LESSONS LEARNED FROM SUCCESSFUL VALUE STREAM MAPPING (VSM)

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ABSTRACT

To improve, it's crucial to see! Vital characteristics of Lean are visualisation and transparency, i.e. allowing everyone to see all what occurs in production. A common tool for this purpose is Value Stream Mapping (VSM). Due to varying flows, performing a successful VSM in construction confers additional challenges. In this paper, lessons learned from successful VSM studies in construction are provided.

Three VSM case studies were performed at different companies ranging from patio door manufacturing to kitchen cabinet assembly. Lessons learned can be structured into three phases; preparing the VSM (selecting "value stream leaders" and VSM team, clarifying values, etc.), performing the VSM (use of mapping tools, approximation of key indicators, waste identification, etc.), and following-up the VSM (Plan-Do-Check-Act, evaluating customer values, etc.).

For the involved companies, the lessons learned imply the start of a "Lean journey" even though the involved companies found it difficult to relate VSM improvements to business strategies. Consequently, there are opportunities to further improve the application of VSM. However, it's important to remember that VSM is about the straight-forward visualisation of flows and that these flows are made transparent for the whole organisation.

KEYWORDS

Value Stream Mapping (VSM), Visualisation, Transparency, Lean Thinking, Value

INTRODUCTION

The Lean philosophy, at least from the point of view of the Japanese society, ultimately originates from lack of natural resources and space, i.e., the dedicated pursuit of waste that maybe is most synonymous of Lean was never a choice; it was a necessity! To achieve enough space, what little space was available was valued. From these circumstances, a way of life grew that was dedicated to bringing out and reducing all that is wasteful; unnecessary use of space, unnecessary activities, etc.

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In the western world, the pursuit of waste has always been a way to cut costs rather than out of necessity. As such, the western "way of Lean" is more often a sub-optimized tool-based approach where specific Lean tools are applied in parts of the system. This results in an isolated Lean event that is not spread throughout the whole organisation. Consequently, the sought cultural organizational change towards a Japanese mindset is rarely achieved.

To identify, and deal with waste, the "Japanese lake" methodology emerged (Yamamoto and Bellgran, 2010); waste emerge by 1) visualizing occurring activities (analogous to characterising and bounding the "lake") and removing so called "surface waste" and 2) making the system vulnerable so that "process waste" emerge (analogous to lowering the water of the "lake" so that the reefs, or rocks, surface). After waste has been removed, new waste is identified in the same manner in a process of continuous improvements.

There are many methods to manage waste, e.g. Value Stream Mapping (VSM), 5S, 5-whys, and standard work, etc. The Last Planner System was specifically developed for construction to identify and deal with waste. In Lean Construction, the VSM methodology has recently won increased attention (Yu et al., 2009). Value stream mapping (VSM) is mainly used to capture the material and information flows and to provide a tool for communication (Alvarez et al., 2009). By focusing on continuous flows rather than machine, transport or personnel utilization, the chance of sub-optimization is reduced (Ballard et al. 2003).

This paper hypothesis that the journey of performing a VSM is just as important as the obtained results, i.e. Lean implementation is mainly about a cultural change! Consequently, successful VSM is to perform the VSM and learn from its implementation, and not necessarily about obtaining good results!

The aim of this paper is to report on lessons learned from the process of performing the VSM case studies, and then to provide guidelines on how VSM can be used to start a Lean journey. Application of VSM in construction was studied through three case studies of "manufacturing for construction"; patio door manufacturing, interior wall manufacturing and kitchen cabinet assembly. All three case studies are about delivering value within a construction supply chain. Also, within "manufacturing for construction", traditional construction work performed by traditional construction tradesmen still dominate.

VALUE STREAM MAPPING (VSM)

Wilson (2009a) argues that VSM can be applied to any business process, e.g. service, product development, manufacturing and office processes. It is not logical to think that a single method can be used to optimize so many different processes. Instead, the focus of VSM on continuous flow enables involvement, transparency, process standardization and reduced variation (Arbulu et al., 2003). Consequently, **VSM is not about optimization!** Instead, VSM is mainly about the visualization of flows and to make these flows transparent for the whole organization (Rother and Shook, 2003). Figure 1 illustrates identified gaps of the VSM method:

- **Complex systems**. The purpose of VSM is to only follow one product or one product group (Rother and Shook, 2003). Thus. VSM does not support analysis of complex systems (Yu et al., 2009) and is mainly for high volume, low variety products (Khaswala et al., 2001; Braglia et al., 2006).

- **Flow**. Understanding takt time may be difficult if the case company does not use takt as a managerial method (Yu et al., 2009). The VSM methodology does not provide any detailed instruction about which tools to use in order to achieve a pull system (Rother and Shook, 2003).

- **The devil is in the details**. A detailed description of the value stream is not created initially (Rother and Shook, 2003) and VSM does not consider layout for material handling (Khaswala et al., 2001).

- **Performance measurements**. Managers do not understand the impact of transforming batch oriented performance measurements to Lean oriented measurements (Anand and Kodali 2009). VSM also lacks an economic measurement for "value" (Khaswala et al., 2001). According to Mehta (2009) performance measures that consider value added time (VAT) and the inventory efficiency are ineffectual for improving throughput.

- **Radical Change**. According to Khaswala et al. (2001), VSM cannot make a rapid change on a low budget.

- **The team**. VSM consumes internal company resources (Serrano et al, 2009) but does not give advice on how to select and educate the VSM team members (Wilson, 2009b).

- **Bottleneck**. VSM does not support identification of bottlenecks (Mehta 2009). VSM should provide clear criteria's for choosing and placing the pacemaker process (Serrano et al, 2009).

- **Cause-Effect Relationships**. VSM does not give instructions on how to use Plan-Do-Check-Act (PDCA) and VSM does not support Root Cause Analysis (Wilson, 2009a).

- **Theoretical development**. VSM need to be user-friendly (Serrano et al, 2009). Lack of key elements in VSM hinders a holistic view (Holweg 2005).

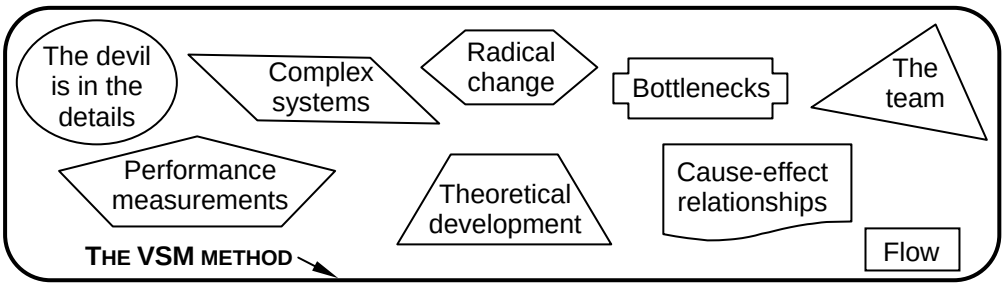

Figure 1: Illustration of identified gaps to further application of VSM.

WHY USE VSM?

Ballard et al. (2003) concluded that VSM is a powerful tool to change the focus from machine and personnel utilization into focusing on lead-time reduction, throughput increase and improved productivity. Using the VSM tool, lead times were reduced and the production system became more robust when errors were caught earlier and the system itself could handle deviations without new planning; the personnel

performing the VSM learned to look at the work-in-process to see if the production system was operating in accordance with its own rules (Ballard et al., 2003).

According to Arbulu et al. (2003), VSM is a helpful method to recognize opportunities of improvements in a supply chain. Álvarez et al. (2009) proved that an assembly line with a small space can achieve high performance through operation redesign using VSM. Holweg (2005) stated that VSM has a unique advantage as it shows the entire process on one map rather than separate the information on several charts. VSM is a simple technique to aid the process of balancing uncertain demand and increasingly expensive resources (Wilson 2009b). Braglia et al. (2006) and Khaswala et al. (2001) conclude that VSM offers the following main advantages:

- VSM enables the choice of key elements of a complex production process in a structured way and enables analysis of the whole value stream.
- VSM unifies methods such as production flow analysis, process analysis and Business Process Reengineering (BPR) that previously has been isolated.
- VSM represents a company "blueprint" for strategic planning.

HOW TO PERFORM A VSM?

There are not many guidelines on how to perform a VSM study. We need to go back to the original sources (Rother and Shook, 2003; Jones and Womack, 2002) for guidance on VSM application. VSM is divided into mapping the current, future and ideal state and implementation of a yearly value stream plan. It is important to begin with an overall picture and later detail the process map where necessary. Mapping the **current state** reveals both value adding and non-value adding activities.

The objective of the **future state** (to-be scenario) is to create a value stream where every individual process is connected to a customer by either continuous flow or a pull system. Each process should strive for single piece flow. The future state is best captured by asking questions such as; what is the takt time? At what single point will you schedule your production? What increment of work will you consistently release? What process improvements will be necessary?

The **yearly value stream map** is a break-down of the future state into goals, objectives, activities and responsibilities, which is actually the implementation plan. The **ideal state** is a representation of the organization vision; a state to strive for but not necessarily currently attainable due to e.g. a low technology level. It is important to have a process owner, a value stream manager, who is responsible for the value stream. Also, the importance of focusing the investigation is mentioned; focus should be on one product, one product group or one family of products.

The deliverables from VSM are maps of three process stages (current, future and ideal) and an implementation plan (yearly value stream map). Someone must draw the maps and someone must analyse them. It is not clear how this work is to be done and since every organisation is different, there is probably no standard way of performing a VSM. However, three stages of performing a VSM study emerge:

- **Preparing the VSM**. Deciding on value stream and VSM team.
- **Performing the VSM**. Mapping the value stream.
- **Following-up the VSM**. Future state map and yearly value stream map.

VSM CASE STUDIES

CASE STUDY 1 – PATIO DOOR MANUFACTURING

The studied value stream is a new production line of patio doors (Figure 2) for Sweden's largest detached housing manufacturer. Eight different models are produced with an expected even demand (in 2008 the demand was 248 doors per month). The detached housing manufacturer orders patio doors every fifth week. The production plan is broken down into a bill of materials for material orders that are placed once a month. The VSM showed a total processing time of 108 minutes and a lead time of 45.2 days, giving a value-adding time of only 0.5 %.

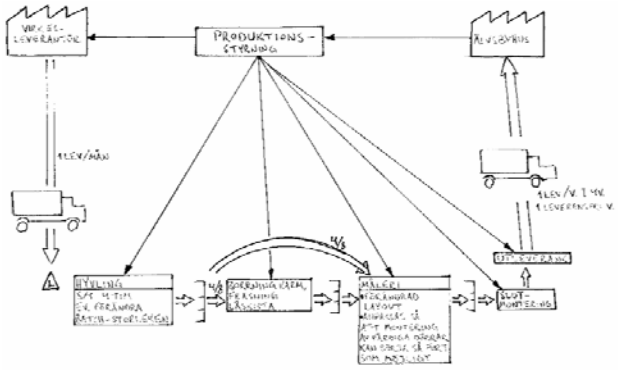

Figure 2: Illustration of patio door and a hand drawn future state value stream map.

Preparing the VSM study

The VSM was initiated through several discussions with the managing director before a first meeting was held with the managing director, the production manager and an operator with detailed knowledge of the process, machines and staff where the Lean philosophy and lean tools were presented. A second meeting was held at the plant, where the VSM team and three PhD students walked through the process to get an overview of activities and to interview personnel.

Performing the VSM study

A three day workshop approach was chosen. During the workshop, frequent visits were made to the shop floor. First, the team walked rapidly through the production flow from raw material to finished goods. Then a map of the current state was made with post-it notes to mark operations and inventories. No discussion about customer value was performed neither did the team talk about customer expectations.

Then a brainstorm was performed; "how would you change the process to world-class performance"? The future state was illustrated by post-it notes. All proposed changes where categorized as "act immediately", 2-5 work days, or >5 work days. To avoid wishful thinking, a Gantt chart was used to make a robust one year plan that was posted in a place were everybody could see. A responsible person was set for all activities and the production manager was appointed as value stream manager.

Following-up the VSM study

The Patio door manufacturer has worked more with 5S, standardized work and process improvements. The Gantt chart has not been used; neither for follow-up nor

to visualize progress. However, several planned activities have been performed. The Patio door manufacturer refers to VSM as a foundation for making decisions on a daily basis and also the basis for their movement towards single-piece-flow. The company has not used VSM in any other of their value streams.

CASE STUDY 2 – INTERIOR WALL MANUFACTURING

The manufacturer is responsibility for development, production and assemblage of inner wall systems for offices (Figure 3). The wall system consists of "ready to assemble" solid walls, room separating walls, doorways and glass walls. The chosen value stream was the production of glass walls. The studied plant produces 800 glass wall elements per month. Customer orders arrive every 15 to 25 days while production is managed with daily production orders. The work schedule is accessible online at every workstation. A value creating time of 897 seconds and a lead time of 7.6 days was measured, giving a value adding time of only 0.4 %.

Figure 3: Illustration of glass wall and photo from the current state workshop.

Preparing the VSM study

During a three day workshop, Lean and VSM were introduced and the VSM team was setup (the purchasing manager, the production plant manager, a production planner, and foremen from painting, the machine shop and assembly). The team was chosen by the purchasing manager, with consent from the CEO who indicated the importance that the whole production flow was represented in the VSM team.

Performing the VSM study

First, the VSM team was asked to define the purpose of the VSM study which resulted in an aggressive goal: halve the lead time! Next, the entire work flow was followed by the whole VSM team. Notes on every work station were taken. Then, a map containing production and information flows was compiled; first as a draft version on white board, and then as a detailed version on paper.

VSM-analysis revealed an uneven flow. Sometimes overtime was necessary and sometimes the assembly and painting divisions had to wait for materials from the machine shop. Analysis of intermediate stocks between activities revealed the bottleneck as the assemblage station. After analyzing the production flow, a future state was developed and visualized in the form of a map. Countermeasures were then developed and a PDCA plan was created.

Following-up the VSM study

One month later, a one-day workshop was held with the VSM team. The objective was to follow-up the countermeasures and to adjusts the PDCA. A short introduction to Lean was repeated so that the team, composed of practitioners, had the possibility to interrelate theory with practical experiences gained during the elapsed month. It was then discussed whether the proposed countermeasures are in accordance with the Lean philosophy and if there are any problems. Finally the PDCA plan was updated.

CASE STUDY 3 – KITCHEN CABINET ASSEMBLY

The studied value stream was assembly of kitchen cabinets at a multi-storey timber housing manufacturer (Figure 4). There are a total of two to six assembled kitchens exiting the factory each day (Bildsten et al., 2010). The kitchens are ordered on a project by project basis and delivered to the construction site according to the production plan (normally a fixed delivery day per week). The total processing time was 20 hours and the lead time was 90 hours from arrival of cabinets at the factory to assembled kitchen, giving a value-adding time of 22 % of.

Figure 4: Illustration of kitchen cabinets (left) and module production (right).

Preparing the VSM study

First, the management was convinced about the need of VSM and the company goals were clarified. A meeting was held with the factory director, purchasing manager and Lean coordinator who setup a VSM team composed of three researchers and the purchasing manager and Lean coordinator. The purchasing manager responsibility was to manage the logistics function while the Lean coordinator worked with tasks concerning efficiency improvements in the factory.

Performing the VSM study

The value stream was observed during several months. As the activities are lengthy, they were written down in regular time intervals. As the activities are not standardized, and every house is unique, it was difficult to generalize a value stream. Later, interviews were held with the production managers, sales managers and purchasing managers concerning their roles in the information flow between management and production. The value stream map was continuously updated and discussed within the VSM team throughout the process.

Following-up the VSM study

The value stream was visualized on paper and then presented to the CEO. Different improvement alternatives of assembly were then discussed. One of the major issues was the large number of incomplete kitchens leaving the factory. After some time the factory was visited again and the purchasing manager was interviewed about the status of process improvements. The company has now successfully implemented an error reporting system in their aim to produce complete products with zero defects.

LESSONS LEARNED FROM THE VSM STUDIES

PREPARING A VSM STUDY

The first step in planning the VSM is to find out the company's needs; it is important to find out what the company expectations and desires are to make them motivated. A team should then be selected that includes all divisions in the studied flow. The company should select the team self, but it is important that the members are open to change. The team members should be prepared with questions before the visit to the factory as it is good that they reflect before doing the actual analysis of the flow.

The whole organization must be informed about the motives of the VSM. The whole organization should be persuaded about the benefits; most important is the top management's commitment as change is only possible top-down. VSM analysis is preferable carried out at the company that is studied. This is because it is good to follow the flow in reality to get the most adequate view of the current state. A process owner or "value stream leader" should be selected at the company. Demand the company to make queries about customer value. What does the customer want? During the preparation, the following activities should be performed:

- **Introduce VSM** in a pedagogic manner to make all participants motivated and active.
- **Set the goals**, i.e. what exactly should be reached? An aggressive goal shows what is possible with VSM! The goal should be related to business goals and be measurable to see improvements. The goal should also relate to customer values through queries with customers or sales people.
- **Decide on product or product family** through e.g. ABC- analysis. The chosen product should have the largest part of the company's turnover. For the first VSM, it's important to not choose a too complex product. Keep in mind that a VSM is done on one product – do not loose focus!
- **Set clear boundaries** for the flow. Common start and end-points for the flow are the trucks going into the factory and the trucks leaving the factory.

PERFORMING A VSM STUDY

When limitations are placed, take pen and paper and follow the chosen product from end to start. When following the flow "backwards" it becomes more obvious what the problems are as they often are revealed at the end of the flow. VSM analysis creates a simple picture, it is therefore unnecessary to determine lead-times too accurately. A rough average value is often enough as the really important thing is to capture the whole flow to know how activities interact with one another.

When the flow is written down, the related information flows should be mapped. A problem when mapping the information flow is the difficulty to measure cycle times as administrative work is not the same as machine work. However, it is important to see the interactions to know exactly how the process flow goes. When everything is written down, bottlenecks should be identified. There seems to be no ready-to-use method to identify or measure bottlenecks. We suggest interviews and walking around the factory. When drawing the currents state map it is important that:

- **The whole team participates** in the walk around the factory so that maximum knowledge is contributed to the process mapping.
- **Basic tools like pen and paper** are used when walking in the factory as it is closer to production and focus is not on the tools but on the process.
- **Large-scale picture with simple symbols** are used to make it visible and easy to understand for the whole team as it's understandable for everyone.

When remodelling the process it is important to focus on the whole process so as not to sub-optimize. Useful methods are e.g. Hejunka box, FIFO, pull and supermarkets (Rother and Shook, 2003; Bicheno, 2004). Project team members can influence each other positively (common understanding) and negatively (focusing on wrong things); subjective beliefs are often valued higher than facts! Discuss how to best handle the human side of change. As it’s difficult to estimate the efficiency of the future state, simulations could be used. Fundamental rethinking is not recommended at an early stage; rather kaizen (continuous improvements) than keikaku (leap in change).

FOLLOWING-UP A VSM STUDY

Remodelling most be followed by an action plan, e.g. PDCA. It is appropriate to use bottleneck thinking with PDCA to improve flow, and SMED to improve change-over-times. Continuous VSM-analyses should be done to measure improvements and see if the factory is on the right track. Recommendations for following-up a VSM are:

- **One person should be responsible** for improvement activities.
- It is important not to loose the focus and to **follow the plan**. However, be flexible and accept that the plan can change!
- **Visual planning** like for example whiteboards are helpful to inform the personnel about the progress of PDCA.
- **Customer satisfaction must be measured** continuously in order to lead the company towards the right goals. A way of measuring customer satisfaction is to continuously write down complaints and act upon them.

CONCLUSION

Many of the involved personnel were struggling to understand the impact of Lean. In this regard, the VSM worked as a change-agent in convincing all involved of the positive effects of working with Lean. A common misconception was that Lean is all about the tools and that working with Lean will give instant results. However, afterwards all involved realised what they had just experienced; a cultural change giving birth to new change-agents ready to continue the Lean transformation.

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