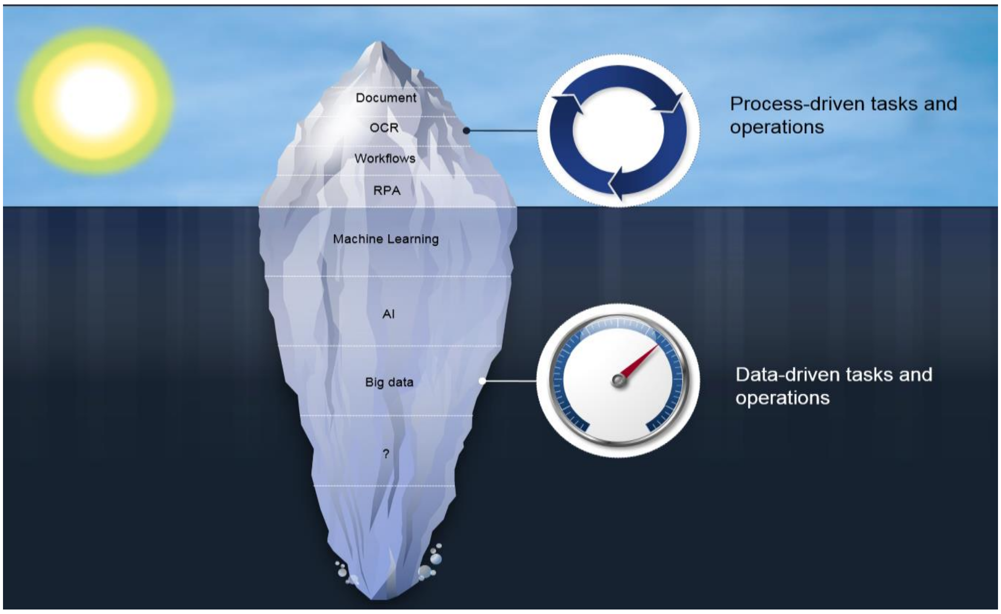

Figure 4 – Graphical illustration about author's concerns in using different technologies

3.5.Cognitive solutions pilot

Large volume of paper invoice processing is not a task that can be adequately handled through manual processes that are slow, error-prone and expensive. Pilot was made in a finance sector company which receives approx. 1.500 invoices per day. Manual invoice processing already included scanning paper documents and archive, as illustrated in Figure 5. Cognitive solution software with machine learning capability was implemented as a new concept. Paper is scanned, automatically processed, data is being collected and extracted to ERP system for further processing. Invoice is basically a structured document. Law prescribes the invoice mandatory information. Besides mandatory information, invoice can include other information and custom design (i.e. company logo). Machine learning enables information recognition on any invoice type based on the knowledge base, defined templates and learning from prior errors.

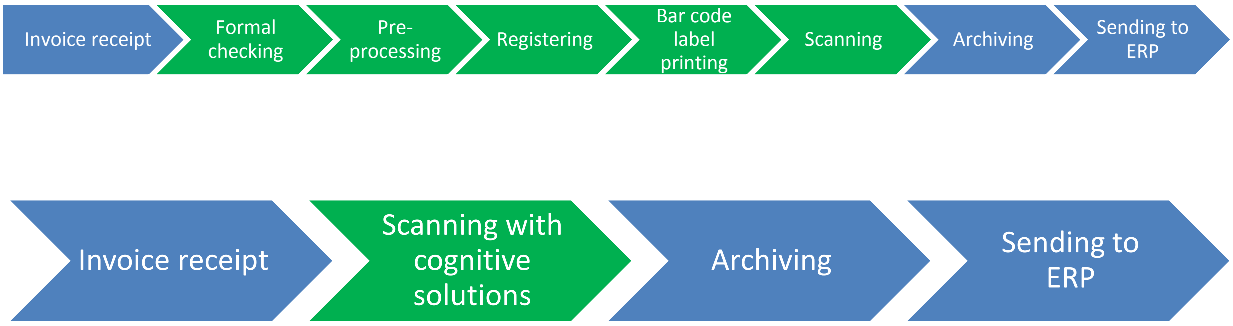

Figure 5 – Graphical illustration on process flow change as a result in piloting cognitive solutions in invoice scanning – manual processing vs. cognitive solutions

In process definitions, some of the process steps are not needed any more as they are automated. This is graphically described with green color boxes in Figure 5.

Software manufacturer only states that usage of this technology improves efficiency, but it is not clear by how much.

After process definition and technology implementation, major challenge was machine learning. It is a live and a parallel process and probably a never-ending story. Results show that for 6 months pilot, 57,41% of total invoices received were processed with cognitive solution. 25% of them were fully automated - read and processed without any manual interference. This resulted in major time savings in invoice processing process. While average time spent on invoice processing with fully automated cognitive solution is reduced by 57,14%, experiment in this pilot shows that daily capacity in manual invoice processing per headcount is lower by 21,11% than compared to cognitive solutions in total (including the need for manual interference). Therefore, hypothesis failed to be rejected.

4. CONCLUSION

Using digital systems in companies, will help reduce paper consumption in an area already facing big environmental challenges. Results from the experiment (pilot) which includes cognitive solutions and machine learning show that digitalization and usage of electronic documents can increase efficiency. This also shows that data-driven technologies are more efficient than process-driven technologies and hypothesis failed to be rejected. Further research should be made to determine in which measure reduction is made in the storage needed for archiving the paper documents, time lost for searching the documents and how it makes data more accessible and secure in comparison to process-driven technologies. Comparative analysis of cognitive solutions based on different types of machine learning algorithms can also be done. This research would probably give an answer to the question - which technology is the most suitable for the business. While technologies can solve problems, they also create issues. New emerging data-driven technologies are probably the new era in paperless and this is yet a wide field for research. While paperless society about which people dreamed of in the 20th century remains a dream, less-paper society is inevitable.

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IDENTIFICATION OF LEAN AND GREEN WASTES IN A WATER SUPPLY ORGANIZATION AND THEIR IMPACT ON WATER LOSSES IN WATER SUPPLY SYSTEMS

Davor POLJAK

Abstract:

Water supply organizations face the challenge of establishing a balance between the efficiency of distribution water supply networks and the efficiency in using natural, human, financial and other resources and are responsible for achieving the goals of sustainable business. The problem of efficiency and sustainability of public water supply is a global problem, and water losses are generally considered an important issue. The aim of this article is to explore Lean and Green wastes in water supply organizations and their direct and indirect connections to water losses in water supply systems. Water supply organizations in their efforts to improve their business use different approaches that are mostly reduced to repairing breakage in the struggle with water losses in water supply systems. This paper deals with the question, whether is possible "by controlling the Lean and Green wastes in a water supply organization can control water losses in water supply systems".

Keywords: Lean management, Green management, Waste, Water Supply, Water Losses;

1. INTRODUCTION

Water supply organizations face the challenge of establishing balance between efficiency of distribution water supply networks and efficiency in using natural, human, financial and other resources, and are responsible for accomplishing goals of sustainable business. Efficiency problem and sustainability of public water supply is global problem, and water losses are considered an important question. In referenced document of European commission [1], water is valuable natural resource that needs to be managed in sustainable way, and all losses must always be minimalized. Public water supply is complex system whose quality and efficiency depend on interaction between different processes inside system [2]. From the report of global council for water in world economic forum[1] [3] legitimate goal has been defined. By 2030 year universal and equal approach towards safer and accessible drinking water for everyone must be reached. According to the definition, safe and drinkable water is water without any physical, biological or chemical contamination. According to the conclusions of sustainable development stated in referenced document of European commission [1], states that water is valuable natural resource that needs to be managed on sustainable way, and all losses of this resource always must be minimalized. With development and growth of water supply infrastructure, problem of continuous growth of water losses from water supply systems which over time with the biggest part causes of old installations but also many other influences, are getting bigger has been sighted. Often, in poorly developed systems water losses cross 80% of affected water.

Battle with water losses in water supply systems began in 1980[2]. In battle against water losses in 1996. International Water Association IWA has joined the battle in the pursuit for negative trend of growth in water losses to be stopped or at least to be soothed. Working group for dealing with water losses WLTF (Water Loss Task Force) has been founded with task norming the terminology and procedures for fulfilling display calculation of water and introducing consistent indicators for judgment of control and financial efficiency of water supply systems [4, 5, 6]. However, after few years of intense efforts in battle against water losses, expected results have absent in most water supply organizations. Change of the form of behavior and application of newest knowledge and accomplishments imposes as imperative in further battle against water losses and desired recovery of water supply systems.

About the same time initiative for enhancing business has been launched which over time was more recognizable under name Lean management. Concept of Lean management was during last four decades

[1] World Economic Forum
[2] Leakage Control Policy and Practice (Report 26), UK 1980.

become integral part of production environment in USA but also leading production strategy in the world. With time, this concept has been expanded on environment protection, so the name has been changed to fit with new structure on Lean & Green management. Companies that recognized and noticed value of concept Lean & Green management have quickly accomplished significant improvements in their business, eliminating disorders and waste in business processes. In the end, results have been achieved with creating a products and services with better quality and at the same time using less work, space, capital and time.

Goal of this work is to research possible application of concept Lean & Green management in water supply organizations for change of established forms of behaviors and application of newest knowledges and accomplishments in battle with water losses and improving business.

2. LEAN & GREEN MANAGEMENT

From all approaches, which have for goal increasing efficiency, most famous is approach under the name Lean management. This approach become integral part of production environment in USA for the last four decades but also leading production strategy in the world. Lean management is described as concept of managing processes with goal of creating exactly the specified value of product or service in accordance with end user requirement. Lean management is international concept whose fundamental principles strive to minimalize or remove completely from process all activities that don't create additional value and all sorts of waste [7].

Concept of Lean production evolved from Toyota production system – TPS in philosophy of management that focuses on increasing value for user through reducing or eliminating resources that don't add any value [8].

According to the knowledge taken from TPS is separated seven kinds of wastes in production [9]. Those are excessive production, stocks, transport, waiting, unnecessary movements, reject and excessive processing. Development of Lean management added another one component to waste list, insufficient use of employee's potentials. Definitions and descriptions of all eight wastes of Lean management is shown in the table 1.

Table 1. – Lean management waste, Source: [9];

	Type of waste	**Description – Lean management waste**
1.	Excessive production	- Production for an unknown customer; - Creating documentation that no one requires; - Excessive documentation in circulation; - Production "for each case";
2.	Stocks	- High stocks are associated with excessive production ("frozen capital" in warehouses); - More material and information than needed;
3.	Transport	- Unnecessary movement of materials (workings) between the operations; - Inefficient and unnecessary sending of information; - Unsuccessful communication, loss of data; - Incompatibility, unreliability of information;
4.	Waiting	- Material waiting time between operations; - Waiting for workers on machines; - Waiting for data, information, decisions, signatures, approval, etc.; - Waiting for delivery (e.g. raw material delay);

5.	Unnecessary movements	- Workers - bad layout of machines; - Workers move to get information; - Manual work to compensate for failure in the process;
6.	Non-conforming product	- Work interruption due to errors, unnecessary time and space consumption and costs for analysis and troubleshooting; - Incomplete, inaccurate, improper information;
7.	Excessive processing	- Oversized machines; - Incorrect or insufficient technological equipment; - Too much processing; - Poor product design (too complex product);
8.	Insufficient use of employee's potentials.	- Employees are not involved in process improvement activities; - Unclearly defined roles and responsibilities for free action; - Limitation of authority and responsibility in making routine decisions;

In order to respond to the legal obligations and customer awareness of products and services that are environmentally sustainable and in compliance with environmental regulations, companies are forced to re-examine the way they handle their jobs and processes and adapt them to new requirements. One of the earlier indicators of such adaptation is the transformation of production systems according to the principles of environmental standard ISO 14001. By introducing the concept of Lean production in the same processes, their correlation and connection with environmental protection measures were also noted [10]. Observation of production systems from the aspect of their impact on the environment with the aim of reducing impacts and environmental protection leads us to the terms Green Production and Green Management. Green management of production and service access to minimize waste, energy consumption and any environmental pollution. Green goals are achieved by designing products or services in the development phase and controlling and managing the process in the production stage of realization [11].

Green Management identifies seven types of green losses: energy, water, materials, waste, transport, emissions (gases, radiation, living organisms, etc.) and biodiversity. Definitions and description of all seven losses green management are shown in Table 2.

Table 2. – Green management waste, Source: [9];

	Type of waste	**Description – Green management waste**
1.	Energy	- Excessive use of energy; - Insufficiently using energy from renewable sources;
2.	Water	- Excessive use of clean water; - No use of grey water; - Insufficient water use in closed processes;
3.	Materials	- Excessive use of materials; - Use of non-recyclable materials; - Use of hazardous materials;

4.	Waste	- Excessive production of waste for disposal. Waste that will no longer be used in other processes (all types of direct and indirect material);
5.	Transport	- Unnecessary movements of materials, people and information;
6.	Emissions	- Emission or release of substances in gaseous, liquid or solid state; - Emission of energy; - Release of organisms;
7.	Biodiversity.	- Too much impact on living organisms (flora and fauna); - Too much use of natural resources;

Womack and Jones in the book „Lean Thinking: Banish Waste and Create Wealth in Your Corporation "[12], define the five basic principles of Lean management: value, value stream, flow, withdrawal, and excellence. From these principles are expected to assist companies in achieving the objectives of Lean management by increasing the value of the product to the end user through the reduction or complete elimination of resources that do not bring value as well as all types of waste. The principles of Lean management appear most often as a closed circuit since the implementation of Lean management is a process that never ends (figure 1).

Figure 1 - The 5 Principles of Lean, Source [12];

Andres-Lopez and others in the paper [13] point to the importance of implementing Lean principles in manufacturing organizations, and the continuous spread and application of Lean principles on service Organizations. They also point out that the results may be unexpected when trying to use typical technical tools developed for industrial processes on non-material products.

3. WASTE IN WATER SUPPLY ORGANIZATIONS

Searching scientific base found only a few scientific papers about the use of Lean management in public water supply activities. It was found also several works about the use of the concept of Lean management but at the side of consumers of water and only for their water resources effective use. The US Agency for environmental protection EPA[3] has developed a methodology [14] for integrating the concept of Lean management processes for the effective use of water in industry. Office for the politics of EPA sponsored and led the development of this tool, while the Office for Water politics made a significant contribution.

[3] United States Environmental Protection Agency (EPA)

When creating the tools used are professional experiences and ideas of many individuals. Their aim is to further research the application of principles and tools of Lean management through positive practice for efficient use of water resources.

According to previous mentioned and because of the definitions (tables 1 and 2), the Lean and Green waste in Water Supply Organizations are identified and described below.

Excessive production:

Water supply organizations produce more water than the actual needs of end consumers. Due to the reasons, a major problem of water supply organizations are water losses from water supply systems, and water losses make excessive production. Authorized consumption (invoiced and not invoiced) is useful consumed water while all other consumption considered losses. Loss of water is divided on the Current Annual Real Losses (CARL), Economic Losses Level (ELL) and Unavoidable Annual Real Losses (UARL). The sustainability of the water supply system based on authorized consumption increased by an economically justified level of losses. Economically justified level of losses is not exactly defined but depends on many factors. Each water supply organizations must define economically justified level of water losses (ELL), as a key performance indicator for the next planning period. In the long run, economic level of losses (ELL) should have a trend of continuous decline to level of unavoidable losses.

Stock:

The problem of excessive stock is a frequent and very pronounced waste at water supply organizations. This problem can be accessed from several different aspects:

- Essential stock are necessary for maintaining a functional core business. Maintenance of the water supply network, which is mostly underground, is particularly challenging task that requires thorough planning activities, and the necessary human and material resources. Because of the need to maintain high availability of water supply system always, water supply organizations operate traditionally. They make excessive stock on principle for a "just in case". Another reason for big stockpiling of materials are the ineffectiveness of the implementation of Public Procurement due to the complex procedures (tenders, framework agreements, purchase orders, delivery times) and due to fear of cancellation of the order or unavailability of desired material or spare parts. In that reason, water supply organizations maximize procurement and warehouses are filled with unnecessary materials and spare parts. Consequently, excessive inventories involve excessive capital in excessive storage space and with too many employees, which cumulatively creates big losses. Usually are present problems of write-offs of unusable stock due to age or improper storage. The problem of excessive inventories can be reduced by better planning the inevitable stock (spare parts and materials which are difficult to supply);
- Unnecessary stock make all easily available parts and materials (on stock of suppliers and retailers) that are used in an indirect process (batteries, tires, office accessories, etc.). With the introduction of JIT[4] principles (better contracting with suppliers) should ensure the availability of materials necessary for the daily operational activities of the core business;
- Unnecessary stock make also materials and spare parts for activities that are not core business of water supply organizations (maintenance of vehicles and machinery, canteen, etc.). By contracting with external partners (outsourcing) all of activities that do not constitute the core business are an effective way of eliminating unnecessary and excessive stock.

Transport:

Waste in a transport processes in a water supply can be observed from two independent aspects:

- The transport losses in water supply systems are losses on transport and distribution water from the water source (water wells) to the consumer. The problem of optimizing the water supply network begins already in the design stage and is performed by mathematical modeling. Wastes are manifested as a loss of water, energy, dynamic pressure losses, failing water flow, etc. Once you have built

[4] Just-in-time (JIT) manufacturing, also known as just-in-time production or the Toyota Production System (TPS), is a methodology aimed primarily at reducing times within production system as well as response times from suppliers and to customers.

pipelines, transport losses would be controlled and eliminate by optimal management of the water supply system. Optimal control is achieved by measuring physical and chemical parameters of the water supply system in real time with the help of mathematical modeling in order to make right management decisions;

- Transport losses in water supply organizations are also the unnecessary movement of employees, vehicles and work machines (Water supply service areas correlate with the size of urban territory) whose size ranges from several square miles to several thousand square kilometers in large cities or a towns community. Personal vehicles, trucks and work machines are used for the management and maintenance of the water supply system. The optimization of their activities is carried out by excellent planning and is supported with the Fleet Management application.

Waiting:

Water supply activity takes place 24 hours a day, 7 days a week, 365 days a year. Interruptions of water services occurs in the following cases:

- exclusion of parts of the water supply network due to failures recovery;
- insufficient water quality.

Unnecessary waiting occurs according to poor organization, lack of work standardization and the unavailability of necessary components and materials in process activities:

- construction of the water supply connection;
- failure repairs;
- reconstruction of the water supply pipelines.

Unnecessary movements:

Unnecessary movements occur according to poor organization in lack of work standardization and the unavailability of necessary information, documentation, spare parts and materials in process of:

- construction of the water supply connection;
- failure repairs;
- reconstruction of the water supply pipelines;
- unnecessary meetings and other business events that require the participation of employees from far off locations.

Non-conforming product:

Non-conforming product in water supply systems are all water loosed or used without purpose (non-revenue water - Q_{NRW}):

- Only the part of this water is authorized and acceptable consumption *Quac*. This is the water consumed in the fire-protection purposes and technological water in water supply process). Fire-fighting activities have intervention character and they cannot be controlled, so neither the quantity of consumed water. Technological water is drained from the water supply system in order to flush the pipeline. Rinse the pipeline is carried out mainly in the peripheral parts of the water supply network where consumption is low and where therefore the water loses its quality (stagnant water). Process water consumption can be optimized;
- All other water consumption makes direct water losses (Q_{WL}) or waste. According to the structure of the water losses are divided into apparent and real. Apparent losses occur due to inaccuracies of measurement of water consumption (water meters) or due to unauthorized consumption (water robbery). The rest are real water losses due to failures in the water supply system. Water losses are one of the key performance indicators of water supply organizations.

Excessive processing:

Losses due to excessive activities of water supply organizations can also be observed with several different aspects:

- Pumping water from the water wells must be optimized. Wells have its capacity which is correlated with the weather, hydrological and environmental conditions. Excessive use of water wells can lead to depletion of wells and lowering the water level. Lowering the water level, the water supply pump coming in the unfavorable operating mode (the QH characteristics of the pumps);

- The water supply stabilization of the water supply system is realized by water reservoirs. Water reservoirs are water structures whose basic function is to regulate the pressure in water supply zones and whose time constants are proportional to the size of water reservoir. Excessive water reservoir filling will be lost on the overflow;
- The water supply system can function without the water reservoir (for example, water supply of Berlin city). In this case, the water supply network managed by highly sophisticated equipment (continuously controlled pumps, remotely controlled valves and gate valves. Those water supply organizations make optimal use of available resources and there is no excessive processing. Unfortunately, most of the water supply organizations are not at this stage of development and they are using water reservoirs for control and stabilization parameters of consumption.

Insufficient use of employee's potentials;

Water supply organizations generally have not will to change themselves. New knowledge and achievements in human resources management are not recognized as a priority and therefore they have no major developments in that field for a longer period. Insufficient use of employee's potentials can further effect on:

- inadequate organization and systematization of jobs;
- too many executives with unclear roles and responsibilities;
- absence of quality job descriptions;
- outdated and inadequate rules of procedure;
- the inability of fair reward employees;
- poor use of additional knowledge and skills of employees;
- absence of professional development of employees;
- absence of internal and external education of employees;
- promotions that are not based on the results of the work.

Energy;

- Excessive consumption of electricity is in direct correlation with the excessive production of water and makes the biggest financial loss in water supply organizations. Water loss reduction means direct energy savings.
- Irrational use of energy. The savings which can be achieved through optimizing the operation of pumping plant during the period of cheaper electricity (filling water tanks during the night).
- The savings can be achieved through optimizing the operation of pumping plants in regimes instability of distribution grids. Savings can be achieved with quality contracting with suppliers of electricity by introducing the most favorable regime. Turning off or turning on pumping plant (large consumers) as order of the distributors in moments of excessive or insufficient electricity demand will stabilize electricity supply. Water supply system will remain stable in accordance with the time constants of water tanks.
- The savings can be achieved by using energy from renewable sources. Protection of water wells from pollution is carried out protection zones (legal obligation). The first protection zone is the zone of water wells whose size is defined by the size of the aquifer, and environmental parameters, and potential sources of pollution. Water wells are typically large areas where no activity is allowed except water supply. However, permitted the production of electricity in solar power plants up to the level of own consumption. Water supply organization shall not engage in other commercial activity other than public water supply activities (Law on water services). Because of this, water supply organizations can produce and use their own energy from renewable sources to the level of own consumption, and thus become a green organization;
- Energy losses due to the low energy efficiency of commercial buildings. Water supply organizations use multiple types of commercial properties containing office space, computer equipment, laboratories, garages, workshops, warehouses etc. Because of age, poor current and investment maintenance (renewal and adaptation), these business objects have usually very low energy efficiency;

- The use of vehicles powered by combustion engines. Water supply organizations are ideal to become electric vehicles user because, they work locally. Today available electric vehicles have some limitation for wide use, but that limitation does not have any negative impact on the operation of water supply organizations. The autonomy of electric vehicles of about 150 kilometers on a single charge is more than enough. Vehicles used by water supply organization rarely go more than 100 kilometers per day, and all night long (over 8 hours) are available for charging energy (their own energy from renewable sources).

Water;

- Losses of water from the water supply system are described in detail in a part about losses due to excessive production;
- Water losses due to the low energy efficiency of commercial water supply organization's builldings. Because of age, poor current and investment maintenance (renewal and adaptation) these business objects usually have large water losses;
- Water supply's technological water is authorized consumption but not invoiced water. It is used in order to flush the pipeline in accordance with request of high quality of water. Flushing the pipeline is carried out mainly in the edge parts of the water supply network where consumption is low, and the water loses its quality (stagnant water). Consumption of technological water can be optimized for the most part if the technological water will be used again on second purpose (washing the streets). This will be achieved by better contracting and coordinating locations where fire trucks and road-washing vehicles are filled.

Materials;

- Application of chemical agents (chlorine, etc.) in the conditioning process before water pumping in to the water supply systems. Chlorine is highly toxic materials whose acquisition and use requires strict legal procedure. Conditioning of the water by physical methods acceptable for humans and the environment and of course for the operational cost (cheaper and easier);
- The use of pipes for water supply systems made of the acceptable materials. Acceptable tubes are constructed from inert (innocuous) of recyclable materials and with the service life longer than 100 years (for example, pipes made of cast or ductile iron). The worst in the practice have proved (now forbidden) asbestos-cement pipes. They are very harmful in the production process (asbestos), with lifetime shorter than 40 years and they are very unacceptable as a waste for disposal after life cycle. They are also very sensitive to disturbances caused by the construction and seismic activity (refraction), and disturbances caused by static and dynamic pressure (rupture). For rehabilitation of water supply network by replacing the pipes should take care when choosing types and materials because the cost of the pipe is less than 10% of the total cost of the rehabilitation of pipelines.

Waste;

- All waste arising in the performance of water supply activities (works on replacement of pipelines, reconstruction and maintenance of water supply networks) should be stored and disposed of in accordance with prescribed rules regarding the disposal of special types of waste and this action have to be documented (registers, certificates of disposal, reports).

Emissions;

- The use of machines driven by motors on fossil fuels, on site to work replacement, reconstruction, and maintenance of water supply networks are the only emissions into the water supply activities. Water loses are also emission but without negative influence on environment.

Biodiversity;

- loss arising from excessive use of surface water (streams, rivers, lakes).

Analyzing the identified Lean and Green wastes, we highlight the most influential and biggest Waste in water supply organizations:

- energy losses;
- losses due to insufficient use of potential employees;

- water losses;
- losses due to excessive, inadequate and useless stock.

4. CONCLUSION

This paper presents the initial phase of research on the possibilities of application Lean and Green management in water supply organizations. Lean and Green wastes which must be reduced or eliminated out of water supply process have been identified. Further research will determine and apply appropriate Lean techniques and tools to improve the water supply process. Key performance indicators (KPI) essential for the effective management will be determined as well as the manner of their follow-up (measurement). The goal of this research will be to create a new model for increasing the efficiency of public water supply.

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IMPROVEMENT OF INCOMING QUALITY CONTROL BY APPLYING PDCA CYCLE

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Abstract

Incoming quality control is an important and integral part of the quality management system of each manufacturing organization, as it provides quality inputs necessary for the continuous production process. This paper presents a case from business practice where incoming non-conformances have significantly influenced the variation and stability of the production process, resulting in customer complaints. Incoming quality control had to be adapted to changes in the business system, and by using the SWOT analysis and the PDCA cycle in four iterations, the observed organization managed to establish a functional and efficient incoming quality control process that, on the one hand, efficiently utilizes existing resources and on the other hand, ensures high quality inputs for production process.

Keywords: incoming quality control, SWOT, PDCA cycle, improvement of business processes.

1. INTRODUCTION

Incoming quality control is an important and integral part of the quality management system because it provides quality inputs necessary for the continuous production process. Any deviation from the set specifications results in unwanted variations, which, in turn, lead to non-conformities and customer complaints about products and services. The aforementioned risks oblige each manufacturer to provide functional incoming quality control because any complaint about the product or service undermines customers' confidence in product quality and manufacturing business as a whole.

By their very nature, the principles of incoming quality control are clear, i.e. they require measurement and control of required specifications and feedback on achieved results in order to correct the process [1]. However, the application of these principles to everyday business situations is very complex and requires a number of decisions, made both by in-house quality control and management and administration. In everyday examination of incoming quality control and decision-making, organizations must be guided by the fundamental principle of quality management, which is aimed at continual and daily improvement of the business system and business processes.
The hypothesis presented in this paper assumes that by applying the PDCA cycle, it is possible to improve the existing process of incoming quality control in the real production process. On the one hand, the production process will be efficient and effective for the observed business system and requires a small number of employees involved, and on the other, it will fully ensure compatible raw materials, semi-finished products and products required for the production process with minimum costs.

The research was conducted in a Croatian company, Klimaoprema d.d., a long-time manufacturer of cleanroom systems, ventilation and air conditioning equipment, and a fire damper product was used as a hypotensive testing product.

2. INCOMING QUALITY CONTROL IN THE 2003-2017 PERIOD

The observed company established a quality management system in accordance with the requirements of ISO 9001: 2000, and the certification according to the mentioned standard was successfully implemented in 2003. Incoming quality control, as one of the basic quality management processes, was being conducted successfully for years and it ensured that input raw materials and semi-finished products were checked. The production process was carried out continuously according to the annual plan and the scheduled delivery deadlines for finished products, and the responsibility for the incoming quality control was given to warehouse workers. Incoming quality control was regularly carried out according to the operating instructions, and technical support was provided by the Technical Office. Engineers-designers, in charge of product design and development, introduced warehouse workers with new incoming components and changes to the existing ones. And for the first inputs of new components or changes of suppliers of external services, they implemented the incoming quality control together with the warehouse workers. During the period from 2003 to 2017, six improvements in the process of incoming quality control and eight audits of accompanying documentation were carried out, together with the accelerated development of the company, and the improved incoming quality control processes fully met all the current needs for incoming quality control of products, semi-finished products and raw material from suppliers.

3. INTERNAL NONCONFORMITIES AND COMPLAINTS IN 2017

In early 2017, variations were detected in the production process of the observed product, and they were associated with changes in product design and changes in the choice of component suppliers and external services. The first deviations were in the form of internal nonconformities recorded in the existing nonconformities recording system, and the increase of internal nonconformities for the observed product during 2017 is graphically shown in Figure 1.

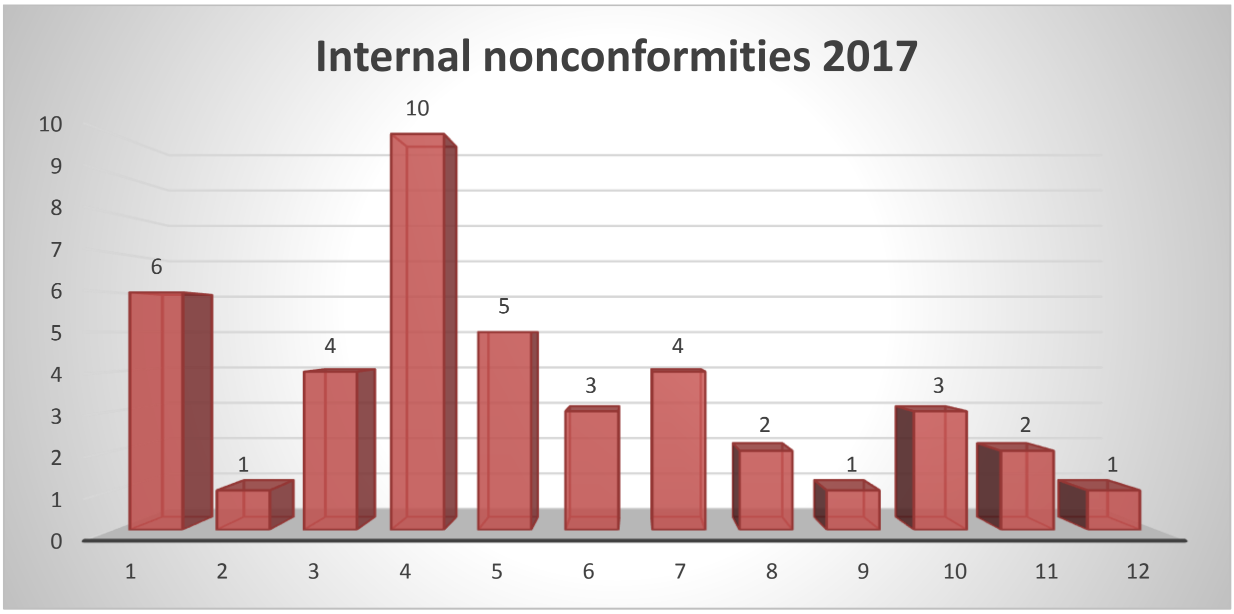

Figure 1 – The number of monthly internal nonconformities in 2017

The increase in internal nonconformities, according to Figure 1, is evident in the first six months when a total of 26 internal nonconformities were observed for the observed product [2]. In addition to non-conformities within the production process, there was an increase in customer complaints, 166 of them in total in 2017 for the observed product [3], and the distribution of complaints by months followed the frequency shown in Figure 1.

These deviations have seriously jeopardized the operations of the observed company in foreign markets and consequently, the management of the business organization initiated an internal investigation and analysis of the new threat. The conducted analysis of documented information, customer complaints and internal nonconformities clearly showed that there was a problem with the supplied components received from the supplier. The share of this type of nonconformity in the total number of internal nonconformities accounted for 82%, and the results of customer complaints analysis showed that 68% of the product complaints related to the supplied components produced in processes outside the organization. The results of the analysis clearly showed it was necessary to change the existing incoming quality control process.

4. METHODOLOGY

SWOT analysis was used to identify the main strengths and weaknesses of the organization, ranked by their relevance, and to identify opportunities and threats according to the probability of their occurrence [4]. The conducted analysis identified key areas for improvement in the observed company, namely:

- Reorganization of the incoming quality control process;
- Check of incoming components using statistical sampling;
- Training of employees for the implementation of incoming control;
- Supervision of the suppliers and
- Additional requirements from the suppliers.

Deming-Shewarth cycle, known as the PDCA cycle was selected as methodology to be used to improve the existing incoming quality control process.

Key improvement activities were focused on five areas identified by SWOT analysis, and PDCA methodology was applied throughout 2017 continuously in four improvement cycles as shown in Figure 1.

5. RESULTS OF THE IMPROVEMENT OF THE INCOMING QUALITY CONTROL PROCESS

As shown in Figure 2, the first implementation of the PDCA cycle was carried out in April and resulted in a reduction of internal nonconformities as shown in Figure 1. However, as the nonconformities and customer complaints were still present, the improvement of the process required further application of the PDCA methodology. The second round of improvements was carried out in June, the third round in August, and with the latest implementation of the PDCA methodology in September 2017, the optimum incoming quality control model was established in the observed organization. Figure 2 also shows the correlation of the improvement process with the increasing complexity of the incoming quality control process. Namely, each improvement round required modifications and refinement of the incoming quality control process, which ultimately resulted in a more complex incoming quality control process than the one used before improvement.

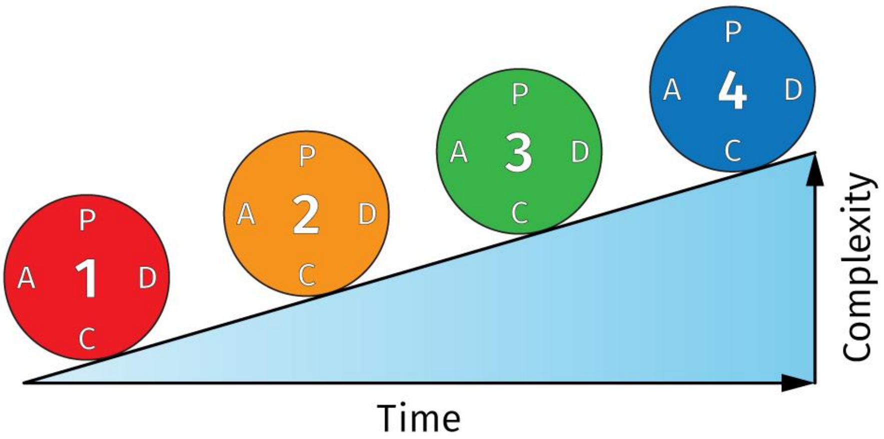

Figure 2 – Improvements by applying the PDCA quality cycle

5.1.Reorganization of incoming control process

An improved and more complex model of incoming quality control is shown in Figure 3. Depending on the type of incoming goods, it is divided into five categories: Control A, Control B, Control C, Control D and Control E.

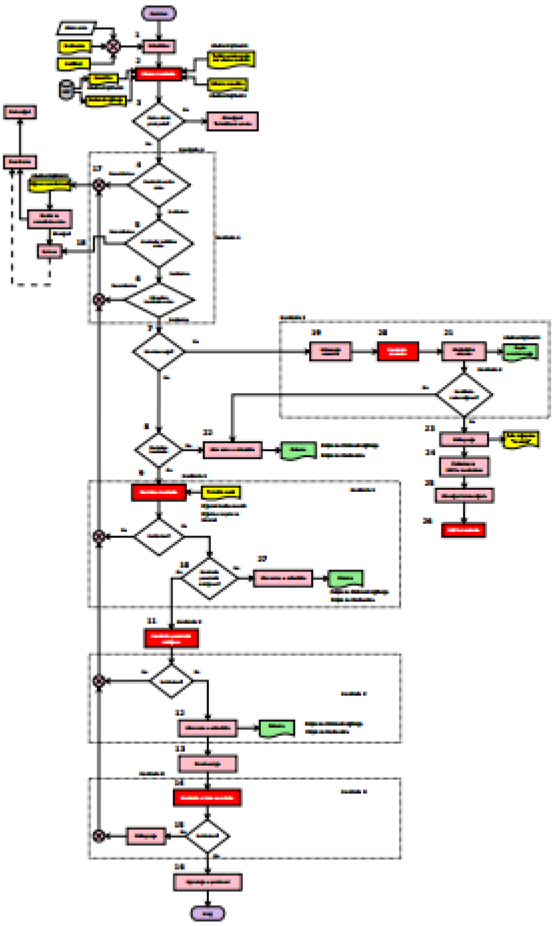

Figure 3 – Flow chart of improved incoming control process

In parallel with the reorganization of the incoming quality control, the document "*Incoming Quality Control and Statistical Sampling Table"* was created as a basis for the warehouse workers to be able to decide which type of incoming quality control would apply to the goods received from the supplier. This table is also the basic document of the incoming quality control process in the observed company.

The incoming quality control procedure begins with the delivery of the input goods and the accompanying documentation in the organization. In addition to raw materials and semi-finished products, suppliers supply invoices, raw material certificates, and other documents that the warehouse worker, as the first person in the incoming quality control process, compares with the order, internal order and table. In the table "*Incoming Quality Control and Statistical Sampling Table",* there are incoming goods codes, raw material and semi-products codes, and the type of incoming quality control that is carried out on the incoming goods.

Control A is carried out by warehouse workers, and it includes identification of goods, quantity and condition of goods (packaging condition and possible transport packaging damage), verification that the supplier met the quality requirements (certificates), and visual inspection of the goods received. In case the goods received do not comply with the specifications in the order or other accompanying documentation (wrong delivery, etc.), the goods received are not unloaded but are returned to the supplier with the complaint lodged by the Purchase Department.

Control B or additional incoming quality control is carried out by warehouse workers if necessary. It includes checking the dimensions of the goods received by measuring those goods. For the implementation of additional incoming quality control, the warehouse worker uses technical drawings, samples, measuring devices and calibrated measuring instruments (flexible measuring strips and movable gauges). If, during the measurement process, the warehouse worker finds an irregularity in the dimensions of the goods received, he places the goods in the area designated for the non-conforming goods, marks them with the red label "Noncompliant", and informs the Purchase Department about it. In cases where the goods arriving conform to the dimension requirements and satisfy the dimension control, the goods are received at the incoming warehouse.

Control C or control of special requirements is carried out by the warehouse workers with the help of the Quality Control Department and/or the designer from the Technical Office. Special requirements control is performed, if necessary, for a particular, pre-defined goods. For example, this type of incoming quality control is carried out in cases where goods enter the warehouse for the first time or when the goods come from a new supplier.

Control D or control during the assembly is carried out by the employees on production lines when installing parts in the products. When assembling components into sets and products, employees can determine different types of nonconformities. In this case, the employee removes all the non-conforming products from the worktable (assembly line) and informs the Head of Production or the Production Manager who initiate the complaint procedure.

5.2. Incoming components control using sampling and statistical methods

The procedure of incoming quality control using a statistical sampling, marked by the **Control E** mark, is performed by the Quality Control Department, upon the warehouse worker's notice. For the procedure of statistical sampling, the standards HRN ISO 2859-1/2012 [7] and HRN ISO 3951-1/2016 [8] are followed.

Based on the analysis of measurement results of the key quality features of the parts on a randomly selected statistical sample, it is concluded whether or not the quality of the incoming delivery meets the quality requirements. The measurement results are processed by statistical computer applications, and the example of incoming control for fire damper shaft (FD and FD-C) by sampling according to ISO 3951 is shown in Figure 4.

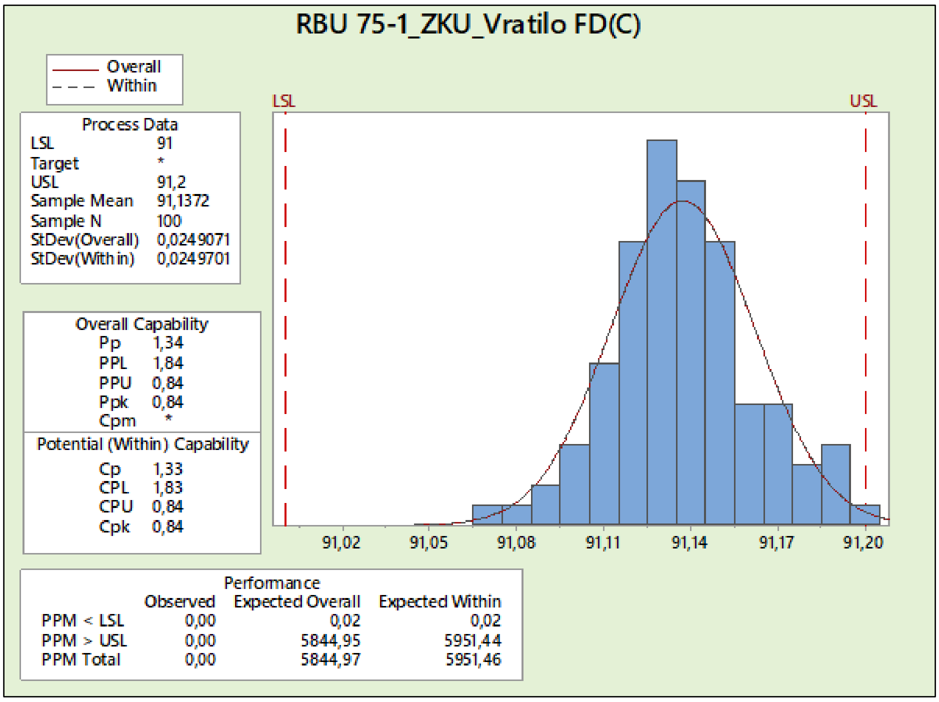

Figure 4 – An example of incoming quality control by sampling

If the quality of the sampled incoming goods fully meets the criteria, Quality Control informs the warehouse worker that the incoming goods conform, and the goods enter the warehouse. When the quality of the samples does not meet the prescribed criteria, the warehouse worker places the said goods in the area designated for non-conforming goods.

5.3.Employee training for the incoming quality control

The third area of improvement focused on the training of warehouse workers about changes in the process of incoming quality control of the goods received. Trainings were carried out in parallel with each PDCA cycle, and discussions with warehouse workers and employees involved, their suggestions and ideas were analysed and evaluated when each new round of improvement started. At the end of the last, third round, a training for employees involved in the process of incoming quality control was organized, with the aim of achieving the necessary competence necessary to perform jobs that affect product quality and of promoting employee awareness of the importance of their work and possible consequences that may result from the deviation from the prescribed rules.

5.4.Supervision of suppliers

The observed company uses production processes of other companies such as suppliers of products or services for those products and services for which they do not have adequate technology and skilled workers. Due to the situation at the time, it was necessary to change the existing supplier supervision model, and with a new, improved approach, all product and service providers are regularly audited through annual audits to create partnerships, cooperation and mutual trust. Audits of suppliers are conducted in agreement with the suppliers in order to gain insight into the quality assurance measures taken and the capability of the process, especially when:

- Supplier delivers two consecutive non-conforming deliveries of the product or service;

- Quality Control concludes that there are serious variations in the quality of a supplier of products or services;
- There is a reasonable suspicion that supplier can supply conforming products or services.

The method and scope of the control of suppliers will vary depending on the past delivery quality indicators. The aim of the observed company is to constantly reduce the scope of incoming control based on partnership cooperation with suppliers and to gain full confidence in the quality of the delivered goods.

5.5.Additional requirements from the suppliers

The fifth area of improvement relates to the information that the business organization delivers to its suppliers. By applying the PDCA cycle, special attention is paid to raw material quality specifications that are part of the order or contract with the suppliers, as well as to the additional requirements of the organization towards the suppliers. New Orders and Contracts with the suppliers have been improved and now they are accompanied by the necessary information on additional requirements, most often the following:

- Documents (certificates) that the supplier should deliver with the delivered goods;
- Verification or validation activities to be performed at the suppliers' premises;
- Certified management systems (quality and other as needed);
- Documented information on the quality control results provided at the supplier;
- Hidden non-conformities notification period;
- Acceptable quality limit expressed as the value of AQL or P_{pk} (in principle, in this case, Quality Agreement is signed with the supplier).

The Purchase Department orders goods or services only from the supplier from the *"List of Approved Suppliers"*. The status of *"approved supplier"* is provided only to those suppliers who have been assessed as having full capacity for the continuous delivery of goods or services meeting the set purchase requirements. Records on the evaluation of suppliers, their products and services are sufficiently comprehensive to demonstrate the suppliers' ability to meet the quality requirements set.

Through the conducted activities aimed at improving relations with suppliers, the business organization has established good cooperation with approved suppliers, thus benefiting all interested parties, and further activities are ongoing with the aim of building a partnership with the suppliers.

6. CONCLUSION

The conducted research shows the effective use of the SWOT analysis used to identify weaknesses and threats for the observed company and the application of the PDCA cycle to improve identified critical business system areas. By applying these methods, the organization has significantly improved the five key areas of business operations and has established an applicable, functional and efficient process of incoming quality control, which on the one hand, efficiently utilizes existing resources and human resources, while at the same time reduces costs, and ensures quality inputs necessary for the continuity of the manufacturing process.

The established incoming quality control model, which is more complex than the previously applied practice of incoming quality control, is adapted to the accelerated growth of the observed business organization, and its modularity allows for an easy upgrade if it is necessary to introduce new products or have incoming control. Still, the goal of developed model is to reduce the incoming quality control process by developing partnerships with suppliers and by transferring part of the risk of incoming quality control onto the suppliers. Previous analysis clearly shows that the hypothesis in this paper has been confirmed and the developed incoming quality control model is fully applicable to the existing company, the manufacturer of cleanroom systems, ventilation and air conditioning equipment.

Furthermore, research shows that the PDCA cycle, despite being used for the first time in the 1950s, is still a very powerful tool for continuously improving business processes in real-world business organizations where efficient solutions and quick responses to risks, opportunities and challenges of the changing demands of the competitive global market are required.

Further research to improve the presented incoming quality control model can be implemented in the area of digitalisation of the information streams presented in this incoming quality control model, connecting it with the information system of the company, where all documented information from the incoming quality control process will be available in real time to all interested parties in the company.

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OUTSOURCING DESIGN - THE LEANER APPROACH

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Abstract

Design adds value. However, we often feel design adds complexity and designers add confusion. How can the science of design help organizations tackle this complexity and confusion, harness the value of design and reduce waste? From the standpoint of lean thinking, this study will look into the most common design process model - project-based outsourced design process - and explain how some key characteristics of that model cause waste. In comparison with this common model, an advanced outsourced design process will be presented that enables organizations to use the design process to create solutions, innovate, improve problem solving abilities and contribute to the creative culture of the organization.

Keywords: culture design, design methodology, science of design

1. INTRODUCTION

Organizations must be smart and efficient in their use of resources to achieve what matters to them. Design as a purposeful activity of creating new values in products, services and cultures is fundamental in realizing that achievement [1]. An organization's ability to harness the value of design enables them to perform better, set themselves apart from their competition and establish themselves as leaders in their field. Furthermore, the science of design provides advanced methods and a structured approach to solution finding that are logical, transparent and repeatable, further improving an organization's ability to achieve.

In Southeastern Europe, the most common model of implementing design is a project-based, outsourced model (referred to as: *common model*). When an organization requires expert design services (referred to as: *organization*), the most common approach is to hire a designer or design firm as an outsourced specialist (referred to as: *designer*). In such a relationship the design process is executed outside of the organization and the completed design solutions are transferred back to the organization. The expectation is that such a relationship enables the organization to temporarily acquire design expertise to obtain a designed solution, implementation of which increases the value of the product or service thus enabling the organization to harvest the benefits of design. Quite literally, design is considered — an added value.

This seemingly elegant solution to an organization's design needs is not universally applicable in practice. Expert design is prevalent in the marketing field, as evidenced in numerous marketing related design festivals, conferences of this region and designers working in the field. However, expert design in industry, engineering, technology and science fields is incidental. In these fields, organizations can be reluctant to implement expert design, considering it something that adds costs, complexity and confusion. In other words, creating *waste* from the standpoint of Lean thinking.

This short discourse focuses on the problems of the *common model* in Southeastern Europe and how that approach presents obstacles to wider implementation of expert design in industry, engineering, technology and science. To elaborate, we will compare the *common model* to an advanced design process model (referred to as: *advanced model*), where scientific methodology allowed for the reduction or elimination of those problems.

Through this discourse we hope to advance the understanding of the social circumstances that arise between the organization and the designer at key points in the design process, emphasize the value of the science of design, and further the ability of organizations in the region to use the design process to reduce waste, create solutions, innovate, improve problem solving abilities and contribute to the creative culture of the organization.

2. METHODOLOGY

For this discourse, we have adopted a Comparative Perspective; a qualitative method from the Social Sciences. Due to the lack of previous insights in this area of research in this region of Europe, this method was chosen for its power in forming conceptual generalizations of social systems and identifying key points of interest for future detailed explanations.

Two social systems will be compared: two models of project-based outsourced design processes. The first, the *common model* mentioned in the preceding section, is a generalization of the most common design process model in Southeastern Europe. The second, an *advanced model*, is a science of design-based model developed at the Kyōto Institute of Technology, Kyōto, Japan under the leadership of professor Katsuhiko Kushi and successfully applied in design projects with Shimadzu, Koto, Ōsaka Gas, Benesse and other companies in Japan. Both models have the same actors (the client organization and the external, expert designer), are project-based (initiated, planned and executed to produce a designed solution over a fixed period of time within fixed constraints) and outsourced (the organization obtains design service from an external expert designer) but vary in overall structure, approach to design methodology and communication during the design process.

To compare, the timelines of both models will be outlined and sequenced into Preparation, Analysis, Ideation, Conceptualization, Development and Outcome phases. While *analysis*, *ideation*, *conceptualization* and *development* are common in design process descriptions, the addition of 'preparation' and 'outcome' phases is crucial, for the understanding of the design process requires knowing the circumstances before and after the designer's involvement. In the preparatory phase, the organization works toward establishing and committing to a meaningful relationship with a designer, the results of which will influence the design process later, while the outcome of the design process influences both actors, impelling them to deal with the new circumstances and act accordingly (e.g. implement the solution, utilize knowledge and experience gained). Within the timeline we will observe key characteristics of each model emerging effected by the actions the actors take during the design process. Of special interest are characteristics regarding Social structure [2] - planned or emergent patterns in the relationship between the actors; Methodological makeup - utilization of design methodologies to achieve design process goals; and Communication - exchange of information/knowledge between the actors. Finally, the key characteristics are discussed in reference to Lean thinking and what they offer in terms of the discovery of deep cause-and-effect relationships, planning and the effect on the organization's culture. (Figure 1)

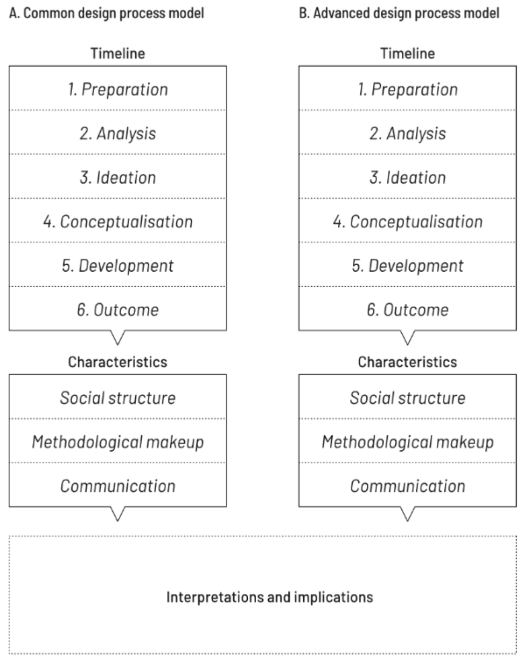


Figure 1 — Overview of study design

3. RESULTS

3.1. Overview of the common design process model

Preparation — (Figure 2) The organization establishes the need for external design expertise and compiles a design project brief stating the design requirements with pertinent background information. The brief is communicated to the designer and the designer commences work. The brief document is subject to formalization and depends on an organization's ability to compile design requirements and pertinent background information. There is a possibility that information herein might be insufficient, irrelevant or redundant. Furthermore, it is subject to the designer's interpretation.

Analysis — Analysis is executed independently by the designer. The analysis phase serves to inform the ideation phase. Communication between actors is prevalently on-demand information exchange (verbal, shared data, meetings) and/or of planned progress report meetings. Independent work and on-demand communication will remain characteristic for the analysis, ideation, conceptualization and development phases.

Ideation — The designer proceeds independently. Similar to an action-centric design process model [3], the design process is improvised, flow-like, and ideas deemed by the designer to be successful solution candidates are evolved further.

Conceptualization — The designer proceeds independently, from initial ideas to concepts and eventually to a rationalized, development stage. Ideation, conceptualization and development are inextricably linked in a free-flow activity, rather than being defined phases. Solution candidates are evaluated both viscerally and against the information contained in the design brief or newer information sources.

Development — The designer works independently to rationalize concepts. Typically, work is invested to produce one or more directions for the final solution, in the hope that one of them is appropriate to the organization's needs. Proposed solutions are presented to the organization, and after consideration and/or additional work the organization decides on acquiring one solution while others are unused.

Outcome — The design solution is 'transplanted' into the organization. Due to the exclusivity of the designer's prior work, after the initial *wow-effect*, the organization needs time to adapt to the design solution. The solution has to *click in* the existing culture of the organization. It is in this phase that the organization typically discovers less obvious aspects of the designed solution which might or might not be beneficial: shortcomings, incompatibilities, hidden benefits or hindrances, etc. Depending on the arrangements, the actors can continue the design process or not.

3.2. Overview of the advanced design process model

Preparation — (Figure 3) The organization establishes the need for external design expertise and produces a rough design framework that is communicated to the designer. A joint team is formed. It includes the designer and experts from the organization (engineers, managers, in-house designers). Due to the methodology that will be applied during the design process, it can be said that at any point in time, the organization possesses a sufficient amount of information and knowledge to begin a design process. Taken reasonably, this can relax planning and reduce costs in the beginning.

Analysis — The analysis phase serves to identify deep needs, deep cause-and-effect relationships the design can provide solutions for, and by providing solutions increase the value for the end user/customer. Using field research methods (e.g. rapid video ethnography, interviews, observations, direct participation) the designer identifies problems and possibilities and presents evidence to the organization. In a collaborative workshop (utilizing e.g. card game, snowball, KJ) the joint team will structure the evidence in the form of a problem map. The designer condenses the problem map further to the level of a general problem diagram. Analysis documentation is then delivered to the organization.

Ideation — Driven by the analysis results, the joint team generates an array of ideas using ideation methods (e.g. visual brainstorming, paper prototyping, selected agile development techniques). Ideas are jointly evaluated and promoted, then correlated so that a general solution diagram can be constructed. Ideation documentation is then delivered to the organization.

Conceptualization — The designer focuses to building one design concept which best fits findings from the analysis and ideation phases. The concept's fitness is verified methodologically (e.g. acting, persona, scenario building, paper/rapid prototyping). Documentation supporting the concept's use scenario is then delivered to the organization.

Development — The designer continues to improve the design concept to the design solution prototype stage. Once completed, the prototype is demonstrated to the organization for evaluation. At this point, the prototype is evaluated against the wealth of documented data and knowledge generated to this point. It is important to mention that, due to the organization's involvement in the analysis, ideation and conceptualization phases, the organization is evaluating the design solution prototype with an updated mindset and understanding of the project's deep needs.

Outcome — By the time the project is concluded, the designer has produced and the organization has received: analytical data, the systematization of deep needs, a general problem diagram, a documented array of relevant, evaluated ideas, a general solution diagram, scenarios and the solution prototype. Also, the organization received experience through direct participation and formed a deep understanding of the designed solution value. This knowledge allows the organization to make better informed decisions in production and/or further development of the designed solution.

Figure 2 — Common model timeline

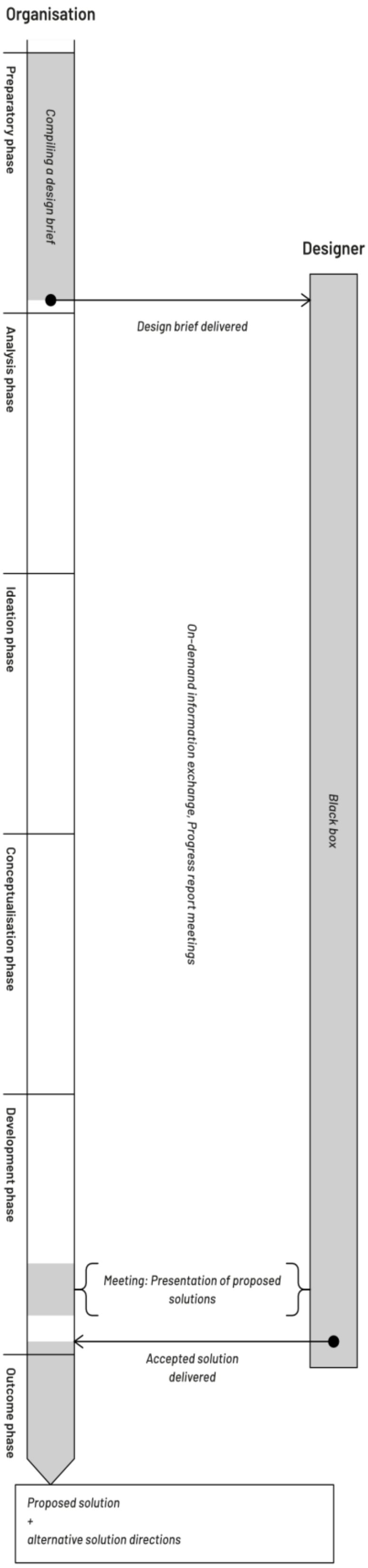
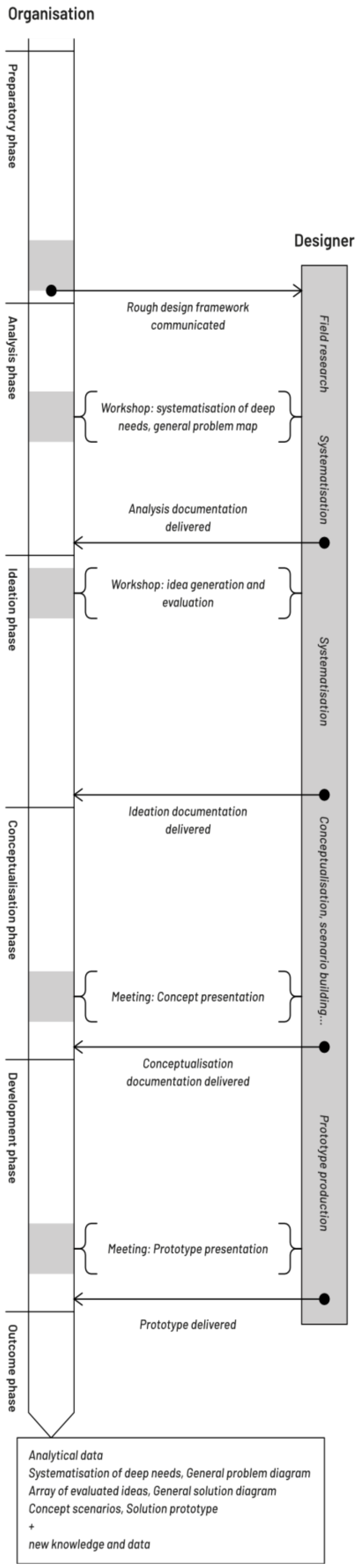


Figure 3 — Advanced model timeline



4. DISCUSSION

4.1. Interpretation of the *common model*

The common model can be described as a *black box*. The designer assumes the role of an external specialist and the greater part of the design process (analysis, ideation, conceptualization, development) is conducted outside the client organization. The designer develops a solution following personal methodologies and teleologies and such a design approach is not compatible to development processes executed by industry, engineering, technology and science where monitoring, solid methods and data are required. To a design non-expert this approach can come across as relying too heavily on elusive artistic inspiration, as confusing or even frustrating, possibly leading to questions about the reliability and value of a design process.

Furthermore, such processes are inherently complex to troubleshoot and do not provide enough structure to enable learning from successes and mistakes.

Communication is formalized (the design brief and solution presentation) and/or sporadic (on-demand information exchanges) allowing for information gaps. Detection of such gaps relies on the designer's punctiliousness or organization's ability to follow the designer's process. Typically, detections occur serendipitously and late in the project. Correcting the gaps at a later stage can introduce additional costs or setbacks. Due to this characteristic of communication, *hidden powers*, ethos and other subtle aspects of the organization are prone to be lost in communication and not contribute to the value of the solution. Likewise, subtle aspects of the designer's approach are prone to be lost and hinder the deep understanding of the solution.

By entrusting the design process entirely to an external designer, the organization is: 1) Excluding itself from a chance to update their thinking or allow field of design to contribute to their abilities and culture. Consequently, without the updates, the organization will evaluate proposed design solution(s) with the same mindset the organization had before the design process. 2) Precluding their valuable accumulated experience, latent knowledge and visceral reactions to contribute in the process of defining the deep cause-and-effect relationships, deep-problems and deep-needs, possibly reducing the value of the final designed solution.

4.2. Interpretation of the *advanced model*

The advanced model takes rational approach. The designer assumes the role of an external specialist and also the role of the design process leader to a joint team of designers and organization's experts. The design process is methodologically divided into managed design phases, each with known inputs, goals and outputs. Each phase applies data and methods to achieve goals and advance to the following phase. It implies a rational structure but purposefully allows for non-rational free-flowing creative processes, so when data is not supported by direct evidence (e.g. during creative workshops) the joint team can evaluate, structure and relate it to other data. Through a collaborative approach, the advanced model provides a platform for actors to continuously exchange information and enrich mutual knowledge, in the process reducing the possibility of information gaps. The joint team shares a common understanding of design process, needs and goals. This allows for subtle information, accumulated experience, latent knowledge and visceral reactions of the actors to be captured and contributed to the solution and in the process of doing so influence actors' cultures.

The advanced model is characterized by high repeatability and reliability. A wealth of structured, documented data, as well as methods used during the design process can be utilized by the organization in their own problem-solving processes later, reducing the organization's costs. Unlike the *common model*, the advanced model does require stronger involvement on the side of the organization, which adds to their workload. Also, structured documentation in each phase adds to the designer's workload. Nevertheless, when solid, long-term solutions are needed, the benefit of the advanced model outweighs its cost.

4.3. Policy and practice implications

The science of design informed design processes offer problem solving tools that significantly reduce the confusion, complexity and overall costs commonly associated with design processes and designers.

Through the application of advanced models, we believe organizations and designers alike will be able to use the design process to innovate, improve problem solving abilities, create sustainable solutions and contribute to their respective creative cultures. The authors have successfully used such models to design robots, laboratory equipment, digital tools for language learning, services, interfaces and applications, corporate identities, foods, concepts and research strategies.

An inherent limitation of this comparative perspective is that societies differ in more ways than can be displayed by the scope of the two design process models presented here. Specifically, the cultural backgrounds of Japan and Southeastern Europe certainly have substantial influence on the outcome of the models in their respective regions. However, this discourse contributes a workable conceptual generalization of the conditions in the field. It presents the groundwork for future considerations and studies, in particular, quantitative studies that could provide the level of detail that this discourse is lacking.

This discourse is a cultural-bridging effort between expert design practice and the needs of organizations in the fields of industry, engineering, technology and science in Southeastern Europe. It is also a contribution towards broader corporate cultures and the teaching-learning processes within organizations. In this sense, this discourse is relevant to design practitioners, design researchers and organizations interested in the development of long-term sustainable values.

5. CONCLUSION

The outsourced design process cannot be considered a simple addition to the existing *modus operandi* of the organization. It is also unreasonable to blame organizations of this region for ‘not understanding’ the value of design as well as the lack of inclusion of expert designers in the fields of industry, engineering, technology and science. A design process benefits if each person involved shares a common culture of understanding of the design process from both the designer and organization perspectives. In this regard, the rationality, reliability and explanatory power of the science of design is helpful as well. Above all, design process models for this region require a careful rethinking of the relationship between the designer and organization; to take local conditions into account and design the design process itself [4].

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SMART DIMENSIONAL MEASUREMENTS IN HIGH-SERIES AUTOMOTIVE INDUSTRY

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Abstract

Dimensional measurements in automotive industry present a critical point in maintaining product quality. This paper tackles the possibilities for dimensional measurements of bearing rings in high-batch production. Considering the very narrow tolerances, contact measurement methods make an established and reliable approach. Contact measurement methods are however time-consuming and demand a highly specialized device for each product measured. With the aim of reducing the time required to measure dimensional and geometrical features of cylindrical parts from the automotive industry while keeping the same level of accuracy, non-contact optical measurement methods based on laser light are proposed. The paper shows the idea of an innovative non-contact measurement system which utilizes laser diode and position sensitive detector.

Keywords: smart dimensional measurement, automotive industry, non-contact measurement, laser diode, PSD

1. INTRODUCTION

Production of parts in automotive industry consider high demands in terms of precise product dimensions and high level of compliant units. Embedded parts cannot compromise the functionality of a car in any way, so the inevitable part of production process is product quality control. Bearing rings production is characterized as high-batch production with narrow tolerance fields for most important i.e. critical dimensions determined by buyer. Critical dimensions of product are controlled 100 % by worker on production line. As the 100 % quality control represents uniform and monotonous type of work, sorting out the good products from the bad ones is highly dependent of human attention and error.

For quality control of mentioned products, contact measurement methods are mostly used. Considering high demands of accuracy in production environment, durability and lower investment costs, contact measurement methods represent good choice for given application. One of the examples of measuring setup is presented in Figure 1.

Figure 1. Contact measurement setup for bearing rings [1]

From the point of view of measurement accuracy, contact measurement methods seem reasonable in automotive industry. But there are few limitations in terms of their use. The most important disadvantages are the need for complex customization to specific product, measurement time and usage of lot of equipment for measuring the entire product [2]. Mentioned disadvantages represent main cause of difficulty for automation of measurement process in production where products are frequently changed. A more flexible measurement system can provide significant money and time savings in terms of system customization to specific product. Another important aspect of product quality control is replacing product control with measurement system. Implementation of measurement system enables data storage and processing which can result in production process monitoring and its improvement. Statistical data processing helps workers to predict certain irregularities in production process and then to correct the cause of that irregularities before they occur. In order to improve and innovate current measurement approach for measuring the bearing rings in high-batch production, an innovative non-contact measurement system which utilizes laser diode and PSD (position sensitive detector) is presented in the paper.

2. NON-CONTACT OPTICAL MEASUREMENT

To improve measuring system and overcome disadvantages of contact measuring method, a new approach is needed. Contrary to contact measurement methods, non-contact method using reflected light beam instead of contact probes provides more flexibility and reduces the need for adaptation of measuring system to specific product. Although non-contact measurement methods provide more flexibility and faster measurement, so far there is no measuring method which could provide enough accuracy. To achieve requested accuracy of measurement, an innovative measurement system which utilizes laser diode and position sensitive detector is proposed. The main idea is to use laser diode as source of light, point the laser beam on the measured surface and detect the reflected beam position on PSD. Working principle of PSD along with control unit (beam aligner) is presented in Figure 2 and Figure 3. Depending on the position of reflected beam on PSD's active area, it generates 4 different voltages on 4 quadrants. Control unit receives voltage's values and calculates the position on PSD.

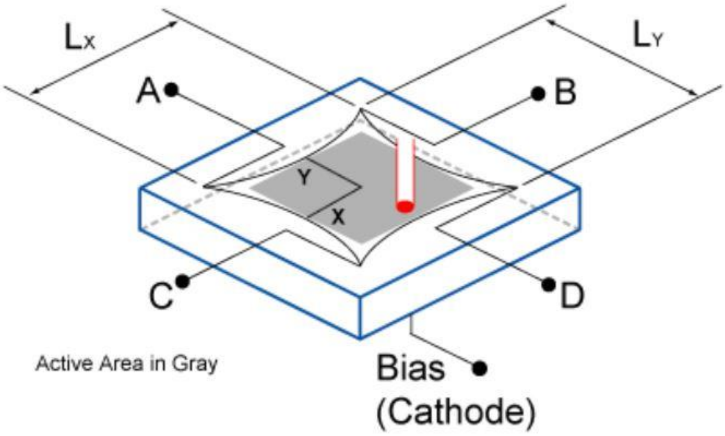

Figure 2. Position sensitive detector working principle [3]

Figure 3. Position sensitive detector control unit [3]

In order to calibrate the measuring system, masterpiece must be used to find reference point i.e. set the position of reflected beam in the centre of PSD. The working principle of described method is presented in Figure 4.

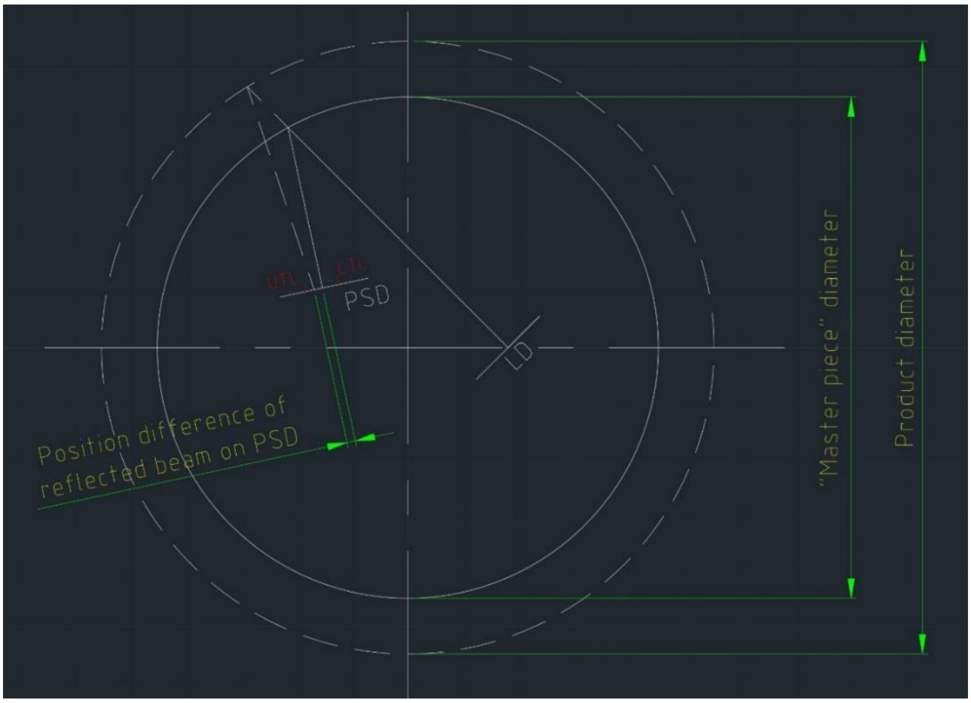

Figure 4. Working principle of proposed non-contact measuring system

The difference in dimension (in this example, inner diameter) of masterpiece and the measured product results in different beam reflection and position on PSD. Using trigonometry, upper and lower tolerance limits can be easily presented as position values on PSD which is possible by keeping the constant angle and position of light source and detector. The main purpose of proposed measurement system is product quality control. If the reflected beam is in tolerance filed, product is qualified as good. Calculating product diameter through beam position on PSD, product quality control is replaced by product measurement. Achievement of mentioned replacement results in great benefits in terms of production process monitoring.

The most influential factors for achieving proper accuracy of measurement are temperature stability of equipment and impurity and higher roughness of measured product surface. Temperature stability of equipment can be disturbed by production environment, but it is solvable through usage of temperature controller and measuring system isolation. Beam reflection however is mostly influenced by impurity and roughness of metal surface [4, 5]. As bearing rings consider turning process of production, high level of emulsion and swarf can be expected on product surface after turning. The problem occurs when emulsion or swarf are present on measured surface, causing the beam reflection in wrong angle which results in different beam position on PSD. Another important issue is product's surface roughness. Reflection of the light can theoretically occur in two different ways – specular and diffuse reflection. Naturally, reflection is not strictly specular nor diffuse, but combination of both. Specular reflection occurs when light beam hits the surface with surface roughness insignificant to the light wavelength. Light beam then reflects in way that is defined by optics laws and the position of the reflected beam can be easily predicted and calculated. Diffuse reflection however can be explained as irregular reflection. Light beam that hits the surface which roughness is significant to the light wavelength causes the light to reflect in different – irregular way.

The best possible case for considered measurement method would be to have mostly specular reflection. However, diffuse reflection can not be avoided, so utilization of optical filters and diaphragm can result in noise reduction. Reducing the noise due to diffuse light reflection can result in achievement of greater measurement system accuracy.

In order to examine the functionality of innovative method, it is necessary to build the experimental setup for measurement of desired product. 3D model of the setup is presented on Figure 5. Dimension that needs to be measured is bearing ring inner diameter.

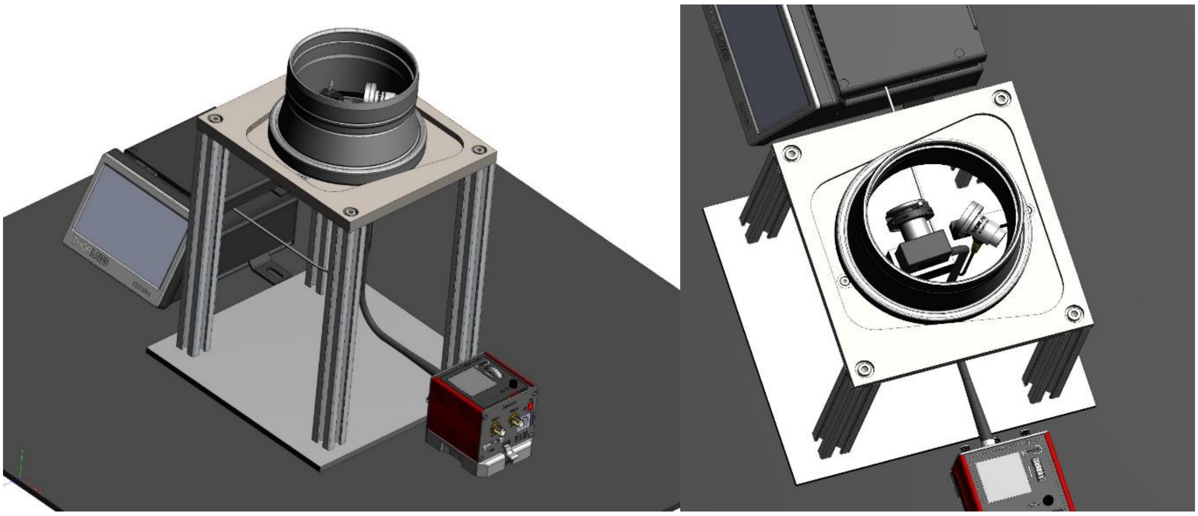

Figure 5. Proposed 3D model of experimental non-contact measurement setup

3. CONCLUSION

Automotive industry is currently one of the biggest and the most growing industries in the world. Production of parts for automotive industries requires 100 % quality control of crucial dimensions. Process of quality control is a recurring process which, performed by people, can lead to sorting errors in two different ways. First and more significant error is accepting bad product as good one (false positive). Mentioned error can result in significant cost of resorting the products or can affect badly on functionality of a car. Another mistake that can occur is rejecting good products (false negative). A proper quality control and measurement of produced parts is needed to be defined and chosen in order to minimize mentioned mistakes. The innovation in field of measurement the automotive parts with narrow tolerance includes implementation of non-contact measurement methods. In this paper, optical measurement method which utilizes laser diode and position sensitive detector is proposed. The proposed method would enable significant improvement in flexibility of measurement system contrary to contact methods. New method would reduce the cost that are common with contact measurements e.g. significant number of probes that are necessary to measure more positions and dimensions of one product, wear of contact probes and building new setup for every product. However, system accuracy and method functionality are yet to be examined. The most important step in new measurement method is to optimize the parameters in order to achieve maximum accuracy of system and to be able to reduce the measurement uncertainty. Considering mentioned, further research and development of optical methods based on usage of laser diodes and position sensitive detectors for measurement of required dimensions is required. The further research should include development of measurement and control system with result in significant time measurement savings and elimination of human influence in product sorting.

4. ACKNOWLEDGEMENT

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IMPACT OF SOCIO-TECHNICAL SYSTEMS USED IN PROJECT MANAGEMENT ON PROJECT SUCCESS

Anamarija MARIĆ

Abstract

Number of projects is increasing in many sectors and the challenges for such projects are significant. Despite the well-known results of research and literature focusing on understanding the project success and establishing success criteria and critical factors, projects in most cases result in failure. Every project has a high degree of uniqueness and thus needs a tailor-made combination of activities to result with success. This paper will investigate the possibilities of applying a socio-technical systems approach on project management and delivering projects with success. As such it gives a solid basis for further research.

Keywords: project management, socio-technical systems, project success

1. INTRODUCTION

Theorists as well as practitioners have tried to identify the causes of project failure and various factors that lead to project success. Every research focusing on the main causes and their impact on project success leads to easier understanding of achieving success, which leads to a successfully realized project. Recent research shows that the team working on the project in combination with project management frameworks and methodologies, is equally important for the success of the project. Collaboration within the team and the success of each team member as well as the team as a whole are critical factors for project success [1]. On the other hand, in the current practice project management hardly uses socio-technical systems. When it does, it relates to strategic management and not at all to project management. This results in a perceived gap between research in the fields of project management and the known socio-technical concepts. However, strategic management and project management become more and more acquainted, as both are increasingly occurring activities in a project management office. The mentioned perceived gap between the socio-technical and project management domain and the designated route between the two via the shared relation with strategic management indicates an opportunity for the construction of new project management theory [2].

It remains to be asked: How are project management and socio-technical system interconnected, what are the benefits of that connection and how can some of the recognized socio-technical systems be used as an example for project managers and project teams to complete the projects with success?

2. LITERATURE REVIEW

2.1. Social elements of project management

In project organization literature, the understanding of social themes like learning, participation, commitment and action is mentioned as crucial when investigating behaviour of project organizations. However, many models found in project management that exist today do not increase the understanding of the mentioned themes. The themes all refer to something that project staff can undertake, and which can have an influence on the behaviour of the project as a whole. Thus, the study of project behaviour becomes a highly social study. A great number of researches in project management focuses on determining critical success and failure factors in projects [1]. Although recognizing the importance of these studies, future research should be more focused on real life project management and the social embeddedness of project management. As with project organization behaviour, again the social aspect of project management is stressed. In a typical deterministic project, the eventual configuration of the project is known before the start of the execution phase. As opposed to traditional projects, many present-day projects are nondeterministic, which means that the eventual project configuration needs to be found as part of the execution process.

Projects that are raised to develop a new product or service can be classified in a midrange application; they have characteristics of both deterministic and nondeterministic projects [3].

2.2.Socio-technical systems

Socio-technical systems, as well as project management, are derived from the general systems theory which was first described by the Austrian biologist Ludwig von Bertalanffy who proposes a systematic approach to the world around us, where more or less everything can be regarded as a system. The core of the concept is the possibility of identification of characteristics that all systems have in common, which are: the existence of a process that transforms input into output, a feedback loop, an environment to the system, a hierarchy of sub-systems within the system and systems mutually, and a goal that can be reached in multiple ways. As the name general systems theory implies, the systems approach is applicable to almost everything and is therefore sometimes questioned as a unique research area. The technological systems approach refers to a non-unitary view of technology. In this view, a technological phenomenon is seen as a hierarchically structured system that consists of connected sub-systems. The technological systems approach not only makes it possible to distinguish different technological sub-systems but, more importantly, makes it possible to analyse how these sub-systems are related and how they interact. Besides technological sub-systems, a socio-technical system also recognizes the end-users and the creators of the technology. These social sub-systems can be individuals, groups or organizations and depending on how the border of the socio-technical system is defined, they can be influenced by external factors. Thus, a socio-technical system consists of one or more social networks and one or more physical networks that interact with each other [2].

2.3.Relation between Socio-technical systems and Project Management

To be able to bring together concepts from the socio-technical systems approach and its theoretical compeers in project management knowledge, an introduction to the main characteristics of project organizations and project management is required. The Project Management Institute defines a project as a temporary endeavour undertaken to create a unique product or service. Projects exist in all kinds of different appearances. No matter how big or small or how short or long run the project is, what is most important is that the project is a unit with set boundaries, a temporary existence and a specific goal [1]. A project is a social construction. Although a lot of projects involve technology, it is still people that find a reason to come together and carry out a linked set of tasks. This also means that a project organisation usually knows a high degree of conflict. Besides the battle for resources (time, money and personnel), a common conflict in many projects' roots in the different definitions of project success that the various stakeholders apply. Projects also tend to interact with other projects within the same organization, with the functional departments of an organization and with projects in other organizations. After the introduction of both the socio-technical systems theory and project management theory, it seems that there are some similarities between the two bodies of knowledge. Both theories recognize a closed entity (system or organization) with input and output (product or service). The entity has an environment and furthermore consists of smaller entities (sub-systems or groups). Finally, both the nondeterministic project organization and the socio-technical system have a goal that is set but that can be reached in multiple ways [3].

3. RESEARCH METHODOLOGY

The research is planned to be staged in three phases. The first phase was a literature review, to recognize the applicability of socio-technical systems and their usability in project management, comparison between the two and their impact on the project success. Conducted literature review has formulated the problem and defined the research direction. Literature pool was gathered from the Google Web and Scholar using the keywords, i.e. socio-technical systems in project management. The second phase of the study has tested the literature findings by conducting a brief assessment of the workplace (to be left unknown due to confidentiality issues) to establish whether the literature findings can be beneficial and used in every day's project management. The brief assessment was conducted in a secluded complex project, comprising of 40 team members, targeting 7 project managers and was in a form of semi-structured interview. However, this brief assessment is planned to be turned into a large-scale future research, which will represent the third phase. The survey will be sent out to the chosen project managers in different areas which are working closely with the social elements in project management in their everyday work.

The survey will be anonymous, but participants will have the opportunity to leave their contact information, if they are willing to discuss the results of the survey with the author or take a part in face to face interviews. Data will be analysed using descriptive and analytical statistics.

4. DISCUSSION

When discussing the application and the use socio-technical systems in every day's projects managing the focus is set purely on the socio part of the socio-technical systems. Socio-technical systems design has been manifested in a wide range of different methods. Different traditions developed in different countries and at different times have led to different approaches. The individual methods reflect national cultures and approaches to work and work organization. The consequence has usually been that each method is created for a particular market, which partly explains why there have never been any significant or successful attempts to integrate approaches to create a more general, standardized method of socio-technical systems. There has been limited transferability of the available methods. In general, those who developed a method have had most success in applying it. One area where user/team member participation has been taken seriously is software development using agile methods, such as extreme programming (XP), Dynamic Systems Development Method (DSDM) and Scrum-which are all different project management frameworks. These methods incorporate at least some face-to-face user involvement—although in practice who plays the role of the user can often depend on who is available to talk to the developers—and use short iterative development cycles to develop evolutionary prototype solutions in a manner that takes account of local contingencies. However, agile methods are mostly concerned with end-user requirements, and make the simplistic assumptions that: (a) suitable users are available to interact with the development team and (b) the user requirements are congruent with broader organizational requirements. While there are certainly interesting ideas emerging from agile methods, their focus on interaction with individual users does not address the need for broader socio-technical awareness in systems engineering [4]. Human-centred design on the other hand follows principles such as basing the design upon an explicit understanding of users, their tasks, and the environments in which those tasks are carried out. It also includes the understanding and specification of the context in which the system will be used and explicitly refers to consideration of social and cultural factors, including working practices and the structure of the organization [4]. This can be closely related to personal characteristics, used in project management, which are the following: optimism, emotional intelligence, team development abilities, confidence-building skills, motivational abilities and improvisation [1]. These personal characteristics-human factors are thought to have a huge influence on project success. Personal characteristics can be defined in more details by using tools such as the Myers-Briggs Personality Indicator (MBTI). Relationships between the MBTI profile and the management styles or success of the project have also been identified.

In addition, it should be noted that importance of managing the project which will result in success is also related to the types of projects. Namely, the complexity of the project has a moderate impact on the relationship between project leadership and success. Project implementation is based on selecting appropriate frameworks and methodologies. The project manager will select the framework that best suits the defined project. Different methodologies use different approaches for achieving project success and include the project manager and project team on different levels in achieving goals and success on the project. Research shows that frameworks and project management methodologies do not have a direct link to achieving project success, but that for achieving project success experience in project management is an important factor as well as adaptation of existing frameworks and methodologies to the current project- and this is where agile comes to play. Collaboration within the team and the success of each team member as well as the team as a whole should be defined as critical factors for project success. When applying the combined recognized methods of project management and social side of socio-technical systems in workplace it can be observed that the change from the standard and traditional methods of project management, heavily concentrated only on the scope, time and budget is greatly noticed and not an easy transition. In order to achieve results by combining these methods project managers and teams need to be introduced to the new ways of working slowly and in repeated training. After the training is finished and the change in teams recognized it simply becomes a new way of working.

Table 1. is showing the benefit of combining both Project Management and Socio-technical systems in workplace when it comes day to day management of tasks and project environments.

The current workplace is however still set in a completely traditional environment, where project management is a sole responsibility of the project manager. Recently an intensive current has started to move the whole company towards agile project management and frameworks where it will be possible to utilize the recognized advantages of the two theories together, starting with shorter and non-complex projects.

Table 1 – Use of socio-technical systems and project management in workplace (Own work based on [1,4])

<table>
<tr><th></th><th>Traditional project teams</th><th colspan="2">Agile project teams</th></tr>
<tr><td>Project Management (PM)</td><td>Traditional frameworks (Waterfall, PRINCE)</td><td colspan="2">Agile frameworks (Agile, Scrum, Lean) -increased complexity</td></tr>
<tr><td>Socio-technical systems (STS)</td><td>No interdependency of roles and tasks, individuals are replaced by other individuals</td><td>Face-to-face user involvement</td><td>Human-centred design-understanding of users, their tasks, and the environments</td></tr>
<tr><td>PM & STS</td><td>Fundamental incongruence between the actual work, design and team performance</td><td colspan="2">Interconnected human activity systems, highly functional self-organizing teams</td></tr>
</table>

5. CONCLUSION

Project management theory and socio technical systems theory share some characteristics, which makes it possible to view a project organization as a temporary socio-technical system. The socio-technical approach takes the social and technical entities that exists in project organizations as a basis for behavioural study. By decomposing the project organization into these entities, the socio-technical approach might make it easier to study project behaviour. Based on this, project management frameworks in a combination with project team and socio-technical approach in terms human centred design and team development are also proven to be highly compatible, both in theories from which they are based on, but also in a realistic workplace situation. It can also be derived that the combination of two theories becomes highly productive only in the certain framework that represents modern project management agile.

In general, it can be concluded that project management and social-technical systems theories can complement each other and thus aid in creating a solid basis for determining how personal characteristics/human factors of individuals and project teams are in fact changing the outcome of projects and how are they affecting the project success of complex projects. Results from this study are expected to help project managements in choosing the best suited method to either prevent the problem from occurring or to prevent it from reoccurring. The overview made in Table 1 will be used as a basis for the planned case study and for further research. The survey will result in confirming the impact of combining socio-technical systems with project management, on overall project success. Finally, it is hoped that this study will be beneficial to all project managers and organizations in general and would stand as a good basis for future research.

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IMPLEMENTING LEAN DIGITAL STRATEGY TO IMPROVE COMPETITIVENESS OF CROATIAN MANUFACTURING INDUSTRY

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Abstract

Global trends such as digitization, fierce competition, and aging population make the concept of competitiveness important for individual companies as well as for the national economies. The term competitiveness in its simplest form refers to the ability of an economic entity to compete for the market share. Lean management and Industry 4.0 are contemporary concepts that organizations are trying to implement as a response to these trends and to achieve a competitive edge. The purpose of this paper is to present a dual strategy which is based on an approach that combines these two concepts, with the aim of increasing the competitiveness of the Republic of Croatia with a special focus on the manufacturing industry. The most interesting results of the analysis regarding the current state of Croatian manufacturing industry are also given. In order to be able to measure the effectiveness of the proposed strategy, the competitiveness indicators have been developed and medium-term target values of these indicators have been set. Implementation of the dual strategy represents a promising solution for increasing the level of competitiveness of the Republic of Croatia. It is necessary to start with implementation projects of the dual strategy to validate its usefulness in real-world settings.

Keywords: Competitiveness, Manufacturing, Dual strategy, Lean, Industry 4.0

1. INTRODUCTION

Placement of products and services on a European or any other foreign market is crucial for the growth and development of the national economy of the Republic of Croatia. The ability to compete with other nations, industries or individual companies to gain market share and to achieve access to human and material resources represents the level of competitiveness of the economic entity. Competitiveness is a complex concept that has been widely explored in the literature [1], however, there is still no unique and widely accepted definition because different types of economic entities (nation, region, industry, company) exhibit competitiveness in different ways [2]–[5]. For example, the European Commission [6] defines competitiveness as an ability to provide citizens with a high standard of living and a high level of employment in a sustainable way. The main conclusion of the research [2] is that competitiveness is a concept that needs to be observed at the level of an individual company or industry and that the national competitiveness depends directly on the competitiveness of its companies and industry. Related to the lack of a unique definition is the fact that there are no common competitiveness measures but a whole range of different indicators are being used. The report [1] emphasized the necessity of defining competitiveness indicators that are aligned with the goals and strategy of an organization. In the same report, it is also stated that the ultimate goal is not to measure competitiveness as an outcome but to have the ability to assess and monitor factors affecting competitiveness. This paper focuses on the manufacturing industry and its impact on the competitiveness of the Republic of Croatia.

Traditionally in European countries, the manufacturing industry is considered to be the driving force of the economy, 32 million people employed and the share of 19.4% in the total gross value added of the European Union clearly reflect this [7]. The industrial sector in the total gross value added of the Republic of Croatia has a share of approximately 15% [7], which is approximately average of the European industry in the total gross value added of European Union. The trends of market globalization, accelerated development of competitor countries, digitization of society and industry, and aging of the population are the current and future challenges of the European industry [8], and thus the Croatian industry. These trends demand adaptation of existing or creation of new business and production models that will ensure an increase of competitiveness of the European manufacturing industry.

Until recently, the dominant approach used by manufacturing companies to become more profitable and create the ability to quickly respond to customer requirements was Lean management [9], [10]. The Lean management was derived from Toyota Production System [11], and it can be described as a methodology and philosophy that aims to increase customer value by removing all sources of waste from value chain by involving all employees in the process of continuous improvement [12], [13]. In the last couple of years, a decent amount of research was done on the application of Lean management in the Croatian manufacturing industry [14]–[17]. A common theme of all previously mentioned studies is that they have explored the application and importance of selected lean tools and principles in Croatian companies. Based on the review of papers, it was concluded that the surveyed companies have varying degrees of understanding of the importance and the potential of lean management, and that in most companies lean has not been applied and implemented as a complete system, rather some lean tools were selectively used. The consequence of the selective application of lean tools prevents the realization of the full potential of lean methodology.

Over the past decade, the emergence of technologies such as Cyber-Physical Systems (CPS) and the Internet of Things (IoT) [8], [18], [19] have prompted the development of a new concept called Industry 4.0. The name and main features of Industry 4.0 were announced for the first time at the Hannover Messe Fair [20]. In the same year, Industry 4.0 was declared to be a strategic initiative by the German government, and as such was included in the "High-Tech Strategy 2020 Action Plan" [20]. Scientists who have researched Industry 4.0. often highlight its main features such as digitization, optimization and customization of production, human-machine interface or automated data exchange and communication [21], [22], while others focus on describing the expected effects and goals of this concept [19], [23], however, the fact is that there is no universal definition of the term Industry 4.0 [24]. Summing up information from the above-mentioned papers, it is possible to give the following description of Industry 4.0: *„Industry 4.0 will include the use of the Internet of Things and Services and the technical integration of CPS into manufacturing and logistics processes, which will, in turn, become decentralized, flexible and self-managed. These technologies will also enable the creation of a Smart Factory, which is the main feature of Industry 4.0. These changes will have a strong impact on the processes of creating value, business models, and the way in which the work is being organized. “.* The most influential research related to Industry 4.0 in the Republic of Croatia was published by Veža et al. [14]. One of the main conclusions of the research was related to the readiness of the Croatian manufacturing industry for Industry 4.0, the results of which showed that the average readiness of surveyed companies is at Industry 2.0 level (index value 2.15).

The demands of the European Commission, the market conditions and the results of the survey on the state of the Croatian manufacturing industry served as a motivation and guidance in the development of a dual strategy based on the lean management and Industry 4.0, which is described in this paper, and was first presented in 2017 [25]. The compatibility of these two approaches and applicability in realistic conditions is the current topic in scientific research, both international [18], [24], [26]–[28] and domestic [16]. In the paper [26] it has been concluded that the technologies that form the basis of Industry 4.0 are complementary with established lean systems and that they extend the ability and efficiency of the lean system. Some authors, such as Sanders et al. [18], argue that application of Industry 4.0 technologies could help to remove barriers in the implementation of lean, as explained through an overview of ten lean dimensions and problems that may arise in the implementation of these dimensions, and concrete solutions to the problem by applying Industry 4.0 concepts. Mrugalska et al. [28] provided an overview of case studies in which combined lean and Industry 4.0 approach was applied to smart products, smart machines and augmented operators. A major disadvantage that limits the application of the system based on a combination of the two approaches to a real system according to papers [24], [26] is a lack of a satisfactory framework that combines Industry 4.0 technologies with lean methods.

One of the contributions of this paper is proposed framework that brings together the concepts of lean and Industry 4.0 as a dual strategy applicable to the manufacturing industry, but also to other economic sectors regarding the universal principles of Industry 4.0 and lean. Another contribution is defined indicators based on which it is possible to monitor the competitiveness of the Republic of Croatia, and hence the effects of the implemented dual strategy. The hypothesis raised is that the implementation of the dual strategy based on lean and Industry 4.0 can lead to increased competitiveness of the Croatian manufacturing industry, and thus the overall Croatian economy.

The remainder of this paper is structured as follows. A summary of the study about the current state of the Croatian manufacturing industry was presented, which served as a guideline in defining the competitiveness indicators of the manufacturing industry. In the third section, the key elements of the lean digital strategy are explained. In section four definition and an overview of the current values of the competitiveness indicators are provided, as well as the projected values of indicators in case of implemented dual strategy. In conclusion, the future steps in the development and implementation of the dual strategy are discussed.

2. THE CURRENT STATE OF CROATIAN MANUFACTURING INDUSTRY

During the development of the National Platform for digitization of industry [29], a detailed investigation of the manufacturing industry of the Republic of Croatia was carried out, below are presented some of the most interesting results.

In order to evaluate the level of competitiveness of the Croatian manufacturing industry, data on the productivity of 27 European Union countries from 2015 were analyzed [7]. Productivity was defined as the ratio of the total gross value added in the manufacturing industry and the number of employees in the manufacturing industry. After the data processing was carried out using the k-means algorithm [30]–[32], clusters of EU countries were created with respect to productivity (Figure 1).

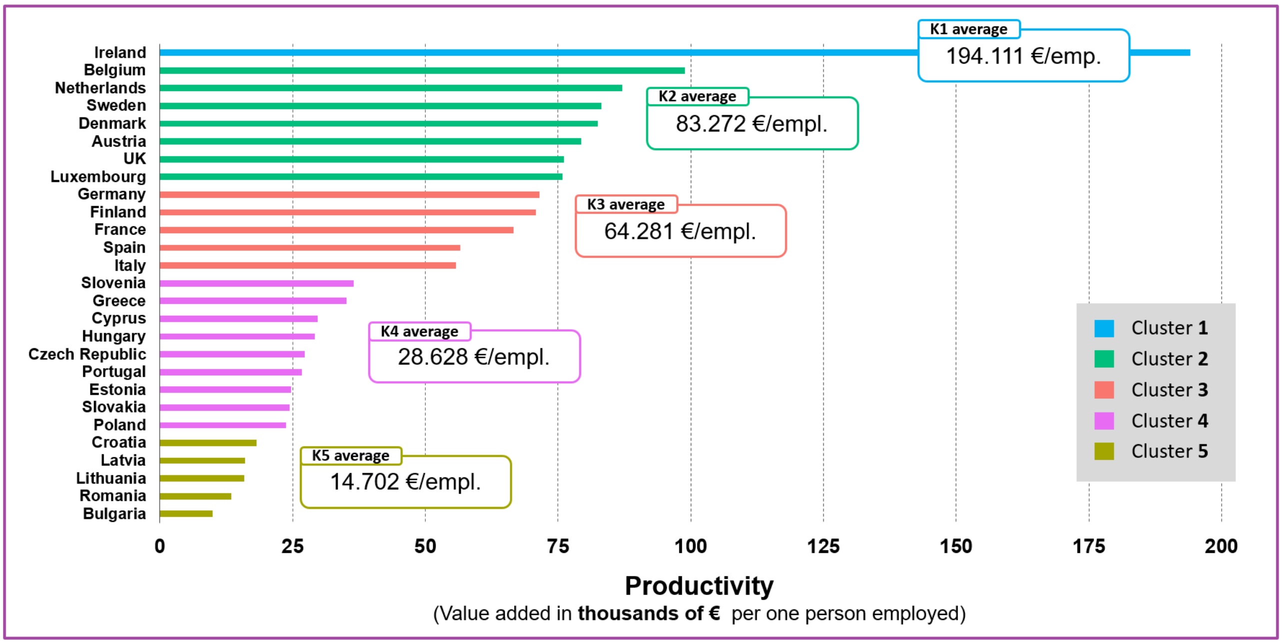

Figure 1. Productivity of EU countries in manufacturing industry

The results showed that the Croatian manufacturing industry is ranked 23rd on the criterion of productivity, and belongs to the fifth cluster of countries, with an average annual productivity of 14,702 euros per one person employed. It is interesting to note that the productivity ratio of the fourth and fifth clusters is 2:1, and the second and third clusters is 1.3:1 result, what can be interpreted as an evidence that the Croatian manufacturing industry is uncompetitive in terms of productivity.

Comparison of the productivity of the Croatian manufacturing industry with industries of neighboring countries (Table 1), showed that the Republic of Slovenia with 26% fewer employees achieved 50% higher gross value added and 100% higher productivity. When comparing the results of the manufacturing industry of Hungary and Croatia, it could be seen that Hungary had 2.7 times more employees and 4.3 times higher gross value added.

Table 1. Productivity of manufacturing industry – regional comparison

Indicator	Croatia	Slovenia	Hungary	Austria
Number of employed *(in thousands)*	254,90	188,70 ↓ **0,74 x**	678,20 ↑ **2,7 x**	621,00 ↑ **2,4 x**
Gross value added (GVA) *(in millions of €)*	4.646,50	6.888,20 ↑ **1,5 x**	19.811,00 ↑ **4,3 x**	49.257,30 ↑ **10,6 x**
Productivity *(€ of GVA per one employed)*	18.228,72	36.503,44 ↑ **2,0x**	29.211,15 ↑ **1,6 x**	79.319,32 ↑ **4,4 x**

According to the latest available statistical information on technology intensity (TI) collected in 2012 by the Ministry of the Economy and the Financial Agency [33], specific activities in the manufacturing industry can be classified into one of the four groups according to technology intensity. Using the gross value added of a specific activity in the manufacturing industry divided by the total gross value added of the manufacturing industry, the ratio we called GVA_C was obtained. In a similar way as the GVA_C, the ratio of employees in specific activities of manufacturing industry was calculated and called EMP_C. The classification of activities according to the technology intensity in the manufacturing industry is given in Figure 2, with specific activities labelled according to the National Occupational Classification - NKD 2007 [34].

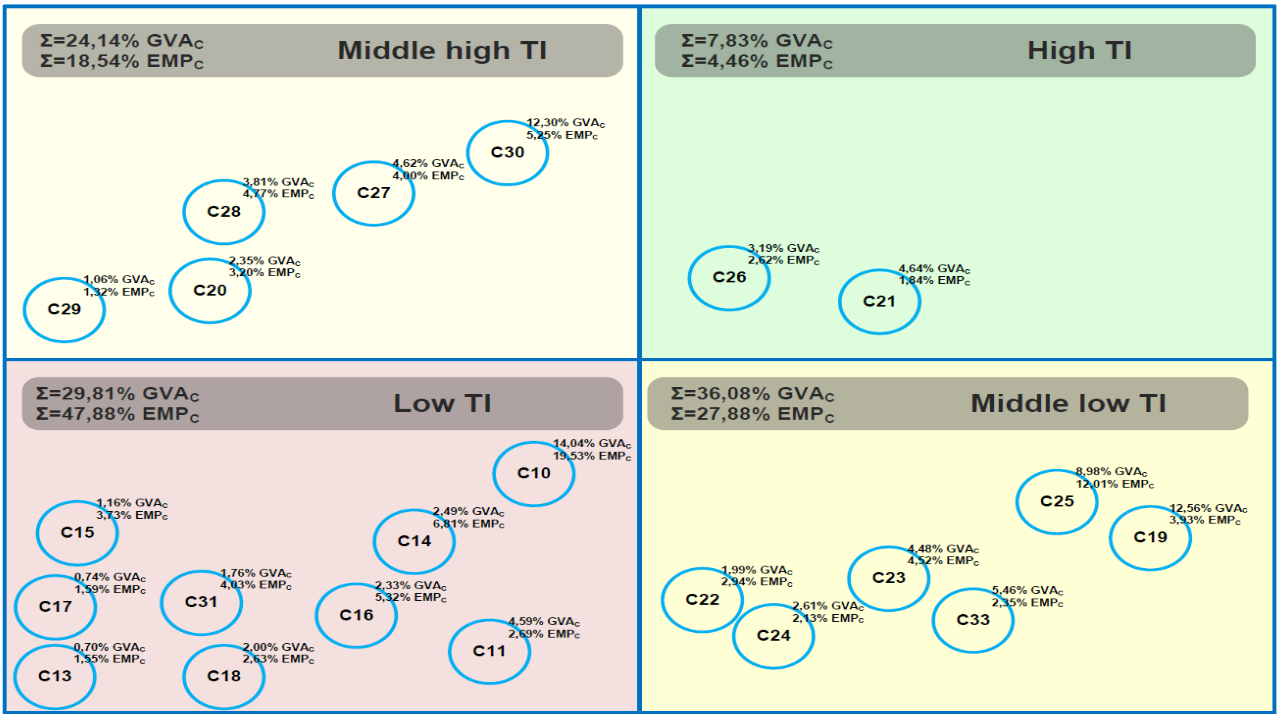

Figure 2. Classification of manufacturing industries based on technology intensity

Manufacturing of food products (C10), which belongs to the group of low technology intensity industries, had a share of 14.04% of the total gross value added in the manufacturing industry. Only one of the five largest sectors of the manufacturing industry, according to the gross value added, belongs to a group of activities with high technology intensity. Using the indicator GVA_C and EMP_C it is obvious that there is a potential for further development of specific activities such as C10 (Food industry), C30 (Vehicle production), C27 (Production of electronic components) and C25 (Manufacture of fabricated metal products). Nevertheless, the activities C26 (Manufacture of computers, electronics, and optical products) and C21 (Pharmaceutical industry) must not be excluded from further development and improvement as they are the leaders of Croatian manufacturing industry.

3. DUAL STRATEGY

The goal of each company is to stay competitive in the market. In present days, it means being at Industry 4.0 level. Since the industry in Croatia is at level 2.15 according to [14], it is not an easy and simple task to achieve. Numerous steps are required. Companies need a blueprint which is going to lead them step by step through an intensive transformation like that.

The dual strategy is methodology innovated at the Faculty of mechanical engineering in Zagreb by professor Nedeljko Štefanić [25]. It gives a clear outlook on how to achieve lean and digital transformation in organizations. The dual strategy consists of five lean and seven digitalization tools and principles, as shown in figure 3.

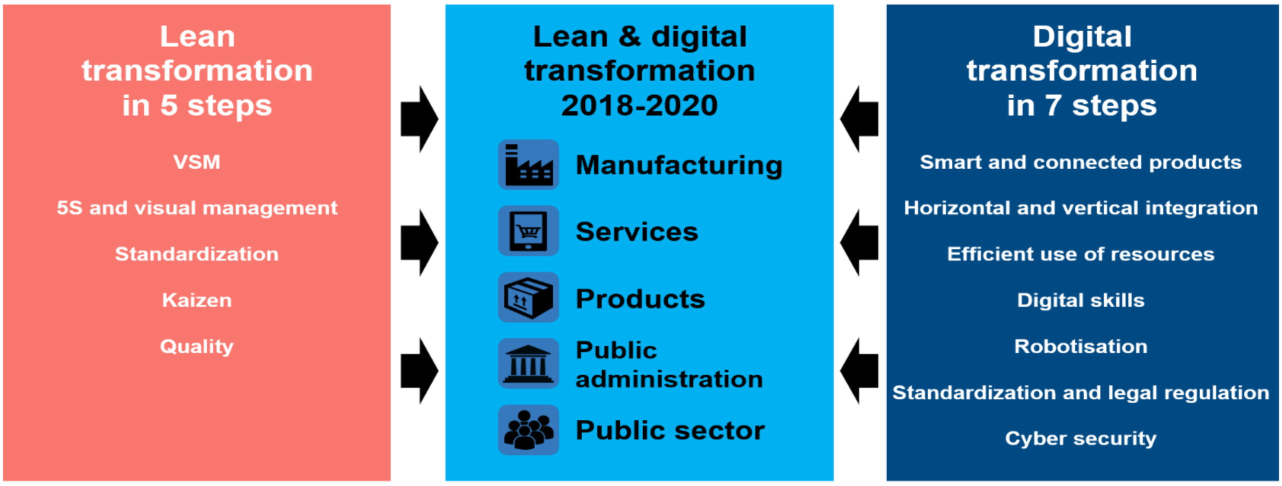

Figure 3. Dual strategy

Five lean steps included in proposed strategy are value stream mapping (VSM), 5S and visual management, standardization, kaizen, and quality control [9], [10], [12]. Each lean transformation starts with value stream mapping. Value stream mapping gives us an outlook on the current state of operation and helps us propose further improvement. In [35] a value stream is defined as "all action (adding value or not) needed to bring a product through all flows essential to each product: production flow from raw material to the hands of the consumer, and the flow of product design, from conception to launching". Each process can be then identified as value adding, non-value adding, or neutral. Next step is 5S which is a tool for organizing spaces so work can be performed efficiently, effectively, and safely [12]. System name comes from five Japanese words which translated to English mean sort, set in order, shine, standardize and sustain [12]. 5S leads to many benefits including reduced costs, higher quality of work, increased productivity, greater employee satisfaction, and a safer work environment [36]. In the last years sixth S was added which represents safety. Kaizen is the Japanese word for improvement, and it refers to activities which continuously improve all processes and involves all employees [37]. Standardization means making clear and transparent process procedures and manuals which make continuous improvement easier to accomplish [12], [13]. The last step ensures that quality is at the highest level through the whole value chain by implementing poka-yoke and Six sigma [38], [39].

After the optimization of the process's digitalization can follow. Successful digital transformation is a prerequisite for Industry 4.0. Success in Industry 4.0 is measured in the capability of adapting to changes and in innovation level [40]. Generally, Industry 4.0 consists of four components. Those are CPS, Internet of Things, Big data and Internet of Services [41]. Digital transformation in the dual strategy is expanded and consists of 7 components: smart and connected products or IoT, horizontal/vertical integration and CPS, efficient use of resources, digital skills, robotization, standardization, legal regulation and cybersecurity. Cyber-physical systems connect psychical with a virtual world [20]. Internet of things, an important step in digital transformation, enables objects to exchange information with each other and collaborate with their intelligent components [41]. Big data refers to a huge amount of data sets that companies save and store regarding their customer behaviors [19]. In combination with artificial intelligence, companies are able to get information and forecasts updated in real time which helps them efficiently optimize the use of resources [19]. Cybersecurity is still underemployed in the industry. Since digital transformations connect all the parts of the process to the internet, companies are getting more vulnerable to the cyberattacks [20]. As a first step of digital transformation, companies need to accomplish vertical and horizontal integration [29]. The first is vertical integration whereby all the systems in the traditional automation pyramid are affected: from field level and control level to production level, operations level, and enterprise planning level [28]. The second is horizontal integration which means end-to-end value chain: from the supplier and the pro-cesses, information flows and IT systems in the product development and production stage to logistics, distribution and finally the customer [28]. Another important prerequisite is investing in human resources. Employees and management must be-come familiar with Industry 4.0 trends and digital skill to become ready for the change it brings [29]. Furthermore, digital transformation requires unique, remodeled business and organization frameworks and transformational management style. But just implementing a transformational leadership style is not enough, it has to implement a specific approach to hiring, training, grouping, compensation and job design [40].

The dual strategy is not limited to manufacturing industries. It can be applied to all businesses including services, public administration, and public sector. Promised results of successful implementation of the dual strategy include higher productivity, better efficiency, and smarter use of resources, more secure and competitive companies, and satisfied workers, as shown in next section.

4. COMPETITIVENESS INDICATORS

In order to be able to observe the effectiveness of the dual strategy regarding competitiveness, seven indicators were defined, which were integrated into the tool called the CRO Improve Business Card (Table 2) developed by Štefanić [25]. Although the primary focus of this paper is on the manufacturing industry, a review and description of all indicators is provided in order to gain an insight into the overall picture of the factors which, according to the authors of this paper, affect the competitiveness of the Republic of Croatia, with indicators 1, 5 and 6 directly related to manufacturing industry. Readiness Index for Industry 4.0 was obtained from [14] and is calculated as shown in the aforementioned study. This indicator was chosen because it is considered that the implementation of Industry 4.0 will be a prerequisite for any form of market competition in the future. Investments in Research and Development (R & D) was defined as the percentage of gross domestic product invested in R & D. The indicator was chosen because through research and development of high-quality products and services competitive advantage can be acquired. According to the reports of Croatian Bureau of Statistics from 2017 [42], Croatia has invested 0.73% of its GDP in R & D, in comparison EU average was 2.03% of GDP [7]. The purchasing power indicator represents the sum of all available funds per capita - net income of citizens [7] and is as important as it points to the well-being of citizens, and the sale of goods and services directly depends on it. According to Eurostat data from 2017 [7], Croatia was among the weakest countries of the European Union, on the penultimate 27th place in terms of purchasing power. The fourth indicator refers to Croatia's position in the world with respect to the level of innovation, which is taken from [43] where the global innovation index is defined. According to the same report made in 2017 Croatia was on the 41st place out of 128 countries. Methods of calculating indicators five and six are already given in section 2. European funds give the beneficiary countries the opportunity to improve and develop targeted elements of an economy through projects and thus enhance their competitiveness. According to the report [44], Croatia used 26.86% of available EU funds.

Table 2. CRO Improve Business Card – Competitiveness indicators

#	Competitiveness Indicators	2017	2020
1.	Readiness Index for Industry 4.0	2,15	3,00
2.	Investment in R & D	0,73% of GDP	1,00% of GDP
3.	The position of Croatia in Europe by purchasing power	27	18
4.	The position of Croatia in the world regarding innovation level	41	34

5.	The percentage of employees in manufacturing industry working in low and middle-low technology intensity industries	75,76%	45,00%
6.	The percentage of industries with low and middle-low technology intensity in total gross value added of manufacturing industry	65,89%	55,00%
7.	Utilization of EU Funds	26,86%	95,00%

In addition to the past results for 2017, the data and projected values of the competitiveness indicators for 2020 are presented in Table 2. The projection, in this case, serves as the goal to be achieved by the implementation of the dual strategy, but also as the expected result considering the potentials of the unified lean and Industry 4.0 approach.

5. CONCLUSION

The main contribution of the article consists of a newly proposed framework called The Dual strategy which unites Lean management and Industry 4.0 approaches. The new framework was needed as previous research was indicating that those two approaches are complementary but also that there was a lack of a satisfactory framework that combines them. Additional contribution are competitiveness indicators that will be used to observe the effectiveness of the Dual strategy. Finally, all the indicators are structured in a new tool called CRO Improve Business Card. Expected results shown in the CRO Improve Business Card (Table 2) are estimated based on the experience of the main author in the implementation of Lean management and Industry 4.0 approaches in Croatian manufacturing companies. As potential results show, the implementation of the Dual strategy is imperative for the future growth of Croatian national economy. Therefore, future research should continue to explore the outcomes of the implementation activities of the Dual strategy on the proposed indicators.

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VSM IMPLEMENTATION AS PART OF DIGITAL TRANSFORMATION STRATEGY

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Abstract

Industry 4.0 is a modern concept that which applies digital technologies in manufacturing processes using cyber-physical systems. Most of the recent literature deals with technology features of digital transformation while the mapping of the current condition and planning the future one is substantially less covered. Since getting the right as-is condition is mandatory to be able to digitally transform the company, VSM is the best tool for doing that. In the simplest of terms, the VSM is a lean-management that is used for the analysis of the current condition or state and the design of a future state for a designated event series that take the product from the production at the manufacturing facility through the use of the customer with the reduction of lean wastes, when and if compared to the current map. The main goal of the paper was to address this challenge by reviewing available scientific articles on topics of value stream mapping in the context of Industry 4.0. Specifically, we have researched which are the most common challenges while implementing value stream mapping. In addition, we were also interested in the aftermath of VSM mapping on the speed of digital transformation implementation. Research findings imply that VSM will have a significant impact on the digitalization strategy since the companies will be able to tackle the weakest links in the chain first. These research lead to the conclusion that if the companies implement thorough VSM mapping of their processes they could achieve digital transformation much more effectively.

Key words: Industry 4.0, value stream mapping, digital transformation strategy, digitalization, lean

1. INTRODUCTION

The term “Value-stream mapping” designates a method or technique used for the current state analysis and drafting/designing a state of the future for an event series that are involved in the life cycle of service or product from the very beginning to the end of its design life. One of the main objectives of this technique is the production of less amount of lean waste in the future state as compared to the current state. The main focus of a value of stream is the firm areas concerned with the quality of the service or product offered the firm. A value chain, on the other hand, is concerned with all the activities take place within a company. Its designation at Toyota company is "material and information flow mapping" [1].

Identification and reduction (or complete removal) of waste in the stream value is the primary purpose of stream mapping. By the removal of waste, an increase in the production of the firm is foreseen. This will be done by the introduction of comparatively leaner operation techniques which, in turn, make the identification of problems related to waste and quality a less complicated process [2]. Value stream mapping is not any rocket science. Rather it is a technique that can be efficiently executed just with the help of a pencil and paper. It provides an understanding of the material flow scenario. Also, the information regarding the performance of the service or product is also recorded using this very technique. Lean is where the technique is usually used. Note that it is different from the six-sigma mapping process in the following way [3].

- More information can and is obtained in case of the value stream mapping when and if compared to other mapping techniques.
- The level of this method (five to ten boxes) is usually higher than other methods of mapping.
- It incorporates a broader series of events i.e. from receiving of raw materials to delivery of the end product.
- It helps to anticipate which projects, subprojects and/or kaizen need to be focused on in the future.

One limitation is encountered if the stream value mapping technique is used in an old-fashioned way. This is the lag or lack of synchronization between meetings and report-backs. This can be quite irritating for those who require or demand a smooth and rapid value mapping method. Then, there is the scenario of considering the effects produced as a result of the changes introduced and implemented. Introduction of a new parameter can produce unforeseen, which are usually unwanted, effects in the flow process. The effects, though beneficial, might not suit the general population simply because they are not used to them [4].

2. METHODOLOGY

Online survey as quantitative research method

The study of causal links is supported by the methods of quantitative research. Hence, these methods are suitable for the given cause. This survey is much more useful than the many factual social research methods. As a result, the survey is chosen because it is appropriate for present information which researchers cannot control, and it helps in answering the questions what, where, who and how much. The variety of special attributes within a population can be analyzed by conducting a qualitative survey in some cases. Here, the amounts of member characteristics are inspected generally, and a qualitative evaluation of data is chosen. So, an online survey is carried out as it requires comparatively less effort, is inexpensive, is quick and results are much more accurate or much closer to a standard. When scheming the study, the design guidelines given by Woodside were used as the basic direction. Basic information on industry, challenges and needed actions, combining industry and lean and basic information on VSM and lean were the four major sections of the survey and had 24 questions. Eventually, a request for the structural data was made. The nature of these questions closed i.e. only specific response could be given as their answers. It was, however, possible in some of the sections to add personal views and comments. For most of the cases, the five-point Likert scales were employed. The evaluation booklet also included a no response option. Two branching questions were an exception to this. The development of the survey took place iteratively in several adjustment rounds. Hence, experts of both practice and theory were engaged in the survey. They were given proper guidance regarding the format of the questionnaire. Moreover, they were directed to take notes. The pretests were then conducted for the purpose of ensuring the questionnaire functionality and the software thus used. The main focus of this study were people who had knowledge of value stream mapping and those who had experience regarding lean management. The operationalization of the survey was done using Lime-Survey and was made available online in the year 2016 from October to December. University of New England, Australia made a total JMTM of 823 members from German companies on 15 April 2018 and invited them to participate in the research through different communication mediums. English and German were the two languages in which the survey was structured. The total number of people who started the survey was 242 but only 170 managed to complete the survey and their data sets were examined. This means a 20% response rate. There is no certain number of companies which comprise the basic population but the people having VSM experience defines it. So, it cannot be further quantified. Therefore, there can be more than one respondent from a specific business. Participants from different industrial sectors make the random sample with over 50% of the respondent coming from mechanical engineering and automotive industry which are also the two largest sectors. Most of the people who are taking part belong to the businesses which are large. Almost 66 percent of the participants belong to the companies with 500 million Euros as their annual turnover. Management team members and senior executives make up to more than 50% of all the people involved in this study. When the members are divided according to their functional area, the members of the lean department make the largest group [5].

3. VALUE STREAM MAPPING

Value stream mapping is one of the most powerful lean tools. It gives the management a total overview of processes happening in the company. The magnitude of the power of VSM can be seen in the next part of this research. VSM can seem like a complex process, but if the rules are followed properly, it can be done.

The first step should always be gathering preliminary information which includes product history such as previous year sales, the volume of the product sold, list of sales goals for the next year, etc. It is followed by production quantity routing analysis. For example, the listing of the various customers and the grouping of the customers and sorting of the materials. Next is sorting of the product families by build sequence. A process quantity routing analysis is constructed for the identification of product families in accordance with a build sequence of similar nature. For this step, it is important to know the products that form 80 percent of the business. Moreover, it is necessary to determine which piece parts or products capable of being grouped together in the form of a value stream. After the analysis, the value stream is selected. Next step in value stream mapping proccess is the creation of an operations flow chart depicting all the operations in the value stream. Gemba is best utilized here. Many pieces of information are not possible to get unless on the spot. When all the data is collected, one can construct a VSM of the current condition.

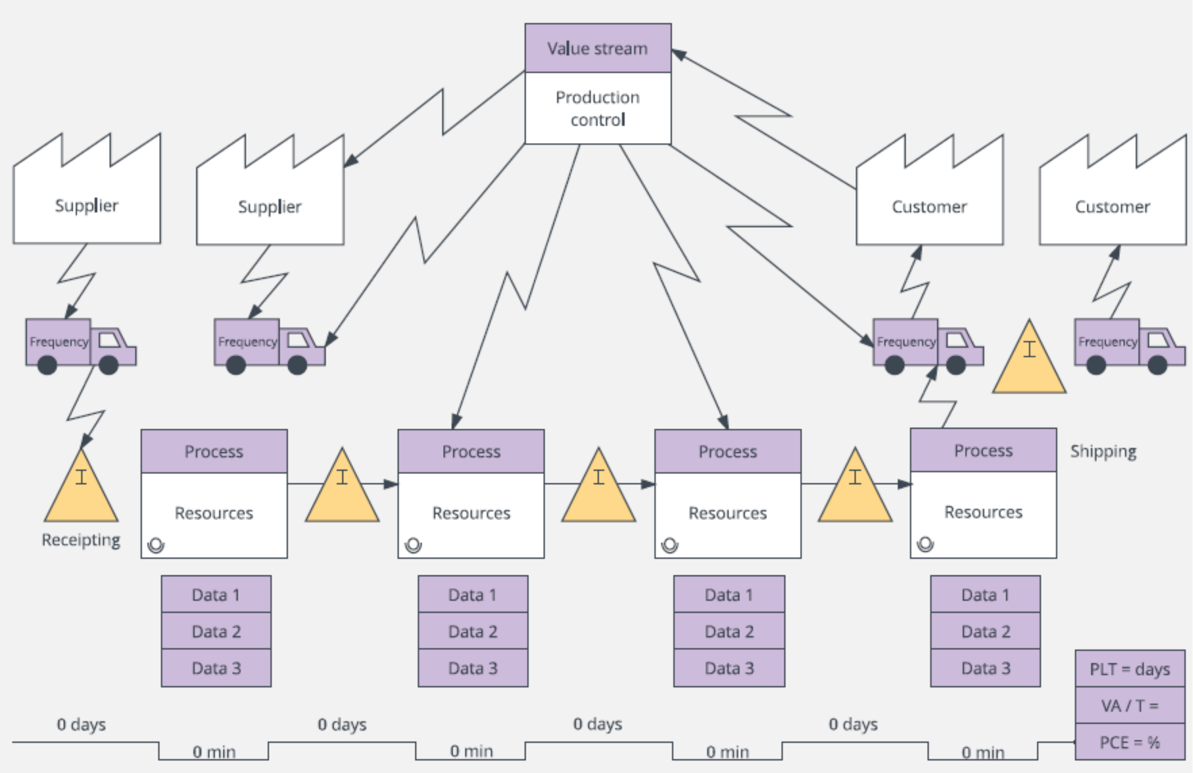

Figure 1 – Example of VSM map [2]

In VSM mapping many different symbols are used.

The location of this symbol (Figure 2) is on the upper left corner of the value stream map which is, indeed, the basic starting point of a material flow process. At this location, the symbol represents the supplier. The same symbol, when placed on the upper right corner of the map, indicate the customer.

Figure 2 - Customer/Supplier

This symbol (Figure 3) is used to represent a single department, a machine or a process operation that is in fixture and is an internal material flow that is continuous in nature.

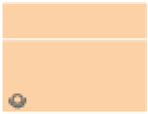

Figure 3 - Dedicated process flow

Figure 4 indicates a department, work center, process or operation that is used/shared by other families in the value stream as well.

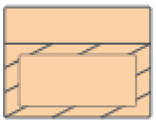

Figure 4 - Shared process

The location of this Figure 5 symbol is under the other icons that require specific data for the analysis of the system. For instance, a data box can be placed below the icon of a factory to show frequency of shipping, data regarding product handling and size of the batch and other important information.

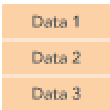

Figure 5 - Data box

4. CASE STUDY: LUFTHANSA INDUSTRY

Following is the demonstration of digitalization approach or strategy:

To make its digital mutation or transformation proceed, a company should be having its own approach based on digitalization. The foundation of a company is laid by this approach and it helps the company to find a way towards success afterward.

From industry to logistics and energy, the digital transformation is a reality in every sector. The new technologies mean new challenges for every company. Relationships of supplier and customer are also undergoing a significant change.

In industries like transport, logistics, mechanical and process plant engineering and automotive, only

40% of companies have been working on the advancement digital transformation until now, by the consulting and market research firm Lunedonk cooperating with Lufthansa Industry Solutions [6].

Organizations should be building first the ideal foundation by digitalizing their approach in order for a company to find crucial aspects of action related to digital mutation. An approach has been made by Lufthansa Industry Solutions in which the three major parts of the process of digitalization; technologies, innovation, and processes, has been taken into consideration.

Strategic analysis and setting targets

In the first step, the collaboration of middle management with senior management should be established for the purpose of producing a digital agenda and vision. This will include the investigation of the patterns of digital development and new technologies for the purpose of exploring the potential that these two parameters bear for the company. The techniques and methods for advancing the business models through the medium of digitalization are presented patterns of digital development. These patterns could be anything from using digital data to creating forecasts that are real-time in nature. This will open new technological gateways in the field of business.

In this step, an analysis is also included that considers competition and sectors. After carrying out the analysis, a digital business model target vision should be developed by the companies along with prioritizing the digital uses that are based on their own IT and business strategy. Hence, the determination of the digital maturity of the company is an important component of this.

Operationalizing the digital transformation strategy

After the development of a digital vision by the company, an agenda is set. Then, the digital maturity of the data needs to be analyzed. This can move to the identification of the expertise and knowledge that might be needed. The outcomes thus obtained will be used for the identification of the innovations in the new types or forms of services, for instance. Hence, it is very important to bring in an IT-based department and the liaison or middle management close to each other so that all the needs of the company and its various departments can be considered [7].

5. INDUSTRY 4.0 IMPLEMENTATION

Planning, designing, production, and sale of a given product constitute the process of product development, abbreviated as PD. PD can include lean techniques as well. Bottom line results can and are obtained by the applications of lean concepts. A wide range of tools and methods are involved in this. On the other hand, the study of waste, pinpointing of factors that produce inefficiencies, marking of the unnecessary steps during the process, etc. are usually done in the VSM technique. However, the method or technique is still in its developing phase. However, the researches carried out till now indicated after the application of the reforms proposed by VSM, a considerable reduction in lead time is anticipated. Here, the word "considerable" means about 50% reduction in the lead time of the design stage in a PD process. As a result, a reduction in the overall lead time of the PD process will be observed [8].

Lean manufacturing is an effective systematic method used nowadays that can minimize waste in a production system without causing problems. This methodology has been well established over the years and the effectiveness of lean thinking has proved it. Considering the example of companies such as Toyota, their growth has been improved and record profits are observed. The practicing of lean management is a formidable challenge. The prospective leaders and their team found themselves in doubt due to the challenging behavioral changes and as clearly indicated by the methodology section of the report, the VSM technique is capable of handling industry 4.0 efficiently and effectively.

According to Disney SM, Naim MM, and Towill DR, authors of "Dynamic simulation modeling for lean logistics", for the service industry, a simulation model was used with VSM for British Telecommunications which successfully exhibited the transportation from current state to future state to improve the performance. Questions which could not be addressed previously were answered using a simulation which used the static view of a VSM. This simulation not only analyzed the results but also described both the current state and the future state for the product line. A factory in Mainland China which produces gear flow meters has used rough set theory and developed a simulation model for the current state VSM to identify where lean control is required and to understand the effect of implementing lean control [9].

A simulation model for VSM was also developed to demonstrate the production system of a high- variety batch manufacturer. Comm CL and Mathaisel Dennis FX identified that for any system to be responsive, two conditions must be satisfied 1) A system should be built on a logic that could align itself to wide range of manufacturing operations 2) We should know the product to be manufactured, its volume, and the process involved in its production. Using these conditions, a conceptual model was developed which could determine the responsiveness of a production system. This model was used to implement lean manufacturing initiatives and VSM was used to evaluate the effectiveness of this model. The results showed that it reduced the non-value-added time, lead time, waiting time and inventory. It also revealed the percentage reduction in all those areas. VSM based numerical model was applied to the food and drink industry. This model successfully revealed the areas of waste and how these can be reduced from the value stream. A simulation model in conjunction with VSM was developed for the construction industry. This model revealed that less the time spent in the value stream, the leaner is a process [10].

According to Jones DT, Hines P, and Rich N, authors of "Lean logistics" material flow was significantly improved through value stream using this model. VSM-based simulation has been utilized in a manufacturer of poultry and pig raising equipment. Discrete event quantified through VSM based simulation was successfully developed and utilized to draw current and future state maps pointing out the inefficiencies and non-value added activates in a warehouse setup. To explore cycle time KPIs and reduce factory variability, factory physics queuing model was used to develop performance matrix which helped in improving those KPIs and reducing factory variability [11]**.**

6. DISCUSSION & CONCLUSION

An unbiased review of the current state of the traditionally used VSM techniques has been demonstrated by the empirical study provided in the methodology section. Note that the review is in accordance with the perspectives of the users. The users have outlined a number of benefits of the VSM technique such as the production of transparency around the bottlenecks along with opportunities of producing innovations and improvements in the techniques that are used for the optimization of the flow of information and materials. However, questions regarding the benefits obtained by freeing up the space or the transparency regarding the manpower. 30 was the value of the percentage of the experts that raised questions that scenarios thus outlined. 14 percent of the experts were concerned regarding budgets deriving opportunity from the VSM. The benefits of VSM regarding the response frequency is shown in figure 1.

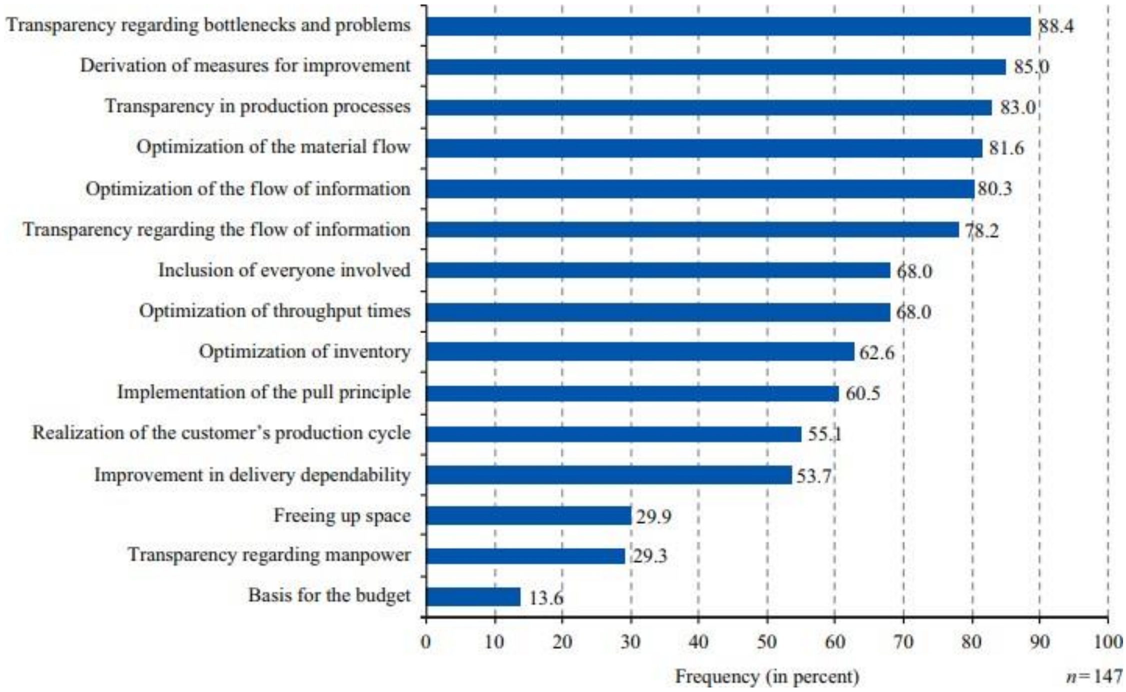

Figure 6 - Advantages of VSM from the perspectives of Users

One of the most significant disadvantages of the method at hand is its static nature or the fact that it is based on a snapshot. This has been confirmed by almost every user. Figure 2 demonstrates this. The percentage of the stakeholders which regard VSM to be rather complex was only 12.2. Though there exist several contrary and controversial opinions in literature, it can be said with fair certainty that the combination of the industry 4.0 and lean approaches leads to the increase in flexibility. This also theoretically leads to the concept that there is no contradiction in the principle of these two techniques. The empirical investigation, presented in the methodology section, focused on obtaining confirmation of this scenario from a practical point of view. A considerable portion of the participants that took part in the research held an opinion that no contradiction exists two approaches thus outlined i.e. lean techniques and Industry 4.0. Establishing a scale with 1 as complete contraction and 5 as no contradiction, the value of arithmetic-mean thus obtained was 3.89. Moreover, the participants were asked additional questions regarding the relationship between progressive digitalization and lean methods. More than 98 percent of experts hold the opinion that lean methods bear great potential with respect to the future.

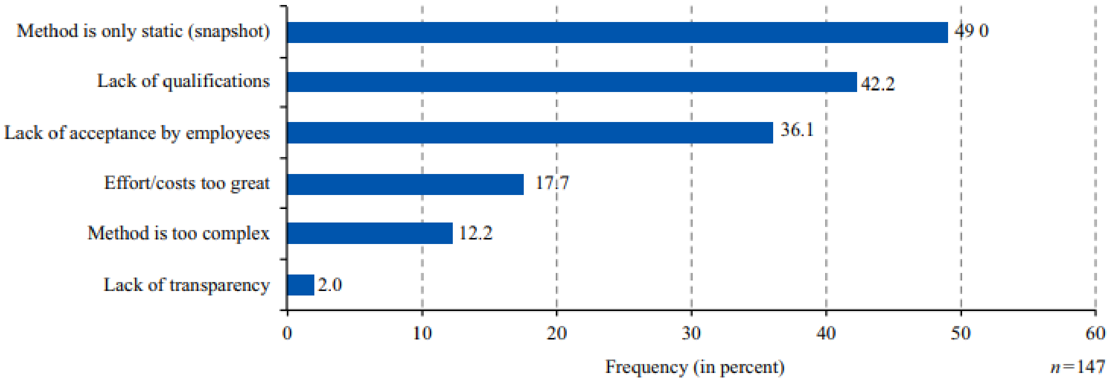

Figure 7 - Disadvantages of VSM from the perspectives of Users

65 percent of the experts stated that the future entirely depends upon lean method. In this case, the mean value thus obtained was 4.62. The number of participants that partially disagreement was very small. Moreover, none of the experts showed complete disagreement. Though there will be certain modifications required, there will be no decrease in the importance of lean methods in the future. Similar results were obtained in the scenarios in which the participants were asked regarding the usefulness and advantages of the two approaches. A total of 94 percent participants agreed that great advantage will be obtained by the integration of the two said approaches i.e. addition in value. This scenario had an arithmetic mean value equal to 4.58 with. As usual, there was a very small number of participants that disagreed. The general comments (without any testing or research scenario) provide by the participants, who took part in this study, also reflected the results obtained from study under specific testing conditions. Included in these were the comments that were related that demonstrated that it was extremely necessary to incorporate lean principles. It was also demonstrated that for the purpose of further reduction in waste, lean production techniques are very crucial. Moreover, it was also highlighted that this goal can simply be achieved through the medium of digitalization. One of the experts presented the opinion that measures of industry 4.0 should be based on the creation of transparency in the processes of production in a systematic manner. This should also include the flow of information and material. In the ends, questions regarding the relationship between the VSM and the current challenges being faced in the field of production were put in front of the participants. The opinion that the traditionally used VSM will affect the current challenges in production was held by 71 percent of the participants. Out of this, 93.4 percent of the total participants, were in favor that the current method should be modified with the use of Industry 4.0 technologies. Figure 3 explains this.

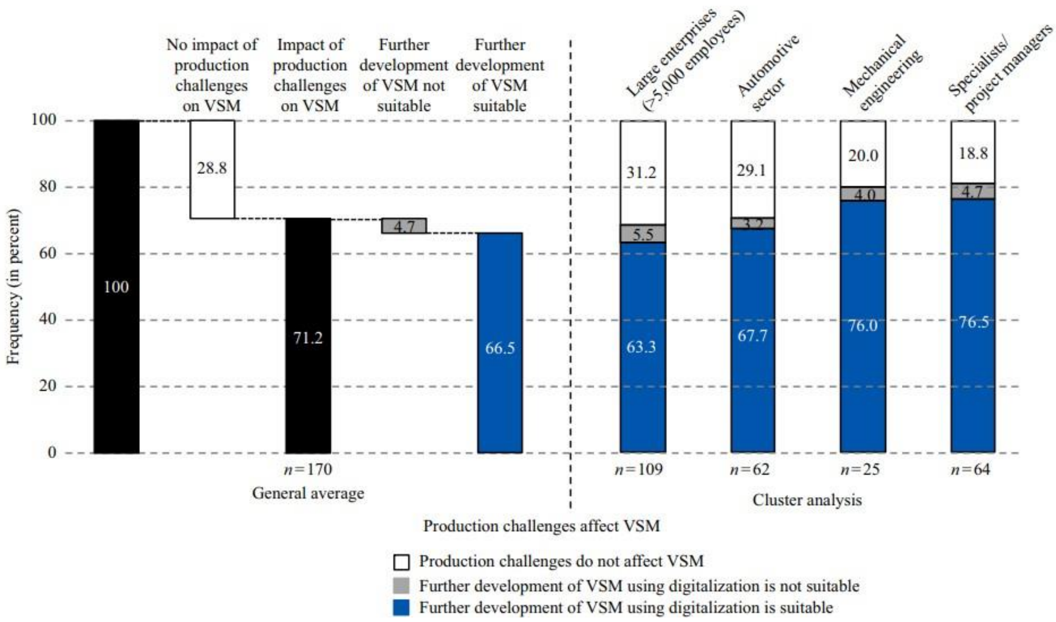

Figure 8 - Clusters function indicating the need of improvement in VSM

Using the cluster analysis, it was determined that when and if compared to the general average, argument regarding the further improvement of the method was put forward a few more participants i.e. (+1.2 percent) that belonged to the automotive sector. If the employees of mechanical engineering are considered, this percentage is significantly higher i.e. (+9.5 percent). Project managers and specialists were also in favor of the development in this method. The percentage of this category was even higher i.e.
10.0 percent. In this assessment, 73 percent of the top management members agreed. However, the sample was too small to produce a generalization. Hence, the establishment of a specific correlation with the previous experience of the correspondents with the lean methods, industry 4.0 or VSM. In the end, questions regarding the conceptual modification of VSM were put in front of the participants. Respondents were certain that the various parameters of the production processes such as real-time data integration and simulation can be used for the creation of MES and ERP systems. Figure 4 shows these results [5].

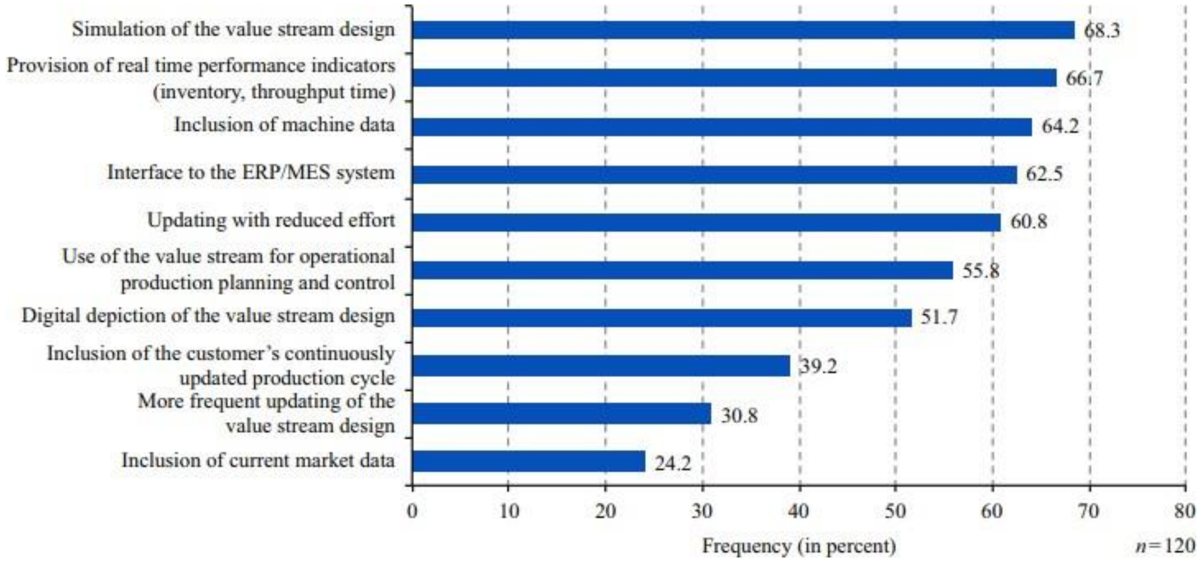

Figure 9 - Likely future VSM developments

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IMPACT OF DIGITALIZATION AND INDUSTRY 4.0 ON DIFFERENT INDUSTRIES

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Abstract

Although the concept of Industry 4.0 is widely introduced and implemented, various industries have different predispositions for digitalization and readiness to use cyber-physical systems in day-to-day activities. Recent researches concluded that there is a huge gap between sectors, national economies and companies within same sector. While some sectors and companies all manual activities have already digitalized, other sectors conduct digitalization slower or even it will be hardly accomplished. Significant impact on digitalization capabilities have different factors: estimated contribution of manpower/technology in production activities, expected costs of digitalization and costs of employees, current company's technology level etc. However, although these parameters are recognized and used by many researches, still, various methodologies were presented by different institutions or experts; all of them calculating their own indexes in order to present digitalization readiness of companies, sectors or national economies. Different methodologies applied different approaches; same parameters had various impact on final digitalization scores among various indexes calculation. Unified and widely accepted methodology is not yet developed and recognized. In this paper, we researched most recognized methodologies of digitalization indexes, presented their similarities and differences and compered benchmarked results for different sectors and national economies.

Keywords: digital transformation, Industry 4.0., digitalization indexes, industry sectors, digitalization of national economies

1. INTRODUCTION

The main concept of Industry 4.0 is grounded on intelligent manufacturing: machines should discover the knowledge, make decisions and deliver the action independently and intelligently [1]. Consequently, Industry 4.0 is often also recognized as smart manufacturing whereby the National Institute of Standards and Technology defines smart manufacturing as fully integrated, collaborative manufacturing system that responds in real time in order to achieve changing demands and conditions in the factory, in the supply network and in customer needs. Smart manufacturing integrates manufacturing assets of today and tomorrow with sensors, computing platforms, simulation and predictive engineering. Smart manufacturing utilizes the concepts of the cyber-physical systems, internet of things, cloud computing, service-oriented computing, artificial intelligence and data science. [2]. Since the beginning of 21st century, mankind has witnessed huge development in AI and robotics. Still, the satisfactory understanding of how digitalization, AI and robotics will impact, for example, the labor market and productivity is not yet achieved, as well as how automation and AI will replace human work and create a powerful displacement effect and cause decoupling of wages and output per worker and a decline of labor in national income share[3].

In some cases, digitalization and Industry 4.0 concepts are understood very simplified without necessary level of critical observation i.e. not all process could be or should be fully digitalized. At least, there are some processes, sectors and industries that will be less affected by automatization and digitalization compared to other. Readiness for digitalization is not defined by sector or industry only, but also by many other internal or external factors such as cost/benefit analysis, digitalization level of competitors and national economy, public and private infrastructure etc. However, currently a widely recognized, implemented and adopted measure of company's, sector's or society's digitalization capabilities, does not exist. Different institutions, researchers and experts within specialized companies defined own digitalization indexes, measures and methodologies whereby different factors have been taken into consideration in order to estimate impact level on digitalization. Different measures in the future could lead to development of more suitable, widely accepted and implemented methodology.

Different approaches implemented in identification of sectors', companies' or countries' digitalization capabilities could lead to different conclusions and results on their level of readiness to be digitalized. Results obtained using different methodologies could mislead readers of information as same sectors, companies or countries could be differently rated. Lack of uniformity in parameters used, leads to uncertainty, different interpretations of same results, wrong conclusions and misleading information.

One of methodology was developed by McKinsey Global Institute (MGI) with the special emphasis on digitization level in different US economy's sectors due to the large and growing gap between sectors as well as gap between companies within sectors. MGI researched the key attributes of a digital leaders as well as how companies benchmark themselves against competitors. They identified 27 different indicators that could be summarized into three main categories: digital assets, digital usage, and digital workers whereby they concluded that the latter two categories make the crucial difference. Combination of all indicators are systemized in methodology presented by Industry Digital Index [5].

Euler Hermes has developed Enabling Digitalization Index (EDI) 2018, which is focused on each country's readiness to build the necessary environment for business to be successful in increasingly digitalized global economy measuring the conditions for companies to transform and thrive digitally whereby the score is made of 5 components and 10 indicators as follows: regulation, knowledge, connectivity, infrastructure and size of economy's internet market [6].

Within its Digital Single Market policy, European Commission has introduced the Digital Economy and Society Index (DESI). DESI represents a composite index that summarizes all relevant indicators on Europe's digital performance and tracks the evolution of EU member states in digital competitiveness. Like EDI, DESI also identified following indicators as the key parameters for emerging digital economy: connectivity, human capital/digital skills, use of internet services by citizens, integration of digital technology by businesses, digital public services and research and development ICT [7].

Next measure is a Digital Economy Index (DEI) that represents a level of digitalization in the German economy based on a survey of high-ranking decision-makers from different 1,061 German businesses. Three aspects are incorporated in the economy index: the use of digital devices, the state of internal company digitalization and the effect of digitalization on the company [8].

DAI is a worldwide index calculated by World Bank Group that measures each individual countries' digital adoption of economy through three following dimensions: government, business and people. It a 0–1 scale covers 180 countries whereby the index is the simple calculated as an average of three sub-indexes. Each sub-index consists from technologies necessary for digital development: increasing productivity and accelerating broad-based growth for business, expanding opportunities and improving welfare for people, and increasing the efficiency and accountability of service delivery for government. DAI was several times updated to reflect new data sources and an improved methodology. Index can be an indicator to policymakers how to design countries' digital strategy with tailored policies to promote digital adoption across different user groups [9].

The focus of this research is to compare different methodologies and digitalization indexes of one economy, sector or individual company. Common denominators will be identified with special emphasis on specific and unique factors implemented in different approaches that could lead to different conclusions. The goal of this work is to identify whether same sectors or national economies could be significantly different appraised in their digitalization capabilities simply as a result of using one of widely implemented, above mentioned, indexes and methodologies or different approaches will result in same or similar conclusions.

2. METHODOLOGY

Most of the research is based on theoretical, not experimental methods and the same methods are used for this research. Development of new methodology for measuring of digitalization capability and readiness would require long term systematical research of individual company's business function and external factors. In order to be able to perform such research, remodeling of current business activities would be required and due to the risks exposed, company's management is mostly not ready to participate. As a result, the framework methodology used to draw conclusions on how different digitalization index are appropriate is based on adoption of step-by-step process that includes systematic literature research and review, summarizing, synthesizing new concepts from old, categorizing them and describing in which direction should research continue.

Research has started using the appropriate literature through scientific sources such as Thomson Reuters, Scholar and Web of Science in order to identify articles with following keywords: Industry 4.0, Artificial Intelligence, digitalization index, digital transformation, digitalization capabilities, digitalization of different industry sectors. Once when critical number of recent scientific articles and numerous essays dealing with these topics were reviewed, we decided on best suitable for next research directions which are referenced in the introduction part. Furthermore, articles and essays researching combination of innovation for digital transformation and their impact on different sectors (manufacturing, health, public sector, finance, R&D, management, logistic) are more closely reviewed, investigated and especially noted. Literature is especially reviewed in order to identify different indexes which calculate digitalization capabilities of sector or economies; therefore, we checked whether main goal of all methodologies researched is the same i.e. to appraise digitalization level of some entity. First when we confirmed that all methodologies try to achieve same conclusions, we included them in our research.

Once when literature is reviewed, the summary has been made choosing the most appropriate concepts for our research. In summarizing phase, we identified key factors and condensed vital information into their own words to solidify meaning. For summarizing, we used a simple method adapted from "Summarizing a Research Article 1997-2006, University of Washington" [4]. First, we defined our focus and how selected article relates to our research asking following questions: are the results reliable, are any of results unusual, how this study contributes to answering the original question and what aspects of the original question remain uncertain?

Once when chosen papers are read, key points are identified followed by answering the questions and summarizing the essential results keeping an especial attention to elimination of wordiness, using specific, concrete and scientific language. In synthesizing, we have taken key points from the previous phase and grouped ideas to new concepts and thoughts. Synthesizing takes the process of summarizing one step further. Instead of just restating the crucial points from the text, synthesizing involves combining ideas and allowing an evolving understanding of a text. The last step was identification of future steps and direction in research in order to understand impact of digitalization of different industries and companies.

3. RESULTS AND DISCUSSIONS

3.1. Digitalization of USA and German economy's sectors

McKinsey Global Institute measured digitalization capability of USA economy through rating of digital assets, digital usage, and digital workers in order to identify which sectors are more digitalized. Digital assets included information on how much companies in different USA sectors invest in IT fixed assets: software, hardware, IT services and data as well as in digitalization of their physical assets such as smart housing, connected vehicle fleets, IoT systems and big data implemented in usage of machinery, equipment and supply chains etc. Digital usage measures how much companies within USA sectors are engaged digitally with their customers and suppliers i.e. how widely did they implement digital payments, digital marketing, design-led product development or e-commerce platforms in their day-to-day business activities. MGI has given special attention to the degree to which companies within different USA sectors have put digital tools in the hands of their employees to increase their productivity. In their research they evaluated more than 12,000 different detailed task descriptions to identify those associated with digital technologies and estimated the share of workers in each sector in technology-related occupations that did not exist 25 years ago.

Results of research draw to conclusion that companies in leading sectors have workforces that are 13 times more digitally engaged than the rest of the economy. In addition, there are some highly digitalized sectors, however, their workforce does not use all advantages of new technology. One of the typical examples are health care organizations which use sophisticated technology in diagnostics, but their workforce uses only rudimentary or no technology. MGI concluded that technology still hasn't penetrated significantly in everyday work of average Americans which means that most businesses are missing opportunities for greater efficiency and better customer experience whereby as main issue was identified non-readiness to break out with their old habits.

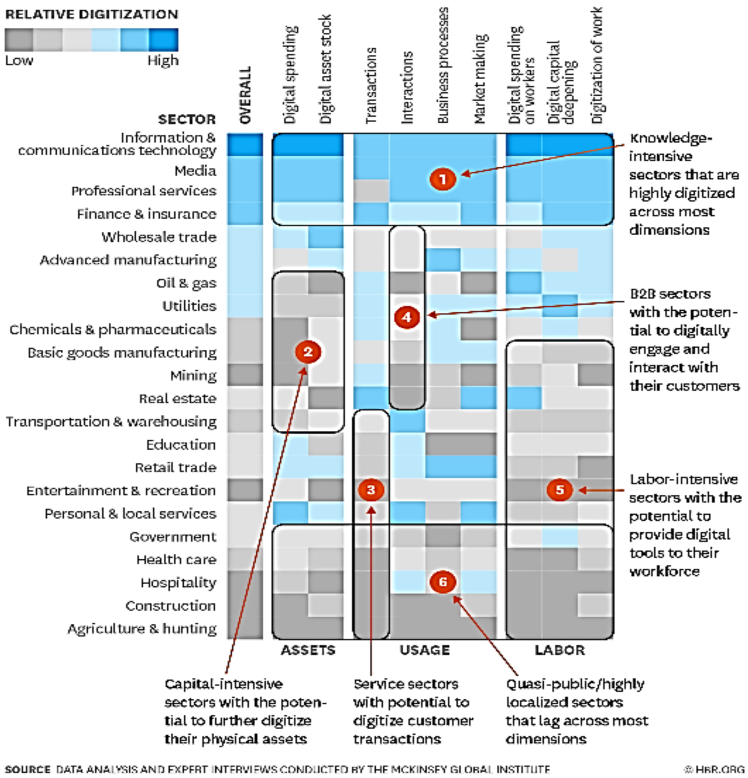

Figure 1: Digitalization of sectors in USA economy measured by MGI, 2016 [5]

As research concluded, the most digitalized sector is technology sector followed by media, finance, and professional services, all of which have far more sophisticated digital capabilities than the rest of the USA economy.

German Federal Ministry of Economic Affairs presents each year Digital Economy Monitoring report where Digital Economy Index (DEI) is measured which sums up the digitalization of the German economy in a number. In year 2018, DEI was measured at (only) 54 points (out of a possible 100) in 2018, the same as the previous year.

According to 2018 Report in some sectors of the German economy, years of digital progress are finished and followed by a period of consolidation. In previous years the service sector was making significant progress in terms of digitalization, but in year 2018 the focus was turned of the industrial sector whereby DEI of German industrial companies has improved significantly since 2016: from 39 points to its current level of 45 points. In terms of both the use of stationary and mobile digital devices, and the use of digital infrastructures, industrial companies are improving as well as improvements in digitalization of internal processes. For example, in 2016 only 46% of industrial companies had highly digitalized internal processes while in 2018 this portion has increased to 58%. While in 2016 almost half of all German industrial companies indicated (48%) that they considered digitalization unnecessary, in 2018 this figure dramatically has dropped to only 29%.

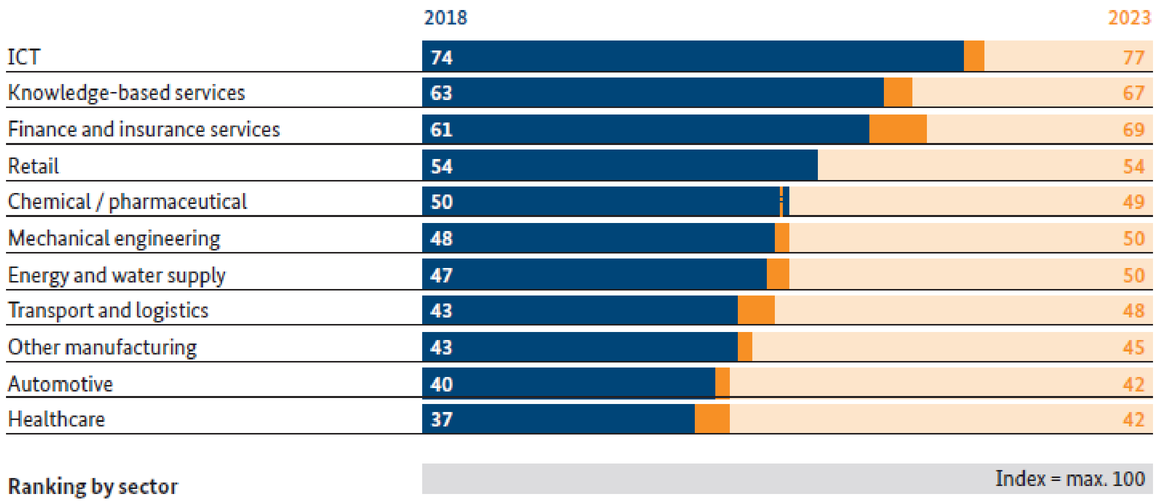

Figure 2: Digitalization of sectors in German economy measured by DEI in 2018 with expectations in 2023 [8]

Regarding the calculation of DEI, it is important to stress out that this is the only measure researched that already implemented expected impact of artificial intelligence (AI) within its methodology with measurement of AI impact on different German economy sectors' digitalization activities. The percentage of companies using AI solutions currently appears to be only just under 5% in the commercial sector but growth rates of this technology in the future and its prospects are much more impressive: the percentage of companies using AI was only 2% in 2017, it has doubled within just one year. In 10% of German companies, company employees are looking at AI, investigating potential applications or planning specific projects; 7% of companies already employed external AI consultants; 16% of companies have identified AI as a key issue and 31% assume that their company will use AI solutions in ten years' time. According to the report, around one quarter of all German companies already implemented AI, are investigating it or have plan to do so soon.

3.2. Benchmarking methods of digitalization capabilities of national economies

Enabling Digitalization Index (EDI) The EDI measures the company's environment and readiness to transform and thrive digitally through five different indicators. First indicator measures how one national economy is (de)regulated whereby the main factor used is the World's Bank Doing Business scale which measures a proxy of regulation aspects for digitagility (ease of getting credit, minority investor's protection). Second indicator measures level of national knowledge whereby different parameters were rated: the higher education and training score, quality of the education system and the innovation score (R&D undertaken by private sector, collaboration between Universities and the private sector, Intellectual property laws) developed by the World Economic Forum. Third EDI's factor is connectivity measured by internet user's ratio (the number of people using internet in % of population), mobile phone and fixed phones lines subscriptions per 100 people, and the number of secure servers per 100 people. Next indicator is a quality of infrastructure measured by Logistic Performance Index (World Bank Doing Business) as a proxy of soft and hard logistic infrastructure. Finally, a size of national internet market is used which takes number internet users and their income captured by nominal GDP into consideration.

Euler Hermes EDI ranked 115 national markets based on their overall index and each score is a simple average of the normalized raw indicator (rescaled to a 0-100 points range). 16 countries out of the 30 top markets are from Western Europe whereby Germany is placed as worlds' 2nd digitalized economy, the Netherlands is ranked as 3th while USA leads by far at a global level. 8 out of the 30 top markets are from Asia-Pacific region with Japan, Singapore, Hong Kong and South Korea as four highest ranked national economies ranked between 7th and 10th place. China is positioned as 17th world's digitalized national economy. Among 115 national economies, in 2018 Croatia was ranked as worlds' 49th digitalized national economy with EDI 43.4 compared to 46th place in year 2017. Similar EDI rate in year 2018 had, for example, Kazakhstan with EDI 42.3 or Saudi Arabia with EDI 43.0 [6].

Opposite to EDI, DESI is focused on EU members national economies exclusively. Although there are some overlaps in two above mentioned methodologies, still, the measures used in index are different. Like EDI, DESI measures level of connectivity i.e. it rates the deployment of broadband infrastructure and its quality whereby access to fast and ultrafast broadband-enabled services is a necessary condition for competitiveness. Second indicator measured is HR capital with measuring of skills needed to take advantage of the possibilities offered by digital. Next parameter is level of citizens' usage of internet services for different online activities such as consumption of online content (videos, music, games, etc.) video calls or online shopping and banking. Integration of digital technology by business is next measure and it represents digitization of businesses and e-commerce. It is observed how companies increase their efficiency, reduce costs and better engage customers and business partners adopting digital technologies. Digital public services are next indicator with measurement of public services digitalization level with a special emphasis on eGovernment and eHealth and their impact on efficiency gains for the public administration, citizens and businesses. Finally, R&D ICT analyses trends of ICT Sector and R&D provided by the EC and external studies conducted at the request of the European Commission.

Three Scandinavian countries i.e. Denmark, Sweden, Finland were in 2018 best ranked national economies among other EU members with DESI score over 70.0. Scandinavian countries were followed by the Netherlands, Luxembourg, Ireland, UK, Belgium and Estonia with the most advanced digital economies in the EU. Romania, Greece and Italy have the lowest scores on the DESI. Croatia was in year 2018 scored as 7th lowest ranked digitalized economy in EU with DESI score slightly below 50.0. According to EC, all member states have made improvement in digitalization index in year 2018 compared to 2017, however, the gap between best ranked and worst ranked countries was increased. Most progress was made by Ireland and Spain (close to 5 points as opposed to an EU average of 3.2), while, at the same time, there was low increase in Denmark and Portugal (below 2 points).

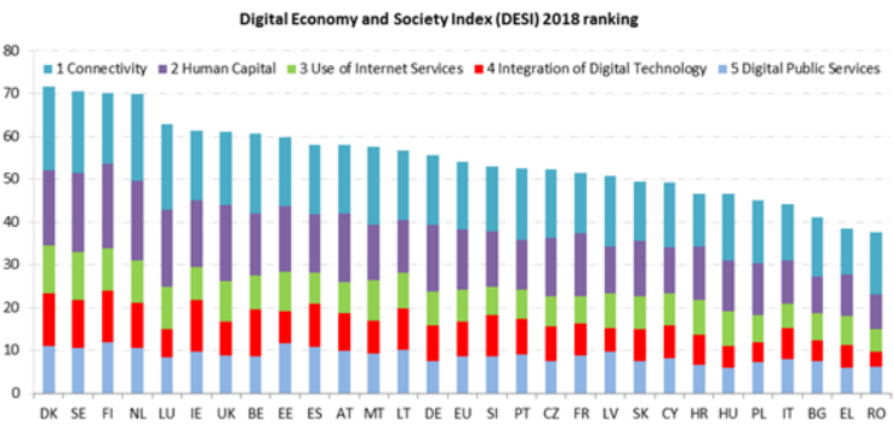

Figure 3: Digital Economy and Society Index (DESI), 2018 [7]

Digital Adoption Index (DAI) is measured by World bank and it is a composite index measuring the extent of spread of digital technologies within and across countries. DAI reflects the extent to which digital technologies are available and adopted by all the key agents in an economy: people, businesses and governments and therefore it provides a more comprehensive picture of technology diffusion. It is constructed using data on coverage and usage from the World Bank's internal. The main purpose of this measure is to assist policymakers in designing digital strategy with tailored policies to promote digital adoption across different user groups. Methodology is a composite index that measures the depth of adoption of digital technologies in 171 different countries, spanning every region and income group. It is based on three sectoral sub-indices covering businesses, people, and governments, with each sub-index assigned an equal weight [9].

4. CONCLUSIONS

Different institution and different experts use different measures of digitalization readiness and capabilities of national economies, sectors within economies and/or companies within sectors. In this paper we researched globally recognized and widely used digitalization indexes calculated by leading worlds experts or institutions. Among measures researched (IDI, EDI, DESI, DEI and DAI), there are various other indexes that implemented different parameters within their methodologies, however they were not further investigated within this paper.

Widely recognized methodologies are developed mostly by public institutions such as World Bank or EC and are mostly connected with identification of digitalization indexes of different countries or world regions. They are not focused on individual sectors within national economies but rather on general conditions and whole economic environment. Although methodologies vary, some parameters used are reiterative: connectivity and accessibility to internet infrastructure, level of digitalization of public sector and overall condition of IT infrastructure. Different approaches have resulted in different results. For example, according to DESI score, Croatia is placed as 21st digitalized economy in EU in 2018. At the same time, according to EDI, in 2018, Croatia was recognized as 3rd worst EU digitalized economy (only Romania and Bulgaria had lower ranking). Moreover, above mentioned indexes scored, for example, one of the largest world's economy i.e. Germany, completely different. As EDI scored Germany as worlds' second digitalized economy, DESI placed Germany in the middle of scale of EU members on 14th place, just slightly above EU average.

Digitalization indexes of sectors were more focused on limited geographic areas, mostly one country. We researched sectors digitalization indexes for two biggest worlds' economies: USA and Germany (IDI and DEI). It is interesting that although used methodologies are very different, results in measuring digitalization capabilities of different sectors in both countries are practically identical. Both methodologies have recognized IT sector as most digitalized, while in top 5 sectors among IT sectors, other 3 are identical (professional services, finance and insurance and trading sector).
As we have researched and presented in this paper, lack of uniformity in different methodologies lead to different conclusions how same economies, sectors or companies are scored on digitalization capability dashboard which could mislead different users of information to draw wrong conclusions. Lack of widely recognized and implemented digitalization measure implicates that there is still a different view of institutions and experts which parameters should be taken into consideration when digitalization impact is calculated. Development of unique, widely accepted methodology should be further investigated and commonly accepted.

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COMPARISON OF PERSONALITY TYPE TOOLS AND THEIR RELATIONSHIP WITH PROJECT SUCCESS

Anamarija MARIĆ

Abstract

Since ancient times, humans have sought to explain behaviour by categorizing personalities into distinct types. Personality assessments have been developed to describe aspects of personality that remain stable throughout a lifetime: the character, behaviour, thoughts. Project management is starting to realize that people matter on projects, but the benefit of using the personality type tools to establish project teams, that will ensure project progression, hasn´t been explored. This research results with the overview of personality tools and gives an indication on which personality tools are compatible for use in project management. As such, it gives a basis for further research.

Keywords: project management, personality type tools, project team, project success

1. INTRODUCTION

When it comes projects in general, success is measured by effectively meeting the triple constraints: complete the project on time, according to budget, and within the scope and quality requirements of the clients [1]. On the surface, this approach seems to concentrate solely on technical aspects of project management, but a project manager needs to have both technical skills along with people skills, as both are crucial for project success. Because the project management field and the technology industry change rapidly, organizations that invest in both “people skills” as well as the management of the triple constraints of project management projects, are more likely to have the greatest chance of achieving project success [2]. In sum, a project manager’s personality must be one that can successfully handle the classic triangle of deadline, scope and budget along with soft skills needed for project success that meets stakeholders’ expectations. It is therefore very important that the organization’s leadership selects the right personality to manage a project. On the other hand, new digital skills and technology that are aiding the process in today’s digital environment by ensuring the combination of digital skills such as data science (data management, analytics, big data), an innovative mindset, security and privacy knowledge, legal and regulatory compliance knowledge, the ability to make data-driven decisions and collaborative leadership, thus improving the success of projects [3].

A project manager’s ability and acquired skills to understand, predict, direct, change, and control human behaviour are often difficult to develop [4]. However, these desirable personal attributes of a project manager are helpful for a project’s success in a variety of interpersonal environments so they must be strongly considered even if the effort proves challenging. Several self-scoring psychological instruments exist that assist people in understanding their own behavioural tendencies as well as the behavioural tendencies of others with whom they come in contact. Understanding personalities is a key to unlocking elusive human qualities, for example leadership, motivation, and empathy, whether the purpose is self-development, helping others, or any other field relating to people and how they behave. Developing understanding of personality typology, personality traits, thinking styles and learning styles theories is a very useful way to improve the knowledge of motivation and behaviour of self and others in the workplace and beyond [5].

The purpose of this present research study is to explore the existing personality type tools and establish a foundation for further research which will clarify their relationship with project success.

2. LITERATURE REVIEW

Behavioural and personality models are widely used in organizations, especially in psychometrics and psychometric testing (personality assessments and tests). Behavioural and personality models have also been used by philosophers, leaders and managers for hundreds of years as an aid to understanding, explaining, and managing communications and relationships. Each of the different theories and models of personality and human motivation is a different perspective on the hugely complex area of personality, motivation and behaviour.

Some theories underpin well-known personality assessment instruments (Myers Briggs®, and DISC); others are stand-alone models or theories which seek to explain personality, motivation, behaviour, learning styles and thinking styles (Benziger, Maslow, McGregor, Adams, VAK, Kolb, Transactional Analysis and others). Some personality testing resources, including assessment instruments, are available free on the internet or at relatively low cost from appropriate providers, and they are tools for self-awareness, personal development, working with people and for helping to develop better working relationships. Some instruments however are rather more expensive, given that the developers and psychometrics organizations need to recover their development costs. For this reason, scientifically validated personality testing instruments are rarely free [6].

2.1.Personality type models

As a general introduction to all o theories and models, it's important to realize that no-one fully knows the extent to which personality is determined by genetics and hereditary factors, compared to the effects of up-bringing, culture, environment and experience. Given that perhaps half our personality is determined by influences acting upon us after we are conceived and born, it's interesting and significant also that no-one actually knows the extent to which personality changes over time. We can however identify general personality styles, aptitudes, sensitivities, traits, etc., in people and in ourselves, especially when we understand something of how to define and measure types and styles. Hippocrates recorded the first known personality model, postulating that one's persona is based upon four separate temperaments. Another Greek physician, Galen, extended Hippocrates' theory by applying a body fluid to each temperament: blood, mucus, black bile and yellow bile, respectively. Different diseases and behaviours had roots in the four humors and the fluid that was dominant was said to be the person's "humor." The four humors theory was to become a prevalent medical theory for over a millennium after Galen's death. The theory experienced widespread popularity throughout the Middle Ages. Late 19th/early 20th century physiologist Wilhelm Wundt expounded on the four humors theory in 1879 and he is noted to be the first person to make clear distinction between human body and personality. Carl Jung is one of the first to emphasize this approach hence, different models have been developed around Jung's theory. One of the better-known theories is the "Big Five Personality Traits" that characterize humans by placement in one or more of the following five traits: Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism. Another model is the Enneagram, a method that describes nine personality types. According to this theory, these nine types are subdivided into three separate groups: the triad of "feelings," characterizing persons with possible "feelings" problems; the triad of "doing," characterizing problems related to performance; and the triad of "power," characterizing problems related to control by power. The Keirsey and Bates (1984) model of personalities is also based on Jung´s theories but gives them new and different meanings. According to Keirsey´s Temperament Theory, people can be classified into four categories of Temperaments (Artisans, Guardians, Rationales and Idealists) [6]. One of the oldest and most popular methods for classifying personality traits as part of job fitting is the Myers-Briggs personality type indicator. The Myers-Briggs type indicator (MBTI) technique is a method based on the personality theory of Jung [7].

2.2.Personality tools [6]

Based on the available literature of the personality tools, this study has identified twelve personality tools. Five of them, based on their use and compability, will be a subject for further study. Chosen personality tools and their impact on project success will be a task for further study.

1. The Four Temperaments/Four Humors

The Four Temperaments, also known as the Four Humors, is arguably the oldest of all personality profiling systems, and it is fascinating that there are so many echoes of these ancient ideas found in modern psychology. The ancient Greeks however first formalised and popularised the Four Temperaments methodologies around 2,500 years ago, and these ideas came to dominate Western thinking about human behaviour and medical treatment for over two-thousand years. In Greek medicine around 2,500 years ago it was believed that in order to maintain health, people needed an even balance of the four body fluids: blood, phlegm, yellow bile, and black bile. These four body fluids were linked to certain organs and illnesses and represented the Four

Temperaments or Four Humors (of personality) as they later became known. Imbalance between the 'humors' manifested in different behaviour and illnesses, and treatments were based on restoring balance between the humors (body fluids). The Four Temperaments provided much inspiration and historical reference for Carl Jung's work, which in turn provided the underpinning structures and theory for the development of Myers Briggs and David Keirsey's modern-day personality assessment systems, which correlate with the Four Temperaments.

2. Carl Jung's Psychological Types

Carl Jung was among many great personality theorists who drew inspiration and guidance from the ancient Greek Four Temperaments model and its various interpretations over the centuries. Jung divided psychic energy into two basic 'general attitude types': Introverted and Extraverted. In addition to the two attitudes of extraversion and introversion, Jung also developed a framework of 'four functional types'.

Jung described these four 'Functional Types' as being those from which the "most differentiated function plays the principal role in an individual's adaptation or orientation to life". Jung's Four Functions of the psyche are: thinking and feeling, which he said are the functions that enable us to decide and judge, (Jung called these 'Rational') and sensation and intuition which Jung said are the functions that enable us to gather information and perceive (Jung called these 'Irrational'). These are 6 'type' behaviours that combine with others create eight main Jung's psychological types, which by adding an auxiliary function to each are finally producing sixteen types.

3. Myers Briggs® personality types theory (MBTI® model)

Myers Briggs® theory and the MBTI® model is a method for understanding personality and preferred modes of behaving. It is not a measurement of intelligence or competence, emotional state or mental stability, 'grown-upness' or maturity, and must be used with great care in assessing aptitude for jobs or careers: people can do most jobs in a variety of ways, and the MBTI® gives little or no indication of commitment, determination, passion, experience, ambition etc., nor 'falsification of type', all of which can have a far greater influence on personal success than a single personality test. The MBTI® model and test instrument was developed by Katharine Briggs and her daughter Isabel Briggs Myers in 1942 after their studies particularly of Carl Jung. Myers Briggs® added a fourth dimension to the three Jung dimensions (Introvert-Extravert, Thinking-Feeling, Sensation-Intuition), namely Judging-Perceiving, which is related to a personality's approach to decision-making, and particularly how the personality deals with the outer world (Extraverted) as distinct from the inner world (Introverted).

The Myers Briggs® Judging-Perceiving dimension can also be used to determine functional dominance among the two preferred functional types (aside from Introvert-Extravert, which are not functions but 'Attitudes', or orientations).

4. Keirsey's personality types theory (Temperament Sorter model)

David Keirsey's ideas extend and develop the Four Temperaments and the ideas of Carl Jung and also relate very directly to the Myers Briggs® MBTI® system. Keirsey's personality model is particularly helpful because of the meaningful personality 'type' descriptions, especially when used alongside Myers Briggs® abbreviated letter codes. The colour-coded groupings reflect Keirsey's view that certain categories of MBTI® or Keirsey types equate strongly to the Four Temperaments.

5. Hans Eysenck's personality types theory

Eysenck's concepts provide a valuable additional perspective compared to the Four Temperaments, Jung, Myers Briggs®, and Keirsey, because they explore and analyze a personality dimension related to emotional stability. Eysenck's approach to personality assessment was the first popular scalable mathematical methodology. Previous theories generally placed a person within one of the defining types, or between two types, or attributed a mixture of types to a person's personality. Eysenck's measures personality using two scales: introversion-extraversion and stability-instability (unemotional-emotional).

6. Katherine Benziger's Brain Type theory

Benziger's theory expresses personality in terms of four quadrants of the brain (basal means rear or back): Basal Left - process and routine, Basal Right - intuition and empathy, Front Left - logic and results, Front Right

- vision and creativity. Benziger relates these modes of thinking to Jung's Four Functions, and Benziger's theory provides many people an immensely helpful way to make sense of what Jung said and advocated. Importantly Benziger acknowledges and uses the Jungian Extravert and Introvert dimension but does not represent it within the four-quadrant model of the four functional types.

7. William Moulton Marston's DiSC personality theory

DiSC® instruments are based on a simple idea - that the foundation of personal and professional success lies in knowing yourself, understanding others, and realizing the impact of your actions and attitudes on other people.

8. Belbin Team Roles and personality types theory

Meredith Belbin initially identified a set of eight roles, which are all present in a team provide good balance and increase likelihood of success. The eight roles were later increased to nine, with the addition of the 'Specialist' role. There are no 'good' or 'bad' roles. People are as they are, and all roles play important parts in successful teams.

9. The 'Big Five' Factors personality model

'The Big Five' is the commonly used term for the model of personality which describes the five fundamental factors of our personality. The Big Five is a very useful model for assessing non-managerial staff, but it lacks some of the rigor required for assessing people in or destined for managerial and executive roles. The Big Five model gives us an accurate and fast way of assessing the main drivers of someone's personality. But the model by itself is not able to drill down into complex management capabilities or competencies. For this we must refer more to work-related behaviours rather than 'pure' personality.

10. FIRO-B® Personality Assessment model

FIRO-B® stands for Fundamental Interpersonal Relations Orientation-Behaviour. The FIRO-B® is an assessment tool used to help individuals and teams better understand their preferences in satisfying three basic social needs: Inclusion (the degree to which one belongs to a group, team or community), Control (the extent to which one prefers structure, hierarchy and influence) and Affection (one's preference for warmth, disclosure and intimacy).

11. The Birkman Method®

The Birkman Method® consists of ten scales describing motivations (Interests) and occupational preferences. It also has eleven scales describing 'effective behaviours' (Usual behaviours) and eleven scales describing interpersonal and environmental 'expectations' (Needs). A corresponding set of eleven derived scales describe the associated 'less than effective' (Stress) behaviours when expectations are not fulfilled. Together, these eleven scales are titled Components.

12. Lumina Spark

Lumina Spark was designed to expand on the Big Five models by measuring both ends of a measurement scale separately. High scores in a certain area therefore do not necessarily mean low scores in another, and participants can claim qualities at opposite ends of a polarity. The Lumina Spark psychometric tool uses several classifications of increasing specificity. This could be described alternatively as levels of sub-categories, each containing narrower and more detailed characteristics.

3. RESEARCH METHODOLOGY

The research is planned to be staged in three different phases. The first phase was a literature review, to recognize the most commonly used personality type tools project management, comparison between the different tools and their impact on the project success. Conducted literature review has formulated the problem and defined the research direction. Literature pool was gathered from the Google Web and Scholar using the keywords, i.e. Personality type tools. Based on the findings, an overview of the identified personality tools is presented in Discussion.

The second phase of the study will test the literature findings using a web-based survey, which will be conducted in Denmark. The survey will be sent out to the chosen project groups which are working closely with the chosen personality tools in their everyday work. The survey will be anonymous, but participants will have the opportunity to leave their contact information, if they are willing to discuss the results of the survey with the author or take a part in face to face interviews. The third phase will analyse the survey data using descriptive and analytical statistics.

4. DISCUSSION

Making a comparison between the most commonly used personality tools, as well as defining the impact of different tools on the project success, should make an easier choice for organizations in future, when starting a new project when selecting the project manager and the project team.

The overview and the comparison between the identified personality tools is shown in Tables 1 and 2. Table 1 focuses on the personality types derived from The Four Temperaments tool. The parallel is drown between the seven personality tools, however the most compatible tools are Jung, Myers Briggs and Keirsey's.

In general, the mostly acknowledged and used theory remains to be Myers Briggs. The remaining two theories have a different approach to personalities, where Katherine Benziger's theory requires a deeper knowledge of human psychology and the William Moulton Marston's DiSC is not detailed enough that a full compability could be recognized. In Table 2 a full compability of profiles can be recognized between Belbin, The 'Big Five' and The Birkman method. The Belbin method gives an easy approach to understanding different personality types.

Table 1 – Personality Type Tools Comparison (Own work based on [6])

Personality type tool compatibilities 1				
The Four Temperaments/Four Humors	Blood	black bile	yellow bile	Phlegm
Carl Jung's Psychological Types	thinking/feeling	thinking/feeling	Intuition	Sensation
Myers Briggs® personality types theory	SP	SJ	NF	NT
	ESTP	ESTJ	ENFJ	ENTJ
	ISTP	ISTJ	INFJ	INTJ
	ESFP	ESFJ	ENFP	ENTP
	ISFP	ISFJ	INFP	INTP
Keirsey's personality types theory	Artisan	guardian	Idealist	Rationalist
	promoter	supervisor	Teacher	fieldmarshall
	Crafter	inspector	Counsellor	mastermind
	performer	provider	Champion	Inventor
	composer	protector	Healer	Architect

Hans Eysenck's personality types theory	stable-extraverted	unstable-introvert	unstable-extravert	stable-introverted
Katherine Benziger's Brain Type theory	frontal left/basal right	frontal left/basal right	frontal right	basal left
William Moulton Marston's DiSC personality theory	Steadiness	Compliance	Influence	Dominance

Table 2 – Personality Type Tools Comparison (Own work based on [6])

Personality type tool compatibilities 2

Belbin Team Roles and personality types theory	Coordinator (CO)	Shaper (SH)	Plant (PL)	Monitor-Evaluator (ME)	Implementer (IMP)	Resource Investigator (RI)	Team Worker (TW)	Completer-Finisher (CF)	Specialist (SP)
The 'Big Five' Factors personality model	Extraversion Confidence	Extraversion Tough-minded, Creative	Extraversion Confidence Tough-minded Creative	/	Detail-conscious, Agreeable Conforming	Extraversion Confidence Creative	Introversion Sensitive Detail-conscious Conforming	Sensitive Detail-conscious Agreeable Conforming	/
The Birkman Method®	Social Orientation	Social, Change, Emotive Orientation	Social, Change, Emotive Orientation	/	Process, Control Orientation	Social, Change Orientation	Process, Change Orientation	Process, Control Orientation	/

5. CONCLUSION

Based on the existing literature, the study has identified ten personality tools, where after the compability study has been carried, two groups of seven and three personality tools have been identified (Tables 1 and 2). The presented overview is expected to help projects to choose the best suited personality tool for creating a project team, when starting a new project, and to raise their attention to the possibility of building a team based on personality types. When choosing the personality tool for use on the project, the focus should be put either on the first group of personality tools, or Myers Briggs as the main personality tool and William Moulton Marston's DiSC personality theory as a tool for quick, starring assessment, or on the second group of personality tools, where the Belbin Team Roles and personality types theory can be used for a brief assessment and The Birkman Method® or The 'Big Five' Factors personality model for the full assessment of the profile.

As such the overview made in Table 1 and 2 gives an opportunity for choosing the personality tool without ensuring the project success, therefore, chosen personality tools will be used as a basis for the planned case study and for further research. The survey and possible interviews will result in recognizing the personality tool and type that should be utilized for a certain project. It will also result in comparison of selected personality types and their contribution to the successful finalization of a project. Finally, it is hoped that this study will be beneficial to all project managers in general and would stand as a good basis for future research.

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EFFECTS OF PROBLEM-SOLVING METHODS ON PROJECT SUCCESS

Anamarija MARIĆ

Abstract

In this information age the use and knowledge of problem solving is required by all employees in all industries. Problems are resolved not in the boardroom, but in the projects or at the location where they are identified. Organizations that do not promote problem solving rely on the skills and knowledge of a few people and are unable to achieve successful project realization. This research results with the overview of problem-solving methods and gives an indication on which methods are successful in project environment and what are their benefits in problem-solving. As such, it gives a basis for further research.

Keywords: project management, problem solving, project success

1. INTRODUCTION

Everyone could solve problems. Conducting employee performance reviews is an effective technique used to identify problems in the project environment [1]. Employee should most likely be the person to identify potential issues that need to be addressed. Some of the methods that can be used to collect this information include questionnaires, surveys and oral interviews. This information can then be used to identify or predict project management issues, such as discrimination, harassment, work-life balance and recognition, among others. Today, problem solving is no longer an exclusive responsibility of those occupying the executive suite [2]. As new and complex business challenges become more widespread, everyone in the organization is undertaking the duty and responsibility of solving workplace problems. In fact, everyone in the organization is responsible for solving problems [3]. However, problems which arise from the repetitive actions or processes during manufacturing or business processes need an entirely different approach. The key to efficient and successful problem resolution is approaching the process with a systematic and logical methodology and accomplishing this through positive interpersonal interaction [4]. Peer-group assessment helps the company identify numerous problems within the firm's departments. Gathering employees together in small groups may help when trying to diagnose problems within the project areas. The groups should consist of staff from the same department or project working toward acknowledging a common problem. A moderator who is unknown to the employees makes it easier for the employees to mention problems they frequently encounter. Achieving successful problem resolution has remained an important endeavour in business for decades. For today's organization, much like the past, successful problem solving translates into enhanced productivity, increased profit and successful projects. The more efficiently, effectively, and quickly problems get resolved the greater the propensity for improved employee morale, enhanced production capabilities, and realization of fewer dollars lost or waste [5].With this said, the currently most used problem-solving methods will be investigated and the technics with the recognized advantages will be selected for further study. The study will focus on project teams and their ability to solve projects as and will try to determine the impact of different problem-solving methods on project success.

2. LITERATURE REVIEW

Currently, there is more than 40 different problem-solving techniques. Some problem-solving methods are more creative in nature and may include brainstorming and obtaining different points of view, the others assume a more investigative slant and may include using personal insights and intuition, check sheets or formal surveys. Problem solving methods can be further divided into five groups: General Problem-Solving Tools, Problem-Solving Approaches, methods focused on the cause of the problem, diagram-based tools and methods focused on improving business processes. In this research focus will be put on the first three groups. General Problem-Solving tools are some of the following: FMEA, Inductive reasoning, Heuristic methods. When finding the cause of the problem is in question, there is several methods that can be considered: Root Cause Analysis, CATWOE, 5 Whys, The Drill Down Technique, Cause and Effect Analysis, Appreciation, The Four

Frame Approach and Interrelationship Diagrams, while the problem-solving approaches are: PDCA, 8D, The Four step innovation process, Creative problem solving, The FOCUS model, Appreciative Inquiry [6].

Every approach to problem solving outlines a structure which describes a thought process required to reach to problem resolution. Organizations are all in search of the one tool or set of skills that are required to help employees solve problems. The issue however, behind problem solving is not the methodology but the ability of employees to be skilled and apply the problem-solving methodology in an objective manner that can yield results. The ability of employees to resolve problems also rests with the culture of the organization, how it is structured, how problem-solving skills are encouraged or rewarded, whether employees are allowed to think freely and whether the use of data is at the center of decision-making. Some of the most notable and usable common problem-solving methods in a project environment are the following [6,7]:

1. The Deming Cycle (PDCA)

This is based on Plan, Do, Check and Act with the overall aim of process improvement. In some instances, the Check phase is replaced by Study. The concept behind this approach is that problem solving, and process improvement is a continuous process (Figure 1).

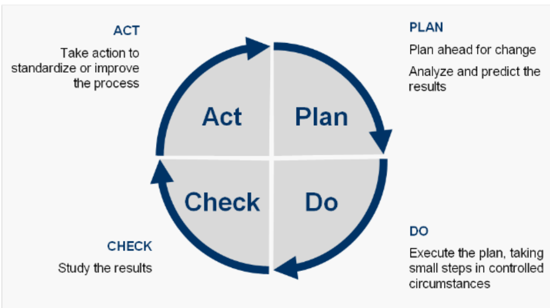


Figure 1 - Deming Cycle (PDCA) [6]

2. The Eight Discipline Methodology (8D)

This system is a team-based approach to solving product and process problems It is used to correct and identify recurrent problems by using statistical methods to initiate data collection, root cause analysis, and problem resolution (Figure 2).

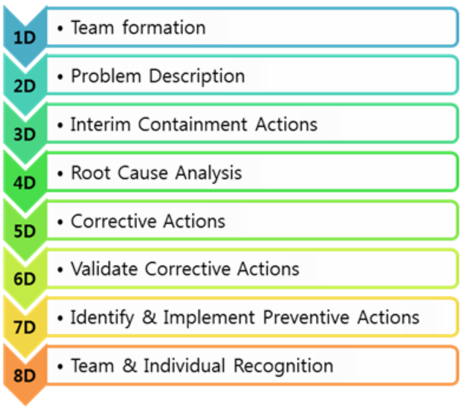


Figure 2 - 8D Methodology [7]

3. Five Whys

This is a system of asking "why" five times until the root cause of the problem is uncovered. It is also important to apply critical thinking principles during use of this method in order to eliminate irrelevant assumptions and logic traps. The Toyota Motor company has used this method successfully to solve manufacturing problems.

4. The Four-Step Innovation Process

Weiss and Legrand's Four-Step Innovation Process helps the team to come up with innovative and creative solutions to complex problems, which are securely grounded in a thorough understanding of the business context.

5. Failure Mode and Effects Analysis (FMEA)

It builds on tools like Risk Analysis and Cause and Effect Analysis to try to predict failures before they happen. Originally used in product development, it is also effective in improving the design of business processes and systems.

6. Appreciative Inquiry

Unlike the traditional problem-solving methods of breaking problems into manageable smaller units analysing the problem, this method looks at what works in an organization identifying the positive and stating what can be done to do more of the same. It is based on Discover, Dream, Design and Destiny.

7. Cause and Effect Analysis

The diagrams created are known as Ishikawa Diagrams or Fishbone Diagrams (because a completed diagram can look like the skeleton of a fish). Though it was originally developed as a quality control tool, you can use the technique just as well in other ways.

8. Kepner-Tregoe Decision Analysis

This is a problem solving and decision making, rational system based on unbiased decisions. It is also a structured analysis for gathering information, prioritizing and evaluating data. There are four steps to this analysis: situation appraisal, problem analysis, decision analysis and potential problem analysis. The overall aim is to minimize the risk of problems.

9. Kaizen

Kaizens (or blitzes, as they are sometimes called) are improvement events where people work only on improvement for a few days, up to a full week. This is a team-based method of problem solving oriented to continuous and incremental improvement at all levels of the organization.

10. Six Sigma-DMAIC

The DMAIC problem-solving method is a roadmap that can be used for any projects or quality improvements that need to be made. The term DMAIC stands for the five main steps in the process: Define, Measure, Analyze, Improve, and Control and focuses on the use of data, root cause analysis, implementing improvement actions and implementing system actions to sustain improvements (Figure 3). Six Sigma emphasizes the use of statistical tools, project selection and project management.

Figure 3 - Six Sigma Methodology [7]

3. RESEARCH METHODOLOGY

The research is planned to be staged in three different phases. The first phase was a literature review, to recognize the most commonly used problem-solving methods, comparison between the different methods and their impact on the project success. Conducted literature review has formulated the problem and defined the research direction. Literature pool was gathered from the Google Scholar using the keywords, i.e. problem-solving methods in projects. The second phase of the study will test the literature findings using a web-based survey, which will be conducted online. The survey will be sent out to the chosen project groups which are working closely with the chosen problem-solving methods in their everyday work.

The survey will be anonymous, but participants will have the opportunity to leave their contact information, if they are willing to discuss the results of the survey with the author or take a part in face to face interviews. The third phase will analyse the survey data using descriptive and analytical statistics.

4. DISCUSSION

Making a comparison between the most commonly used problem-solving methods, as well as defining the impact of different methods on the project success, should enable project managers and project teams to quickly and efficiently overcome any problems that occur during the project lifetime.

Based on the available literature on the problem-solving methods, this study has identified ten problem solving techniques, as listed in the literature overview. The methods were categorised by usability and recognised advantages (Table 1). Five of the methods listed in the Table 1, based on their use and compability and their impact on project success will be a task for further study.

Table 1 - Overview of problem-solving methods, usability and advantages (Own work based on [6,7])

Problem-solving method	**Usability**	**Recognized advantages**
The Deming Cycle (PDCA)	process improvement	continuous process
The Eight Discipline Methodology (8D)	recurrent problems	team based approach
Five Whys	manufacturing problems	root cause definition
The Four-Step Innovation Process	complex problems	innovative and creative solutions
Failure Mode and Effects Analysis (FMEA)	product development, improving processes and systems	predict failures before they happen
Appreciative Inquiry	whole organization	identifies and copies positive influences
Cause and Effect Analysis	quality control tool	Identifies causes of problems
Kepner-Tregoe Decision Analysis	problem solving and decision-making tool	minimizes the risk of problems
Kaizen	oriented to continuous and incremental improvement	team based, improvement events
Six Sigma-DMAIC	roadmap projects or quality improvements	root cause analysis

Since the focus for the study is a project team, 8D method was used as an example, to verify its usability, for recurrent problems. It is also a method that uses Cause and Effect Analysis, PDCA as well as the 5 Why method in the process of finding the problem solution. A brief workplace assessment (unnamed due to confidentiality issues) was conducted in a form of a structured interviews, amongst 10 project team members to localize a single reoccurring problem, present at the time in question. The problem was identified and described as: The quality of the following moulds, based on the same element design, cannot be approved in mould qualification.

The complexity of the problem requires the engagement of the team and the solution is potentially usable by the whole organization. The solution of the problem will be shortly described, pointing to the most informative areas. After the team is established and the problem was described, a containment was made, to follow the 8D method procedure. The containment was to make new insert for the moulds (significant cost) and to measure the drilled holes in the moulds. The problem was localised by using Cause and Effect diagram and the root of the problem was found using 5 Whys (Figure 4 and Figure 5). It was defined as the misalignment of the drilled holes in the mould cavity inserts. The root of the problem is that the standards for drilling holes in inserts in not detailed enough.

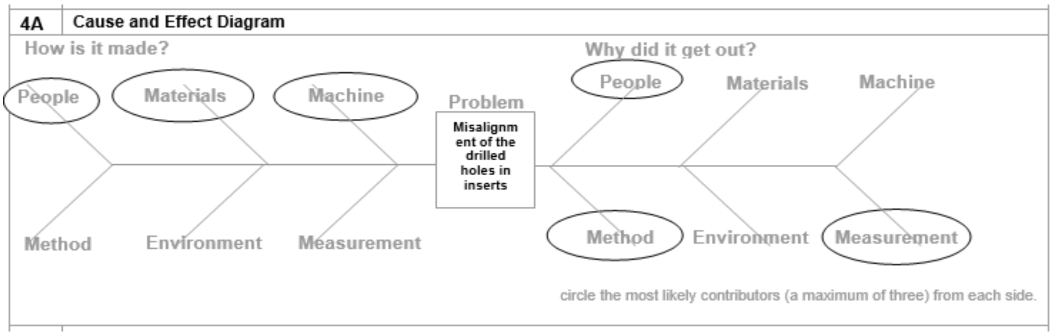
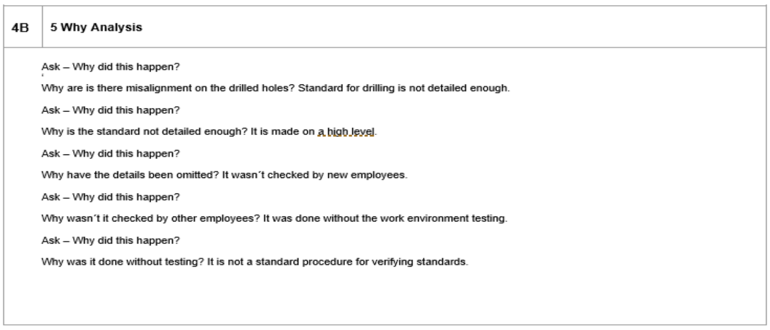


Figure 4 - Cause and Effect Analysis



4B 5 Why Analysis

Ask – Why did this happen?

Why are is there misalignment on the drilled holes? Standard for drilling is not detailed enough.

Ask – Why did this happen?

Why is the standard not detailed enough? It is made on a high level.

Ask – Why did this happen?

Why have the details been omitted? It wasn´t checked by new employees.

Ask – Why did this happen?

Why wasn´t it checked by other employees? It was done without the work environment testing.

Ask – Why did this happen?

Why was it done without testing? It is not a standard procedure for verifying standards.

Figure 5 – 5 Why Analysis

After the root of the problem was located the permanent corrective actions were found and the action plan was made. For following up the status of the action plan PDCA was to be used.

Implement & Verify Actions

Action	Who Responsible	Planned	Actual	Status
Revision of the standard	Kim N.	Wk. 36	Wk. 36	P
Implementation of the standard	Martin H.	Wk. 36	Wk. 36	P
Training in the new standard	Johannes J.	Wk. 37	Wk. 37	P
Investigate the standard for error proofing	Johannes M.	Wk. 38	Wk. 38	P
Remove the containments	Per J.	Wk. 50	Wk. 50	P

Figure 6 – Action plan status

After the reoccurrence of the problem was stopped the team was congratulated by the team leader and the production manager.

Recognition of the team was done in the quality area and the feedback was given to each team member. Team members congratulated each other and shown their appreciation for the efforts made and they resumed their everyday duties.

8D methodology has proven to be the right choice for the recurrent problems as well as that high effort of the team members working on the problem had to be present in order to find the right solution. It has positively contributed to effective and timely problem resolution and has increased the likelihood of successful implementation. Without a positive interpersonal interaction, troubleshooting would have been unsuccessful. Therefore, combining successful people and an effective and appropriate method should be able to create an environment where solving problems will ensure secure project progression and in the end project success.

5. CONCLUSION

Results from this study are expected to help projects and organizations in choosing the best suited problem-solving method to either prevent the problem from occurring or to prevent it from reoccurring.

Organizations should strive to develop a comprehensive troubleshooting and deployment strategy that increases the speed and probability of resolution and enables teams within the organization to take responsibility for successful problem solving.

The overview made in Table 1 will be used as a basis for the planned case study and for further research. The survey and possible interviews will result in understanding the effect of chosen problem-solving methods on overall project success. If the certain problem-solving methods has proven to have an high impact on project success, the recommendation will be given in this research on how to best utilize the given method. Finally, it is hoped that this study will be beneficial to all projects and organizations in general and would stand as a good basis for future research.

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ROBOTIC PROCESS AUTOMATION – A JOURNEY THROUGH DIGITAL TRANSFORMATION

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Abstract

This paper presents a review on the advances of robotic process automation technology and obstacles in automating processes by giving the roadmap towards RPA implementation.

Many companies, shared service centers and universities acknowledge automation technology and software robots are the basis in important driver for Industry 4.0. Hopefully, from this report it will become clearer how to get the most with the RPA technology as well as to create the business mind for a better future.

Keywords: Robotic Process Automation, RPA, Digital transformation, Lean, Industry 4.0

1. INTRODUCTION

Digital transformation brings the improvement of everyday business activities. User experience, speed, productivity, and cost-effectiveness are still imperative. To keep the companies competitive, they need to go a step away from implementing ERP software, outsourcing, and digitizing information itself. The center of successful global companies is information - which requires quick access, processing and reaction. The business challenge of today is no longer the digitization itself and the "paperless" concept, but the access to information. Information is most commonly stored on multiple IT systems (including "legacy" applications), as well as on multiple external sources such as websites, portals, or any other external information sources. Integration and automation of data collection activities is extremely difficult and challenging. Robotic Process Automation (RPA) is a technology that, with the help of artificial intelligence and software, enables automation of tasks. Technology is applicable to almost all platforms, whether they are on internal or external IT resources. The basic goal is to replicate human interaction with user software. Regarding employees, task robots perform faster and error-free, and working hours are 24/7/365. In this way, people are disengaged from common tasks and can focus on activities that necessarily require their engagement or emotional intelligence.

2. ROBOTIC PROCESS AUTOMATION

Robotic Process Automation (RPA) is a combination of technologies. It combines software, hardware, network, automation and knowledge to deliver outcome results in a more efficient way. RPA is an advanced hybrid technology in the area of information technologies, computers science, communications, electronics and mechanical engineering.

For any business to sustain, it is essential to have a strong business leadership, “know-how” manpower and the right technology. Organization should recognize the importance of robotic solutions. They perform tasks faster, more accurately and with less error, releasing employees to focus on other activities that necessitate their engagement, emotional intelligence, and interaction with their clients. The application of the RPA concept is particularly useful in situations where IT resources and budgets are limited or when back-end applications that do not have application interfaces (integration APIs) or their development are expensive. This technology can be upgraded to existing systems and is an excellent way to improve business efficiency with relatively low costs. Because of the low cost associated with RPA and its implementation, it represents an economical option for all companies that independently manage all their activities and employees. The main features of RPA are that there is no need for coding or programming skills, the concept is oriented to business users who do not need advanced IT knowledge, there is a clear visual definition of the process, no impact on existing applications and processes, relying on existing application functionality and assumes the way of doing so. These features allow a return on investment, resource optimization, increased efficiency and employee productivity, cost reduction, fast response to an increasing number of requests in line with growing bureaucracy for which no human intervention is needed, Continuous Automated Process Execution (24/7/365) and Reduced Risk in Everyday Business.

Because of the attractiveness of the solution and the necessity of the challenges caused by digitization the use of robotic applications in all aspects of business will significantly increase in the upcoming years. According to [1.], automation could get rid of 435 million jobs till 2030.

As with any other technology, understanding of technology - its advantages, specifics, advantages and potential constraints is needed for successful implementation and maximum results.

3. RPA ROADMAP

3.1.Background and reached obstacles

According to [2.]: there are 3 main barriers why organizations cannot achieve higher level of automation (Figure 1) and RPA implementation can be a turbulent journey [3.]. The main barrier is the process fragmentation and the wide variation of tasks. This is proven as an obstacle in the 3-phase implementation project which has been done in the company and which is also partially described in this paper below.

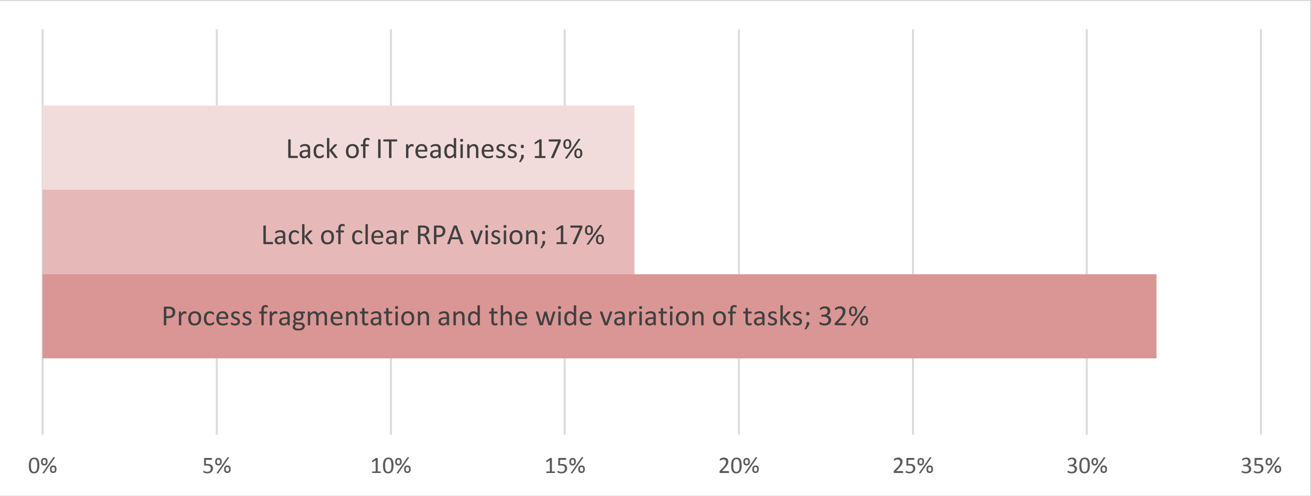

Figure 1 – Three main barriers why organizations cannot achieve higher level of automation

In phase I, proof of concept was done by implementing 1 process in production. Approach used in implementation was not lying on the strictly developed model for RPA. Instead, best practices from project management combined with prior experience in other IT-related projects was used. Applied approach is shown in Figure 2.

In phase II, additional 8 processes were implemented by using the same approach. There were minor technical issues, but those didn’t affect project delivery, nor did they affect the timeline scheduled.

In phase III, plan was to implement additional 23 processes by using the same approach. Unfortunately, at the same time, problems with processes from the first two stages started. Main reason were poor process assessment and definition combined with technical issues. Only the first stage in this approach - Business Analysis and Technical Design - concentrated on the process analysis. Purpose of this phase was only to familiarize consultants with the business context of the process, record the steps that are performed in the existing process and to define the applications that were involved in the process as well as to check whether there are any major technical obstacles using the RPA technology. As RPA technology advances fast, there were basically no restrictions in using the technology in any process and this resulted as the least important.

The whole approach resulted in 5 months project extension, additional work and costs. Obviously, there is a need to define the new model for RPA implementation which would be more concentrated to the process assessment and definition stages.

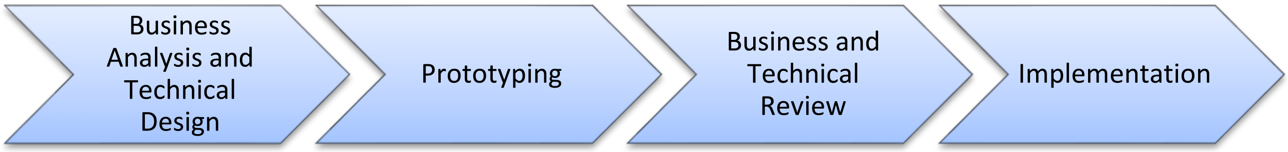

Figure 2 – Approach used for RPA implementation in phase I - III

3.2.Lean thinking

Lean is a quality improvement methodology, which began in 1960s with Japanese automobile manufacturing. Lean concentrates on the interconnection between the processes.

Basically, when working with projects in a Lean way of thinking, project managers should bring complete transparency on the both positive and negative aspects and issues they are facing in the project.

Main target of lean thinking is to eliminate waste through continuous improvement and to concentrate on the value-added activities. Waste can be any non-value-added activity such as waiting times between value-added work activities. Waste can also include rework, scrap, and unneeded process steps. Rework and scrap are often the result of excess variability, so there is an obvious connection between Six Sigma and lean, but Six Sigma concept was not part of this research.

The value-added activities include:

- Defining value
- Identifying the value stream
- Working only what customer/client demands
- Keeping the flow move continuously
- Improving the process continuously

In a lean way of looking at the process - the process is nothing but the continuous flow and a completion of a task which should be monitored and improved continuously.

3.3.Process definition and RPA model

There are still no standard operational models developed on the use of the Robotic Process Automation operations. While automation can be complicated, the beauty of the technology is its ability to easily scale from simple to complex. The key to understanding if automation can be used on a process is to rediscover every aspect of that process and to redefine what can be streamlined or eliminated as a waste in each process step.

Combination of Lean thinking, lessons learned from a company project and observed literature showed that the most important is the process definition. It is necessary to analyze the process and to understand the existing way the process works. Quality process analysis should be prerequisite for process automation. On the described business case and approach, additional effort had to be done to finish the project. This included analysis, re-definition of the process and making a new streamline. Combining the lessons learned from business case and Lean thinking, RPA roadmap (Figure 3) has been created for the purpose. Phase explanation is given below.

- Choose the process – pre-assessment must be done to assure business will have the benefit at the first place.
- Understand how it works – screening of the existing process should be done. Best practices from the RPA software manufacturers include screen recording of the manual work as well as more traditional process charts.
- Collect and understand demands – as given before, only what customer/client demands should be done to avoid waste

- Analyze – each process step must be analyzed as well as the whole process; propositions for change should be done in this stage
- Identify waste – all waste should be eliminated at this stage
- Define – definition of a new process steps which eliminate the waste
- Make a streamline – some manual processes should be combined to a streamline or a new, larger process while some of the “bulk” processes should be divided to “smaller” ones in order to eliminate the waste and utilize the technology at the most
- Automate – development of automated process and practically the first step in automation
- Test – testing phase; every bug and issue must be resolved before migration to production stage
- Monitor and improve – according to Lean and Six Sigma, continuous improvement is an imperative and should be done

Although it was already stated that there were no records in technology restrictions, re-definition of the automated process tasks must consider the consistent methodology and standards of Robotic Process Automation system and tools.

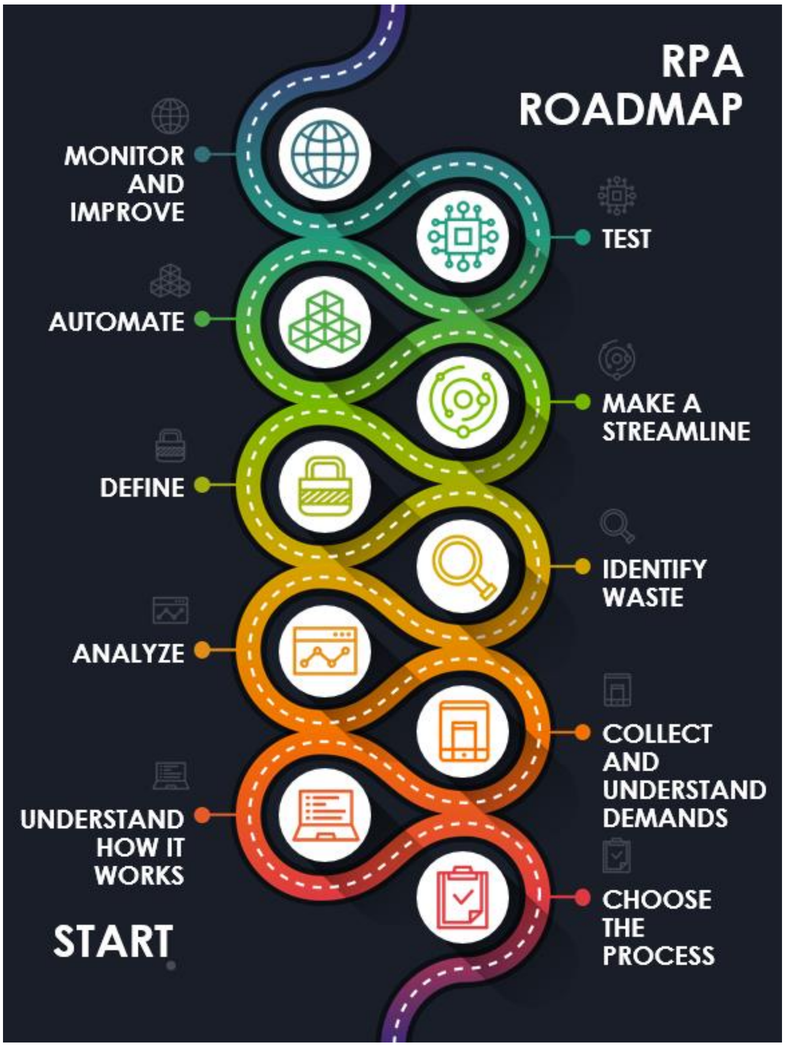

Figure 3 – RPA roadmap

4. CONCLUSION

One of the leading technologies can also be an obstacle. While organizations complain that they have reached a saturation point and that they do not know what the important processes are, in this paper the essential assumptions that formed the basis of the scientific approach lies under one of the Lean principle key assumption: waste disposal will automatically and obviously result in a fundamental improvement in performance. Traditional IT project management approach can be used but business case showed that there is a need for a new tailor-made model for RPA. Given model is only a partial answer as a roadmap and it doesn't include all lifecycle stages. RPA model should also include production stages and post-production stages. Finally, considering continuous improvement concept, the final model should be described as the cycle-diagram. While Lean thinking gives a partial answer described in this paper, as described in waste identification, rework and scrap are often the result of excess variability and it is obvious that there are overlapping with Six Sigma. Further research should involve DMAIC concept and Six Sigma tools. Any technology constraints weren't actually obstacles in analyzed business scenario but are theoretically and practically possible. Further research could also consider other approaches as Theory of Constraints and combining these methodologies in a hybrid model.

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THE IMPACT OF PALLETIZATION ON THE FLEXIBILITY IN MANUFACTURING SYSTEMS

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Abstract

In modern flexible manufacturing systems (FMSs), which consist essentially of CNC machine tools, there is a wide range of operations for which they can perform machining, relying on clamping devices that position and clamp the workpiece. Among the concepts of clamping devices, there are also pallet systems with a defined zero point that reduce the limits of flexibility. Such a system allows fast and secure replacement of base plates without the need for alignment between the modular device and the pallet. In this paper, a palletization system and a corresponding control system are introduced, enabling the rapid configuration of pallets, utilizing the additional levels of flexibility provided by zero-point systems.

Keywords: FMS, pallet systems, zero-point, automatization

1. INTRODUCTION

The Flexible Manufacturing System (FMS) is a production system model that enables production in conditions of dynamic market demand, the size of the series, and increasing product variants with modifications. These systems include automation processes, sensors, numerical control, etc., to perform a wide range of processing operations. The level of flexibility has increased considerably in modern FMSs, which are usually programmable, equipped with automatic tool changers for changing tools and workpieces, and are characterized by a work area where they can provide optimal usability and quality of workpieces. However, the potential flexibility of FMSs is still limited by the interaction between the system and the physical characteristics of the workpieces. For example, every time a new product has to be put into production or whenever an existing product is being modified or needs to be machined in a different way, the clamping devices used must be properly designed, thereby significantly limiting the mobility of FMS flexibility in the short term [1]. In addition, auxiliary times are also large losses, referring to times when no value is added to the workpiece itself. Auxiliary times are, among other things, the tool changing time, the tool presetting time, the time of preparing, clamping, and changing the workpiece, equipment failure, etc. Many new features of the control system or the machine itself have significantly shortened auxiliary time, but none of these features solve the problem of clamping individual workpieces to the machine tool [2].

New product models, new variants of the model, new materials, new processing technology, as well as unexpected internal and external events, require adaptation of the production system's behavior in conditions that are evolving. This need for continuous adaptation, cited by Wiendahl et al. [3] in his work, has been identified with the concept of co-evolution, i.e. shared evolution of different characteristics in the production system. In order to manage co-evolution, change-making factors must be embedded in the production system to support the modification of its structure and capabilities when needed.

One of the biggest turning points in this area is the application of palletization on machining systems. The market trend of reducing the size of the series and increasing product variations entails the need for a large number and types of clamping devices to better utilize the flexibility of the machines, reduce preparatory-finishing time, and increase economic efficiency.

2. AUTOMATIC TOOL AND WORKPIECE CHANGING SYSTEMS

Machine tools are required to possess certain properties that guarantee their effectiveness and quality performance, such as rigidity, process stability, high dynamism, and accuracy. Running machine operations on machine tools can be described in the context of the four-way application of the handling system. In addition to the handling of tools and workpieces, the machining process itself and the machine tool can be in terms of handling criteria. The results of the mutual influence of these four handling tasks are multiple, ranging from impact on the surroundings to positioning [4]. Figure 1 shows the handling systems of the interface for the machine tool, tools, and workpieces, closing the loop of the machining process. An essential component of the

FMS is a system for handling products, i.e. raw and finished products, which must possess the following features [5]:

- allows for self-moving of the workpiece between machine tools, ensuring a greater number of workpiece trajectories and the availability of replacement machine tools if the planned machine tool is occupied.
- enables manipulation of various shapes and configurations of workpieces thanks to the ability to quickly change using standard elements in order to quickly customize the tools for the given workpiece.
- provides temporary storage where at least one workpiece is awaiting processing, thus achieving a high level of exploitation.
- provides convenient access to loading and unloading the workpiece.
- enables compatibility with the computer management system.

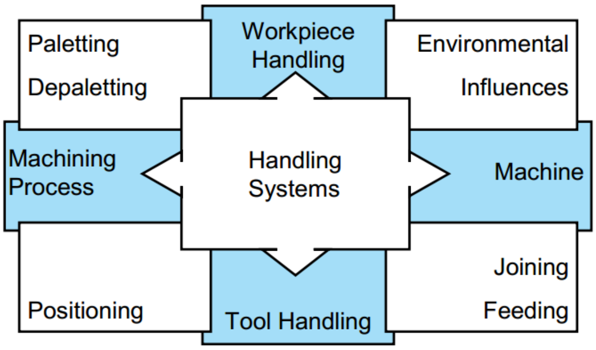

Figure 1 – Handling system [4]

The handling equipment includes various conventional and modern devices and transport systems, and inside the line, various auxiliary mechanisms and industrial robots.

In order to carry out the particle separation process, the cutting tool and workpiece, along with the defined positions and orientation, must be brought to the same position in the machining area of the machine tool. The functions of the devices that perform the task of changing either the cutting tool or the workpiece, according to [2] can be separated into the steps of clamping, changing, and storing a particular tool or workpiece. Finally, during the machining process, the cutting tool and the workpiece must be kept under controlled conditions to ensure the desired quality and efficiency of the process. The basic task of the system for handling tools and workpieces is to bring the workpiece and the tool into the machine tool and finally into contact during machining by separating the particles. At short processing times, the high dynamics of tool or workpiece changes plays a significant role. On the other hand, the importance of the short duration of the auxiliary processes decreases by increasing the processing time, and the importance of process parameters, stability and wear, gains significance.

3. PALLET SYSTEMS

By using pallet system elements, it is possible to significantly reduce the downtime of the machine tool due to the need to change the workpiece. The pallet system performs receiving and positioning the workpiece on the pallet, holding the pallet in the machining area of the machine tool, changing the pallet, and transporting and storing the pallet. Regardless of the manner of pallet changing (manual or automatic), all pallet system elements must be constructed according to modular construction principles and must be mutually substitutable. Characteristics and technical advantages of palletization [6]:

- high repeatability and positioning accuracy (<0.005 mm) of the pallet on the pallet carrier,
- positioning without travel during the machining process,
- a sufficiently good definition of the center of the pallet and the table when it is received on the conveyor or magazine turntable,
- symmetry, to introduce the pallet on both sides,
- without deformation during clamping and small deviations caused by temperature differences,
- high rigidity of the clamping system under the influence of variable forces,
- positioning via a taper pin,
- In addition to clamping, pallets are also used for changing, transporting and storing workpieces.

The following requirements are set before the automated pallet handling:

- as short a time as possible to change the pallet,
- the pallet should be solid and rigid enough for high working accuracy and reliability,
- dimensional flexibility for receiving workpieces of different dimensions and shapes,
- the clamping surface of the pallet should be flat and parallel with the tracks,
- the clamping surface should not be elastically deformed when clamping the raw product,
- manipulation of pallets on machine tools should be simple,
- changing the pallet should be performed automatically, and clamping should be performed reliably by the machine according to the machine program,
- the machine tool should have the capability of receiving and clamping the pallet.

3.1.Pallet systems elements

The basic element of the pallet system is the pallet, clamping elements, changing, taking over, transporting, and storing workpieces. The pallet is an automated movable table that clamps the workpiece, which moves along with the workpiece into or out of the machine tool. Multiple pallets allow for clamping of a workpiece while the machine tool handles another workpiece. The number of workpieces there on the pallet depends on the processing time and the characteristics of the workpiece. It is desirable to keep the pallet as long as possible in the work area of the machine tool, which ensures greater productivity. When time spent per workpiece is short, placing multiple workpieces on one pallet can be considered. This is accomplished by a clamping device which is attached to the pallet, and the workpieces are clamped from the side of the interchangeable clamping device shown in Figure 2.

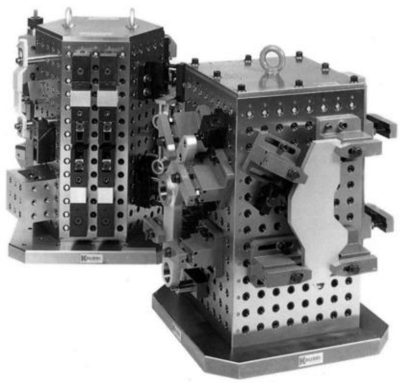

Figure 2 – Pallets with vertical clamping surfaces and interchangeable clamping elements

The pallet connection with the workbench of the machine tool is achieved by moving or fixed reception of the pallet as shown in Figure 3. A standardized interface between the workbench of the machine tool and the pallet, or any clamping device, enables fixed positioning, removal and repositioning without re-calibration. Such a system consists of two parts, the first fixed to the work top of the workbench, and the other attached to the clamping device. The concept of the modularity of the machine tool conceived in such a way provides greater flexibility, positioning and clamping security, shortening the transition time to a new set of workpieces or returning to the previous one with shortening of the auxiliary time and idle operation and prolonging the service lifetime of the machine.

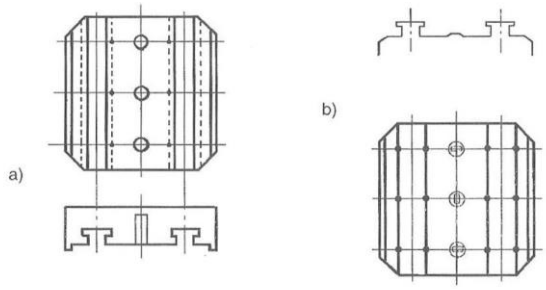

Figure 3 – a) Pallet connection with b) pallet holder [6]

The next element of the pallet system is a reference system consisting of a reference base, i.e. pallet reception and corresponding pallets, which are optionally clamped over the clamp piston. The reference systems serve to quickly and accurately position the pallet on the workbench through receiving the pallet. Reference systems for changing workpieces are most commonly divided according to dimensions and mass of the workpieces. For a given dimension of the pallet, there is a recommended mass and dimension of the workpiece. However, when choosing a reference system, consideration should be given to the material and processing type of the workpiece.

Switching the pallet from the pallet repository to the machining center or the transport system is done by two manipulation tables, a rotating manipulation table with two pallets, a pallet switching device, or directly from the pallet repository, Figure 4. If the workpieces are not large and mass, robots are often used to handle pallets. The pallet repository allows continuous operation of the machining center, flexible machining cells, or flexible machining system, without a server. This enables operation in the third shift and non-working days, significantly increasing the capacity utilization of the system. Pallet repositories can be line, circulating, circular, and oval. On the side of the input station, pallets with raw materials are manually inserted into the pallet repository, and from the machine tools, the pallets with the processed workpieces automatically enter the pallet repository. The transport system can be constructed as a separate system or as part of the pallet repository [6]. The basic division of the system of automatic pallet changing:

- with two manipulation tables placed in front of the machine tool where the change of the pallet is performed automatically by means of a transfer mechanism
- with a rotating table with two pallets where only one serving space is needed. This way, it is possible to achieve a change of the pallet that takes from ten to twenty seconds. This system is also used to fill the pallet repository.
- special manipulators adapted to change the pallets on one or between two machine tools, Figure 4c). This type of manipulator may have a built-in pallet repository.
- open-architecture manipulators that can be adjusted to change pallets between multiple machine tools and repositories. They are suitable for quick system automation and do not take up a lot of workspace.

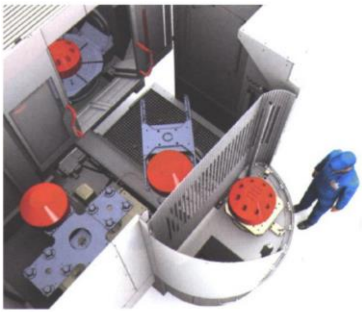


Figure 4 – a) Two-palette manipulation table; b) Paletized FMS for changing pallets between multiple CNC machines and EDM machine

In fully automated machining structures, different pallet repositories are often used. Pallet changing devices and stationary pallet storage stations are integral components of the pallet repository. The transport unit can operate as a separate system or as an integral part of the pallet repository. Circular and oval pallet repositories perform the functions of transporting, storing, and changing pallets. The pallet repository layout is shown in Figure 8. Filling the pallet repository is carried out independently of the work of the machine tool, so it does not affect the processing time. The pallet repository can be modularly executed, most often in combination with a manipulator that performs pallet transport and changing. Apart from the manipulator integrated in the system, it is possible to use an autonomous manipulator that performs the changing of the pallets from the preparation area of pallets and workpieces to the repository within the production system, shown in Figure 9.

3.2.Pallet systems with a defined zero-point

Clamping systems with a defined zero-point, shown in Figure 5, provide accurate and repeated clamping of the workpiece. Using this system, the workpiece can be set up and moved from one machine tool to the other with a minimal waste of clamping and positioning time. Positioning is an important function when placing the workpiece in the exact position on the clamping device. It is also the same when determining the position of the clamping device within the machine tool. Positioning is a defined and machining-specific position of the workpiece in the clamping device or on the work surface of the machine tool [5]. The elements for achieving the correct position of the workpiece in the clamping device are usually the different supports, plugs, pins, cones, prisms, parallel planes, guide rails, etc. A standardized interface between the workbench of the machine tool and the clamping device enables fixed positioning, removal and repositioning without re-calibration. Such systems, shown on Figure 6, consist of two parts, the first fixed to the work top of the workbench, and the other attached to the clamping device.

Figure 5 – Clamping systems with a defined zero-point

The concept of the modularity of the machine tool conceived in such a way provides greater flexibility, positioning and clamping security, shortening the transition time to a new set of workpieces or returning to the previous one with shortening of the auxiliary time and idle operation and prolonging the service life of the machine [4].

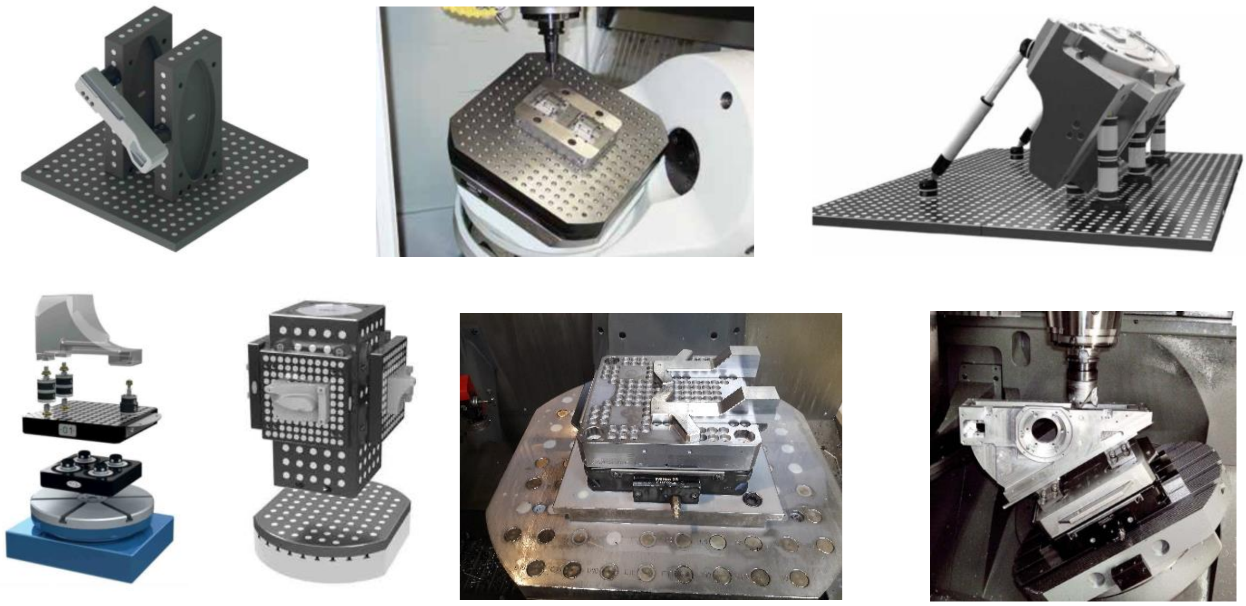

Figure 6 – Examples of the pallet systems with a defined zero-point

4. AUTOMATION OF PALLET SYSTEMS

Pallet system automation achieves shorter preparation times, increased flexibility and product quality, higher productivity, and a faster return on investment. With the pallet system, it is possible to automate the process of changing the workpiece on a single machine tool or between several if the workpiece is to be processed on multiple machine tools. The zero point of the workpiece on all machine tools is defined, without re-clamping or re-positioning the workpiece.

Automation enables the integration of all elements of the pallet system into an IT-linked whole. In addition to the physical elements of the pallet systems, automation requires a system of transferring information on the workpiece between the control units of the machine tools, as well as appropriate program support. The information transfer system consists of two parts: a passive transponder i.e. code carrier, and code reader. The transponder is a wireless communication device that receives and automatically responds to the incoming signal. The passive transponder serves to identify an object using a computer or robot. The passive transponder is used with an active sensor that decodes and transcribes the contents of the transponder. Each palette has a corresponding transponder embedded with its own unique identification code (ID code). It is permanently programmed; the code is unique to each transponder and cannot be erased or changed. The reading of the code is very easily automated by placing the code reader on the robotic hand or manipulator, Figure 7.

Figure 7 – Palette code reading in the pallet repository, using the manipulator

By applying new technologies and connecting the entire production system, it is possible to communicate between and manage all the elements in the production system. The production cell itself, Figure 8a), can be upgraded with accompanying manipulative units or autonomous vehicles, Figure 8b), which contain a pallet manipulator inside, and, upon call, perform the actions necessary for the process to take place without the presence of people. The entire production system's management system coordinates interdependence in the process of manipulation.

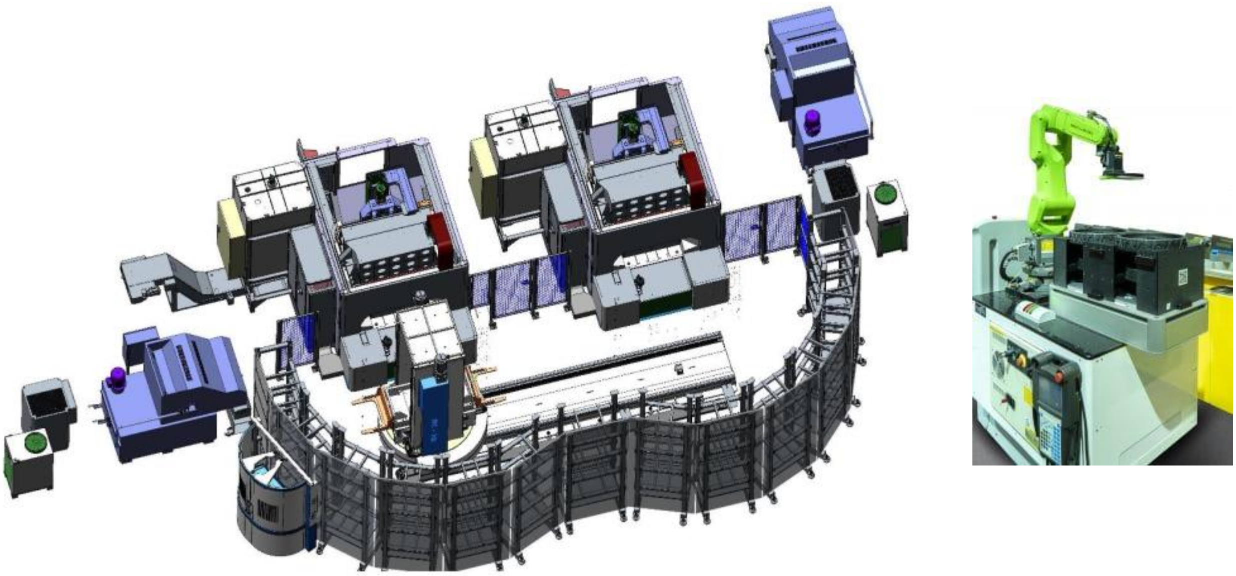

Figure 8 – a) An example of an automated flexible palletized production system with the application of two 5-axis CNC machines and a new interface, b) An example of an autonomous robot for manipulating

5. CONFIGURABLE CONTROL SYSTEMS

Process control in flexible manufacturing systems based on Industry 4.0 principles can be easily configured in today's conditions. Modern control systems are suitable for use with individual machining centers as well as for complex production units or cells. The main functions are to initiate transport procedures with pallets and workpieces, supply control devices with production data (e.g. NC programs, offset data, ...) as well as support for tool data transfer from the preparation area to the cutting tool used in the machine. Intelligent and digital networking systems enable self-organized production. People, machines, systems, logistics and products directly communicate and cooperate with each other through transponders and interfaces. Networking should be organized and optimized not only at one level of the base process, but also throughout the value chain. In addition, all product life cycle phases should be documented and transparent – from idea to development, production, use and maintenance to recycling.

The latest generation of control systems that control and organize the automatic operation of flexible production systems, are the central interface within a flexible automated manufacturing system, shown schematically in Figure 9.

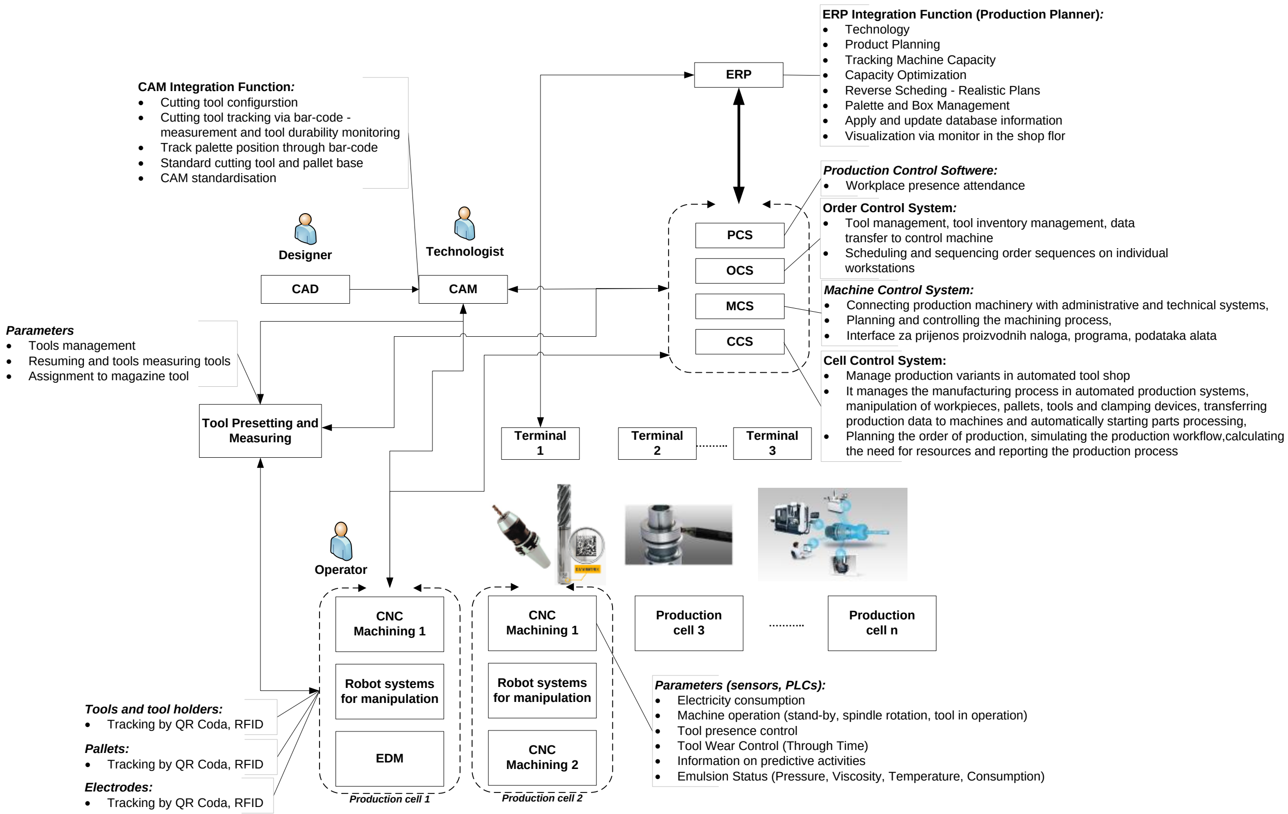

Figure 9 – Representation of the interdependence of the functional elements within the control system

Digitalization of production processes up to active control of automated production systems is the foundation of Industry 4.0. The control systems offer a comprehensive product range ranging from detailed dynamic planning and order control to fully automated service. Control systems are easy to understand and use and are modular in their setup. Organizational processes are presented in a transparent way and lead users to the optimal completion of their production processes, Figure 10.

Control systems are easy to understand and use and are modular in their setup. Organizational processes are presented in a transparent way and lead users to the optimal completion of their production processes. Application-based function modules allow expansion to the required levels that can be customized at any time to new or changing requirements in the context of mass customization. Cell Control System (CCS) represents the latest generation of control systems that control and organize the automatic operation of flexible manufacturing systems. As a central interface within a flexible, automated manufacturing system, the CCS takes over all the tasks that ensure productive operation.

In addition to CCS, Order Control System (OCS) and Management Control System (MCS) complete the range of control elements. The OCS is focused on order flow optimization in conventional, non-automated workplaces and machines. The MCS controls the production processes of the autonomous machine. The three control systems can be combined freely. The benefits achieved in this way are: single operation, the same interface, standardized organization processes, improved machine utilization, and maximum flexibility.

Figure 10 – The control system organizes, controls and visualizes production systems

5.1.Information and process flow

The OCS organizes and controls order flow and the use of tools on machine tools. As a communication element, a desktop computer with a touch screen is used on which the control system is installed. The system is installed on a virtual server. The industrial computer can be used as a station that can be installed near the machine. Communication between the elements of the production system is done through interfaces that facilitate the automatic exchange of production protocols. The following interfaces are integrated:

- exchange of order sequence data with the ERP platform for the transfer of production orders
- transferring NC data from CAM
- exchanging data on tools and pallets with CAM
- exchanging tool data with the tool pre-setting device
- exchanging machine status information – machining centers

Procedures for transmitting information are as follows:

- developing production plans and NC program transfer (CAM, ERP -> Control System),
- NC program transfer (CAM -> Control System),
- queries and delivers basic information on the tool and pallet (Control System -> CAM -> Control System),
- production order transfer (ERP-> Control System),
- tool request (Tool Setup -> Control System -> Tool Setup),
- tool calibration (Tool Setup -> Control System),
- reading and setting tools and pallets on the machine (Control System -> Production System)
- reporting on startup (Control System -> ERP)
- reporting on the completion of processing or completion of works (Control System -> ERP)
- discharging tools from the machine

6. ECONOMIC JUSTIFICATION OF THE PALLET SYSTEM APPLICATION

The goal of every economy in modern industry is to increase the profitability and flexibility of existing equipment. One way to achieve these goals is a greater level of automation and the application of the pallet system. Machine tool is mainly divided into processing that takes up 50% of total time, clamping and positioning 24%, changing workpieces 16%, tool change 7%, and “other” 3% of total time [7]. By applying the pallet system, an effort is made to reduce the time it takes to change, clamp, and position the workpiece, which amounts to a total of 40% of the occupancy of the machine tool. The achieved time savings on handling operations should be used to increase processing time, as only this operation creates added value.

By applying pallet systems, time-savings are achieved in terms of reduced preparation time, because the clamping and positioning process is performed independently of machine operation, so it does not take away from the processing time of the machine tool. Another major reason is the quick and accurate changing of the workpieces using reference systems. For these reasons, the application of pallet systems increases the flexibility of the machine tool. The application of the pallet system allows for a quick transition from one production program to another. Thanks to a shorter processing time, the machine tool has a higher working time potential, which effectively means more products are produced in one working day. By using automatic pallet changing, machine operation is enabled in all three shifts and on weekends and holidays without operator presence. The graph of the savings and benefits of the pallet system is shown in Figure 11.

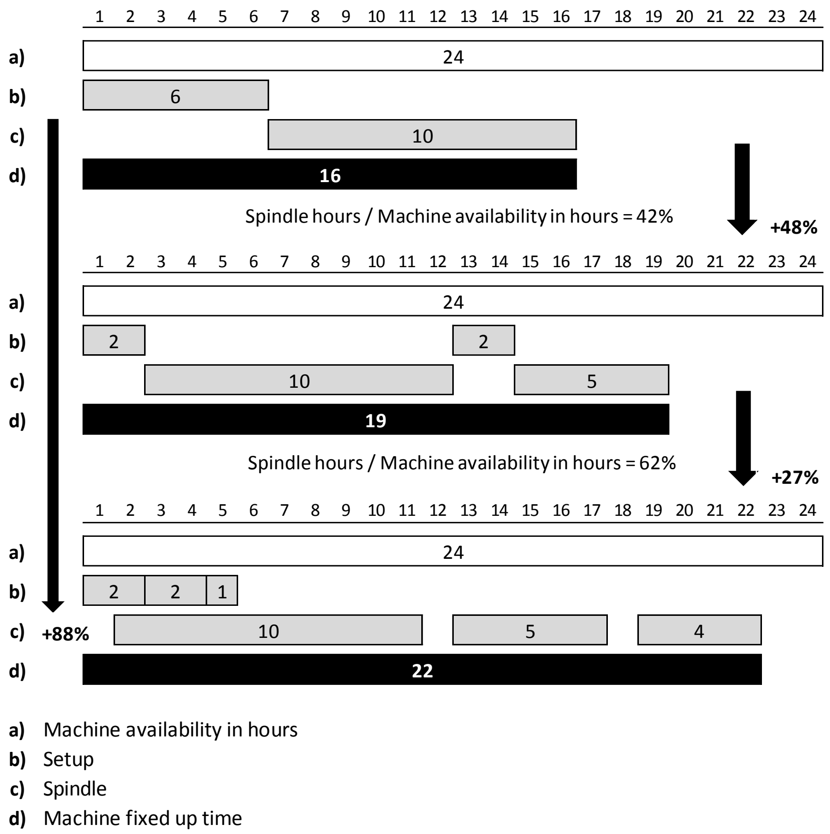

Figure 11 – Achievements and savings achieved by using a pallet system [8]

From Figure 11, three stages can be discerned for better utilization of production time:

Stage 1 – Clamping is a process of finding solutions and improvising that lasts for a long time on the machine's workbench. This means that machine utilization is 42% of the total available time. The time of machine resumption and delay constitutes 60% of the available time. Clamping is far from perfect, and sometimes results in workpiece travel.

Stage 2 – The clamping problem is solved in the CAD-CAM phase according to standard clamping methods. Since there is no improvisation and effort by the operator, the clamping on the workbench of the machine takes a short time. Machine utilization is at 62%, and resumption and delay at 38%.

Stage 3 – The machines are connected in an automatic line by the serving robot. Set-up was made earlier in offline mode. Now, the set-up time does not affect the availability of the machine: the machine is idle only during robot service. Machine utilization is at 80%.

By applying pallet systems for changing workpieces, significant time-savings are achieved in terms of reduced preparation time, primarily because the process of clamping and positioning the workpiece is performed independently of machine operation, so it does not take away from the processing time of the machine tool. Another major reason is the quick and accurate changing of the workpieces using the reference systems. For these reasons, the use of pallet systems increases the flexibility of the machine tool because it allows quick transition from one production program to another. Thanks to a shorter workpiece changing time, the machine tool has a higher working time potential, which effectively means more products are produced in a single time unit. By using automatic pallet changing, machine operation is enabled in all three shifts and on weekends and holidays without operator presence. Using palletization significantly increases the productivity and therefore the profitability of the machine tool. The results show that in the future there is no room for conventional changing of the workpieces, even in individual production. Advantages of automation:

- Organization and process efficiency: standard and proven clamping methods are used,
- Standardization of technology strategies: standard and proven cutting tools are used,
- Optimization of technological procedures: application of standard technological operations in the known sequence,

- All participants in the process are thinking in a way dictated by the process of automation – creativity is focused at the level of 50-80%
- In practice, better use of the machine during night work and on weekends was confirmed, as well as fewer errors and better control over the process.

7. CONCLUSION

The development of pallet systems is constantly increasing the accuracy of positioning and stability of pallet systems, as well as shortening the time of pallet changing. However, the development of pallet or reference systems could go in the direction of application in new industries wherever there is a need for fast and accurate changing of workpieces, but also some tools. Palletization has already been applied to changing tools in electro-erosion processing, but it can be used to change tools in laser processing, for example. Palletization could also be applied to measuring devices for quick and accurate changing of measured samples.

There is room for development in the area of optimizing the way and time of clamping workpieces to pallets, which does not directly contribute to the productivity or profitability of the machine but accelerates and raises the quality of work of people. There is a possibility of developing automation using robots and vision systems. Palletization systems should be a necessary part of each production plant, whether it is serial and mass production or individual and flexible production. In order to optimize the planning and organization within a cell, it is necessary to connect with the ERP system supported by a high level of discipline in the planning and execution of orders. Such systems are being developed and installed in TEH-CUT d.o.o. with the aim of optimizing the utilization of production equipment, achieving competitive prices on the market and engaging young professionals. To work in such systems, human resources capable of controlling complex systems with less physical work are required. Production will be geared to multiple shifts with a high level of system integration. Integration and software become key factors. In order to ensure optimum functioning, it remains to provide high mechanical reliability as the most important element in automation.

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DIGITAL LEAN IN SMART FACTORY

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Abstract

With the appearance of Industry 4.0 and new digital technologies, the ability to reach higher value indicators of business and operational excellence in manufacturing companies was achieved. Management is facing the challenge of choosing a new concept of company's transformation from traditional to smart factory concept. This paper suggests new Digital Lean concept that connects Lean management and digital technology and is applied in a new type of factory, smart factory. Digital technologies add value to traditional Lean tools and thus provide new opportunities to improve operational excellence.

Keywords: lean management, digital technology, smart factory, digital lean

1. INTRODUCTION

Lean management, which emerged in the nineties of the last century, is the world's most well-known strategic methodology applied by business and manufacturing systems to optimize the use of enterprise resources, increase productivity and competitiveness, reduce operating costs, increase employee motivation, and minimize harmful side effects of the work process on environmental process. Companies that implemented Lean's principles and tools in business have achieved over-the-top business results (Toyota, General Electric, LG, Deutsche Telekom, Sony, Allianz, Fiat, Volkswagen, Airbus, Boeing, Nestle, Koncar Energy Transformers, Pliva, Metalind Assa Abloy, Eko Medjimurje, Carel, Phoeinx Pharmacy, Proklima, Klimoprema). As one of the three most important strategic goals for 2020, the European Union has pointed out the organization and management of production and service processes based on the Lean principles and the Green Principles. In its 2010 Strategic Guidelines, the European Commission has set the goal of creating a new industry based on digital technologies, which will be the engine of the new European economy based on knowledge, high efficiency of resource use and low emission of harmful gases and substances. Although Lean management has started to apply in the automotive industry, its application is also found in metal processing and electro-industry, pharmaceuticals, food industry, construction, architecture, banking, education, health and state institutions (ministries, counties, agencies).

Lean Management is based on five main principles: define value, map the value stream, create flow, establish pull and pursue perfection. Successful application of Lean management enables greater productivity, innovation and creativity, reduces business risks, increases sales, reduces operating costs, boosts the culture of continuous improvement and growth.

Industry 4.0 is a new concept introduced for the first time by the Government of Germany at the Hanover Fair in 2011 and a lot of countries in Europe and world has started to apply it. Enterprises that undergo a digital transformation process achieve greater productivity, lower costs, provide to products and services added value (smart and related products and services) and accelerate the implementation of new digital technologies (artificial intelligence, big data, IoT, digital twins, additive technologies, robots, advanced materials ...). While Europe is talking about Industry 4.0, the United States is talking about Industrial internet, in Japan about Industry 5.0 (Super Smart Society) and in China "Made in China 2025" strategy is being implemented. Every country in the world could take advantage of the new industrial evolution, Industry 4.0 and so on.

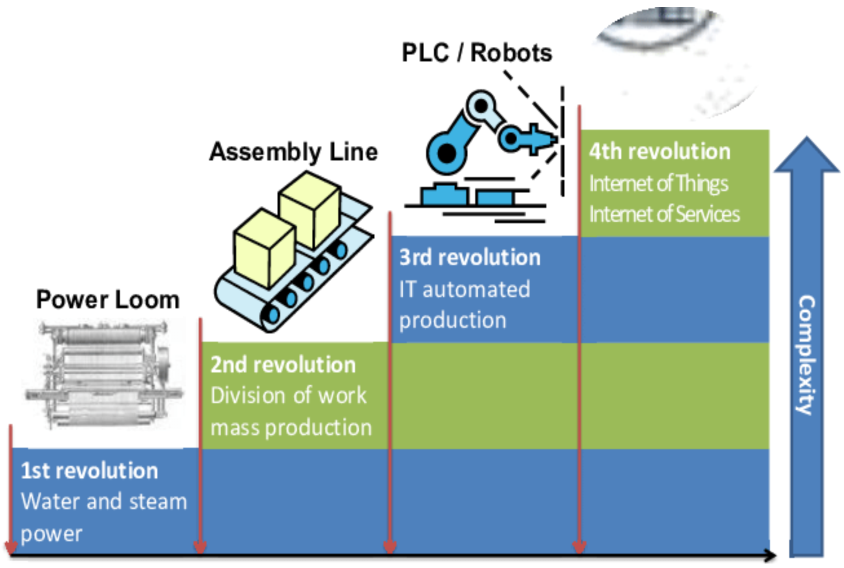

Figure 1: Four Industrial revolutions [1]

2. SMART FACTORY

In the next 2-5 years all industries will experience changes: Auto Industry, Steel Production, Electronic Components and Appliances, Automotive, Pharmaceuticals, Metal Processing Industry, Textile Industry, Medical Equipment Industry, Footwear Industry, ICT Industry, Biotechnology, Construction , architecture, mobile communication, food and beverage manufacturing, mobile phone industry, mobile communications, information technology, health services, logistics services, transportation services. The use of new digital technologies in the industry will lead to new type of factory, smart factories that represent the most important product of Industry 4.0.

Smart Factory is a new kind of factory that combines existing production technology with the latest IT technology that uses sensors, accurate metering, connectivity, data collection and analysis. Sensors and controllers ensure the functioning of a smart factory, contributing to higher product quality and better production results. Smart Factory is a new generation of manufacturing companies that will produce products and provide services needed for the new digital world. They will fundamentally change how the products will be produced and shipped to customers, and in such factories the safety of workers and labor will increase and will ensure environmental protection through low CO2 emissions and less incidents.

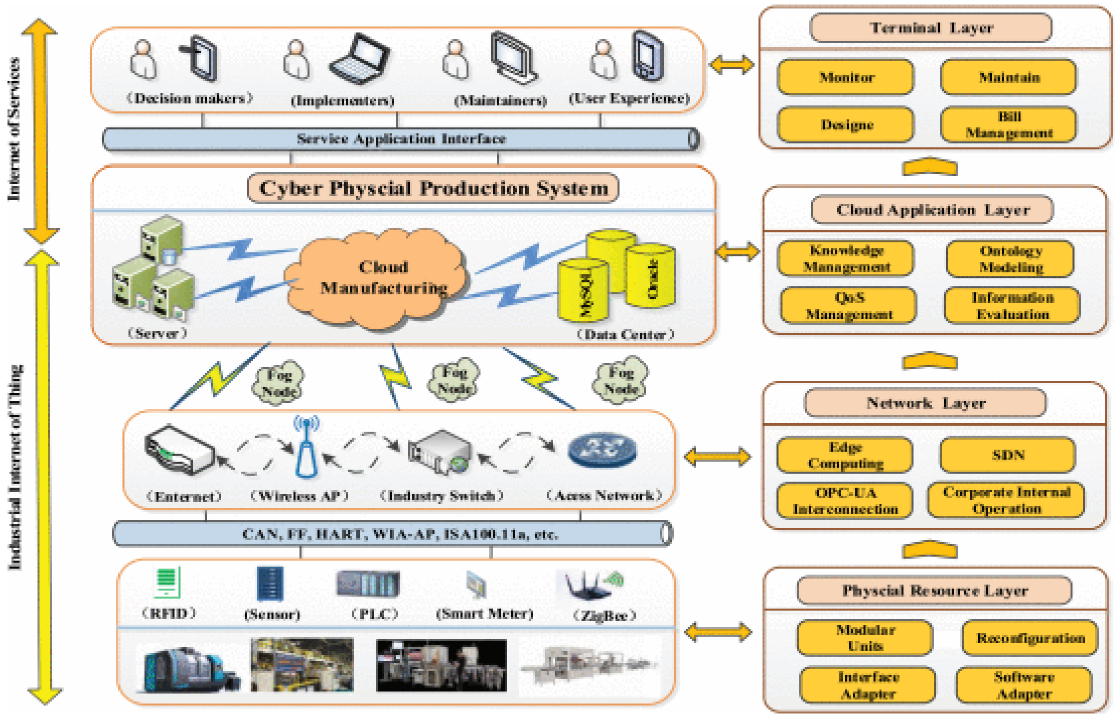

Figure 2: Smart Factory architecture [2]

3. DIGITAL LEAN

Digital Lean is a new concept that represents the synergy of traditional Lean tools (Value Stream Mapping, 5S, Kaizen, Kanban, SMED) and new digital technologies (Artificial intelligence, Big data, Internet of things, Cloud computing, Simulation). This concept could be very successful in the implementation of digital transformation of manufacturing companies whereby digital technologies will increase the efficiency of traditional Lean tools and provide more levels of Key performance indicators. Also, the advantage of Digital Leana is the ability to predict future activities as a result of gathering and analysis large amounts of data during manufacturing processes. On that way, greater availability and reliability of equipment can be ensured through the use of predictive and prescriptive maintenance. Figure 3 illustrates one possible approach to connecting Lean tools and digital technologies using simulations, holistic modeling, and advanced analytics. One of the possible obstacles to the full application of Digital Leana is the lack of experts with the necessary knowledge to simultaneously apply lean tools and digital technologies.

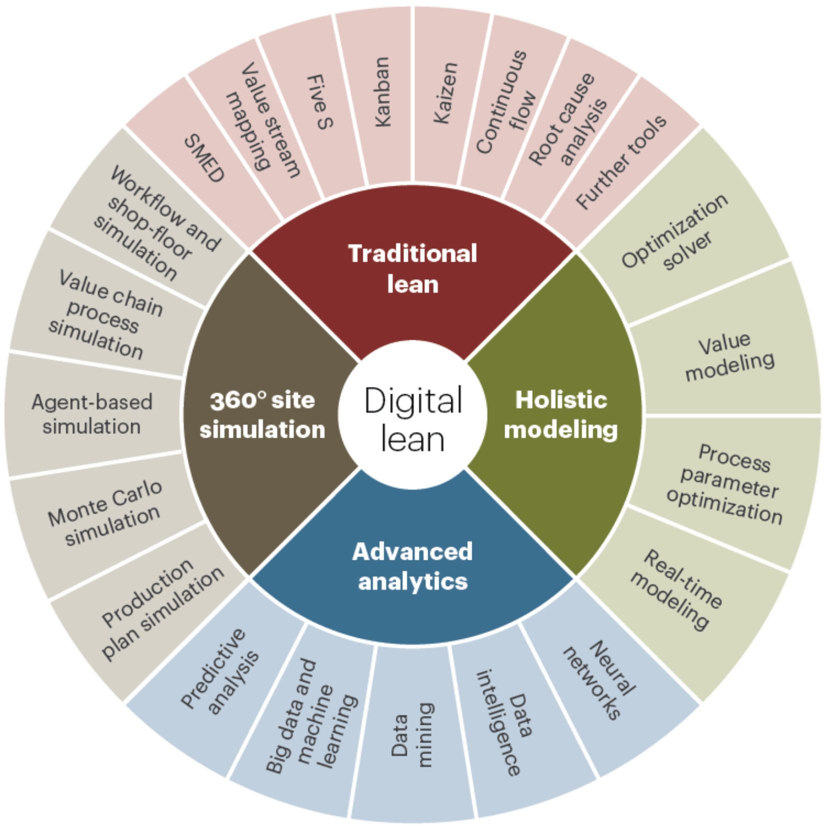

Figure 3: Digital Lean radar [3]

4. CONCLUSION

In the next several years many industries will experience changes: Auto Industry, Steel Production, Electronic Components and Appliances, Automotive, Pharmaceuticals, Metal Processing Industry, Textile Industry, Medical Equipment Industry, Footwear Industry, ICT Industry, Biotechnology and many others. The use of new digital technologies in the industry will lead to new type of factory, smart factories that represent the most important product of Industry 4.0. To make successful digital transformation of traditional company in Smart Factory it is important to apply appropriate methodology. One of the available methodologies is Digital Lean that presents synergy between traditional Lean tools and new digital technologies like Artificial intelligence, Big data, Internet of things, Cloud computing and Simulation. One of the possible obstacles to the full application of Digital Leana is the lack of experts with the necessary knowledge to simultaneously apply lean tools and digital technologies.

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DIGITAL TRANSFORMATION OF INDUSTRY IN CROATIA

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Abstract

Germany initiated "Industry 4.0" to promote its economic development and pursue stronger global competitiveness in 2010. The initiatives, the status quo, and the perspectives on Industry 4.0 in Europe and Croatia are briefly reviewed. First, regarding Croatia, it is stressed that Croatia needs a new strategy, Digitisation Impulse 2020 - industry for the future. Some resultant issues are introduced on the development of Industry 4.0.

Keywords: Industry 4.0, IoT, Global competitiveness, Digitisation Impulse 2020

1. INTRODUCTION

The first three industrial revolutions came about as a result of mechanization, electricity and IT. Now, the introduction of the Internet of Things and Services into the manufacturing environment is ushering in a fourth industrial revolution: Industry 4.0. This new type of industry is based on the Smart Factory model.

The embedded manufacturing systems are vertically networked with business processes within enterprises and horizontally connected to the dispersed value networks. Smart Factories allow individual customer requirements to be met and mean that even one-off items can be manufactured profitably. In Industry 4.0, dynamic business and engineering processes enable last-minute changes to production and deliver the ability to respond flexibly to disruptions and failures on behalf of suppliers, for example. Hence, the main features of Smart Enterprise can be summarized into the following:

- Smart personalized product – requires flexibility and a high level of ICT integration into manufacturing;
- Product and service provider – the ability to offer extended products: product and service integrated into single, or to be a manufacturing service provider;
- High level of collaboration – requires a high level of ICT integration to support collaborative product development and collaborative manufacturing.

In the following sections, the initiatives, the status quo, and the perspectives on Industry 4.0 in Europe and East Asia, especially in Croatia, China, and Japan, are briefly reviewed.

2. DIGITAL TRANSFORMATION OF INDUSTRY IN EUROPE AND CROATIA

The idea about Industry 4.0 originates from German High-Tech strategy in 2006. In 2012, the German government made Industry 4.0 as one of 10 future projects of their High-Tech strategy [1].
Now, the introduction of the Internet of Things and Services into the manufacturing environment is ushering in a fourth industrial revolution – Industry 4.0 [2] (Fig. 1):

- 1st Industrial revolution – the introduction of water-powered and steam-powered mechanical manufacturing facilities.
- 2nd Industrial revolution – the introduction of electrically-powered mass production based on the division of labor
- 3rd Industrial revolution – the introduction of electronics and IT to achieve automation of manufacturing.

- 4th Industrial revolution – the introduction of Internet of Things and Cyber - Physical Systems into the manufacturing environment

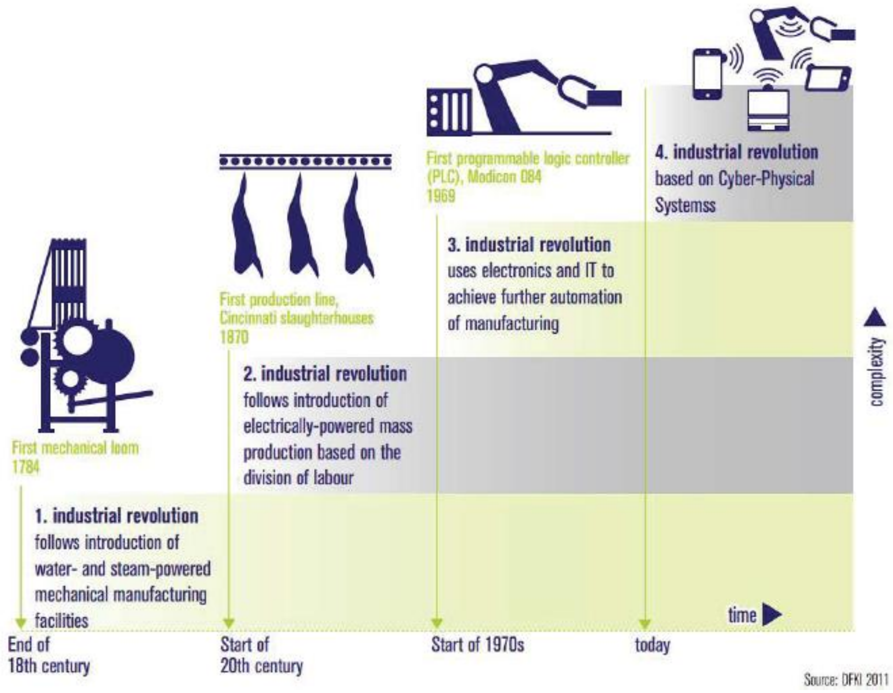

Fig. 1 The four stages of the Industrial Revolution [2]

Every global manufacturer has its unique manufacturing system (Toyota, Daimler, Bosch, etc), and some countries are developing their own unique enterprise model, like Germany – Industry 4.0, Sweden – Production 2030 etc. (Fig. 2) [3]. Models are aligned with their vision, strategy, values and culture.
According to Roland Berger's research, Croatia has a very low index of Industry 4.0 readiness and they belong to the ''hesitators'' country group (Fig. 3) [4]. It means that it is necessary to develop a new strategy that would raise Croatian Industry 4.0 readiness index.

Republic of Croatia hasn't developed its own model of enterprise. The main objective of the INSENT (Innovative Smart Enterprise) project is to develop Croatian model of Innovative Smart Enterprise (HR-ISE model). The aim is to perform model's regional fit, i.e. to harmonize Innovative Smart Enterprise model with specific regional way of thinking, manufacturing and organizational tradition, and specific education.
In order to obtain a maturity level of Croatian industrial enterprises, a specialized methodology has been established. It consisted of a profound literature review, questionnaires and visits with interviews. The literature review was a foundation for the design of questionnaires for Web and for visits (Fig. 4).
Besides the basic questions about the enterprise itself, a set of nine questions was given, that represent the most important aspects of manufacturing as follows: Product Development, Technology, Work Orders Management System, Production Traceability Monitoring, Materials Inventory Management, Stocks of Finished Products Management, Quality Assurance, Product Lifecycle Management, and Application of Toyota Production System and Green and Lean Production Concept. Each answer was converted to a score from 1 to 4 representing one of the four historical industrial generations.

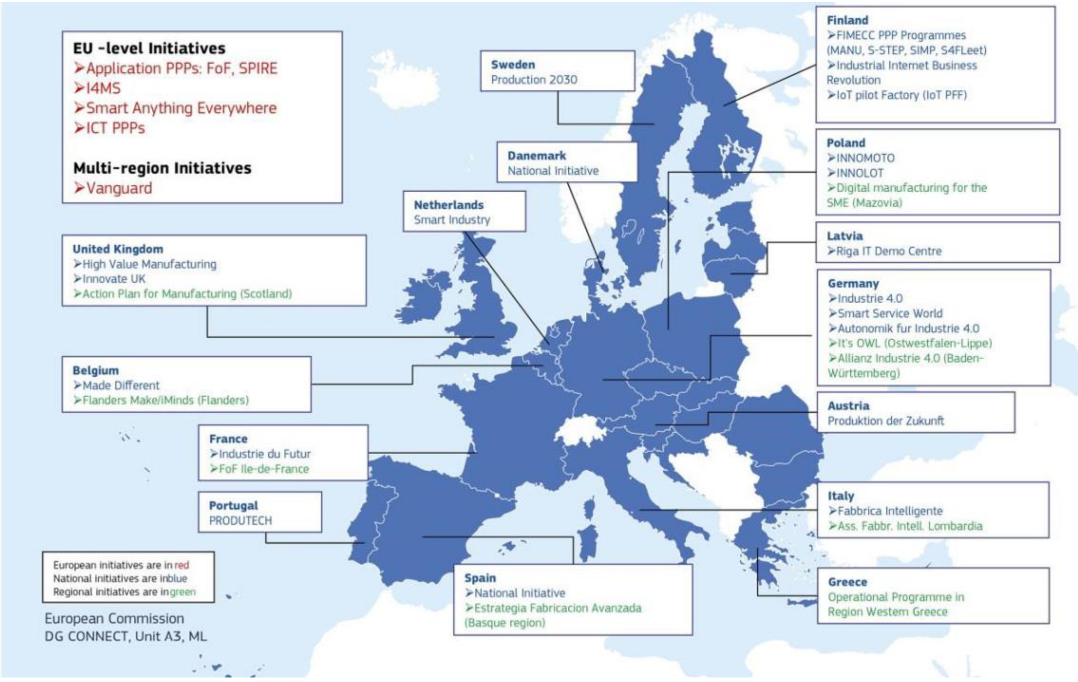

Fig. 2 Digital transformation of industry in Europe [3]

Fig. 3 Relation between industry shape in BDP and readiness of European countries for introduction of Industry 4.0 [4]

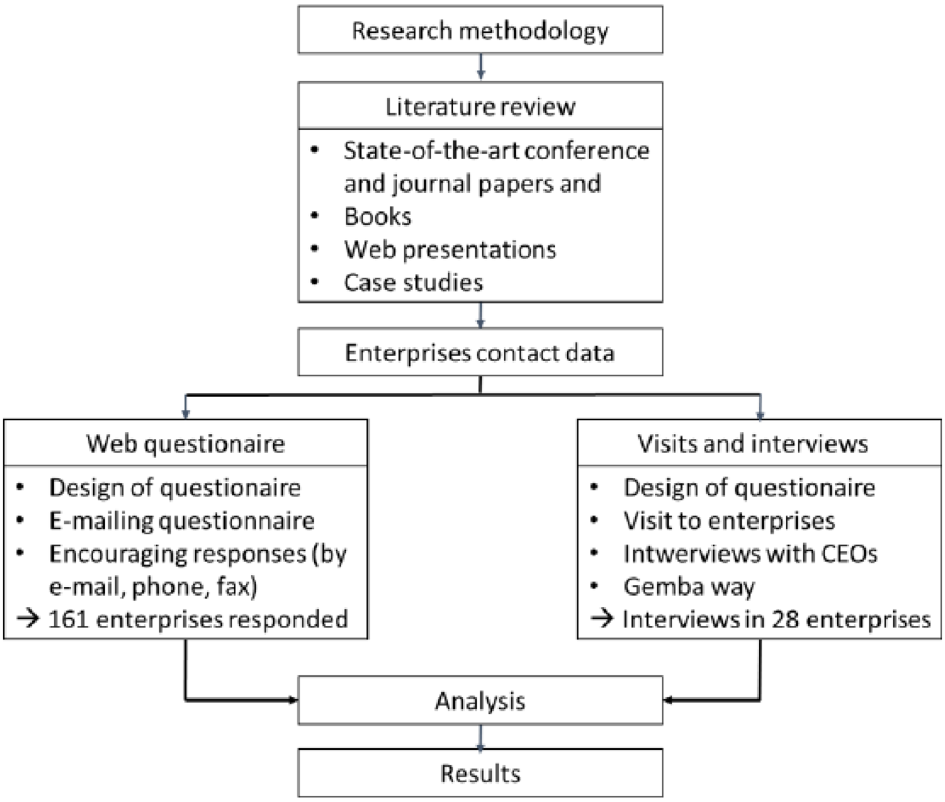

Fig. 4 Methodology for obtaining maturity level of Croatian industrial enterprises [5]

The analysis of the current state of Croatian manufacturing industry with regard to Industry 4.0, shown that Croatia is far away from Industry 4.0. An average industrial maturity level of Croatia was estimated to 2.15 which represent the 2nd industrial generation, i.e. middle of the 20th century [5] (Fig. 5). It means that in Croatian manufacturing practice technology and organizational concepts are still similar to those 50-60 years ago. 3rd industrial generation (automatized production, production robots, etc.) is not mainstream in Croatian manufacturing industry. Less than 30% of enterprises belong to Industry 3.0 according to this research.

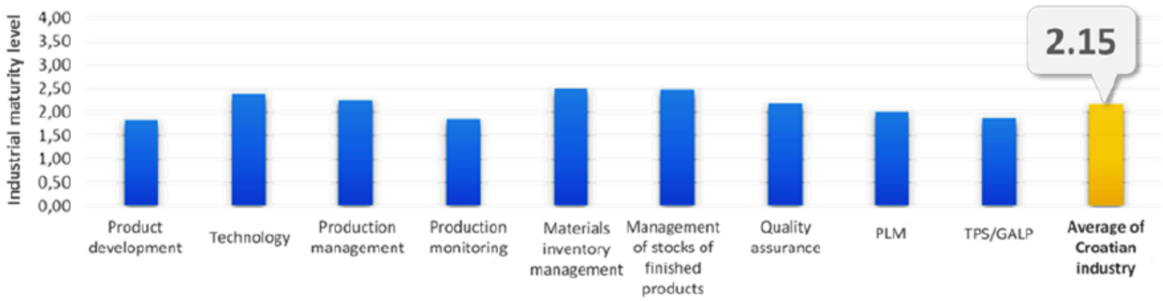

Fig. 5 Level of industrial maturity for specific segment of production and average of entire Croatian industry [5]

The aim is to perform model's regional fit, i.e. to harmonize Innovative Smart Enterprise model with specific regional way of thinking, manufacturing and organizational tradition, specific education, and especially to help Croatian enterprises to bridge the gap between their competencies (Industry 2.0) and EU enterprises' competencies and capabilities (Industry 3.0 moving to Industry 4.0).
The Ministry of Economy and Ministry of Entrepreneurship formed a workgroup in the middle of 2016 for digitization of Croatian industry in order to modernize industry that is based on the concept of Industry 4.0. The project was ordered by the Ministry of Economy and Ministry of Entrepreneurship. The project leader is the Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb.

This concept represents a strategic approach of connecting systems based on Internet technology to establish communication between machines, people, products and business systems. Development of the National

Platform for digitization of industry is part of a European Union project that is called "The digitisation" of European industry.
The working title of Croatian platform is Digitisation Impulse 2020- industry for the future. The main goal is to create smart companies and to digitize business and production processes in order to increase the overall quality, reduce production costs and to increase the flexibility and efficiency of production.
The basic feature of this platform is the Dual strategy: Lean transformation in 5 steps and digital transformation of industry in 7 steps (Fig. 6).

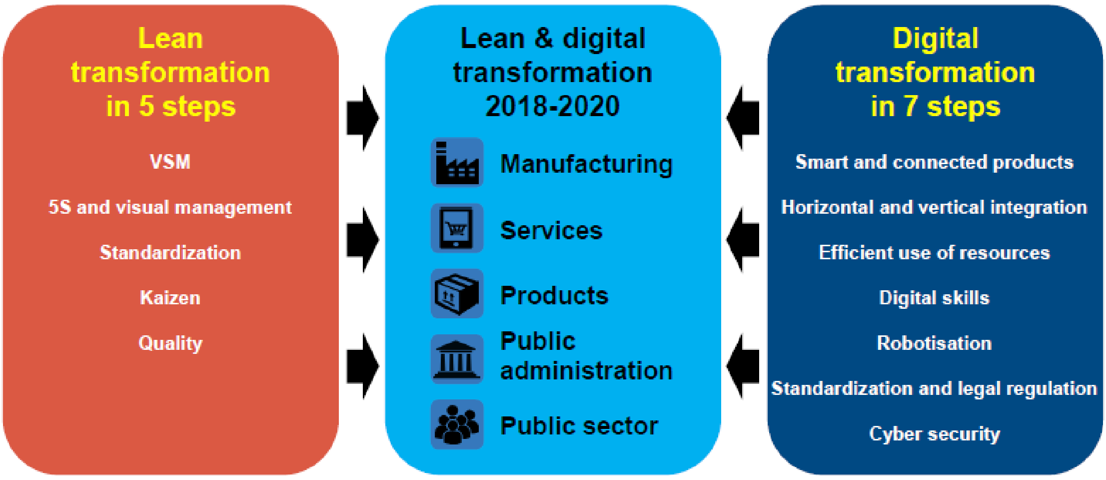

Fig. 6 Dual strategy: Lean and digital transformation of industry [6]

3. CONCLUSIONS

(1) The initiatives, the status quo, and the perspectives on Industry 4.0 in Europe and Croatia, were briefly summarized.
(2) The title and contents related to Industry 4.0 for each country or region vary and are closely related to the governments' industrial strategies. In addition, when the leader of the government of a country changes, the initiative and the associated industrial strategy may change.
(3) It seems necessary for Croatia to develop a new strategy, Digitisation Impulse 2020- industry for the future.

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TOWARDS BALANCED PRODUCTIVITY AND ERGONOMICS IN THE PURSUIT OF LEAN WAREHOUSING

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Abstract

The paper focuses on tactical Lean Warehousing, more precisely on the implementation of rules to carry out manual order picking in a more efficient and safe way into the warehouse organizational model. In manual order picking, humans are routed with picking lists to items' storage locations to retrieve items for orders fulfilment. Warehouse managers suffer from ageing workforce and long and recurrent workers' absences from work due to back and muscle pain. For identical customer order, we can achieve the same order retrieval time with different proportions of overall traveling, searching times and contribution to "daily dose" of cumulative loading on the low back depending on the storage assignment, which means assignment of items to storage/picking locations. No prior work studied the possibility of designing the storage assignment model that would provide improvements in order retrieval time and in structure of required postures. Study includes a laboratory experiment, time study and use of Revised NIOSH Lifting Equation. Final goal is to create a bi-objective assignment model. Preliminary results are presented.

Keywords: lean warehousing, picker-to-parts, order picking, ergonomics, productivity, NIOSH

CONCLUSIONS

No prior work studied the possibility of designing the storage assignment model that would provide improvements in order retrieval time and in structure of required postures. Presented study includes a laboratory experiment, time study and use of Revised NIOSH Lifting Equation in order to contribute to this observed gap. Final goal is to create a bi-objective assignment model. Preliminary results are presented.

The laboratory experiment and time study were needed for creation of picking time model. The results showed that all factors (box size, box weight, shelf position) included in the design of laboratory experiment have significant impact on picking time. The box size has the smallest impact on picking time in comparison to the box weight and shelf position. The characteristics of the worker (age, height, weight) have not got a significant impact on picking time, except that workers over the age of 50 are significantly slower in terms of picking than the group below 50. The differences are larger in cases of large masses and at the highest shelves. The importance of placing the largest and heavier boxes in golden zone is increasing by increasing the number of employees over 45 years of age where is no significant statistical differences between order-picker's age and the picking times [24].

In order to achieve the optimal solution in bi-objective problem it is necessary to model also some kind the ergonomics response surface in the addition to picking time model. In the paper, we present our experiment with the equation of FILI index across the whole experimental area. RNLE was used to calculate the value of the FILI index for the experimental points, which were previously used for the calculation of the picking time model. We researched the possibility to use the regression model of the FILI as an approximation. The main contribution would be to simplify the calculations in multi-criteria experimental optimization. If the FILI of the first task in an order is less than 1.0, than this task is not stressful for the order-picker in terms of strength requirements. Experimental work resulted in conclusion that the FILI index rises significantly when the box weight increases. Thus, there is a minor, but also significant, difference in FILI values across the various shelf positions. In this research phase, our results show that there is an optimal solution where the FILI and picking time is minimal. But the result is not satisfactory and requires further research work. FILI does not consider the contribution of additional lifting or lowering tasks in the case of multi-task process, it is only an indication of an individual activity stress for the worker.

Manual order-picking in general warehouse is multi-task process. Order-pickers are lifting and lowering boxes, which differ in weight, size and position in the rack. Developed picking time model is prepared for use for solving bi-objective problems but we still must improve ergonomics model. From theory or RNLE it is proposed to perform multi-task analysis in which we should use the single task RWL equation and additional indexes to determine the overall cumulative or composite physical demands of following picking tasks. Multi-task analysis is used in lifting operations where weights and heights vary. For each possible picking situation, the Single Task Lifting Index (STLI) must be computed. The STLI is latter used to identify individual tasks with excessive physical demands. If any STLI value exceeds 1.0 then than that specific picking situation should not appear, that specific kind of item should not be assigned to that specific storage location. Further research will seek to calculate the Composite Lifting Index (CLI), which determines the additive effect of several tasks. We see the problem in doing so because in this way we are moving away from the idea of designing the ergonomics response surface to calculating the CLI for all possible variants of retrieving items in storage shelves.

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