Lean and Industry 4.0—How to Develop a Lean Digitalization Strategy with the Value Stream Method

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Abstract This paper presents a methodology that allows manufacturing companies to develop an individual digitalization strategy. The Lean Digitalization Strategy is based on Value Stream Mapping and aims to lead companies on their digital transformation journey. This field-tested approach is put into practice by a workshop series. In six steps, companies achieve a common understanding of Industry 4.0 and Lean, understand the long-term vision and overall challenge, grasping the current state of their value stream, defining its target condition. This is the basis for the workshop participants to select process-oriented technologies towards the defined target condition and digitally connect them.

Keywords Value Stream Method · Digitalization · Strategy · Industry 4.0

1 Introduction

Today we live in a VUCA world. This abbreviation stands for volatility, uncertainty, complexity and ambiguity [1]. Our environment is becoming increasingly volatile. Customer requirements change ever faster and are increasingly unpredictable. Short-cyclical demand for individual products with new or improved performance and increasing division of labor lead to increased complexity in value chains. All this leads to the fact that companies are desperately seeking ways to solve these challenges. In this context, digitalization and Industry 4.0 appear to many as "promises of salvation". However, after trying several ad hoc measures, companies quickly realize that there

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is no digitalization strategy behind them. Mostly there exists no target condition for Industry 4.0 that could lead the way into a digital future.

The aim of this paper is to show how to create a Lean-compatible digitalization strategy in a customer- and process-oriented way using the Value Stream Method 4.0.

2 Industry 4.0

2.1 Definition

The term Industry 4.0 is a synonym for the fourth industrial revolution and describes the vision of a future industrial society under the influence of the internet where the physical world of manufacturing will merge with the virtual world. People, machines, objects and systems will operate in networks and exchange information in real time. It will be possible to meet individualized customer requirements (batch size one) with greater flexibility and robustness as well as optimal resource utilization [2, 3].

2.2 Obstacles and Problems of Digitalization in Practice

When trying to implement Industry 4.0 technologies, manufacturing companies encounter certain obstacles and problems. According to [4], Industry 4.0 is a mainly technology-driven approach (technology-push). Although technologies are available in a wide and constantly growing range, their selection and implementation are done in a mostly unstructured manner. There is a great focus on experimentation and gathering experience. But only few companies employ a holistic and target-oriented decision-making process that aligned the many technologies with an overall strategy. *In summary, there exists a methodological gap for developing an individual digitalization strategy which allows to systematically select and implement Industry 4.0 technologies*.

3 Developing a Lean Digitalization Strategy with the Value Stream Method

3.1 The Link Between Lean and Industry 4.0

For almost three decades, Lean Management has been acknowledged in research to help transforming organizations so they can compete under ever-changing market

conditions. Especially in a VUCA world, enabling employees to plan and execute lean, waste-free value chains should remain an essential part of a digital strategy.

Lean and Industry 4.0 pursue very similar objectives: Lean aims to meet customer requirements in terms of the highest quality, low costs and short lead times which are a prerequisite for short delivery times. In addition, Industry 4.0 intends to achieve the individualization of products and services mostly by new business models. While the objectives are similar, the approaches to achieving them differ significantly. Lean focuses intensively on the dimensions people and processes. It is therefore suggested to first optimize all processes and structures of a company following the Lean philosophy. Only in a subsequent step, it should be examined if, with the help of Industry 4.0 technologies, the companies' processes can be further optimized towards the targets set by Lean [5].

In this context, technology can only be an enabler, not an end in itself. A company's long-term goals should not be changed for Industry 4.0. It is solely determined by a company's customers and their requirements. Digitalization and Industry 4.0 only offer (new) technical building blocks to realize customer requirements more effectively. *Therefore, the authors' clear credo is Lean before Industry 4.0.*

3.2 Value Stream Mapping—A Method for Developing a Customer-Oriented Target Condition

A digitalization strategy does not mean the rigid implementation of a plan, but the gradual convergence towards a vision. Value Stream Mapping is a methodology which derives strategic steps (customer-oriented target conditions) from a company's long-term goals or vision in four steps [6]:

1. In consideration of *a long-term vision* (*True North*) and an *overall challenge*,
2. with a first-hand, informed grasp of the *current condition* (*Value Stream Analysis*),
3. a next *target condition* on the way to the vision is defined (*Value Stream Design*),
4. Moving towards the target condition uncovers *obstacles* to be worked on.

Value Stream Mapping therefore aims to analyze the current state and to develop a future state for all processes a product passes along its way to the customer. The Value Stream Design describes the target condition mentioned above. It directs all improvement activities towards an overall challenge. The Value Stream Design is used to specify requirements for improving single processes as well as for selecting enabling technologies towards a global optimum. Figure 1 illustrates the relation between the terms described.

Value Stream Mapping is the basis of the Lean Digitalization Strategy, because it is the process mapping method that is best suited for visualizing the interaction of the flow of information and material along a value chain. Their synchronization is one of the core aspects of a Digital Transformation [8]. The result is, that its standardized visualization provides a common language for a better communication between manufacturing and IT departments.

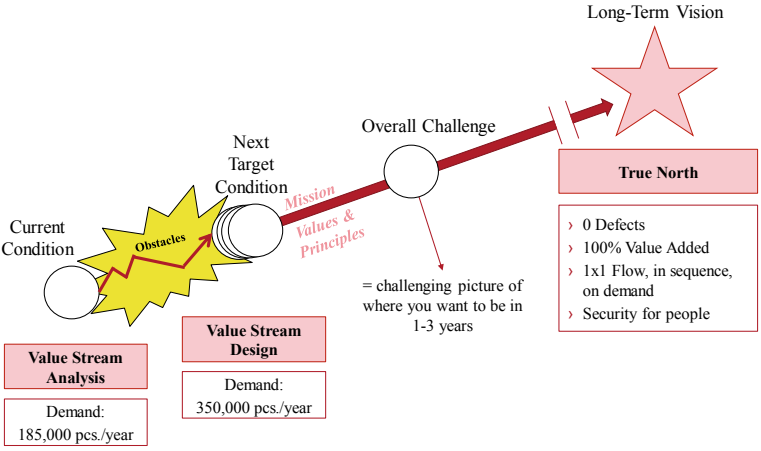

Fig. 1 Developing a customer-oriented target-condition with Value Stream Mapping [7]. Described by means of the fictional medium-sized manufacturing company BBW Inc.

3.3 The Methodology for Creating a Lean Digitalization Strategy

Figure 2 provides a comprehensive overview of the methodology for creating a Lean Digitalization Strategy. The six steps were field-tested in several workshop series with German manufacturing companies.

First Step: Fundamentals of Industry 4.0 and Value Stream Mapping. Before implementing the Lean Digitalization Strategy, it is essential to start with a common understanding in digitalization and Lean. Kick-off begins with the basics of digitalization and Industry 4.0. Furthermore, if a company lacks the necessary fundamentals of Lean, additional time is to be invested in the core concepts of Lean as well as in Values Stream Mapping.

Second Step: Defining the Overall Challenge. It is the responsibility of the executive management to define and share a clear and bright vision—the company's True

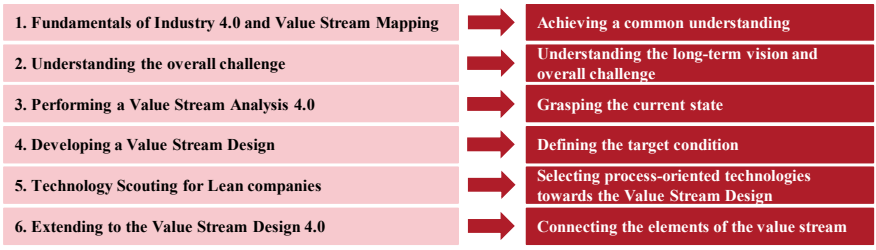

Fig. 2 The six steps of the Lean Digitalization Strategy

North. A vision is an aspirational description of what an organization intends to achieve in the long-term future. How to get there is not defined. If the employees understand, in which direction a company is to develop, they also understand which actions are necessary to get there. As a result, employees in every department and hierarchy are motivated to act independently in the direction of the common vision.

The steps of developing a Lean Digitalization Strategy are subsequently described by means of a simplified example from the workshop series. The fictional medium-sized manufacturing company BBW Inc. produces transport dollies. After being trained in the fundamentals of Industry 4.0 and Lean, the executive management defines the company's True North (see Fig. 1): The long-term vision of BBW Inc. includes zero defects, 100% value-added activities, one-piece flow in sequence and to the demand of the customers, as well as secure processes for all employees.

In a subsequent workshop, the True North is presented to the participants, so that everyone understands the overall challenge of the Lean Digitalization Strategy.

Third Step: Performing a Value Stream Analysis 4.0. Next, the current state needs to be grasped. A well-established tool for this is the Value Stream Analysis.

As described in [9], the purpose of this tool is to illustrate the current state of a company's material and information flows. Since the Lean Digitalization Strategy aims to systematically select and implement Industry 4.0 technologies, a second type of information flow is to be analyzed: The digital connectivity of the elements of the value stream. The Value Stream Analysis 4.0 is an extension of the Value Stream Analysis and helps to additionally map data flows between order or process information and analog or digital storage media (see Fig. 3). Analogous to the Value Stream Analysis, it is used to identify information logistical waste [8].

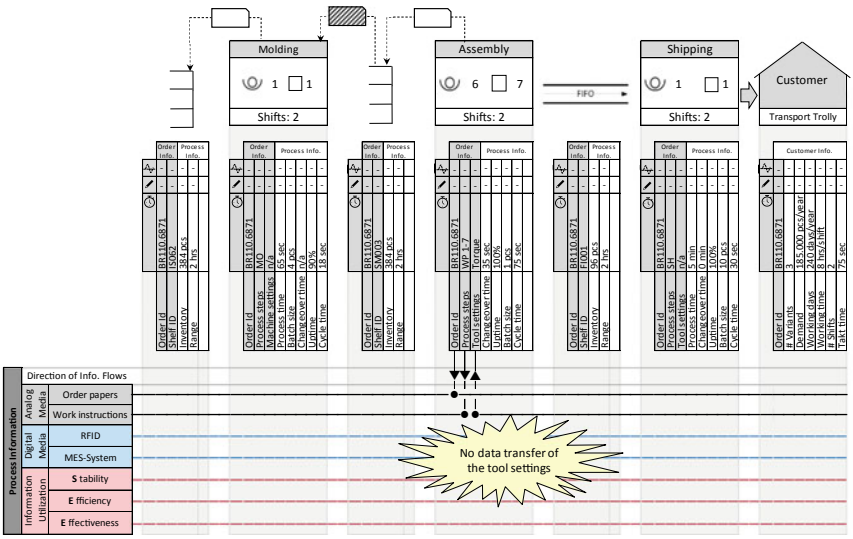

Fig. 3 Value Stream Analysis 4.0 of BBW Inc.

In the example of the BBW Inc., the current condition is a yearly demand of 185,000 transport dollies leading to a takt time of 75 s (see Fig. 1). A detailed analysis of the final assembly reveals, that for the different screwing process, the torque of the screwdrivers is set manually according to paper work instructions (see Fig. 3). This leads to quality issues and cycle time losses due to changeovers. From an information flow point of view, there is no data transfer between the order ID, the process step and the torque of the tools.

Fourth Step: Developing a Value Stream Design. The Value Stream Design is the preferred method to create a customer-oriented target condition, which should be achievable in the next six to twelve months and derived from the True North. A detailed description for creating a Value Stream Design can be found in [9].

In order to create a target condition for the value stream of the transport dolly, the workshop participants of BBW set a target condition of increasing yearly production from 185,000 to 350,000 pieces to meet future customer demand (see Fig. 1). This requires a reduces takt time from 75 to 40 s. To meet this requirement, final assembly needs to reduce its setup time and thus cycle time as illustrated in Fig. 4.

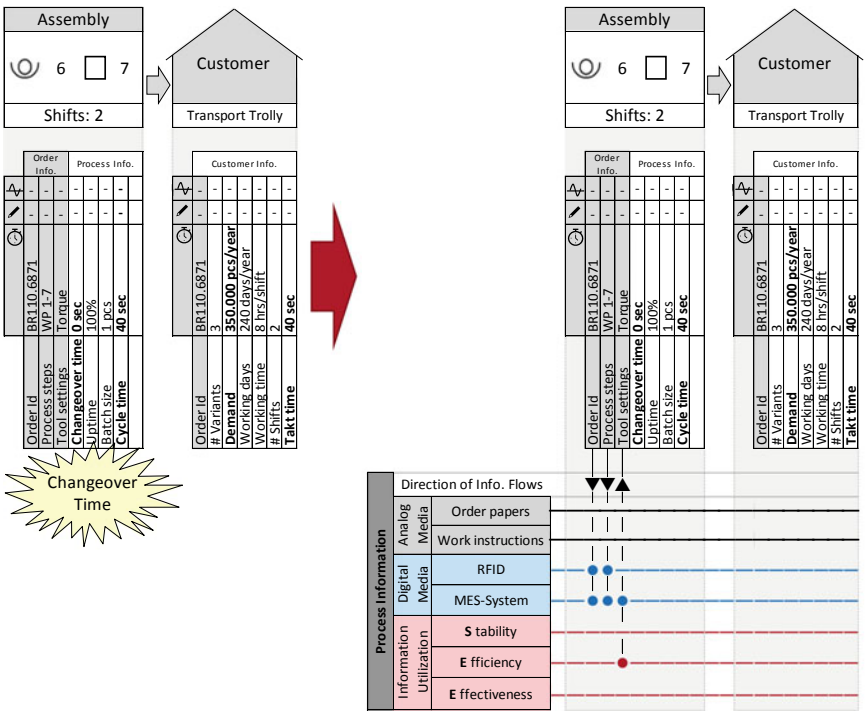

Fig. 4 Simplified Value Stream Design (left) and Value Stream Design 4.0 (right) of BBW Inc.

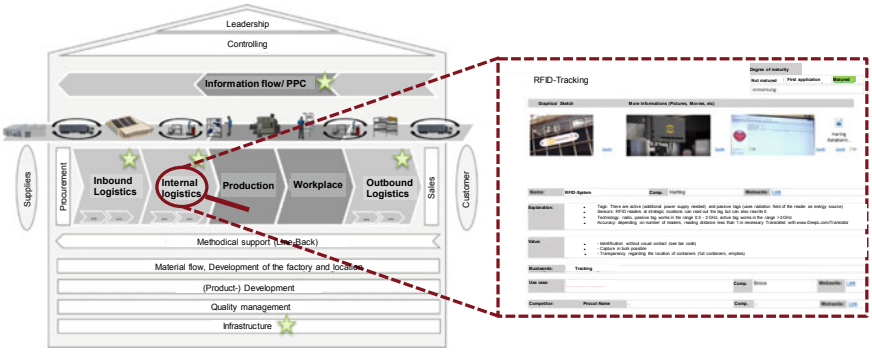

Fig. 5 Extract from the Technology Catalogue as part of the Technology Scouting

Fifth Step: Technology Scouting for Lean Companies. On the way to the Value Stream Design, obstacles occur which are not always predictable and plannable. They show on what to work on next. When recalling the credo "Lean before Industry 4.0" or process before technology, these obstacles are to be first tackled with process solutions. If and only if these potentials are exploited, the use of connected technologies can help to achieve the target condition.

While selecting suitable technologies, several questions are to be answered: What is the current state of the art? Which solutions are available today and which in the near future? If technologies are not known, they cannot be integrated into the problem-solving process. Hence, the first step is to expand the solution space. Technology Scouting serves this purpose.

Technology Scouting comprises the structured observation and early recognition of changes, potentials and relevant expertise in technological developments and processes. Methodically, this involves the use of a catalogue of technologies that is structured along the process of a value stream. For each technology there is a profile with the most important information (see Fig. 5).

Regarding the example of BBW Inc., the workshop begins with a *technology-push* approach. This allows a comprehensive overview of technological possibilities. It is followed by a *market-pull* approach: Based on the target condition of Value Stream Design, possible solutions from the Technology Catalogue are discussed by asking the following questions:

1. *Which aspect of the value stream needs to be improved?* What needs to be done next in order to reduce changeover times in final assembly of BBW Inc.? The workshop team identifies that losses occur during the manual setup of screwdrivers between different screwing processes and product variants. An automated setup allows to reduce changeover times and therefore cycle time losses.
2. *Which industry 4.0 technologies help us to realize this?* Now the question is which technology can contribute to solving the problem. This is where Technology Scouting provides an answer. The profiles help with the process-oriented

selection of certain technologies. In case of BBW, RFID-tracking and upgraded screwdrivers are best-suited for achieving an automated setup.

3. *What is the value added for the customer?* Once it is clear what is required to overcome the next obstacle, and the corresponding technology is identified, the value added for the customer is to be determined. Only with this information the usefulness of the technology can be assessed. By implementing RFID-tracking for automated tool setup, the value added for the customers of BBW is an increased efficiency. The elimination of setup times allows the workers in final assembly to deliver transport trollies to the increasing demand of the customers.

Sixth Step: Extending to the Value Stream Design 4.0. Until now, only technologies for single process steps such as workstations are selected. However, a considerable value added of digitalization is the connectivity of data and objects. This is a key step towards an improved synchronization of material and information flows and therefore faster and more efficient value streams. The visualization of connectivity and of data points is realized with Value Stream Design 4.0.

For the implementation of an automated tool setup in final assembly, the semi-finished transport trolleys are equipped with RFID-tacks. When checking in at a process step in final assembly, the screwdrivers automatically match the product variant (order ID) and the process step with the MES-System. It then retrieves information for the suitable torque setting (see Fig. 4).

4 Summary

This paper presents a methodology that allows manufacturing companies to develop an individual digitalization strategy. The Lean Digitalization Strategy show how to create a Lean-compatible digitalization strategy in a customer- and process-oriented way using the Value Stream Method 4.0.

Starting with the Value Stream Analysis 4.0, digitalization gaps are revealed. The Value Stream Design is used to develop an ideal target condition from the customer's point of view. In order to achieve this target condition, suitable technologies are then selected with the Value Stream Design 4.0 and finally connected via an IIoT platform.

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