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Requirement Analysis for the Design of Smart Logistics in SMEs

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5.1 Introduction

The fourth industrial revolution, also called “Industry 4.0,” is currently transforming the manufacturing and connected supply chain industry. After the advent of mechanization, electrification, and computerization, it represents the increasing digitization and automation of the manufacturing industry, as well as the establishment of digital value chains to enable communication between products, machines, and human operators (Lasi et al. 2014). The focus of Industry 4.0 is to combine the internet, information, and communication technologies (ICT) with classical industrial processes (Bundesministerium für Bildung und Forschung 2012).

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An important transformation that comes with Industry 4.0 is the shift from centralized to decentralized control to reach a highly flexible production of customized products and services. An increased individualization and personalization of products leads to customer interaction strategies like X-to-order (make-to-order, build-to-order, configure-to-order, and engineer-to-order) and ultimately to the concept of “mass customization” where products can be configured by the customer at costs similar to those of mass production. The increasing fusion of the information technology (IT) environment with production and logistics allows flexible and reconfigurable manufacturing and logistics systems (Spath et al. 2013).

Another important part of Industry 4.0 are cyber-physical systems (CPS) that allow self-organization and self-control of manufacturing and logistics systems (Rauch et al. 2016a, b). CPS are computers, sensors, and actuators that are embedded in materials, equipment, and machine parts and connected via the internet, the so-called Internet of Things (IoT), allowing the physical and digital worlds to be merged (Spath et al. 2013). A further big benefit that comes with the introduction of CPS is the acquisition of a high amount of data that is available in real time. This allows better production planning and control (PPC) and efficient counteraction of unforeseen events in manufacturing and logistics processes (Dallasega et al. 2015a, b). In summary, it can be stated that the potential of a successful implementation of Industry 4.0 is enormous.

So far, Industry 4.0 is mainly brought forward by bigger companies and SMEs are risking not being able to exploit this huge potential. According to the European Commission, SMEs are characterized

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by having not more than 250 employees and an annual turnover of less than €50 mio or a balance sheet of no more than €43 mio (Kraemer-Eis and Passaris 2015). In more detail, micro and SMEs provide around 45% of the value added by manufacturing and around 59% of manufacturing employment and therefore, they can be considered as the backbone of the European economy (Vidosav 2014). As the previous economic crisis showed, SMEs proved to be more robust than bigger companies because of their flexibility, their entrepreneurial spirit, and their innovation capabilities (Matt 2007).

As such, the successful implementation of Industry 4.0 has to take place not only in large enterprises but even more important in SMEs. Because of often limited financial and human resources, the implementation of Industry 4.0 represents a special challenge for SMEs. Up to now, SMEs are only partially ready to adapt to Industry 4.0 concepts. In particular, smaller enterprises face a high risk of not being able to benefit from this industrial revolution. As a result, further research and action plans are needed to prepare SMEs for the stepwise introduction of Industry 4.0 (Sommer 2015). According to the authors, SMEs will only benefit from Industry 4.0 by following customized implementation strategies, approaches, concepts, and technological solutions that have been appropriately adopted. Otherwise, the current effort for publication and sensitization of SMEs for Industry 4.0 will not lead to expected results.

This book chapter presents an explorative set of hypotheses of requirements to implement Industry 4.0 concepts in logistics processes in SMEs spread over the world. They were identified in the course of the research project “SME 4.0 – Industry 4.0 for SMEs” by using expert workshops with SMEs from the north-east part of the USA, Central Europe, and Northern Thailand.

5.2 Problem Formulation

Requirements of larger companies regarding the successful adoption of Industry 4.0 concepts and technologies may not be suitable for SMEs. Compared to bigger companies, SMEs have at their disposal fewer resources in terms of budget and qualified workforces for doing research

and innovation actions. Up to now, there are only a few studies available that propose requirements for the adoption of Industry 4.0, especially considering companies in specific geographical areas. However, little to almost no studies are available that deal with the requirements for SMEs to support the logistics part. Therefore, the authors conducted workshops with SMEs from South-East Asia, central Europe, and Northern USA to identify the first hypothesis of requirements to support logistics management with Industry 4.0 concepts.

5.3 Related Work

In order to build a profound theoretical foundation for the explorative investigation of the specific requirements of SMEs to use Industry 4.0 concepts in their logistics management, the authors have conducted a systematic literature review. Thereby, the main results will be briefly outlined within the next paragraphs (Dallasega et al. 2019).

In summary, Glass et al. (2018) identified barriers for implementing Industry 4.0 in SMEs by investigating the literature and using a survey approach in German companies. They emphasized specific barriers to Industry 4.0 implementation such as missing standardization and an inappropriate company strategy. Maasouman and Demirli (2015) developed a lean maturity model and designed a framework for assessment of concepts like just-in-time in manufacturing cells. Schumacher et al. (2016) developed models for assessing the readiness and maturity of Austrian companies regarding Industry 4.0. The model considers elements like the strategy of the organization, customer, people, and technology. Qin et al. (2016) developed a framework to show the gap between the state of the art in UK companies and the requirements for Industry 4.0 readiness. Similarly, Benešová and Tupa (2017) analyzed the Industry 4.0 requirements of Czech Republic companies where the digital representation of a factory in real time, the horizontal and vertical data integration, and the self-controlling of manufacturing and logistics processes emerged. Furthermore, the results showed that education and qualification of employees is one of the main requirements for the implementation of Industry 4.0. Kamble et al. (2018) used interpretive

structural modeling (ISM) and fuzzy technology to analyze the barriers to implementing Industry 4.0 in Indian companies. Barriers like the lack of clear comprehension about IoT benefits, employment disruptions, organizational, and process changes (needed to implement Industry 4.0) emerged. Luthra and Mangla (2018) evaluated key concepts and challenges of implementing Industry 4.0 in Indian manufacturing companies with a special focus on sustainable supply chain management. Here, technological as well as an appropriate strategic orientation of the companies emerged as the main challenges to Industry 4.0-implementation.

5.4 Research Design/Methodology

In accordance with the theoretical foundation, the authors have conducted expert workshops, which followed pre-defined methodological guidelines to systematically evaluate the requirements of smart logistics in SMEs. In total, the research team conducted six workshops with 37 participating SMEs and 67 participating experts in Italy, Austria, USA, and Thailand in the timeframe between 9 June 2017 and 22 March 2018. The quantitative content analysis resulted in 548 statements for further investigation. Moreover, the statements for smart logistics in SMEs were divided into the sub-sections “smart and lean x-to-order Supply Chains,” “intelligent logistics through ICT and CPS,” “automation in logistics systems and vehicles,” and “main barriers and difficulties for SMEs.” Thereby, the results are briefly summarized in Table 5.1.

Axiomatic design theory states that the best design solution first, maintains the independence of the functional elements (axiom one), and second, minimizes the information content (axiom two).

Table 5.1 Facts and figures of SME workshops

	Italy	Austria	Thailand	USA	Total
Number of workshops	1	2	1	1	5
Participating SMEs	10	7	10	10	37
Participants	13	13	25	16	67
Total statements	213	97	98	140	548
Logistics-related statements	93	41	36	33	203

The axiomatic design method applies the theory during top-down, parallel decompositions of the functional requirements (FRs), and the design solutions, or parameters (DPs) and possibly process variables (PVs) which are how the DPs are produced or realized.

The decompositions start with the abstract concepts and develop detailed functions, FRs, the design problems, and solutions, DPs the design solutions, with more and more detail, level by level for each functional branch. At each level of detail, for each functional branch, the candidate design solutions are tested against the axioms. The individual DPs are finally integrated into a complete physical solution to the design problem (Suh 1990).

The value of the design is established by the customer needs (CNs) in the customer domain. In the functional domain, the FRs satisfy the CNs, and FRs are the next link in the value chain. In the physical domain, the next link in the value chain, the DPs, fulfills the FRs. In the process domain, PVs produce the DPs. The elements of the decomposition, FRs and DPs, at each level should be complete, or collectively exhaustive, with respect to the higher levels of abstraction in their domain. At each level, they should be mutually exclusive with respect to each other in their domains to satisfy axiom one.

Functional metrics can be selected for the FRs. Physical metrics should be implicit in the DPs. The relations between the parent and children FR, DP, and PVs, adjacent decomposition levels, in each of their domains, are described with decomposition equations. The relations between the FRs and DPs are described with design equations, which form the design matrix. The relations between the DPs and the PVs are described in the process equations that form the process matrix.

Design thinking demands the development of the functions first. The FRs should be stated to foster creativity in the design solution. FRs should create a large solution space. The FRs should be developed carefully, because no design solution can be better than the FRs. The FRs are the independent functions that define criteria for the success of the design solution. To maintain independence, each FR needs a different DP. Customer needs, like “low cost” or “ease of use,” often should be non-FRs, which are represented in selection criteria (SCs),

or optimization criteria (OCs), which are used to select between candidate DPs (Thompson 2013).

There is a tendency, especially for engineers, to seek and select physical design solutions before the functions have been adequately defined. This is not good design thinking.

If FRs contain physical attributes, this can inappropriately limit the solution space and inhibit creativity. Generally, it should be possible to generate several candidate DPs for each FR. If this is not possible, then perhaps the FR is too limiting and it should be reformulated. The solution space can be enlarged so it is possible to find more candidate DPs to fulfill the FRs by appropriate reformulation of the FRs. This can be done by asking why an FR is required. In essence, the FR should be moved closer to the CN and further from the DP, which makes a larger space for more creative, potential solutions.

5.5 Hypothesis of Requirements for Smart Logistics in SMEs

This section presents the identified statements as the hypothesis of requirements, which were recorded in the course of the SME workshops as an explorative approach based on a systematic literature analysis. Consequently, the statements were assigned to nine thematic clusters.

5.5.1 Lean and Agility

This cluster contains the requirements of the usage of advanced planning techniques that, for example, allow a production on-demand and delivery just-in-time. Workshop participants mentioned the requirement to ensure flexible supply chains. The identification and avoidance of material flow breaks and the timing of orders, to minimize transportation costs, were recorded. The reduction of buffer stocks, raw material, WIP, and finished parts was mentioned.

Strategies to increase the material efficiency in automated logistics systems such as the optimization of material yields at the vendor

and the grouping of trucking routes of complimentary suppliers were recorded. Additionally, the reduction of buffer stocks at the workplace, preventive “rhythms” (delivery, preparation, etc.), efficient storage and removal systems for the holding of raw material, WIP, finished parts, parts produced and packaged at machines, and moved to shipping were mentioned.

5.5.2 Real-Time Status

This cluster includes the requirements for an infrastructure and digital feedback system, which monitors the status of production, storage, and shipping in real time. In particular, the short-term availability of information about the shipment/delivery status of material is very important for proper supply chain management. Moreover, the visibility of the supplier’s status in real time for quick access to information for improved supplier risk management was mentioned. Even further, participants mentioned that a system, which enables real-time status information, could also assist in the predictive maintenance process.

5.5.3 Digitization, Connectivity, and Network

This cluster entails the necessity for an improved customer–supplier connection to gain the ability to communicate and/or share capacity, materials, infrastructure, and information with internal and external customers and suppliers. Even more, information should be provided and visualized everywhere and every time to reduce waiting times and unnecessary delays. Thereby, the requirements included the automated tracking of prices, the automation of processes (e.g., the generation of bill of materials), and the automated communication between multiple systems. The material flow should be visualized from upstream to downstream companies. This includes the visualization of tools and parts used throughout the supply chain processes. The requirement to increase transparency by visualizing stock and delivery times throughout the supply chain through the interconnection of suppliers with manufacturers and customers over the internet was recorded. Here, aggregator

websites to determine the short-term availability of material or capacity in the supplier network, following the example of Skyscanner for the search of flights, were mentioned.

Moreover, the interconnection of customers with suppliers to avoid causes of missing parts/materials and to increase the reliability of supplies was recorded. Here, the following practical example was named by the experts: “when an order is received, the system should generate the bill of materials and automatically send the purchase order to the suppliers.” In more detail, the need for an automatic on-site measurement and electronic submission of order data to the fabrication shop was collected. Digitalization should be implemented especially in the order receiving and procurement processes. Some of the participating experts stated that digitalization should limit the accessibility of related stakeholders to obtain optimal data. Moreover, the workshop participants mentioned the sharing of transport capacities. As a practical example, the geographical visualization of transport routes for the analysis of losses and inefficiencies in delivery routes was recorded. Another mentioned requirement was flexibility regarding the scalability of logistics systems and the predictive maintenance of logistics systems. Systems should be synchronized throughout the supply chain to avoid re-work and communication interruptions. Data are required to be integrated in order to support a uniform database system.

5.5.4 Tracking, PPC, and WMS

This cluster includes the requirements of digitally tracking and localizing (tracing) products throughout supply chains. Tracking systems should provide better information about the status of inventory, the tracking of multiple parts through multiple processes being able to monitor the status of production in real time.

Advanced PPC methodologies and tools should forecast demand changes quickly by interacting with internal and external systems for planning, control, and logistics. As a specific requirement, the automatic triggering of orders for tools and materials when processed orders come in was recorded. Moreover, the need for automatic “Pull” systems that

allow a synchronized workflow across networked machines to minimize downtime, tool changes, and predictive maintenance was listed.

Furthermore, a better knowledge of the state of the art in warehouse management systems (WMS) was listed. Here, as a specific requirement, an automatic adjustment of inventory levels through low inventory levels that automatically trigger stock runs was collected. Furthermore, according to the participants, warehouse management systems should be implemented in a way that allows for easy exchange and storage of all needed information concerning command control and logistics. Moreover, an automated and permanent inventory control by comparing planned vs. actual data and the intuitive visualization of where the material is stored in the warehouse were mentioned.

Other requirements like automated assistance in order and distribution processes based on historical assumptions were mentioned. The provision of data for inventory decision making, such as inventory turns and reorder point arrangements to support economic order quantities (EOQ), were recorded. WMS should also be able to allocate and optimize storage locations and display accurate locations for product pick up.

5.5.5 Culture, People, and Implementation

In this cluster, the SME's needs to access the financial, informational, digital, physical, and educational resources to ensure that Industry 4.0 is fully implemented rather than passed by are summarized. The requirement to increase the visibility of Industry 4.0 among professionals who might not have been exposed to it otherwise was collected. Moreover, top management should be aware and support Industry 4.0 to avoid missing acceptance throughout the company. The need for qualified and trained employees to implement and handle Industry 4.0 concepts in daily business was recorded. Here, the participants stated that employees should be specifically trained in software and data collection. For successful implementation of Industry 4.0 into SMEs, the necessity of having an overview of existing Industry 4.0 concepts and tools for logistics and their suitability for SMEs for specific industry sectors

was mentioned. Here, the need for a specific distinction of SMEs in countries with high-labor cost and countries with low-labor cost was specified.

5.5.6 Security and Safety

According to the workshop participants, security and safety issues should not be forgotten while implementing smart logistics in SMEs. Here, specifically, the internal traffic optimization for safety and efficiency in the workplace and required ICT to monitor and control safety in driverless transport systems were mentioned. Moreover, the ensuring of data security and intellectual property protection were recorded.

5.5.7 Ease of Use

According to the workshop results, the implementation of smart logistics concepts should be easily understandable and easy to use. The requirement for intuitive and role-related user-interfaces for software or machine control was mentioned. Different views for different roles (e.g., operator, supervisor) should be provided. Digital assistant systems should facilitate the work for operators, the communication of needs to R&D, and the communication of work metrics to supervisors.

5.5.8 Transportation

This cluster contains the automated material transport by using automated guided vehicles (AGVs) including all related activities (e.g., loading, transport, unloading, safety issues) aiming at a fast and cost-efficient distribution of materials.

5.5.9 Automation

This includes requirements for decreasing the manual workload in logistics systems. Thereby the experts mainly focused on the automated

labeling of products, automatic picking and delivery, automated storage systems for materials and transport containers, and the automated removal of scrap in the course of the production process. Moreover, the participants were interested in cause–effect analyses aimed at the impact of automation approaches on business success.

5.6 Creativity and Viability Through Axiomatic Design

Industry 4.0 is often defined by the physical solutions, DPs, like a vision system and algorithms for managing the supply chain. It is supposed that these are fulfilling FRs, which satisfy CNs, which are common to many enterprises. The responses to the workshops often reflect the desire to use these physical solutions.

These Industry 4.0 solutions generally fit into the segmentation somewhere in an intermediate level of abstraction. Higher levels might result in maximizing return on investment (ROI), an appropriate upper level CN for an enterprise. In a manufacturing enterprise, maximizing ROI can be decomposed to add appropriate value and minimize cost.

Rather than starting with the highest level CNs and developing FRs first, Industry 4.0, like the previous industrial revolutions, tends to begin in the middle of the domains and the decomposition. To discover if implementing some aspect of a design solution like this is appropriate for a particular enterprise, and consistent with good design thinking, the higher levels of the decomposition and the functional domain need to be considered.

5.7 Conclusions and Outlook

Industry 4.0 has been mainly brought forward by bigger companies and SMEs are risking not being able to exploit this huge potential. However, micro and SMEs provide around 45% of the value added by manufacturing and around 59% of manufacturing employment and therefore,

they can be considered as the backbone of the European economy (Vidosav 2014). Therefore, Industry 4.0 concepts should not only be conceived and implemented in bigger companies but even more importantly, customized implementation strategies, approaches, concepts, and technological solutions should be proposed for efficient implementation in SMEs.

The book chapter presents an explorative set of hypotheses of requirements for the implementation of Industry 4.0 concepts in logistics processes for SMEs. The hypotheses were identified by using expert workshops with SMEs, conducted by the Free University of Bolzano (Italy), the University of Leoben (Austria), the Worcester Polytechnic Institute (USA), and the Chiang Mai University (Thailand). Axiomatic Design was used as a methodology to structure the identified hypothesis of requirements. From the customer needs, functional requirements are to be derived. Following the Axiomatic Design approach, we can define design parameters, in order to specify the properties of the system to implement.

The recorded statements were clustered into nine thematic groups and different elements emerged as being important for the definition of requirements like “Lean and agility,” “Real-time status,” “Digitization, connectivity, and network,” “Tracking, PPC, and WMS,” “Culture, people, and implementation,” “Security and safety,” “Ease of use,” “Transportation,” and “Automation.”

When applying the axioms and domains of Axiomatic Design, it can clearly be seen that a high percentage of the requirements defined by the respondents are not solution-neutral. This applies mainly to the categories “Digitization, connectivity, and network,” “Tracking, PPC, and WMS,” “Transportation,” and “Automation” which clearly include not FRs but rather DPs or PVs. This, in turn, limits the solution space, and it is not possible to ensure the best solution is reached. Again, the inputs from the workshops need refinement to derive the “true FRs” behind them. The FR derivation technique seems a good methodology to derive solution-neutral requirements.

Future research will consist of validating the identified hypotheses by using a structured survey. So far, the survey has been launched in Austria, Italy, and Slovakia and in the near future, it will be launched in

the USA and Thailand. Furthermore, after having validated the hypotheses of requirements, an assessment of the maturity and level of implementation/application of different Industry 4.0 concepts to satisfy the requirements will be undertaken. This will take place during the second phase of the research project, “SME4.0 – Industry 4.0 for SMEs.”

References

- Benešová, A., and J. Tupa. 2017. Requirements for Education and Qualification of People in Industry 4.0. *Procedia Manufacturing* 11: 2195–2202. <https://doi.org/10.1016/j.promfg.2017.07.366>.
- Bundesministerium für Bildung und Forschung. 2012. *Zukunftsbild „Industrie 4.0“*. Berlin.
- Dallasega, P., E. Rauch, and D.T. Matt. 2015a. Sustainability in the Supply Chain Through Synchronization of Demand and Supply in ETO-Companies. *Procedia CIRP* 29: 215–220. <https://doi.org/10.1016/j.procir.2015.02.057>.
- Dallasega, P., E. Rauch, D.T. Matt, and A. Fronk. 2015b. Increasing Productivity in ETO Construction Projects Through a Lean Methodology for Demand Predictability. In *2015 International Conference on Industrial Engineering and Operations Management (IEOM)*, 1–11. IEEE. <http://doi.org/10.1109/IEOM.2015.7093734>.
- Dallasega, P., M. Woschank, S. Ramingwong, K.Y. Tippayawong, and N. Chonsawat. 2019. Field Study to Identify Requirements for Smart Logistics of European, US and Asian SMEs. In *Proceedings of the International Conference on Industrial Engineering and Operations Management*.
- Glass, R., A. Meissner, C. Gebauer, S. Stürmer, and J. Metternich. 2018. Identifying the Barriers to Industrie 4.0. *Procedia CIRP* 72: 985–988. <https://doi.org/10.1016/j.procir.2018.03.187>.
- Kamble, S.S., A. Gunasekaran, and R. Sharma. 2018. Analysis of the Driving and Dependence Power of Barriers to Adopt Industry 4.0 in Indian Manufacturing Industry. *Computers in Industry* 101: 107–119. <https://doi.org/10.1016/j.compind.2018.06.004>.
- Kraemer-Eis, H., and G. Passaris. 2015. SME Securitization in Europe. *Journal of Structured Finance* 20 (4): 97–106. <https://doi.org/10.3905/jsf.2015.20.4.097>.

- Lasi, H., P. Fettke, H.-G. Kemper, T. Feld, and M. Hoffmann. 2014. „Industry 4.0”. *Business & Information Systems Engineering* 6 (4): 239–242. <https://doi.org/10.1007/s12599-014-0334-4>.
- Luthra, S., and S.K. Mangla. 2018. Evaluating Challenges to Industry 4.0 Initiatives for Supply Chain Sustainability in Emerging Economies. *Process Safety and Environmental Protection* 117: 168–179. <https://doi.org/10.1016/j.psep.2018.04.018>.
- Maasouman, M.A., and K. Demirli. 2015. Assessment of Lean Maturity Level in Manufacturing Cells. *IFAC-PapersOnLine* 48 (3): 1876–1881. <https://doi.org/10.1016/j.ifacol.2015.06.360>.
- Matt, D.T. 2007. Reducing the Structural Complexity of Growing Organizational Systems by Means of Axiomatic Designed Networks of Core Competence Cells. *Journal of Manufacturing Systems* 26 (3–4): 178–187. <https://doi.org/10.1016/j.jmsy.2008.02.001>.
- Qin, J., Y. Liu, and R. Grosvenor. 2016. A Categorical Framework of Manufacturing for Industry 4.0 and Beyond. *Procedia CIRP* 52: 173–178. <https://doi.org/10.1016/j.procir.2016.08.005>.
- Rauch, E., P. Dallasega, and D.T. Matt. 2016a. The Way from Lean Product Development (LPD) to Smart Product Development (SPD). *Procedia CIRP* 50: 26–31. <https://doi.org/10.1016/j.procir.2016.05.081>.
- Rauch, E., S. Seidenstricker, P. Dallasega, and R. Hämmerl. 2016b. Collaborative Cloud Manufacturing: Design of Business Model Innovations Enabled by Cyberphysical Systems in Distributed Manufacturing Systems. *Journal of Engineering* 2016 (3): 1–12. <https://doi.org/10.1155/2016/1308639>.
- Schumacher, A., S. Erol, and W. Sihn. 2016. A Maturity Model for Assessing Industry 4.0 Readiness and Maturity of Manufacturing Enterprises. *Procedia CIRP* 52: 161–166.
- Sommer, L. 2015. Industrial Revolution—Industry 4.0: Are German Manufacturing SMEs the First Victims of This Revolution? *Journal of Industrial Engineering and Management* 8 (5): 1512–1532.
- Spath, D., O. Ganschar, S. Gerlach, T.K. Hämmerle, and S. Schlund. 2013. *Produktionsarbeit der Zukunft – Industrie 4.0*, 2–133. Stuttgart: Fraunhofer Verlag.
- Suh, N.P. 1990. *The Principles of Design*. New York: Oxford Press.
- Thompson, M.K. 2013. A Classification of Procedural Errors in the Definition of Functional Requirements in Axiomatic Design Theory.
- Vidosav, D.M. 2014. Manufacturing Innovation and Horizon 2020-Developing and Implement „New Manufacturing“ (9. edit.): 3–8.

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