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Human-centric approach of the Lean management as an enabler of Industry 5.0 in SMEs

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Abstract: From the very beginning, Industry 4.0 was seen as evolution, more than revolution. So, there is nothing strange about first drafts of Industry 5.0, which are published about 10 years after the first draft of Industry 4.0. Very significant is the European Commission's document about Industry 5.0 which promotes sustainable, human-centric and resilient European industry. The European draft of Industry 5.0 is very much affected by the COVID-19 crisis. It is one of the reasons why human-centric aspect is much more important in the Industry 5.0 than in Industry 4.0. However, there are many open questions and challenges how to implement all these ideas about sustainability, human-centricity and resilience. On the other hand, there is a 40-year-old proven methodology for organization and process improvements based on the human-centric approach – the Lean management. The Lean is based on philosophy of the worker's engagement in process improvement, therefore it seems to be suitable philosophy for human-centricity of Industry 5.0. Particularly for Small and Medium-sized Enterprises (SMEs) who are always struggling to adopt new industrial concepts. In this paper, the key success factors for Lean implementation into SME are selected based on the review of large number of studies, analysis and reviews. These factors are then put in the context of Industry 5.0 to explore the possibilities of Lean managements as an enabler of Industry 5.0.

1. Introduction

1.1. Industry 4.0

In the last 10 years, the further development of the idea and possibilities to integrate Information and Communication Technology (ICT) and the Industrial Internet of Things (IIoT) into production systems [1] introduced some new terms in operations management: Industry 4.0 [2], Smart Factory [3] & Cyber-Physical Production System [4]. For a quick distinction of the plethora of different terminology, a commonly agreed description is as it follows: The technology base making use of ICT is named IIoT. A production system making use of an IIoT technology base may be described as a Cyber-Physical Production System (CPPS), which in an ultimate vision may represent a full integration of value-driving strategies: the Smart Factory. Industry 4.0, however, describes the economic impact of the previously described approaches. As this set of definitions does not follow an official agreement, the notions are occasionally used synonymously.

The term Industry 4.0 was first described in Germany in 2011 [1]. It is used as a synonym for the 4th industrial revolution, which is triggered by the introduction of ICT into production systems. The first three industrial revolutions came about as a result of mechanization through steam-powered machines (1st industrial revolution), mass production based on electrical production lines (2nd industrial revolution), and automation based on microcontrollers and IT (3rd industrial revolution). Industry 4.0 as a new industrial platform is based on the Smart Factory concept [1]: Manufacturing systems are vertically connected to business processes within companies, as well as horizontally embedded in distributed value-adding networks that can be managed in real time. Smart Factories allow individual customer requirements to be met and mean that even one-off items can be manufactured profitably. Hence, the main features of Smart Factory can be summarized into the following: Smart personalized products (with the support of Cyber-Physical Production System [4]), Product and service provider (product and service integrated into single product [5], or manufacturing service provider [6]), and High level of collaboration (collaborative manufacturing [7] and all other value adding processes through production networks [8]).

Furthermore, one of the key elements of Industry 4.0 is Cyber-Physical Production System with following advantages and challenges ([1], [3] and [9]):

- *Smart products* – product which fits the customer's exact needs and which is uniquely identifiable, may be located at all times and knows

its own history, current status and alternative routes to achieving customer.
- *Single-item production* – CPPS should help plan and control of the single-item products, and make it as much economical as serial mass production.
- *Production without rigid plans* – CPPS should manage production without rigid plans, since it is needs to manage production of single-item products.
- *Energy-efficiency* – CPPS represents a backbone for more energy-efficient manufacturing and decisions that results with environmental-friendly solutions.
- *Cyber Security* – CPPS and its computer cloud should be more secure from hacker attacks than IT systems of today, since it is a most weak point of the CPPS.
- *Production networks* – collaborative product development, collaborative manufacturing and all other value adding processes supported by mutually networked CPPSs.

1.2. Industry 5.0

Although the new industrial platform – Industry 4.0 – had a significant impact on research community and became one of the most trending topics in last 5 years, the COVID-19 pandemic caused the breaking of global value chains and forced the rethinking of the world manufacturing paradigms [10]. The resilience of the manufacturing system with people as it most valuable, yet very vulnerable part, became important focuses of the new paradigms. In 2020, European Commission's workshop on Industry 4.0 and its new challenges [11], has resulted with completely new paradigm [12]: "Industry 5.0 – Towards a sustainable, human-centric and resilient European industry".

From the very beginning, Industry 4.0 was seen as evolution, more than revolution. So, this change toward Industry 5.0 was expected in the near future, but, due to COVID-19 pandemic, it came sooner. The main change in Industry 5.0 is the focus on its three core elements presented in Figure 1.

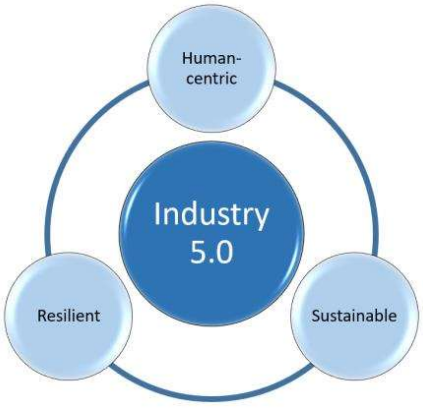

Figure 1. Industry 5.0 with three core elements [12]

These core elements should re-found and widen purposefulness of industry, beyond producing goods and services for profit, through [12]:
- *Human-centric approach* – putting human needs and interests at the heart of production process, by sub-ordering and adapting technology to humans, not vice versa.
- *Sustainability* – development of circular processes that re-use, re-purpose and recycle natural resources, to ensure the needs of today's generation, without jeopardizing the needs of future generations.
- *Resilience* – development of higher degree of robustness in industrial production to become resilient for disruptions in global value and supply chains.

It is important to note that Industry 5.0 is the evolution of Industry 4.0. At the beginning, the idea was to have some kind of a "patch" for Industry 4.0 called "Industry 4.1" or similar [11]. The aim was to address some issues like the problem of techno-centric approach of Industry 4.0, concern about the future of shop-floor workers with further automation, etc. However, COVID-19 pandemic occurred and the "patch" grew into the "upgrade" of European industrial paradigm. With Industry 5.0, the industry is seen not just as another sector in economy, but it is seen as a power able to achieve societal goals beyond jobs and growth, to become a resilient provider of prosperity [11].

The Industry 5.0 with its three core elements opens enormous research perspective, and that is the one of its ideas: to promote research and innovation. In this paper, the focus is limited on research about using proven human-centric methodologies, like Lean management, as an enabler of Industry 5.0 in SMEs.

1.3. Lean management

For more than 40 years, Lean management (also known as Lean production, Lean thinking, Lean philosophy, or, simply, Lean) has been on the scene, making all other business improvement approaches outlasted and becoming the most successful approach to business improvement [13]. Lean was born in Toyota in Japan in 1970s and 1980s, but it become world-wide known in 1990s [15].

Lean represents a complete system for management, production planning and control, and continuous improvement of the business processes and whole organization. So, it is clear that Lean is more than a set of methods or toolbox, it is a philosophy and a way of thinking [14]. The main aspects on which Lean focuses are customer, value stream, continuous improvement, and employees' education. Therefore, Lean philosophy is reflected within:

1) System thinking;
2) Value for the customer;
3) Waste elimination;
4) Lead time reduction;

5) Respect for people;
6) Continuous improvement.

Lean is seen as a continuous improvement approach that has spread across almost all type of industries and businesses [16]. But, there is no universal approach, or the best way, to implement Lean [14]. Each enterprise needs to find its own way on a journey toward Lean organization. A whole set of Lean tools and methods are available as a support on that journey.

Although there are many Lean principles, methods and tools, some of them become unavoidable terms in operations management: Just-In-Time, Value Stream Mapping, Kaizen, Jidoka, 5S, etc. Interesting fact is that many of these Lean tools use only pencil and A3 sheet of paper to identify problems and design improvements, and that is the one of the main advantages of Lean approach.

Since Lean is focused on process identification, process measuring and improvement, it is seen by many researchers as a kind of pre-requisition for Industry 4.0 ([17] and [18]). Because, it is not possible to "digitalize" production process without knowing it and measuring it.

Furthermore, Lean has a human-centric approach that puts people in the center of the model, as it can be seen on the well-known model of Toyota Production System (Figure 2) and on HR-ISE (Croatian model of Innovative Smart Enterprise [19]) model (Figure 3).

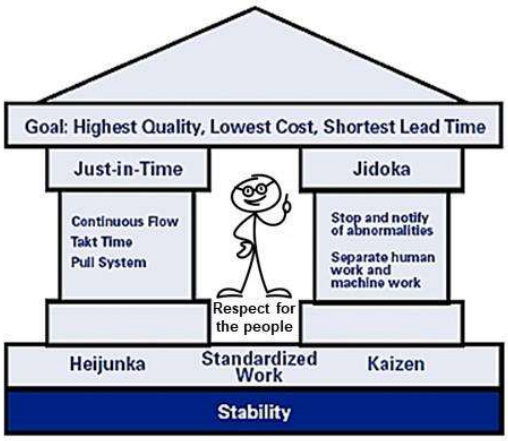

Figure 2. People in the center of model of Toyota Production System

This human-centric approach of the Lean management, i.e. its philosophy of the people engagement in process improvement from shop-floor workers to managers, seems like an excellent perspective for human-centricity of Industry 5.0. This fact has been taken for a base of this research.

Figure 3. People in the center of HR-ISE model – Croatian model of Innovative Smart Enterprise [19]

2. Key success factors of Lean implementation in SMEs

2.1. Methodology

SMEs do not acquire new cutting-edge technologies and modern organizational approaches with ease [20]. Very often, SMEs are hesitators [20], so both, Industry 4.0 and Lean management, are not easily accepted by them.

The problem is that implementation of new technology or organizational approach has exploration phase in which the benefits are not so visible [21]. The enterprise needs to force the implementation until the exploitation phase with high benefits occur [21], but it is not an easy task.

Therefore, a review of large number of studies, analysis and reviews (35 in total) has been made to identify key success factors of Lean implementation is SMEs (Table 1). Most of them are scientific papers, but there are also professional reports and white papers. The focus has been put on key success factors of Lean implementation, but the usage of the Lean tools in SMEs has been investigated as well.

Table 1. Studies, analysis and reviews of key success factors of Lean management and Lean tools implementations in SMEs

No.	*Study / Analysis / Review*	*Key success factors*	*Lean tools*
1)	Achanga P., Essam S., Roy R., Nelder G. (2006). Critical success factors for lean implementation within SMEs. Journal of Manufacturing Technology Management 17 (4).	X	
2)	Hu Q., Mason R., Williams S.J., Found P. (2015). Lean implementation within SMEs: A literature review. Journal of Manufacturing Technology Management 26 (7).	X	

No.	*Study / Analysis / Review*	*Key success factors*	*Lean tools*
3)	Rose A.M.N., Deros B.Md., Rahman M.N.Ab., Nordin, N. (2011). Lean manufacturing best practices in SMEs. Proceedings of the 2011 International Conference on Industrial Engineering and Operations Management, Kuala Lumpur, Malaysia.	X	X
4)	Bakås O., Govaert T., Van Landeghem H. (2011). Challenges and success factors for implementation of Lean manufacturing in european SMEs. MITIP 2011 - Norwegian University of Science and Technology, Trondheim, Norway.	X	
5)	Pearce A., Pons D., Neitzert T. (2018). Implementing lean - Outcomes from SME case studies. Operations Research Perspectives 5.	X	X
6)	AlManei M., Salonitis K., Xu, Y. (2017). Lean Implementation Frameworks: The Challenges for SMEs. Procedia CIRP 63.	X	
7)	Antosz K., Stadnicka D. (2017). Lean Philosophy Implementation in SMEs – Study Results. Procedia Engineering 182.	X	X
8)	Ulewicz R., Kucęba R. (2016). Identification of problems of implementation of Lean concept in the SME sector. Engineering Management in Production and Services 8 (1).	X	
9)	Mirzaei P. (2011). Lean production: introduction and implementation barriers with SMEs in Sweden. Master Thesis, Jönköping University, Sweden.	X	
10)	Kundu G., Manohar B.M. (2012). Critical success factors for implementing lean practices in IT support services. International Journal for Quality research 6 (4).	X	
11)	Noori B. (2015). The critical success factors for successful lean implementation in hospitals. International Journal of Productivity and Quality Management 15 (1).	X	
12)	Seppänen O., González V.A., Arroyo P. (2015). Global Problems - Global Solutions. IGLC 2015, Perth, Australia.	X	
13)	Ainul Azyan Z.H., Pulakanam V., Pons D.J. (2017). Success factors and barriers to implementing lean in the printing industry: A case study and theoretical framework. Journal of Manufacturing Technology Management 28.	X	X
14)	Vermaak T.D. (2008). Critical Success Factors for the Implementation of Lean Thinking in South African Manufacturing Organizations. Doctoral Thesis, South Africa.	X	
15)	Knol W.H., Slomp J., Schouteten R.L.J., Lauche K. (2018). Implementing lean practices in manufacturing SMEs: testing 'critical success factors' using Necessary Condition Analysis. International Journal of Production Research 56 (11).	X	
16)	Alhuraish I., Robledo C., Kobi A. (2014). Key Success Factors of Implementing Lean Manufacturing and Six Sigma. Excellence in Services, Liverpool, UK.	X	
17)	Ward S.A. (2015). Critical Success Factors for Lean Construction Intervention. Doctoral Thesis, University of Dundee, UK.	X	
18)	Belhadi A., Touriki F.E., El Fezazi S. 2016. A Framework for Effective Implementation of Lean Production in Small and Medium-Sized Enterprises. Journal of Industrial Engineering and Management 9 (3).	X	X
19)	Alefari M., Salonitis K., Xu Y. (2017). The Role of Leadership in Implementing Lean Manufacturing. Procedia CIRP 63.	X	
20)	Desai T.N. (2016). Review of lean manufacturing practices – critical success factors and performance measures for SMEs. International Journal of Quality and Innovation 3 (1).	X	
21)	Krichbaum B.D. (2007). Lean Success Factors: 10 Lessons from Lean: White paper, Process Coaching Inc., USA.	X	
22)	Nasrollahzadeh T., Marsono A.K., Masine, M. (2016). Critical Success Factor for Industrialized Building System Process ProtocolMap by Lean Construction management. Journal of Civil and Environmental Engineering 2016.	X	
23)	Minh N., Nguyên N., Tuấn, L. (2015). Framework of Critical Success Factors for Lean Implementation in Vietnam Manufacturing Enterprises. VNU Journal Of Science: Economics And Business, 31 (5E).	X	
24)	Kobus J., Westner M., Strahringer S., Strode D. (2018). Lean Management in IT Organizations: A Ranking-type Delphi Study of Implementation Success Factors. JITTA 19.	X	
25)	Chelangat B. (2016). Critical Success Factors (CSFs) For Implementation of Lean Six Sigma in Commercial Banks in Kenya. IOSR Journal of Business and Management 18 (12).	X	
26)	Albliwi S., Antony J. (2013). Implementation of a lean six sigma approach in the manufacturing sector: a systematic literature review. Proceedings of the 11th International Conference on Manufacturing Research, Cranfield University, UK.	X	
27)	Maleyeff J. (2007). Improving Service Delivery in Government with Lean Six Sigma. Report, IBM Center for The Business of Government, USA.	X	
28)	Salonitis K., Tsinopoulos C. (2016). Drivers and Barriers of Lean Implementation in the Greek Manufacturing Sector. Procedia CIRP 57.	X	X
29)	Sieckmann F., Ngoc H.N., Helm R., Kohl H. (2018). Implementation of lean production systems in small and medium-sized pharmaceutical enterprises. Procedia Manufacturing 21.	X	

No.	*Study / Analysis / Review*	*Key success factors*	*Lean tools*
30)	Baviskar P. (2015). Critical Success Factors For Effective Implementation Of Lean Assessment Tools/ Framework In Manufacturing Industries. Master Thesis, KTH, School of Industrial Engineering and Management, Sweden.	X	
31)	Mishra R.P, Chakraborty A. (2014). Strengths, weaknesses, opportunities and threats analysis of lean implementation frameworks. International Journal of Lean Enterprise Research 1 (2).	X	
32)	Kumar M., Antony J., Singh R.K., Tiwari M.K., Perry D. (2006). Implementing the Lean Sigma framework in an Indian SME: a case study. The Management of Operations 17 (4).		X
33)	Saboo A., Garza-Reyes J.A., Er A., Kumar V. (2014). A VSM improvement-based approach for lean operations in an Indian manufacturing SME. International Journal of Lean Enterprise Research 1 (1).		X
34)	Miina A. (2013). Critical Success Factors of Lean Thinking Implementation in Estonian Manufacturing Companies. Doctoral Thesis, Tallinn University of Technology, Estonia.		X
35)	Matt D.T., Rauch E. (2013). Implementation of Lean Production in small sized Enterprises. Procedia CIRP 12.		X

The data used in this research is gathered from 35 sources (Table 1) of which 31 have identified key success factors of Lean implementation and 10 have identified usage of Lean tools in SMEs. The most common success factors with their importance, and the most common Lean tools have been identified.

2.2. Results

The distribution of most important success factors for Lean implementation in SMEs is presented in Figure 4. The data are from 31 different sources involving several hundred SMEs from all around world.

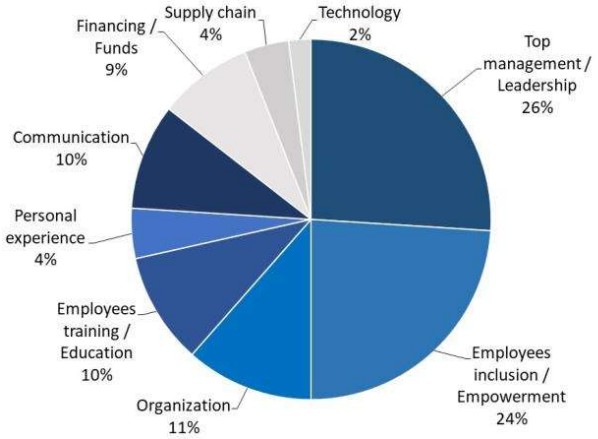

Figure 4. Key success factors of Lean implementation in SMEs and their relative importance

Most of the analyzed researches have evaluated the importance of each success factor, and for the rest of the researches the importance was approximated. Therefore the relative importance represents mean value of 31 inputs. The analysis has shown:

- *Most of the factors are related to people*: Top management / Leadership, Employees inclusion / Empowerment, Organization, Employees training / Education, Personal experience, and Communication. In total, they count for 6 out of 9 key success factors, but they also count for 85% of importance for success!
- *The remaining factors are*: Financing / Funds, Supply chain, and Technology. In total, they count for 3 out of 9 key success factors, but they also count for only 15% of importance for success.

The results are very intriguing, because SMEs are usually not satisfied with their technology level and insufficient funds, but in the case of Lean management, these factors are not important.

Regarding the most common Lean tools in SMEs, the data from 10 different sources, involving dozens of SMEs, have shown what Lean tools are most often implemented in SME (Figure 5).

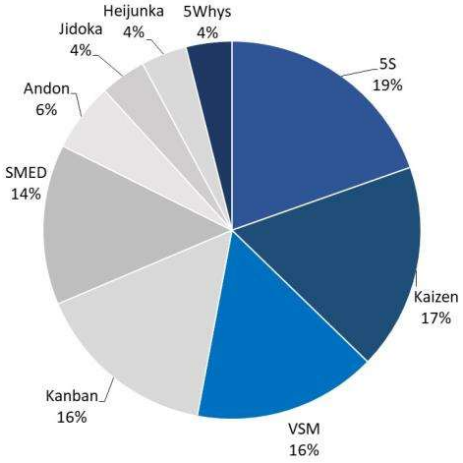

Figure 5. The most common Lean tools implemented in SMEs

Again, the most common tools are people oriented: 5S, Kaizen, VSM, and 5Whys. They count for 4 out of 9 most common tools, but they also count for 56% of the most common tools. Other tools (Kanban, SMED, Andon, Jidoka, and Heijunka), beside employees engagment, also require the purchase of some equipment or tehncology. While 4 most common tools require nothing but a pencil and A3 sheet of paper to identify problems and design improvements.

3. Discussion on Lean as Industry 5.0 enabler

Although the process awareness of the Lean management was seen as a kind of pre-requisition for Industry 4.0, the interest for Lean and organizational changes was

overtaken by the technology-push strategy of the Industry 4.0. However, with Industry 5.0 the human-centric approach is restored with important premise [12]: "rather than asking what we can do with new technology, we ask what the technology can do for us".

Therefore, the Lean management can be seen as one of the enablers of Industry 5.0. First of all, the Lean philosophy has a human-centric approach which cares not just about employees, but also about customers. Second, the Lean approaches are the system thinking and the lead time reduction, which can result with more resilient production process and supply chain which is capable to sustain different kind of crisis. At last, the Lean aims are waste elimination (no over production, scrap reduction, etc) and continuous improvement of the processes, which ultimately lead toward sustainable production without threatening the environment and socio-economic stability. This relationship between Lean and Industry 5.0 has been presented in Figure 6, as a proposal and conclusion of this research.

Figure 6. The relationship between Industry 5.0 and Lean philosophy with identified key success factors of Lean implementation in SMEs

4. Conclusion

This research has shown that a 40-year-old proven methodology for organization and process improvements based on the human-centric approach – the Lean management – shows potential to be one of enablers of the Industry 5.0 in SMEs. The analysis of key success factors of Lean management and Lean tools implementations in SMEs has shown that most of the success factors and tools are people oriented, thus giving the human-centric approach to the organizational and process improvement, as required by Industry 5.0.

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Research group for Industrial Engineering (IE)

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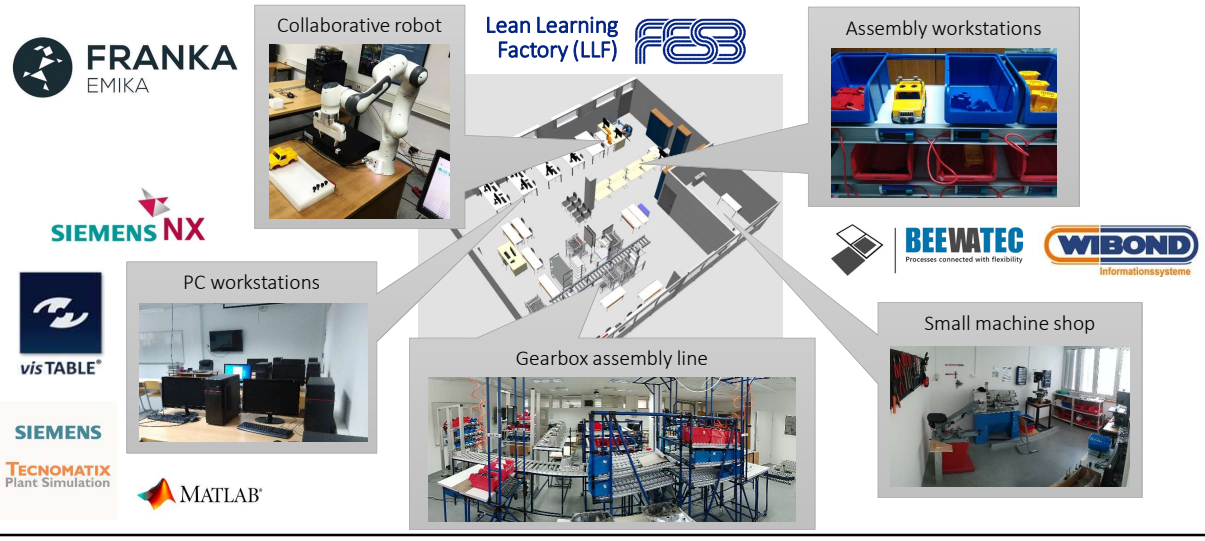
- **Laboratory for IE organized as a Learning Factory**: Lean Learning Factory at FESB (member of the International Association of Learning Factories)
- **Research interests**: Industry 4.0/5.0, cyber-physical systems, decision support systems, collaborative robotics, Lean management, cognitive systems, multi-criteria decision-making, multi-objective optimization, simulation, etc.

Research group for IE – Learning Factory



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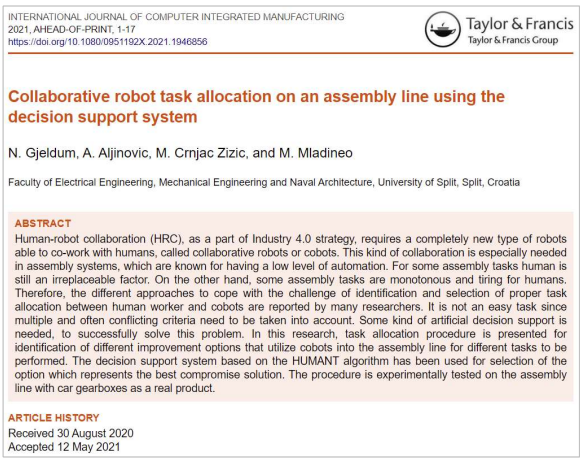

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Collaborative robot task allocation on an assembly line using the decision support system

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ABSTRACT

Human-robot collaboration (HRC), as a part of Industry 4.0 strategy, requires a completely new type of robots able to co-work with humans, called collaborative robots or cobots. This kind of collaboration is especially needed in assembly systems, which are known for having a low level of automation. For some assembly tasks human is still an irreplaceable factor. On the other hand, some assembly tasks are monotonous and tiring for humans. Therefore, the different approaches to cope with the challenge of identification and selection of proper task allocation between human worker and cobots are reported by many researchers. It is not an easy task since multiple and often conflicting criteria need to be taken into account. Some kind of artificial decision support is needed, to successfully solve this problem. In this research, task allocation procedure is presented for identification of different improvement options that utilize cobots into the assembly line for different tasks to be performed. The decision support system based on the HUMANT algorithm has been used for selection of the option which represents the best compromise solution. The procedure is experimentally tested on the assembly line with car gearboxes as a real product.

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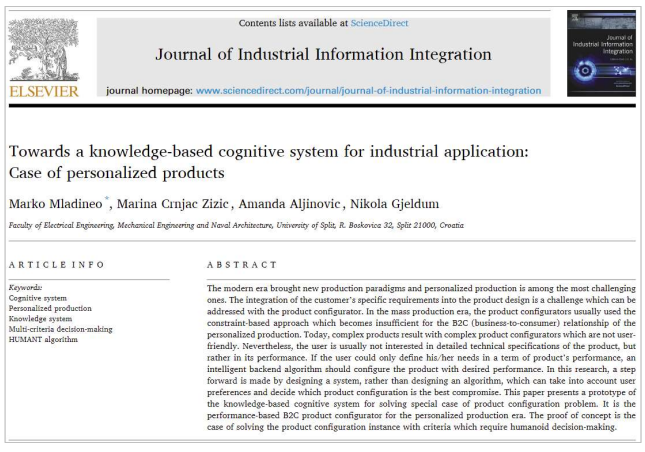

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ELSEVIER

Towards a knowledge-based cognitive system for industrial application: Case of personalized products

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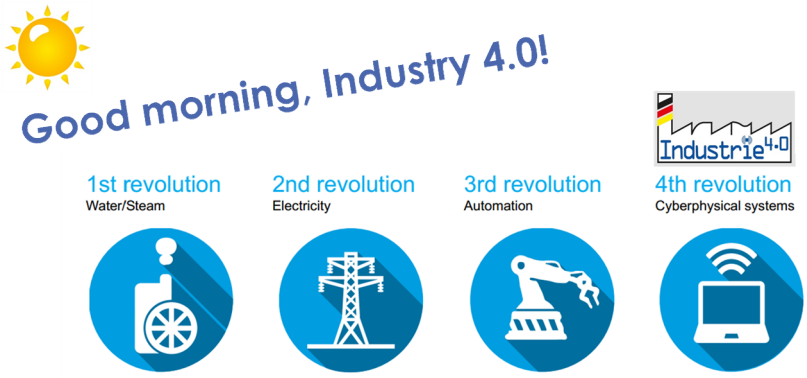
HUMANT algorithm

ABSTRACT

The modern era brought new production paradigms and personalized production is among the most challenging ones. The integration of the customer's specific requirements into the product design is a challenge which can be addressed with the product configurator. In the mass production era, the product configurators usually used the constraint-based approach which becomes insufficient for the B2C (business-to-consumer) relationship of the personalized production. Today, complex products result with complex product configurators which are not user-friendly. Nevertheless, the user is usually not interested in detailed technical specifications of the product, but rather in its performance. If the user could only define his/her needs in a term of product's performance, an intelligent backend algorithm should configure the product with desired performance. In this research, a step forward is made by designing a system, rather than designing an algorithm, which can take into account user preferences and decide which product configuration is the best compromise. This paper presents a prototype of the knowledge-based cognitive system for solving special case of product configuration problem. It is the performance-based B2C product configurator for the personalized production era. The proof of concept is the case of solving the product configuration instance with criteria which require humanoid decision-making.

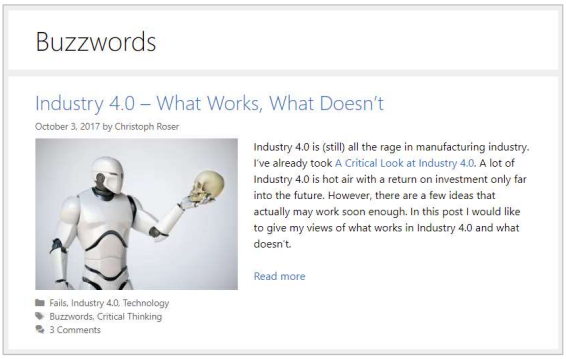
Introduction – Industry 4.0

- It all started in Germany with strategic document: Industrie~~revolution~~ 4.0
- It was a **technology-push** strategy



Introduction – Industry 4.0

- From the very beginning there were many critics of Industry 4.0
- Is it just a 'buzzword'? Or a good PR story?



Introduction – Industry 4.0

- The real reason for such a technology-push was the post global economic crisis reality: **the manufacturing in Europe is not longer sustainable!**
- Some countries have accepted this destiny …

Croatian industrial strategy (2014)

Main aim of the strategy:

"Repositioning of the strategic activities in global value chain toward high value adding activities (**from manufacturing activities toward pre-manufacturing and post-manufacturing activities: design, R&D, marketing, etc.**)"

In other words:
"Shut down the industry!"

Introduction – Industry 4.0

- … but, Germans have found the way **how to achieve that manufacturing in Europe becomes sustainable with competitive advantage**:

German industrial strategy (2013)

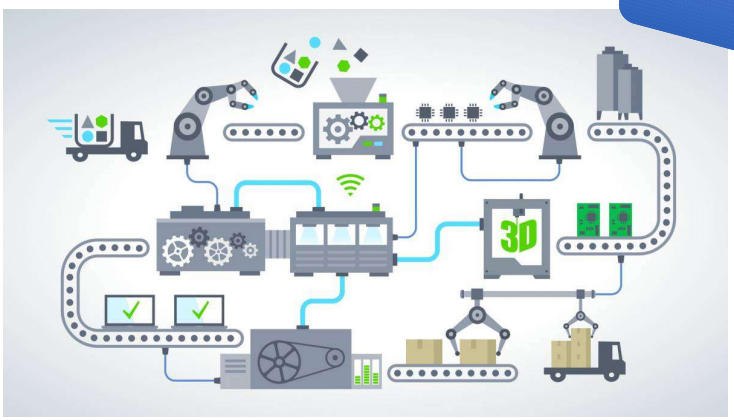
Main aim of the strategy:

"Germany's strong machinery and plant manufacturing industry, its globally significant level of IT competences and its know-how in embedded systems and automation engineering mean that it is extremely well placed **to develop its position as a leader in the manufacturing engineering industry.**"

"Germany is thus uniquely positioned to tap into the potential of a new type of industrialisation: Industrie 4.0."

Introduction – Industry 4.0

- Yet, some critics of Industry 4.0 are true:



Where are **the people** in this story?

Introduction – Industry and COVID-19

- In January 2020, one reviewer was holding a article in his hands claiming that human transmission of the new virus SARS-CoV-2 has been recorded in Hong Kong!
- He broke the rules of the reviewing process and sent an article to the World Health Organization
- Few days later, WHO issued a COVID-19 global pandemic alert!
- The global pandemic is still ongoing
- But, what have we learned?

Introduction – Industry and COVID-19

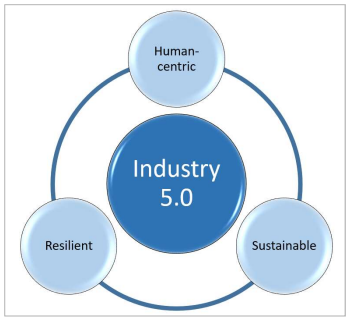
- **Lessons from COVID-19 global pandemic:**

1. "The sanctity" of the article review process is not that important
2. We, the people, are much fragile than we thought
3. The nature can strike back, and it can be tough
4. **Everything cannot be "made in China"**!
5. **Industrial manufacturing was pretty resistant to pandemic** (compared with other sectors)!





Introduction – Industry 5.0



Introduction – Industry 5.0

- Industry 5.0 = Industry 4.0 critics + Lessons from COVID-19
- It is a strategic document of the European Commission published in January 2021
- It is the evolution of Industry 4.0, not its replacement (the original working paper was named 'Industry 4.1')
- With Industry 5.0, the industry is seen not just as another sector in economy, but it is seen as a power able to achieve societal goals beyond jobs and growth, to become a resilient provider of prosperity!

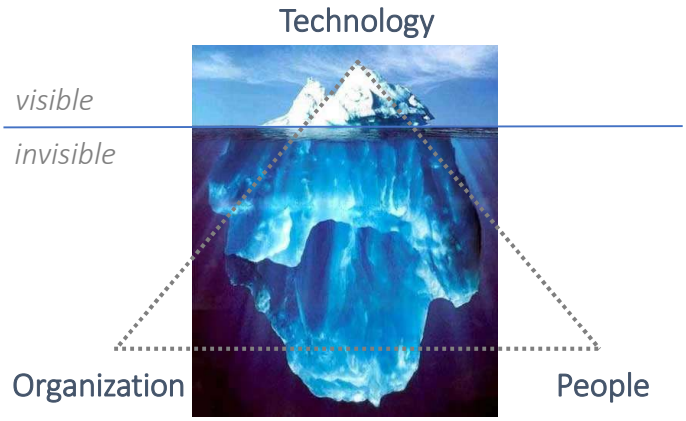
Introduction – Industry 5.0

- Three core elements of Industry 5.0:

1) *Human-centric approach* – putting human needs and interests at the heart of production process, by sub-ordering and adapting technology to humans, not vice versa
2) *Sustainability* – development of circular processes that re-use, re-purpose and recycle natural resources, to ensure the needs of today's generation, without jeopardizing the needs of future generations
3) *Resilience* – development of higher degree of robustness in industrial production to become resilient for disruptions in global value and supply chains

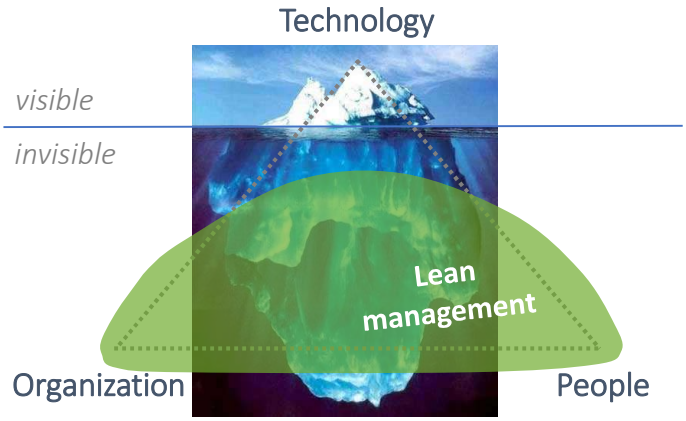
Research – Industry 5.0 and Lean management

- Core elements of enterprise:



Research – Industry 5.0 and Lean management

- Core elements of enterprise:

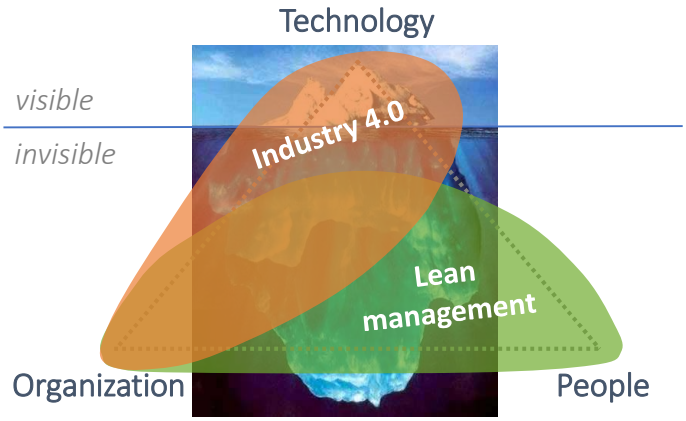


1980 – 2010
Lean management era
No. 1 organizational improvement approach

2020
Lean is 40 years old
Crisis of middle age

Research – Industry 5.0 and Lean management

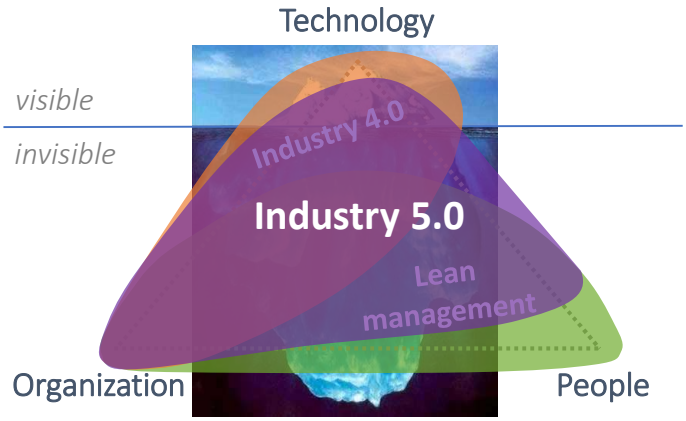
- Core elements of enterprise:



2010 – 2020
Fourth industrial revolution - Industry 4.0
Technology Push
ICT, IoT, robotics

Research – Industry 5.0 and Lean management

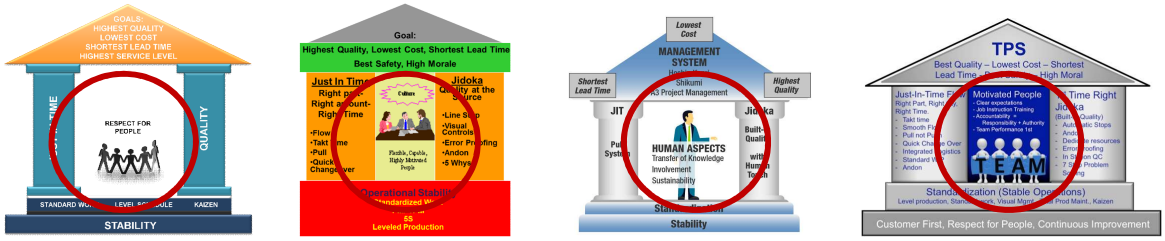
- Core elements of enterprise:



2020 – 2021
Global pandemic
Resilience
Employees importance
Human-centricity

Research – Industry 5.0 and Lean management

- Industry 5.0 is **human-centric**
- Lean management is **human-centric**, as well
- Both, Industry 5.0 and Lean management, are focused on value chain and sustainability
- **So, can Lean management become an enabler of Industry 5.0?**



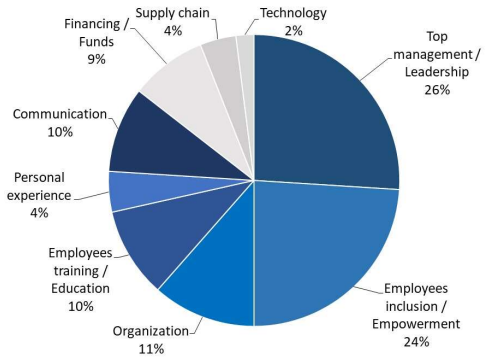
Research – Industry 5.0 and Lean management

- Our research was focused on small and medium-sized enterprises
- Research questions were:
  1. What are the **key success factors of Lean implementation** in SMEs?
  2. What are **the most common Lean tools**?
  3. Is there are a **relationship between Industry 5.0 and Lean management**?
- Research was based on analysis of 35 studies, analyses and reviews covering several hundreds of SMEs from all around world

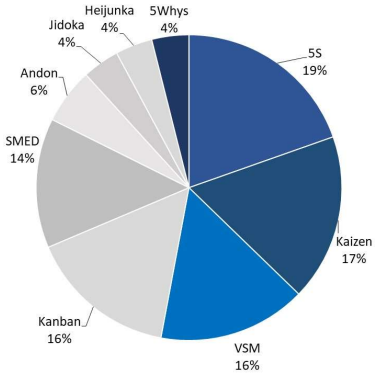
Research – Industry 5.0 and Lean management

- Results of analysis:

Key success factors of Lean implementation in SMEs



The most common Lean tools implemented in SMEs



Conclusion – Industry 5.0 and Lean management

- The **process awareness** of the Lean management was seen as a kind of pre-requisition (or homework) for Industry 4.0
- But, the interest for Lean and organizational changes was overtaken by the technology-push strategy of the Industry 4.0
- However, **the human-centric approach is restored with Industry 5.0**:

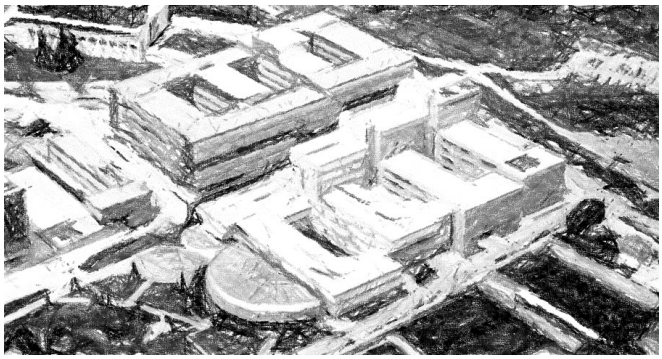
  "Rather than asking what we can do with new technology, we ask what the technology can do for us."

- Furthermore, the Lean approaches are the system thinking and the lead time reduction, which can result with more resilient value chain
- Lean also aims for waste elimination and process improvement

Conclusion – Industry 5.0 and Lean management

- Our **proposal of the relationship between Industry 5.0 and Lean philosophy** (with identified key success factors of Lean implementation in SMEs):

Thank you!



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