Lecture 4
Value Stream Mapping
2013-09-16
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Agenda lecture 4

- Introduction and overview
- Presentation material VSM
- Exercise
- Templates

Objective and content of the module

- To create an understanding of what a value stream map (VSM) is and how to use it
- Learn how to develop a current state and future state VSM diagram
- Introduction and overview
- Presentation material VSM
  - Current state VSM
  - Future state VSM
- Exercise
  - Current state map
- Template
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Introduction and overview

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Definition

• Value stream mapping (VSM) is one of the basic methods within Lean, in order to understand and communicate the material and information flow for a product, plant or supply chain
• It is a helpful way to identify sources of waste and opportunities for improvement as well as supporting the design process for future production flows
• Always create a VSM for a value stream before diving into the task of waste elimination

The origins of value stream mapping lie at Toyota

Taichi Ohno’s problem
• Managed a machine shop
• Had a large area of responsibility
• Had an unsatisfied customer
• Could not see waste or flow at a glance

The Solution
• Needed a standard method for visual flow mapping
  – Value Stream Mapping was used
VSM is a method of viewing the combination of flows, and this is the way it looks like.

A VSM is always a clear, single-sheet overview.

The detail of a VSM is adjusted according to the level of application (e.g., across supply chain or across one factory).

VSM is focusing on two types of flows which can be observed in any business environment.
Taking a view on the complete value stream – not just one process – enables optimization of the entire system.

Why do value stream mapping?
- Makes you see the sources of waste in your value stream, also in between different processes.
- The connection between information and material flows is shown.
- Allows everyone to see the value stream through the same lens.
- Provides a common language for talking about manufacturing processes and discussing improvement opportunities.
- Supports the design process for future production flows.
- An action plan can be created taking into account the whole process.

Why shorten the lead time?
- Eliminate waste
  - The longer time it takes to complete a product, the more cost increases and quality decreases.
  - Shorten the lead time will lower the cost and increase the quality.
  - Your problems are no longer hidden in the inventories.
  - Long lead time implies higher risk of products being damaged while stored.
  - Long lead time also implies risk of decreased customer demand on products in progress.
- Shorten time from order to delivery will make you more responsive to customer demands.

- Shortening the lead times gives:
  ⇒ Lower WIP
  ⇒ Lower inventory
  ⇒ Increased cash flow
  ⇒ Increased possibilities for investments.

- On time in full (Delivery accuracy)
- Increased Order
- Increased delivery flexibility
- Reduced lead times
- Reduced inventory costs
- Reduced transportation costs
- Reduced production costs
- Increased product quality
- Increased component quality
- Reduce obsolescence/scrap/defects.
Symbols – VSM provides a common language for describing manufacturing processes and discussing improvement opportunities

Who should use VSM

• The Value Stream Manager, e.g., the person who is responsible for the value stream of the product, from supplier to customer

• VSM is led by a person who is trained in the method

• A cross-functional team with representatives from production, manufacturing engineering, quality, maintenance etc. supports the VSM leader

• The result of the VSM is used by the people who are planning and implementing the improvements

Two types of VSM diagrams

<table>
<thead>
<tr>
<th>Current state diagram</th>
<th>Future state diagram</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purpose</td>
<td>Purpose</td>
</tr>
<tr>
<td>Current</td>
<td>Creative, synthesized</td>
</tr>
<tr>
<td>Future</td>
<td>design</td>
</tr>
<tr>
<td>Rigorous, fact based</td>
<td>Provides a detailed visual description of the current value stream</td>
</tr>
<tr>
<td>analysis</td>
<td>Force best practice in creating a vision of the ideal lean value stream</td>
</tr>
<tr>
<td>Objectives</td>
<td>Set baseline for tactical implementation planning by identifying future value stream loops</td>
</tr>
<tr>
<td>Show a holistic view</td>
<td>Assist in quantifying improvement potential</td>
</tr>
<tr>
<td>of the entire current</td>
<td>Serve as communication tool for the future state</td>
</tr>
<tr>
<td>system</td>
<td></td>
</tr>
<tr>
<td>Highlight waste and</td>
<td></td>
</tr>
<tr>
<td>its sources throughout</td>
<td></td>
</tr>
<tr>
<td>the system</td>
<td></td>
</tr>
<tr>
<td>Identify improvement</td>
<td></td>
</tr>
<tr>
<td>opportunities</td>
<td></td>
</tr>
<tr>
<td>Provide common picture</td>
<td></td>
</tr>
<tr>
<td>for discussion</td>
<td></td>
</tr>
</tbody>
</table>
When to use the Value Stream Mapping cycle

- Map the value streams for your product families before diving into the task of waste elimination
- When the current state map is created, create a realistic future state map and start to plan and implement the identified improvement steps.
- After implementation, when the future state VSM has become the current state, a new future state map should be drawn.
- And the value stream mapping cycle keeps going...

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Select a product family

- Select a product or a product family to map
- Focus on one product/product family for each VSM
- A product family is a group of products that pass through similar processing steps and over common equipment in your downstream processes
Follow four basic principles to assure a good VSM

- Gather your own data; believe nothing that is given by others
- If you see for yourself, you will understand! Do not divide the flow, you should understand the end-to-end activity.
- First, "Walk" quality and get a sense of the flow and sequence of processes. Then, "Walk" the process from customer requirements back to inputs, e.g., from shipping dock back to raw materials. Capture all relevant process data as you go.
- Sketch out the flow as you go. Modify on the fly. Focus on the flow and inter-relationships, not on making it look pretty.

A current state VSM is created in 7 steps

1. Draw customer
2. Draw process steps
3. Gather process data
4. Gather inventory data
5. Reference customer data
6. Reference internal data
7. Calculate lead time

- Draw customer
- Add data boxes
- Draw process steps
- Gather process data
- Gather inventory data
- Reference customer data
- Reference internal data
- Calculate lead time

Step 1: Determine customer requirements

- Draw in customer
- Add customer data box:
  - Quantities of orders per variant
  - Order size (minimum, maximum, average)
  - Packaging size
  - Shipment schedules
  - Customer lead time
  - Order adjustments

- Inventory, FIFO or supermarket
- Collect and add process data
- Cycle times
- Machine uptime
- Changeover time
- Batch size
- No. of shifts

- Delivery receipt
- Customer delivery
- Frequency
- Processing time
- Draw push or pull arrows or put other push arrow as needed
- Add production control information (trucks, etc.)
- Add information arrows (externally and internally)
- Do the calculations
- Lead time
- Shipment time
- Order time
- Capacity
- Cost

Company
- Packaging quantity
- 2 shifts
- Amount/year

- Company
- Packaging quantity
- 2 shifts
- Amount/year
Step 1: Define customer requirements

- Draw all process steps
  - A process is an activity where material can stagnate on either side
  - A process is not the same as a department or function
  - Parallel processes are to be drawn above each other
  - A box can be drawn around processes in the department
  - To distinguish stations on a line, use multiple data boxes

- Draw inventories, where they exist, between processes including inventory before and after production

Step 2: Draw process steps and inventory

- Draw all process steps
  - A process is an activity where material can stagnate on either side
  - A process is not the same as a department or function
  - Parallel processes are to be drawn above each other
  - A box can be drawn around processes in the department
  - To distinguish stations on a line, use multiple data boxes

- Draw inventories, where they exist, between processes including inventory before and after production
Step 3: Gather process data

- Add process data box:
  - Machine and manual cycle times
  - Process time
  - Changeover time
- Machine uptime
  - Available time (scheduled time – management allowances)
  - Batch size
  - Number of operators
  - Number of product variations
  - Shipment quantities and timing (supplier and finished goods)
  - Scrap and re-work rate
  - Shared or dedicated process

Step 3: Definitions (1/2)

- Cycle time (C/T)
  - Time that elapses between one part is coming off the process until the next part is coming off
- Process time (P/T)
  - Equals the time one unit needs in the process. It is equal to C/T if one unit is processed at a time
- Changeover time/Set-up time (C/O)
  - The time it takes to change from producing one product variant to another
- Machine uptime
  - The available time for a machine when maintenance and breakdown time is subtracted

Step 3: Definitions (2/2)

- Available time
  - Scheduled working time minus breaks
- Numbers of operators
  - The number of operators it takes to run the process
- Shared or dedicated process
  - Is the process dedicated to this specific product or is it shared with other value streams?
### Step 3: Gather process data

<table>
<thead>
<tr>
<th>Process</th>
<th>C/O (min)</th>
<th>Uptime (%)</th>
<th>Cycle Time (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welding No 1</td>
<td>10</td>
<td>100</td>
<td>39</td>
</tr>
<tr>
<td>Welding No 2</td>
<td>0</td>
<td>100</td>
<td>40</td>
</tr>
<tr>
<td>Assembly No 1</td>
<td>0</td>
<td>100</td>
<td>62</td>
</tr>
<tr>
<td>Assembly No 2</td>
<td>0</td>
<td>100</td>
<td>46</td>
</tr>
</tbody>
</table>

### Step 4: Gather inventory data

- Use inventory symbol if inventory is not controlled
- Controlled inventory is either FIFO or supermarket
**Step 4: Gather inventory data**

- Draw process steps
- Gather process data
- Gather inventory data
- Calculate lead time

**Step 5: Determine material flow -external**

- Draw in main supplier(s)
- Add data box for supplier
- Draw deliveries from supplier and to customer
- Add data box for frequency of deliveries and box size

**Typical information**

- Order size (minimum, maximum, average)
- Packaging size
- Shipment schedules
- Customer lead time
- Order adjustments

**Step 5: Determine material flow -internal**

- Draw push or pull systems as appropriate
- Draw suitable pull trigger symbols
Step 5: Material flow

- Determine customer requirements
- Draw process steps
- Gather process data
- Gather inventory data
- Determine external material flows
- Draw internal material and information flows
- Calculate lead time

Company Cutting
- C/O = 1 hour
- Uptime = 85%
- C/T = 1 sec

Company Welding
- 1
- C/O = 10 min
- Uptime = 80%
- C/T = 46 sec

Company Assembly
- 1
- Despatch dep.

- C/O = 0 sec
- Uptime = 100%
- C/T = 40 sec

- C/O = 10 min
- Uptime = 80%
- C/T = 46 sec

Company Despatch
- C/O = 0 sec
- Uptime = 100%
- C/T = 62 sec

I: 12000 Left
R: 6400 Right
18400 pcs/month
Box: 20 pcs
2 shifts
5 days of production

L: 4600 pcs
R: 2400 pcs
L: 1100 pcs
R: 600 pcs
L: 1600 pcs
R: 850 pcs
L: 1200 pcs
R: 640 pcs
L: 2700 pcs
R: 1440 pcs

Step 6: Draw information flows

- Add right type of information flow arrows
- Add receivers of info (systems and departments)

Step 6: Rate information flow – Pulling or pushing

Push
- The most common push situation is that no required rate information is communicated; material is just pushed in at the beginning. Daily quotas may be measured
- When MRP is implemented, push occurs as different rates are communicated, based on non-perfect assumptions

Pull
- Pull occurs when rate information is communicated through a signal from the immediate customer (downstream) process, so pulling material flow
Step 6: Internal material and information flows

- Determine customer requirements
- Draw process steps
- Gather process data
- Gather inventory data
- Determine external material flows
- Draw internal material and information flows
- Calculate lead time

- Company
- Supplier

- 1 x day
- Tuesday, Thursday

- 1700 m/roll
- Raw Material

- ► I ► I
- C/O = 1 hour
- Uptime = 85%
- C/T = 1 Sec

- ► I
- L: 4600 pcs
- R: 2400 pcs

- ► I
- L: 1100 pcs
- R: 600 pcs

- ► I
- L: 1600 pcs
- R: 850 pcs

- ► I
- L: 1200 pcs
- R: 640 pcs

- ► I
- L: 2700 pcs
- R: 1440 pcs

- 5 days of production demand

- 12000 Left
- 6400 Right

- 18400 pcs/month

- Box: 20pcs
- 2 shifts

- Production planning
- 90/60/30 days forecast
- Daily delivery schedules
- Daily faxes
- Weekly production schedule
- 6 weeks forecast
- MPS

Step 7: Exercise in calculating lead time

- Takt time = available time per shift / customer demand per shift
- (27600 sec / 18400 pcs / 20 days * 2 shifts) / 24 hours (1 item is finished each 24 hour)
- Inventory lead time = takt time * inventory
- 60 * 1840 = 110400 sec, which is equal to 30.2 h
- Inventory lead time (days) = inventory lead time (h) / available hours per day
- 30.2 / (7.7 h * 2 shifts) = 2 days

- Customer demand: 18400 pcs/month
- Working days/month: 20 days
- Available time/day: 15.4 hours (2 shifts)
- Takt: 60 sec/pcs
- Inventory: 1840 pcs (1200+640)
- Inventory lead time (sec) 110400 sec (1840*60)
- Inventory lead time (h) 30.2 h (110400 s / 3600 s)
- Inventory lead time (days) 2 days (30.2 h / 15.4 h)

- Individual parts may be expedited, or left behind, but this gives an accurate calculation of total lead time

Step 7: Calculate lead time

- Draw the trace along the bottom of the diagram
- Calculate inventory lead times and add these to the trace together with process times
- Calculate value adding time (%)
- Look at the details of the trace to find the worst contributors to lead time
- If mapping a product family: Choose the longest component stream in the product family and calculate total processing time and lead time for that product

- Sum of processing time
- Sum of manufacturing lead time

- ⇒ Value adding ratio of the time the product spends in the factory

- Takt time = available time per shift / customer demand per shift
- Inventory lead time = takt time * inventory
- Inventory lead time (days) = inventory lead time (h) / available hours per day

- Example:
- Customer demand: 18400 pcs/month
- Working days/month: 20 days
- Available time/day: 15.4 hours (2 shifts)
- Takt: 60 sec/pcs
- Inventory: 1840 pcs (1200+640)
- Inventory lead time (sec) 110400 sec (1840*60)
- Inventory lead time (h) 30.2 h (110400 s / 3600 s)
- Inventory lead time (days) 2 days (30.2 h / 15.4 h)

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- Takt time = available time per shift / customer demand per shift
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Step 7: Lead time

- Determine customer requirements
- Draw process steps
- Gather process data
- Gather inventory data
- Determine external material flows
- Draw internal material and information flows
- Calculate lead time

Company
Supplier
Production planning

90/60/30 days
Forecast
Daily delivery schedules
Daily faxes

Daily delivery schedule
Weekly production schedule
1 x day
Tuesday, Thursday

6 weeks
Forecast
MPS

1700 m/roll
Raw Material

► I
Cutting
1
C/O = 1 hour
Uptime = 85%
C/T = 1 Sec

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L: 4600 pcs
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Welding No 1
1
C/O = 10 mjn
Uptime = 100%
C/T = 39 sec
L: 1100 pcs
R: 600 pcs
L: 1600 pcs
R: 850 pcs

► I
L: 1200 pcs
R: 640 pcs
Welding No 2
1
C/O = 0 sec
Uptime = 100%
C/T = 40 sec

Assembly No 2
1
Despatch dep.

► I
L: 2700 pcs
R: 1440 pcs
C/O = 0 sec
Uptime = 100%
C/T = 62 sec

Assembly No 1
1
Despatch dep.

5 days of production demand
5 days 7.6 days 1.8 days 2.7 days 2 days 4.5 days
1 sec 39 sec 46 sec 62 sec 40 sec
L/T: 23.6 days
V/A: 188 sec

12000 Left
6400 Right
18400 pcs/month
Box: 20pcs
2 shifts

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Hints
- Don’t worry about structure on the first draft – use paper an pencil or post-its to draw the processes and organize them
- Keep the map visually simple, but rich enough to expose waste and problems. Use common sense to handle exceptions
- Use the knowledge and the support of the operators
- Check the data and information
- While drawing the map, highlight problem areas
- Begin at the shipping end and walk upstream
Leanspelet

- Ett exempel på tillämpning av Lean
- Exemplet är från produktion, men...
- ...Lean handlar om hele företaget
Steg 1 – rita upp de ingående processerna och eventuella lager på undre halviet:

Steg 2 – fyll de olika informationsrutorna och respektive lagringspunkt med fakta:

VFA nuläge – Leanspel 1.0

Exempel VFA nuläge – Leanspel 1.0

Layout leaneptet:

VFA nuläge – Leanspel 1.0
Steg 3 – rita in kunder, leverantörer, transporter och typ av system för materialhantering:

Steg 4 – rita in typ av materialflöde i fabriken:

Steg 5 – rita in informationsflödet:
Steg 6 – rita in trappan värdehöjande/genomloppstid:

Värdehöjande kvot: 87/687 = 0,127 = 12,7%

VFA nuläge – Leanspel 1.0

VFA nuläge – Leanspel 1.0

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A future state VSM depicts the target state of the redesigned production system

Future state map

- Forces end-to-end thinking
- Breaks the system into manageable but related “loops” for implementation
- Assists in quantifying the improvement potential

The hardest piece: Improve the manufacturing process!

Developing an “ideal” future state map can be a useful visioning tool

1. First step is to evaluate a current state map
2. Second step is to make an visionary/ideal state map, representing the vision and long term goals, without going into details
3. Third step is to create a future state map. It should be concrete, detailed and realistic to reach within a medium term time period (6 – 18 months)
4. Implement the immediate state through a step change improvement
5. Improve over time, make a new future vision mapping cycle

Follow these 7 guidelines and answer key questions to develop a future state VSM

1. Produce to Takt time: What is the future Takt time for the chosen product family?
2. Develop continuous flow whenever possible: Where can you introduce continuous flow?
3. One supermarket to control production where continuous flow does not extend upstream: Will you build a finished goods supermarket or directly to shipping?
4. Try to send the customer schedule to only 1 production process (information entry point): At what point will you schedule production (“Pacemaker”)?
5. Determine the production of different products every time at the production process: How will you level the production mix at the pacemaker?
6. Set the “pitch” at the pacemaker process by establishing a pull of small, consistent increments of work: How consistent increments of work will be released to and taken away from the pacemaker?
7. Develop the ability to make “every part everyday” in upstream processes

What issues could prevent you from achieving the future state design?
Guideline 1 – produce to takt time

• Takt time is the time allocated to produce one part or product, based on the rate of sales, to meet customer requirements. It is calculated by dividing the available working time per shift (in seconds)* by customer demand per shift (in units).

• Takt time is used to synchronize the pace of production with the pace of sales. It is a reference number that provides a sense for the pace.

\[ \text{Takt time} = \frac{\text{Available production time per shift}}{\text{Customer demand rate per shift}} \]

*Available work time = production time less scheduled breaks

Guideline 2 – develop continuous flow wherever possible

Continuous flow refers to producing one piece at a time, with each item passed immediately from one process to the next without waiting in between. Continuous flow is the most efficient way to produce, and may require substantial creativity to achieve.

Guideline 3 – use supermarkets to control production where continuous flow does not extend upstream

• There are often spots in the value stream where continuous flow is not possible and batching is necessary. There can be several reasons for this, including:
  - Some processes are designed to operate at very fast or slow cycle times and need to change over to serve multiple product families.
  - Some processes, such as those at suppliers, are physically removed from the operation and shipping one piece at a time is not realistic.
  - Some processes have too much lead time or are too unreliable to link directly to other processes in a continuous flow.

• Instead of individual scheduling through a production control department, Kanban signals link production to downstream customer demand.

<table>
<thead>
<tr>
<th>Supermarket</th>
<th>Production Kanban</th>
<th>Withdrawn Kanban</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Product</td>
<td>B</td>
</tr>
</tbody>
</table>

"Supermarket" is a controlled inventory of parts that is used to schedule production at an upstream process.
First view of future state map showing takt time, weld/assembly cell, and finished goods supermarket

Guideline 4 – try to send the customer schedule to only 1 production process

- By using supermarket pull systems, you will typically need to schedule only one point in the door-to-door value stream. This point is called the pacemaker process. The method in which production is controlled at this process sets the pace for all the upstream processes. All processes after the pacemaker collectively make up the customer order-to-delivery lead time.
- Material continuously flows from the pacemaker downstream to finished goods and on to customer. On the future state map, the pacemaker is the production process that is controlled by the outside customer's orders.

Second view of future state map showing stamping and raw material supermarket
Guideline 5 – distribute the production of different products evenly over time at the pacemaker process

By leveling the product mix at the pacemaker process, you can respond to different customer requirements with reduced lead times while holding minimum inventory. This in turn reduces the size of supermarkets.

This is the symbol for leveled production: GOGO

Guideline 6 – set the “pitch” at the pacemaker process by establishing a pull of small, consistent increments of work

Establishing a consistent or level production pace creates a predictable production flow, which indicates problems and enables you to take quick corrective action. A good place to start is to regularly release only a small, consistent amount of production instruction (usually 5- to 60-minutes’ worth) at the pacemaker process, and simultaneously take away an equal amount of finished goods. This consistent increment of work is often called pitch.

Guideline 7 – Develop the ability to make “every part everyday” in upstream processes

By shortening changeover times and running smaller batches in the upstream processes, those processes will be able to respond to changing downstream needs more quickly. In turn, they will require even less inventory to be held in their supermarkets. EPE stands for “every part every…” after which you can write a time such as a week, day, shift, hour, pitch, or takt.

By reducing changeover times, it is possible to run smaller batches and to carry less inventory.
Completed view of future state map

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  - Future state VSM
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Practical tips for creating the future-state value stream and quantifying the improvement potential

- Make 1-2 future-state value stream maps so you have intermediate “check points”
- Simplify . . . simplify . . . simplify – otherwise the maps will collect dust and the insights will be lost
- Work closely with team members across functions, being wary not to make people “afraid” by overcomplicating the tool
- Build the future state by selectively improving element-by-element of the current-state map
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Current state map of a machined component

Future state map of the same component
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Moving forward – from words to action

- Value Stream Mapping is only a tool to find improvement opportunities; real benefit is achieved when the identified improvements are carried out.
- Make an action plan, showing how to change the production process, including:
  - How to implement the identified improvements
  - When (step by step) to implement the identified improvements
  - Check points and deadlines
  - Measurable goals
  - Identified responsible people
- Follow-up your action plan according to a fixed routine
- Hint: Start the change in an area where the process is well-known and where the likelihood of success is high.

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Template for creating a VSM

Further reading

- If you want to learn more about Value stream mapping, the book *Learning to see* (Rother, M. et al (1998) The Lean Enterprise Institute) is recommended