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Self-Assessment of Industry 4.0 Technologies in Intralogistics for SME's

Martina Schiffer¹[0000-0001-7376-2362] Dr.-Ing. Hans-Hermann Wiendahl¹[0000-0002-5307-3444]
Benedikt Saretz¹[0000-0003-2055-7888]

¹ Fraunhofer Institute for Manufacturing Engineering and Automation IPA, Nobelstraße 12,
70569 Stuttgart, Germany

Martina.Schiffer@ipa.fraunhofer.de

Abstract. The 4th industrial revolution generates a high potential for smart production systems. Many manufacturing companies considering therefore the application of cyber-physical systems in the sector of intralogistics. The aim is to achieve better logistics performance or lower costs. However, small and medium sized enterprises (SME) are hesitant about introducing Industry 4.0 technologies. They fear high implementation costs, low benefits and the lack of know-how increases the reluctance of the companies.

This paper presents a procedure which enables SME's to assess the benefits of Industry 4.0 technologies by themselves. The model follows the recognized principle: First improve your processes, then automate them:

- Methodical basis is a process model intralogistics, which also considers self-controlling cyber-physical systems. In addition, the benefit aspects are assigned to the individual process steps.
- In the specific application, the company first determines the digitization potential of the individual activities and then the associated benefits of Industry 4.0 technologies.

The procedure reduces on the one hand the uncertainty regarding of wrong decisions and creates on the other hand the possibility for companies to select Industry 4.0 technologies goal-oriented. The described procedure was validated with SMEs.

Keywords: Intralogistics, Industry 4.0, Cyber physical systems, Smart factory,

1 Introduction

Production companies are in a constant state of change. Comparable service offers with regard to functionality, quality and price of the products bring logistics services, such as short delivery times, to the fore as a competitive factor. The introduction of Industry 4.0 Technologies, in particular cyber-physical systems (CPS), is seen as a possible solution to the requirements of the market. Most of the companies examine the planning and evaluation of Industry 4.0 Technologies in value-added processes [1,2]. The ad-

joining areas, such as Intralogistics, have received little attention. But the implementation of Industry 4.0 Technologies in this area hides a high potential. On the one hand, Intralogistics secures the flow of materials and information within the company and, on the other hand, enables a successful supply chain [3]. Despite this high potential, many companies don't invest in Industry 4.0 Technologies. In particular, small and medium-sized enterprises (SME's) have deficits in planning and implementation. [4] The reasons are the high introduction costs, the missing know-how of the companies as well as the non-evaluable benefits of Industry 4.0 Technologies.

The contribution of this paper is a two-step process which enables SME's to assess the benefits of Industry 4.0 Technologies by themselves. The procedure was validated with SME's in workshops. The procedure was profitably developed within the framework of the research project Industry 4.0.

2 Related Works

Intralogistics is responsible for the material and information flow between the value creation steps within a company. The use of cyber physical systems can realize great improvement potentials along the internal operational processes. Cyber physical systems can communicate with each other via the Internet and record their environment with their sensors. The generated data are evaluated, linked and used for the control of corresponding actuators. The result is a decentralized network that can optimize itself and counteract problems along the entire value creation process. CPS technologies offer great advantages especially for SMEs, which often produce small series or individual products. Through intelligent linkage of the material flow a flexible and fast reaction factory is realized [5,6,7].

For the introduction of CPS Technologies an economical evaluation is necessary. A benefit or potential analysis is especially important for SMEs with tighter budgets as large enterprises. A quantification of the potential of a certain CPS technology is however very difficult due to the cross-sectional function of logistics. In the literature different evaluation methods are called dependent on the problem definition and the area of application. Consequently, a uniform procedure for the potential analysis of CPS technologies for use in intralogistics has not yet been defined [6,8].

3 Methodic Procedure

The process model intralogistics build the methodical basis of the procedure. A (process)-model is a reflection of the reality which, through abstraction and simplification, provide conclusions about states, changes and functional relationships [9,10]. The requirement criteria for the process model intralogistics are simplicity, completeness and intuitive presentation. Thus, the SME-suitability is on the one hand granted as the adaptability on larger enterprises is possible.

The model subdivides six process modules:

- Incoming goods
- Internal transport
- Storage
- Order picking
- Packaging
- Outgoing goods

The object of consideration is the characteristics of the material and information flow, the used resources and the relevant data for planning and scheduling. **Fig. 1** shows the generic process model. The model follows the process sequences preparation, implementation and completion of general process and action models [11]. The process sequences apply to information and material flow level and give the model a clear structure.

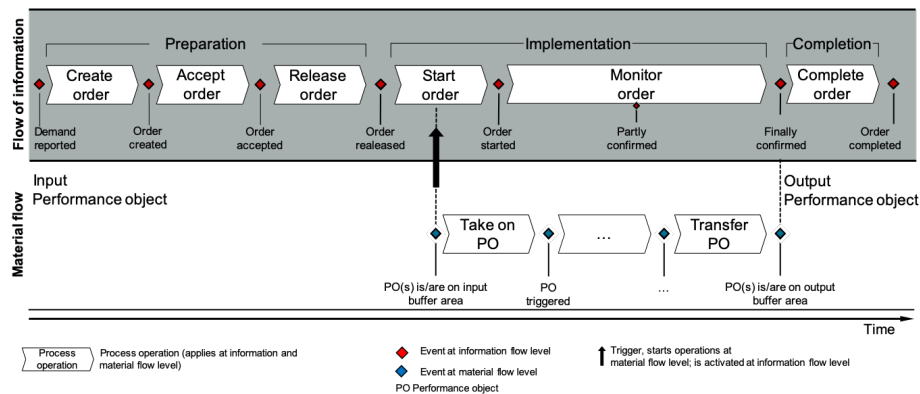


Fig. 1. Generic Process Model

Process activities describe the respective process module in a sequential order. This applies both, information and material flow, levels. The preparation phase includes the steps 'Create order', 'Accept order' and 'Release order' on the information flow level. After each activity a result must take place, which represents the possibility of a system-technical illustration. The trigger arrow forms the interface between information and material flow. The phase implementation starts only with the order release and the physical availability of the material on the input buffer area. In the implementation phase, the 'Start order' and 'Monitor order' activities are at the information flow level. Both activities reflect the progress of the order on the one hand and provide on the other the data basis for calculating the lead time. At the material flow level, implementation begins with the transfer of the performance object (PO) from the buffer area. Generically, the two activities 'take on PO' and 'transfer PO' take place within the model. Specific process-module activities are possible, e. g. 'Check PO' in incoming goods-process.

In order to consider the above-mentioned requirement criteria, assumptions and application limits of the process model must be drawn. The intralogistics activities of SME's

and the associated interfaces to extra logistics are the object of consideration. The model is subject to the following assumptions:

Information flow level

- Rework or cancellation orders are not taken into account
- Generation of demand is prerequisite

Material flow level

- Within the six process modules transport is neglected
- Complete and error-free order processing
- The input and output buffer area is a defined transfer point for the upstream and downstream processes

Based on the generic process model, a detailed process module refinement was developed, see **Fig. 2**:

Process	Activity	I/M	Variant of Activity	Subactivity	Variant of Subactivity	Characteristics	Incoming goods	...	Outgoing goods
Preparation	Create order	I	Demand driven manual			Appointment (When?)	Delivery date	...	Delivery date
			Demand driven automatically			Location (Where?)	Place of dispatch Unloading area	...	Customer Unloading area
			Consumption driven manual			Type (What?)	Material classification	...	Material classification
			Consumption driven automatically			Quantity (How much?)	Material quantity	...	Material quantity
						Responsibility (Who?)	Carrier	...	Carrier
						Tools (How?)		...	Type of transport (e. g. ship, airplane)
	Accept order	I		Check resource availability		Work, equipment, personnel, area	x	...	X
				Reserve resources		Work, equipment, personnel, area	x	...	X

	Completion	Complete order	I		Execute finale feedback	Order status	Lead time, work content (Piece/Positions/Route/Hour)	- Acceptable /defects parts - Incoming goods positions	...

I Information Flow M Material Flow ■ alternative variants

Fig. 2. Detailed Process Model (cut-out)

The detailed process module reflects the structure of the generic model. Only variants of the activities, sub-activities and variants of the sub-activities were created. The characteristics show the possible attributes of the respective activity. The color differentiation indicates whether the values are additive or alternative.

The potential assessment aims to make the benefits of Industry 4.0 Technologies in intralogistics transparent. A multi-stage procedure is recommended for estimating the potential, see **Fig. 3**. In the first step, the digitization potential of the individual intralogistics activities is determined. The potential is identified with the help of the four target dimensions variability, quality, velocity and effort [12]. In order to take full account of the potential of Industry 4.0 Technologies, transparency is added as a fifth dimension.

To ensure that corporate strategy and goals can be taken into account when evaluating the digitization potential, it's possible and recommended to prioritize the dimensions. [12] Furthermore, there are conflicting objectives between the dimensions which must be taken into account when determining the digitization potential [13]. The step of determining the digitization potential enables the company to make a strategically correct selection of the processes to be digitized.

The degree of detail of the target dimensions is not sufficient for estimating the potential of Industry 4.0 Technologies. Therefore, in the next step KPI's were defined on the basis of the target dimensions, see **Fig. 3**.

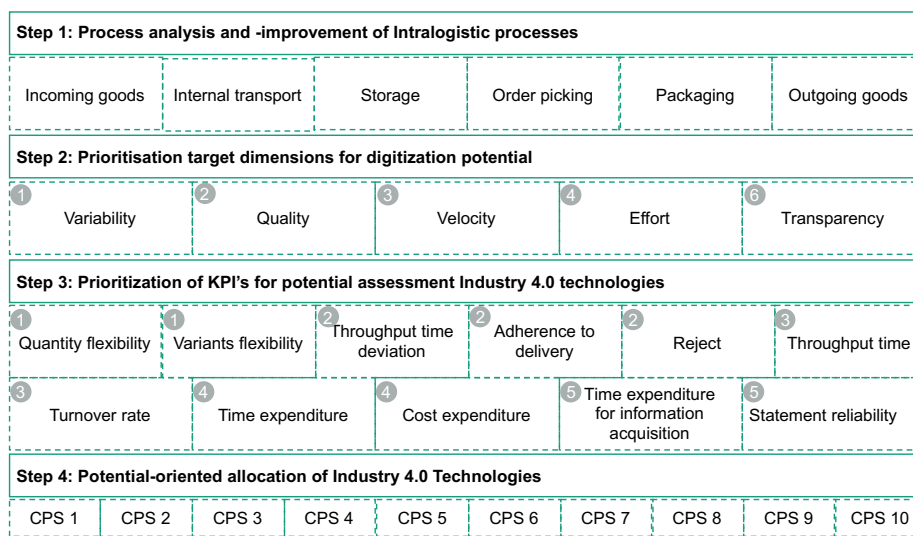


Fig. 3: Procedure for Potential Assessment

The calculation of these KPI's does not deviate from the commonly used one in the literature, so that no further definition is given here. The potential estimation is carried out with the values low, medium and high.

As with the determination of the digitization potential, the conflicts of objectives of the KPIs must also be taken into account when estimating the potential of Industry 4.0 Technologies. The process model forms the basis of the potential estimation. Possible Industry 4.0 Technologies were assigned to the activities of the process model. The assignment of the technologies as well as the estimation of potential took place with the help of experts from research and industry.

4 Results / Validation

The validation of the methodical approach took place at two medium-sized factory equipment suppliers during a workshop. Within the scope of the workshop the requirements for the applicability of the procedure in SME's were to be examined. Criteria for

this included comprehensibility, extensibility, survey effort and consistency. The procedure for the self-assessment of Industry 4.0 Technologies was essentially confirmed. In particular, the approach of optimizing the processes first and then digitizing them met with approval. For example, the process model revealed gaps in process responsibility and thus provided initial fields of action for process improvement. The procedure for determining the digitization potential and the benefit potential of Industry 4.0 Technologies was confirmed under the aspects of SME suitability. Three extension requests were mentioned by the participating companies:

1. Possible combination of the process modules

It was noted that in SME's, several process modules are often processed together, e.g. combined picking and transport orders. **Fig. 4** shows the possible combinations of the individual process modules. For a better understanding the production / assembly has been included in this overview. The internal transport is shown in this diagram between the process modules.

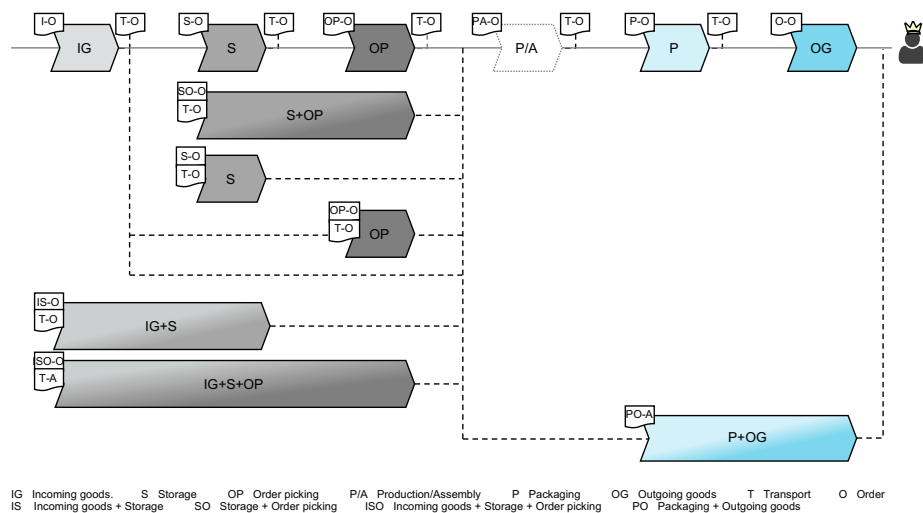


Fig. 4: Possible combination of the process modules

2. Extension of the KPI's by soft factors

In the course of the potential assessment, participants would note that Industry 4.0 Technologies are not only being introduced to improve process capability. Especially for SME's the external impact is very important. On the one hand towards the customer but also towards potential employees. SME's often have the problem to find suitable personnel. To be seen as an innovative and sustainable company, companies should also invest in new technologies because of these aspects. To this end, the potential assessment could be supplemented by KPI's such as degree of innovation and employee motivation.

3. Extension of the model by life cycle costing

Not only the estimation of potential is relevant for the introduction of Industry 4.0 Technologies. As already mentioned, SME's fear the introduction of such technologies. These results are on the one hand from the not recognizable benefit and on the other hand from the high costs. In order to have a comprehensive picture for the decision, the procedure should be extended by the life cycle costing. The extension of the life cycle costing in relation to Industry 4.0 Technologies is also currently part of the research project Industry 4.0 profitable.

5 Conclusion

Industry 4.0 Technologies will gain in strategic importance in the future. SME's in particular should not lose their connectivity with regard to digitalization. Nevertheless, the approach is: First improve your processes and then digitize them. The step-by-step approach in this article supports SME's in improving intralogistics processes and in making decisions about these Industry 4.0 Technologies. After the process improvement the procedure gives a decision assistance which process step the company should digitize first and afterwards with the help of which Industry 4.0 Technology. The results of the validation show that the procedure appears conclusive and plausible. The extensions to the procedure requested by the companies are currently being examined and subsequently taken into account in the model.

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