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Value stream method 4.0: holistic method to analyse and design value streams in the digital age

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Abstract

The value stream method (VSM) is a well accepted, widely used and holistic method for mapping, analyzing and designing value streams in order to reduce waste. However, the new, promising opportunities of digitization and Industry 4.0 to integrate information flows, lower lead times and improve flexibility or productivity in complex environments are not covered by VSM. While a large number of guidelines and maturity models for Industry 4.0 is available, no sound method with a step-by-step-guidance for designing value streams holistically exists to date.
With the VSM 4.0, consisting of a previously published Value Stream Analysis 4.0 (VSA 4.0) and a Value Stream Design 4.0 (VSD 4.0), we close this gap. The easy understandable and meanwhile often validated VSM 4.0 method helps to see classical as well as information wastes and designs lean value streams in terms of material and especially information flows.

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Keywords: Lean; Optimization; Value Stream

1. Introduction

Value Stream Analysis (VSA) and Value Stream Design (VSD), combined in the Value Stream Method (VSM), are well-known and widely used methods of Lean Production Systems. While the goal of VSA is in modelling and depicting an existing value stream (current state) in the most transparent way for easily identifying and eliminating any kinds of waste, VSD subsequently helps in defining an ideal state as well as a realistic future state. Here, the primary goal is to enable a continuous material flow at shortest throughput times. Any production activity is only triggered by a specific customer demand. [1,2]

There are several enhancements of the VSM in the literature, which focus on different entities of an enterprise. Examples are the extension to logistics [3] or the application of the VSM to the field of product development [4]. The method was also conducted to areas like multi-variant production [5], IT [6] and to indirect business areas [7].

However, digitization and Industry 4.0 result in new, additional demands for value streams. For example, the different elements of value streams need to be linked to each other much tighter, interactions with customers are more frequent and information technology gains importance. [8] Authors like UCKELMANN discussed design principles for value stream oriented information logistics in accordance to industry 4.0, but have not developed a holistic method [9].

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To react to the changed demands and the missing of a holistic method, the VSA-method has been enhanced in previous research to the method VSA 4.0 and has been successfully tested in over 20 different companies. With this enhancement, additional informational wastes resulting from inefficiencies in data generation, data transfer, data processing, data storage and data utilization are visualized and thus, analyzed. [10]

Similar to the classic VSA, the VSA 4.0 identifies the current state of information handling and utilization in a value stream, but does not give any guidance for finding and implementing improvements. Thus, in order to leverage the advantages of digitization and make full use of the opportunities offered, a systematic further development of the VSD to a VSD 4.0 is required. The results of the underlying research work are presented in the following sections. Fig. 1 gives an overview on the full method VSM 4.0 and its steps.

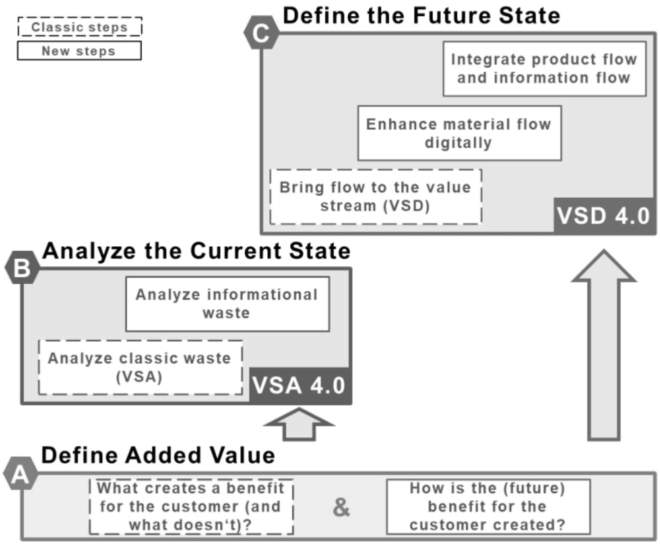

Fig. 1. Overview on the proposed method VSM 4.0. [11]

2. Defining added value (Phase A)

As a prerequisite for VSA 4.0 and VSD 4.0, a clear understanding needs to be established how the product - consisting of hardware, software, service and data - creates customer value today and in the future. This is helpful to distinguish between value adding and non value adding activities within the value stream and recognize classical wastes. Beyond that, a general understanding of the requirements of future business models can be obtained. The idea is, to build a competitive advantage by the setup of the value stream itself.

Historically, in lean production environments the customer has just been regarded as the trigger for manufacturing and as its endpoint: With placing an order he launches the production processes and receives the finished product in the end. In between, there is no to little interaction foreseen between the customer and individual elements in the value stream. Increasing digitization in manufacturing and rising individualization of products enable changes to this historic attitude in two ways. Firstly, information on the customer-specific demand can be delivered to each affected station consistently and in quasi real time. The idea is, to enable every station to perform to individual customer requirements without any loss in performance or quality. Secondly, information on a customer's demand can be captured along the whole value creation process. This information can include e.g. the current state of completion, test results or instructions for the future product utilization. By that, it can help the customer to improve his own processes.. The consequences of these possible new opportunities need to be reflected in the analysis and in the design of the value stream.

3. Analyzing the current state – VSA 4.0 (Phase B)

For analyzing value streams with regard to (digital) information in Industry 4.0-environments, the VSA 4.0 has been developed and validated (see MEUDT et al. [10] and MEUDT et al. [12] for a detailed description of the method).

4. Defining the future state – VSD 4.0 (Phase C)

The goal of the VSD 4.0 is the design of the future state of the value stream that has been analyzed previously, including all related information streams. The VSD 4.0 is divided into three steps:

Step 1: Bring flow to the value stream (VSD)
Step 2: Enhance material flow digitally
Step 3: Integrate product flow and information flow

4.1. Bring flow to the value stream (Step 1)

The first step is the execution of the "classic" value stream design known from lean production literature (see e.g. [1]). In this part, the material streams in the value chain are designed to "flow" as much as possible with the intent of shortest throughput times and lowest inventories at stable output and the elimination of waste. Beginning with the classic approach helps to avoid the pure digitization of a wasteful process. According to ROTHER and SHOOK [1] the following leading questions need to be answered:

1. What is the takt time for your product (family)
2. Is the production meant for a finished-product supermarket or for direct shipment?
3. Where is continuous flow production achievable?
4. Where should supermarkets according to the pull-principle be installed?
5. Which element in the value-stream interact with production planning and control?
6. How is the balancing of the product mix in the pacemaker-process organized?
7. In which periods is the work released at the pacemaker-process?
8. Which process improvements are required to actually realize the future state value stream in industrial practice?

4.2. Enhance material flow digitally (Step 2)

In a second step, a systematic check is conducted, where the product flow can be further enhanced digitally. In three iterative sub-steps, various digital technologies are considered and tested, as shown in Fig. 2.

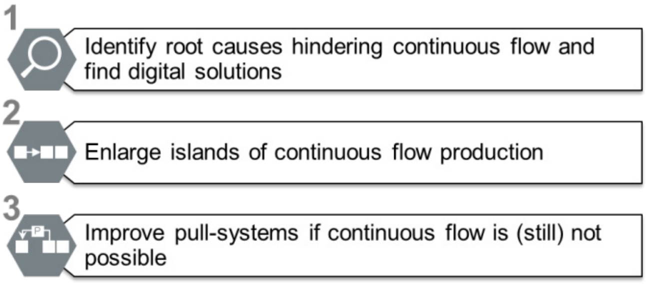

Fig. 2. Enhance material flow digitally [13]

Identify root causes hindering continuous flow and find digital solutions

After "bringing flow to the value stream" with the classic value stream design, VSD 4.0 specifically focusses on problems that still lead to instability, increased stocks and which hinder the production flow. These problems are systematically addressed by lean methods and digital solutions.

Fig. 3 shows that digitization and Industry 4.0 open up an extended solution space for process-stabilization and process-improvements beyond the classic solution approaches of lean production. The idea is that each communication needed for the process is supplied in a way that a human or a machine can use an information to start working directly (e.g. pick by light system instead of standardized operating procedure on paper or Dynamic Numeric Control system instead of inserting machine program codes by hand). At that point, it must be ensured that no new technical instabilities or waste in dealing with information (e.g. media breaks) are implemented.

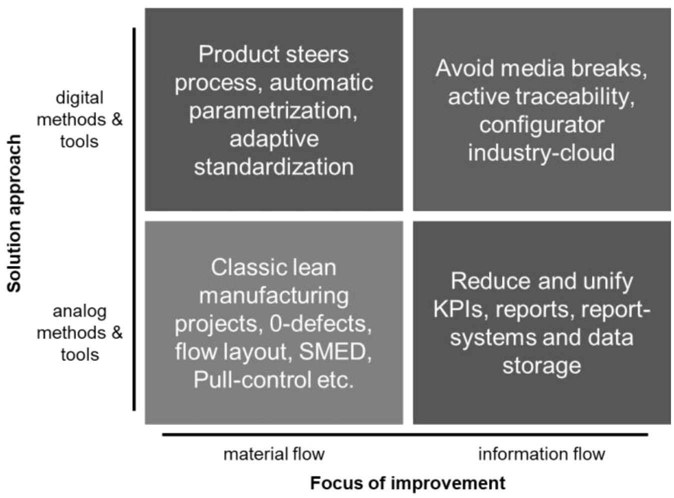

Fig. 3. Solution space for material and information flow [11]

Enlarge islands of continuous flow production

Processes that have been stabilized, improved or accelerated by actions of the previous sup-step may allow a connection with other processes to achieve larger areas of flow. Opportunities have to be checked consequently.

Improve pull-systems digitally if continuous flow is (still) not possible

If a connection of processes supported by IT-solution is not possible, pull systems should be used to limit inventories. The use of digital information flows should also be examined in order to reduce inventories and make inventories more flexible. For example, Kanban systems can be replaced by eKanban systems to reduce response times in intralogistics and therewith stocks of supermarkets which automatically shorten lead times.

4.3. Integrate product flow and information flow (Step 3)

The information flows in a company are becoming more extensive and complex due to higher product variants or even due digitization and Industry 4.0-solutions. For a better understanding it is helpful to divide the information flows into product- and process-information flows. Product information flows include all information related to a specific customer product. These can be, for example, drawing data, design data or machine programs. Process information includes information about processes themselves that are partly independent of products, such as status data or general key performance indicators. [11]

All information on control, documentation and process improvement has to be defined and linked to the future storage media along the entire value stream. The procedure is shown in Fig. 4 and explained in the sections beneath.

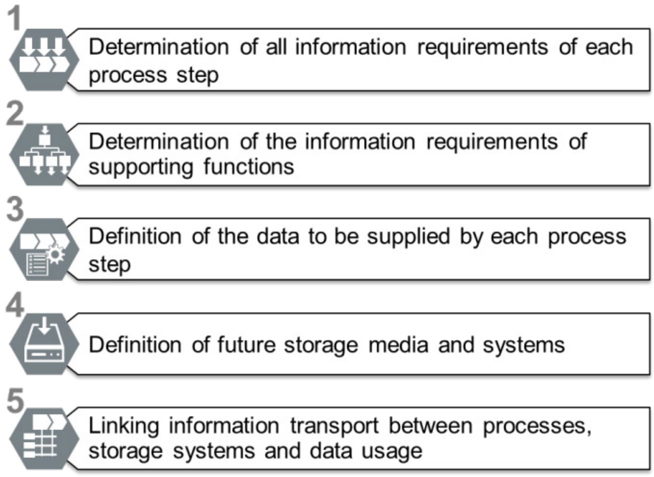

Fig. 4. Integrate product flow and process information flow [13]

Determination of all information requirements of each process

Processes should be able to start a scheduled order without delay due to information losses. This assumes that, in addition to the raw materials, auxiliary materials and operating supplies, all necessary and associated information has to be available on time. Therefore, in this sub-step, the information requirements of all processes in a value chain to fulfill a customer order are recorded. For example, the release process needs a part list from the construction for assembly (see Fig. 6).

Determination of the information requirements of supporting functions

The information requirements of all supporting functions are defined in this step. The supporting functions are listed as additional horizontal swim lanes (horizontal lines in Fig. 5 and Fig. 6) in the usage section of the value stream map. Shop Floor Management is a supporting function and depicted in Fig. 5 and Fig. 6 as a horizontal swim lane. KPI`s like output rates, cycle times, reject rates, OEE and request rates shall be visualized in daily Shop Floor meetings. Other possible examples of information requirements are scrap rates for quality management, liquid levels and vibration data for maintenance or energy data for energy management.

Definition of the data to be supplied by each process

Processes not only have information requirements for themselves, they also have to provide or generate information for other process steps or functions and activities as mentioned and defined in the previous steps. The previously defined information requirements allow to determine, which information must be provided by each process. With regard to the example this means, that the assembly process has to deliver output rates, reject rates, cycle time and request rates to the Shop Floor Management and the construction process has to prepare a part list for the release process (again, see Fig. 5 and Fig. 6).

Definition of future storage media and systems

Storage media and systems have to be defined depending on the previously set information requirements of the company. These media and systems are drawn as horizontal swim lanes in the storage media section of the value stream map. In this step, for example, it can be determined that the output rates of all processes will be automatically recorded in a MES or an ERP-System.

Linking information transport between processes, storage systems and data usage

In this last step, the origins of information are connected to either storage systems or data users. On the value stream map, this is shown through continuous vertical lines between the information/ data points from processes and the corresponding storage media as well as through dashed vertical lines for data usage. Points must be set at the corresponding connection. In general, there should be as less storage media systems as possible used in a company.

5. Quantification of waste in information logistics

With specific value stream KPIs, it is possible to quantify wastes and problems related to the information logistic in a specific value stream. Three exemplary KPIs are presented in this section [10]:

Digitization rate (DR) – The KPI indicates, how much of the information is acquired automatically and captured digitally without any manual interaction by humans or even information storage on paper. The number of automatically acquired and digitally captured data of the processes in the value stream is divided through the number of all data captured in the value stream.

Data availability (DA) –This KPI is the ratio of captured information compared to all the information desired from a value stream. DA assesses, how much of the desired or needed information is available.

Data usage (DU) – Stored data should have a defined usage, e.g. decision support. Otherwise, it is considered as waste. [10] This KPI indicates, how much of the captured and stored information is used for process improvements or has a benefit for a customer compared to all information captured in a value stream.

6. Practical Example

The VSM 4.0 has been applied to the value stream of a German medium sized company. Fig. 5 shows the results of the VSA 4.0 and Fig. 6 the result of the VSD 4.0 executed according to the method described in the previous chapter.

The defined KPI’s DR, DA and DU indicate the problems. None of the process steps works digitally or was even automated in the value stream. The necessary information have not been recorded and used. The KPI’s for the initial value stream are:

$$DR = \frac{\sum automatically\ acquired\ and\ digitally\ captured\ data}{\sum total\ captured\ data} = \frac{0}{20} = 0\% \quad (1)$$

$$DA = \frac{\sum captured\ information}{\sum desired\ information} = \frac{0}{20} = 0\% \quad (2)$$

$$DU = \frac{\sum used\ information}{\sum captured\ information} = 0 = 0\% \quad (3)$$

With the use of the VSD 4.0, these KPIs have been improved in the target state. Process steps have been automated and necessary information is recorded now. Also, a usage for the stored information has been defined. The improvement in the value stream shows itself also in higher KPI values:

$$DR = \frac{14}{29} \sim 48\%$$

$$DA = \frac{11}{15} \sim 73\%$$

$$DU = \frac{8}{11} \sim 73\%$$

With the VSM 4.0, it was possible to reduce the total internal lead time from 6.5 hours to 15 minutes. This was realized with an implementation of an online configurator and direct connection of nearly all information flows. Therefore, the number of storage media was reduced from twelve to seven. This example shows, how the VSM 4.0 systematically reduces waste in the information logistics and classical lean manner with reduced lead times by digitizing and automating processes.

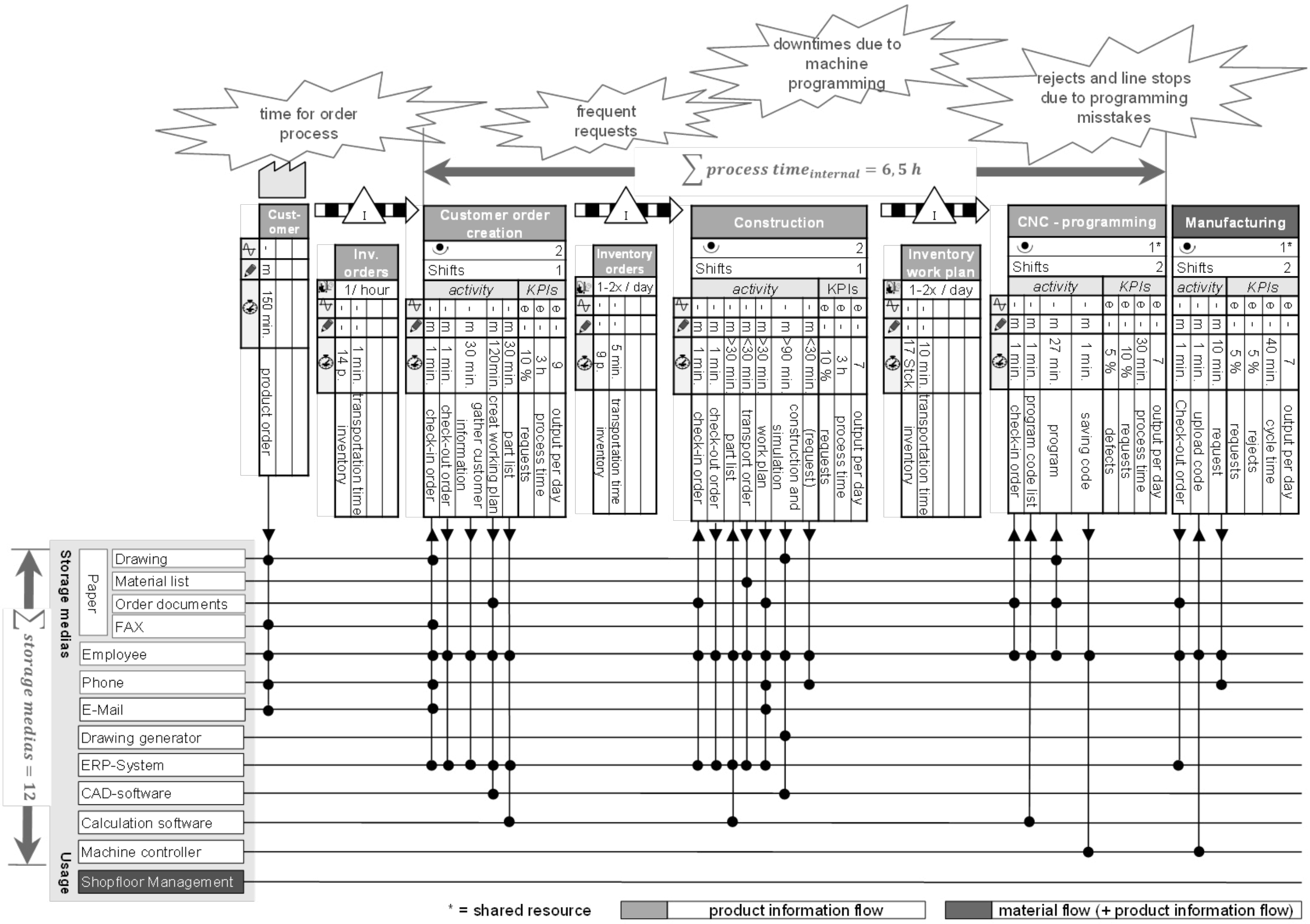

Fig. 5. VSA 4.0 of an exemplary company [11]

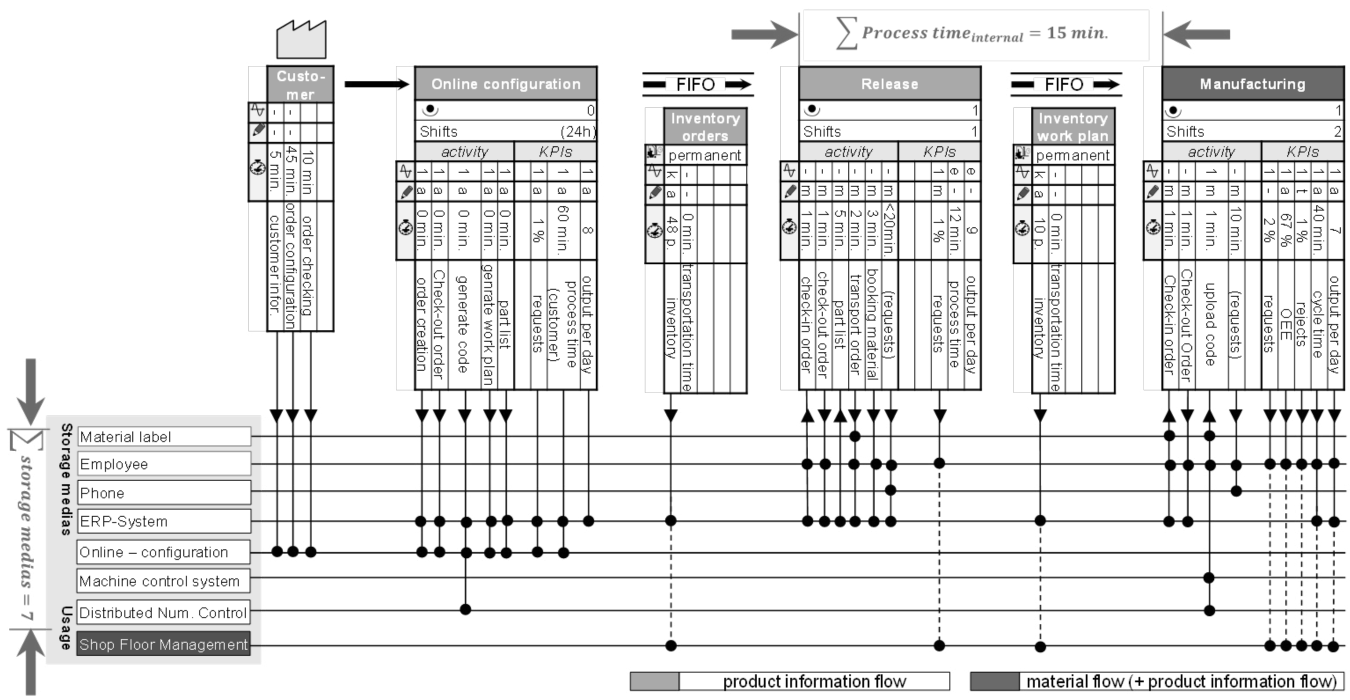

Fig. 6. VSD 4.0 of an exemplary company [11]

7. Conclusion

The presented method VSM 4.0 is an extension of the known VSM. VSM 4.0 focuses on a standard process redesign in a lean manufacturing manner as well as on the handling of all information needed in a value stream (so called information logistics).

In the classic VSM, the information view was only used for production control. Information flows to machines, instructions for workers or information for shop floor management were not analyzed or even mapped. The VSM 4.0 method closes this gap and brings a new understanding of information in value streams. All information flows have to be accurate and always actual ("real time") to avoid material still stands while information is not available. All existing information flows in a value stream must have a reasonably defined usage, which is drawn in the value stream map.

The VSD 4.0 as part of the VSM 4.0 was introduced in this article with a step by step guidance through the method. A practical example of a company shows, how waste in informational logistics was eliminated so that the company could reduce the lead time from 6.5 hours to 15 min. Also, there was a big improvement in the usage of storage media which were reduced from 12 to 7 different systems.

In future research, a more detailed design of the individual steps will be developed. For example, relevant methods and tools in the different phases of VSM 4.0 must be analyzed. Additionally, the method should be applied to other companies and branches.

References

[1] Rother M, Shook J. Learning to see: Value-stream mapping to create value and eliminate muda. 1st ed. Cambridge, Mass.: Lean Enterprise Inst; 2009.

[2] Erlach K. Wertstromdesign: Der Weg zur schlanken Fabrik. 2nd ed. Berlin, New York: Springer; 2010.

[3] Durchholz J. Wertstromdesign für die Logistik – ein Planungsleitfaden. In: Günthner WA, Boppert J, editors. Lean Logistics. Berlin, Heidelberg: Springer Berlin Heidelberg; 2013, p. 145–161.

[4] McManus HL. Product Development Value Stream Mapping (PDVSM) Manual. Cambridge, Mass; 2005.

[5] Halmosi H, Löffler B, Vollmer L. Wertstromdesign in der variantenreichen Produktion. ZWF 2005;100(1-2):47–52.

[6] Bell S. Lean enterprise systems: Using IT for continuous improvement. Hoboken, NJ: Wiley; 2006.

[7] Magenheimer K, Reinhart G, Schutte CSL. Lean management in indirect business areas: Modeling, analysis, and evaluation of waste. Prod. Eng. Res. Devel. 2014;8(1-2):143–52.

[8] Metternich J, Müller M, Meudt T, Schaede C. Lean 4.0 – zwischen Widerspruch und Vision. ZWF 2017;112(5):346–8.

[9] Uckelmann D. Wertstromorientierte Informationsflüsse für Industrie 4.0. Kernprozesse und Gestaltungsvariablen. Industrie Management 30;2014(6):14–6.

[10] Meudt T, Metternich J, Abele E. Value stream mapping 4.0: Holistic examination of value stream and information logistics in production. CIRP Annals 2017;66(1):413–6.

[11] Metternich J, Meudt T, Hartmann L. Leitfaden Industrie 4.0 trifft Lean: Wertschöpfung ganzheitlich steigern. Frankfurt: VDMA Verlag; 2018.

[12] Meudt T, Leipoldt C, Metternich J. Der neue Blick auf Verschwendungen im Kontext von Industrie 4.0. ZWF 2016;111(11):754–8.

[13] Hartmann L, Meudt T, Seifermann S, Metternich J. Wertstromdesign 4.0. ZWF 2018;113(6):393–7.