VALUE STREAM MAPPING
PROCESS INDUSTRY OPERATIONS

Peter L. King
Lean Dynamics, LLC
January 2010
AGENDA

- Value Stream Map basics
  - Material flow
    - Process boxes
    - Icons
    - Data boxes
  - Information flow
  - The Timeline

- Mapping considerations ~ good VSM practices

- Benefits of VSMs

- Summary
Lean is all about removing WASTE from our process ...

and improving FLOW

- How do we see waste?
- How do we understand the flow?

A Value Stream Map
- Based on Toyota's material and information flow diagrams
- Standardized and popularized by Rother and Shook in Learning To See
MATERIAL FLOW ON A VSM
Each major process step will be represented by a PROCESS BOX
- A machine
- A process vessel, a tank
- A process system
- Includes the quantity of similar machines
- Includes the approximate number of operators assigned

The process box is accompanied by a DATA BOX
- Lists all data relevant to flow and capacity
- Helps to indicate waste
- Identifies bottlenecks
- Highlights quality issues

**SLITTING**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Eff Capac</td>
<td>10.3</td>
</tr>
<tr>
<td>TAKT</td>
<td>7.2</td>
</tr>
<tr>
<td>(Bonded Rolls/Hr)</td>
<td></td>
</tr>
<tr>
<td>Utilization</td>
<td>70%</td>
</tr>
<tr>
<td>Lead time</td>
<td>10 Min</td>
</tr>
<tr>
<td>Yield</td>
<td>98%</td>
</tr>
<tr>
<td>Reliability</td>
<td>95%</td>
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<tr>
<td>UPtime</td>
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<td>Batch size</td>
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<tr>
<td>EPEI</td>
<td></td>
</tr>
<tr>
<td>C/O time</td>
<td>5 Min</td>
</tr>
<tr>
<td>C/O loss</td>
<td>~ 0</td>
</tr>
<tr>
<td>Avail time</td>
<td>168 hr/wk</td>
</tr>
<tr>
<td>Shift schd</td>
<td>3 x 8 x 7</td>
</tr>
</tbody>
</table>
PUSH Material Movement

Material flow in a Pull environment

Material to a customer or from a supplier
TRANSPORTATION ICONS

Fork Truck

Conveyor

Tractor Trailer

Railcar
<table>
<thead>
<tr>
<th>Process</th>
<th>Inventory</th>
<th>Takt</th>
<th># SKUs</th>
<th>Utilization</th>
<th>Lead Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slitting (3)</td>
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<td>10.3</td>
<td>200</td>
<td>70%</td>
<td>10 Min</td>
</tr>
<tr>
<td>Calendaring Bonding (4)</td>
<td>4000</td>
<td>7.2</td>
<td>1000</td>
<td>90%</td>
<td>10 Min</td>
</tr>
<tr>
<td>Chopping (3)</td>
<td>29</td>
<td>24</td>
<td>1000</td>
<td>83%</td>
<td>10 Min</td>
</tr>
<tr>
<td>Wrapping Packaging Labeling (4)</td>
<td>322 M sq ft</td>
<td>200</td>
<td>2,000</td>
<td>60%</td>
<td>10 Min</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Process</th>
<th>Takt</th>
<th># SKUs</th>
<th>Utilization</th>
<th>Lead Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Slit Rolls/Hr)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Bonded Rolls/Hr)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Cut Rolls/Hr)</td>
<td></td>
<td></td>
<td></td>
<td>8 Min</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Process</th>
<th>Inventory</th>
<th>Takt</th>
<th># SKUs</th>
<th>Utilization</th>
<th>Lead Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slit Roll</td>
<td>168 hr/wk</td>
<td>5 Min</td>
<td>1000</td>
<td>98%</td>
<td>5 Min</td>
</tr>
<tr>
<td>Cut Roll</td>
<td>168 hr/wk</td>
<td>0</td>
<td>1000</td>
<td>98%</td>
<td>5 Min</td>
</tr>
</tbody>
</table>

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<th>Process</th>
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<th>Takt</th>
<th># SKUs</th>
<th>Utilization</th>
<th>Lead Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master Rolls</td>
<td>3 x 8 x 7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slit Rolls</td>
<td>3 x 8 x 7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cut Rolls</td>
<td>3 x 8 x 7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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List all data relevant to FLOW and Capacity
Think of it from an Industrial Engineer’s perspective
- Total quantity = the sum total of all products ordered by all customers

- Takt = The time available to produce one unit of customer demand, or the rate at which product must be produced to meet customer needs

- Lead time = The maximum time the customer allows from receipt of order to receipt of goods

<table>
<thead>
<tr>
<th>Customer Data Box</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Quantity per unit time</td>
</tr>
<tr>
<td>TAKT</td>
</tr>
<tr>
<td>Lead Time Expectations</td>
</tr>
</tbody>
</table>
### MANUFACTURING PROCESS STEP DATA BOX

<table>
<thead>
<tr>
<th>Process Step Data Box</th>
<th>xx</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cycle Time (Capacity)</td>
<td>xx</td>
</tr>
<tr>
<td>TAKT</td>
<td>xx</td>
</tr>
<tr>
<td>Utilization</td>
<td>xx</td>
</tr>
<tr>
<td>Lead Time</td>
<td>xx</td>
</tr>
<tr>
<td>Yield</td>
<td>xx</td>
</tr>
<tr>
<td>Reliability</td>
<td>xx</td>
</tr>
<tr>
<td>Uptime</td>
<td>xx</td>
</tr>
<tr>
<td># SKUs</td>
<td>xx</td>
</tr>
<tr>
<td>Batch Size</td>
<td>xx</td>
</tr>
<tr>
<td>EPEI</td>
<td>xx</td>
</tr>
<tr>
<td>C/O Time</td>
<td>xx</td>
</tr>
<tr>
<td>C/O Losses</td>
<td>xx</td>
</tr>
<tr>
<td>Available Time</td>
<td>xx</td>
</tr>
<tr>
<td>Shift Sched</td>
<td>xx</td>
</tr>
</tbody>
</table>

- **Utilization** = The % of available time needed to meet customer demand.
- **Cycle Time/Takt**
- **Lead time** = the time for a unit of material to move through this process step
- **UPtime** = OEE
- **Batch size** = the quantity made as one lot. Several batches of the same material = a **campaign**.
- **EPEI** (Every Part Every Interval) = the time span over which all products are made

*Note: Not all of these data will be relevant in every case - and others may be added to completely describe issues relevant to specific processes.*
The inventory data box is short and simple – but it is very important and very enlightening as a symptom of waste!

- There should be an inventory data box for each inventory, including:
  - Raw materials
  - WIP (work in process)
  - Finished products

- Average inventory = The average total inventory of all products at this step in the process (NOT necessarily all products at this location!) in pounds, gallons, square feet, rolls, cases, etc.
- Days of Supply = Total inventory/throughput

<table>
<thead>
<tr>
<th>Inventory Data Box</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Inventory</td>
</tr>
<tr>
<td>Days of Supply</td>
</tr>
<tr>
<td># SKUs</td>
</tr>
</tbody>
</table>
TRANSPORTATION DATA BOX

A data box should be shown for each significant transportation step

- Deliveries to customers, warehouses, distribution centers
- Supply of major or critical raw materials

Delivery frequency = how often shipments are received; how often shipments are made (sum of all destinations)

<table>
<thead>
<tr>
<th>Transport Data Box</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delivery Frequency</td>
</tr>
<tr>
<td>Lot Size</td>
</tr>
<tr>
<td>Transport Time</td>
</tr>
</tbody>
</table>

- Lot size = the average quantity shipped or received. Same units as production and/or customer demand data: gallons, pounds, square meters, rolls, etc.
- Transport time = the average time from shipment to receipt
Not all raw material suppliers need to be shown on the VSM.

- If they supply a very significant percentage of total raw materials
- Low volume, critical materials which could shut down the process

- Order lead time = the time from placing the order to the time the supplier ships
- Does not include transportation time

- # SKUs = the number of material types or part types normally received from that supplier
MATERIAL FLOW ON A VSM

Process boxes

icons

Data boxes

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The VSM should show all of the major communications which influence production planning, forecasting, order fulfillment, and detailed scheduling.

- Starts with customer input – orders and forecasts
- Moves backward through various information processing steps
- Goes through to detailed manufacturing schedules, releases for raw materials
Any resource which, if not properly scheduled and managed, is likely to cause the actual flow of product through the plant to deviate from the desired product flow.

- Integrating material flow and information flow on the same map helps to uncover Capacity Constraints

From SYNCHRONOUS MANUFACTURING – Umble and Srikanth, South-Western Publishing, 1990
THE VSM TIMELINE

- The timeline appears on the bottom of the VSM, below the material flow and data boxes
- It is a square wave – contrasts value-add time with non-value-add time
- Normal convention – NVA time is the high part of the wave, VA time the low portion

- The timeline highlights all those wastes that add time (most of them do!)
- In many assembly processes, NVA is 90% of total time
- In process plants it can exceed 99%
Don’t get too hung up on what is value-add time vs non-value-add time!
1. It gives the team a sense of flow, inventory, bottlenecks
2. It creates understanding of how value is created for customers
3. Brings everyone to a shared understanding of the end-to-end process
4. It highlights key areas of waste
5. It links planning and scheduling processes to material flow
6. It gives clues to root causes of waste
7. It provides a template for improvement plans, leading to the *Future State VSM*
VSM BEST PRACTICES

- Takt as a rate measure
- Accounting for yield losses
- Using the most appropriate units
- Where to start the map
- Convention on direction of flow
- Parallel assets
- Representing FLOW vs geography
**Takt**

- A measure of the rate of customer demand
- Takt in German means rhythm, or drum beat
- Goal is to synchronize production to customer needs

\[
\text{Takt Time} = \frac{\text{Total available time}}{\text{Customer demand}}
\]

- Units
  - Minutes (per car, per roll, per batch)
  - Also hours or seconds
- A measure of how much time you have to produce a unit and meet customer needs
Available Time

- The time you plan to run, the planned work schedule
  - Number of shifts
  - Hours per shift
  - Deduct time for lunch and breaks

- If a plant runs 16 hours per day, 5 days each week, available time would be 80 hours per week
- If production suspends for an hour each shift for lunch and breaks, available time is 70 hours per week
- Do NOT deduct for equipment downtime

Takt Time = Total available time / Customer demand
Example

- A salad dressing line has weekly demand of 45,000 cases for the flavors made on that line
- Three eight-hour shifts per day, 5 days per week
- Production continues through lunch, breaks, shift changes
- Available time = $3 \times 8 \times 5 = 120$ hours/week
- Takt = $120$ hours / $45,000$ cases = $9.6$ seconds
- So the plant must produce a case every $9.6$ seconds to satisfy customer demand
The units for Takt Time can be awkward in a process plant

- For a chemical process with a demand of 100 gal/min, Takt time = 0.6 seconds/gal
- For a plastic film line with a demand of 400 feet/min, Takt time = 0.15 secs/foot
- For our salad dressing line, if customer demand = 300 bottles/min, Takt time = 0.2 secs/bottle

Rate based parameters are often used instead of time based units

\[
\text{Takt Time} = \frac{\text{Available time}}{\text{Customer demand}}
\]

\[
\text{Takt Rate} = \frac{\text{Customer demand}}{\text{Available time}}
\]
So on our salad dressing line

- **Takt Time** = 120 hours / 45,000 cases = 9.6 seconds
- So the plant must produce a case every 9.6 seconds to satisfy customer demand
- **Takt rate** = 45,000 cases/120 hours = 375 cases/ hour
- So we must produce 375 cases per hour to meet customer demand
- **Takt Time seems to work best in most parts operations**
- **Takt Rate seems more appropriate in most process operations**
TAKT and YIELD LOSSES

**Takt Rate** = \( \frac{\text{Customer demand}}{\text{Available time}} \)

Takt must be adjusted to account for yield losses

---

**Step 4**

Avail time = 24 hr/day  
Yield = 100%  
Takt = 55 rolls/hr

---

**Step 5**

Avail time = 24 hr/day  
Takt = 50 rolls/hr  
Yield = 90%

---

**Step 6**

Avail time = 24 hr/day  
Takt = 50 rolls/hr

---

CUSTOMER  
Demand = 1200 rolls/day
**TAKT and AVAILABLE TIME**

Takt Rate = \( \frac{\text{Customer demand}}{\text{Available time}} \)

*If Available time changes, Takt changes*

<table>
<thead>
<tr>
<th>Step 4</th>
<th>Step 5</th>
<th>Step 6</th>
<th>CUSTOMER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avail time = 16 hr/day&lt;br&gt;Yield = 100%&lt;br&gt;Takt = 83 rolls/hr&lt;br&gt;Eff Capac = 102 rolls/hr</td>
<td>Avail time = 24 hr/day&lt;br&gt;Yield = 90%&lt;br&gt;Takt = 50 rolls/hr&lt;br&gt;Eff Capac = 54 rolls/hr</td>
<td>Avail time = 24 hr/day&lt;br&gt;Takt = 50 rolls/hr&lt;br&gt;Eff Capac = 85 rolls/hr</td>
<td>Demand = 1200 rolls/day</td>
</tr>
</tbody>
</table>
Units of Production

(Pounds?, Gallons?, Rolls?, Square Meters?)
The units by which production is measured may change from step to step.

In a ketchup production line:
- Raw materials: pounds, gallons, cases
- Kitchen: gallons per minute
- Bottling line: Bottles per minute (BPM)
- Label applicator: BPM
- Case packer: Cases per hour
- Palletizer: Pallets per hour

Two considerations:
1) *Use the units most directly related to equipment throughput.*
2) *Use the units generally used within the area (by operators, mechanics, process engineers, lab technicians).*
MATERIAL FLOW

UNITS OF PRODUCTION

POUNDS or GALLONS

Roll Forming Machine 1
Roll Forming Machine 2
Roll Forming Machine 3
Roll Forming Machine 4
Roll Bonder 1
Roll Bonder 2
Roll Bonder 3
Roll Bonder 4
Roll Slitting Machine 1
Roll Slitting Machine 2
Roll Slitting Machine 3
Roll Slitting Machine 4
Chopper 1
Chopper 2
Chopper 3

Polymerization Reactor

MILL ROLLS

MILL ROLLS

SLIT ROLLS or SHEETS

SLIT ROLLS or SHEETS

Boxes, Sheets, or Square Meters

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In an paper sheet goods manufacturing line

- Raw materials: pounds, gallons
- Sheet forming: Mill rolls
- Bonding: Mill rolls
- Slitting: Mill rolls or slit rolls
- Chopper: Slit rolls, cut rolls or sheets
- Packaging: Cut rolls or sheets
- Palletizing: Cut rolls or boxes
- Customer orders: Square feet, square meters

Again – two considerations:

- Use the units most directly related to equipment throughput.
- Use the units generally used within the area (by operators, mechanics, process engineers, lab technicians).
**CUSTOMER TAKT CONVERTED FOR EACH PROCESS STEP**

<table>
<thead>
<tr>
<th>SKU Number</th>
<th>Product Description</th>
<th>Average Monthly Sales (Sq FT)</th>
<th>Cut Roll Length (Feet)</th>
<th>Cut Roll Width (Feet)</th>
<th>Chopping Yield</th>
<th>Cut Rolls Required</th>
<th>Slitting Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>R551100</td>
<td>1 X 100 Roll, Grade R55</td>
<td>100,000</td>
<td>100</td>
<td>1</td>
<td>100%</td>
<td>1000.0</td>
<td>98.0%</td>
</tr>
<tr>
<td>A533500</td>
<td>3 X 500 Roll, grade A53</td>
<td>500,000</td>
<td>500</td>
<td>3</td>
<td>100%</td>
<td>333.3</td>
<td>98.0%</td>
</tr>
<tr>
<td>B475500</td>
<td>5 X 500 Roll, Grade B47</td>
<td>200,000</td>
<td>500</td>
<td>5</td>
<td>100%</td>
<td>80.0</td>
<td>97.5%</td>
</tr>
<tr>
<td>B476150</td>
<td>6 X 1500 Roll, Grade B47</td>
<td>50,000</td>
<td>1500</td>
<td>6</td>
<td>100%</td>
<td>5.6</td>
<td>98.0%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Master Roll Width (feet)</th>
<th>Slit Rolls required</th>
<th>Bonding Yield</th>
<th>Bonded Rolls Required</th>
<th>Spinning Yield</th>
<th>Master Rolls Required</th>
<th>Basis Weight (oz/sq ft)</th>
<th>Raw Material Consumed (pounds per Master Roll)</th>
<th>Raw Material Required (pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>22.7</td>
<td>0.86</td>
<td>2.2</td>
<td>0.87</td>
<td>2.5</td>
<td>0.6</td>
<td>2025</td>
<td>5114.3</td>
</tr>
<tr>
<td>12</td>
<td>37.8</td>
<td>0.84</td>
<td>11.2</td>
<td>0.87</td>
<td>12.9</td>
<td>0.75</td>
<td>2531.25</td>
<td>32725.5</td>
</tr>
<tr>
<td>10</td>
<td>9.1</td>
<td>0.87</td>
<td>5.2</td>
<td>0.87</td>
<td>6.0</td>
<td>0.6</td>
<td>1687.5</td>
<td>10162.9</td>
</tr>
<tr>
<td>12</td>
<td>1.9</td>
<td>0.89</td>
<td>1.1</td>
<td>0.87</td>
<td>1.2</td>
<td>0.6</td>
<td>2025</td>
<td>2471.0</td>
</tr>
</tbody>
</table>

* ALL MASTER ROLLS, BONDED ROLLS, AND SLIT ROLLS ARE 4500 FEET IN LENGTH

* ROLL QUANTITIES ARE NOT ROUNDED UP - OTHER PRODUCTS MAY NEED THESE SLIT ROLLS, SO THE TOTAL IS ROUNDED UP TO THE NEXT INTEGRAL NUMBER OF ROLLS
Creating the VSM should be a team activity

- Cross-functional
  - Process engineers
  - Operators
  - Mechanics
  - Lab technicians
  - Customer service reps
  - Production schedulers
  - Supervisors

- Creates shared learning across different process areas
- Builds ownership for potential improvements
- Knowledge base to understand root cause

Kaizen Event!
Two approaches

1. Walk the line
   - Sketch the flow as you go
   - Engage operators in discussions of flow and problems

2. Gather the team in a conference room
   - Discuss the process
   - Generate the VSM electronically
   - Then *walk the line*
   - Return to conference room and upgrade the VSM
Two mapping approaches

1. Start at the shipping dock and work backwards
   - Begins with customer needs
   - Works very well for converging processes

2. Start with receipt of raw materials and work forward
   - The way most people think of their process
   - May put more focus on the process vs the customer
   - Works better for diverging processes
Good VSM Practices

- Always depict flow from left to right
Keep the map at a relatively high level
Detailed enough to see flow and barriers to flow
Not so detailed that main messages get buried
4 to 8 process steps is typical
If additional detail becomes important, can be shown on more specific process maps
Auxiliary processes may be shown if they affect flow
  - Re-work areas
  - Testing labs, QC labs
  - Waste streams
Adopt an “interstate map” mindset
<table>
<thead>
<tr>
<th>Process</th>
<th>SKUs</th>
<th>Effective Capacity</th>
<th>TAKT</th>
<th>Utilization</th>
<th>Lead Time</th>
<th>Yield</th>
<th>Reliability</th>
<th>Avail Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slitting</td>
<td>4000</td>
<td>10.3</td>
<td>7.2</td>
<td>70%</td>
<td>10 Min</td>
<td>98%</td>
<td>69%</td>
<td>168 hr</td>
</tr>
<tr>
<td>Wrapping</td>
<td>2000</td>
<td>20.0</td>
<td>12</td>
<td>60%</td>
<td>8 Min</td>
<td>100%</td>
<td>98%</td>
<td>168 hr</td>
</tr>
<tr>
<td>Narrow Roll Chopper (1'-3')</td>
<td>3</td>
<td>9.8</td>
<td>8.9</td>
<td>89%</td>
<td>10 Min</td>
<td>100%</td>
<td>98%</td>
<td>168 hr</td>
</tr>
<tr>
<td>Universal Chopper (1'-6')</td>
<td>5</td>
<td>8.0</td>
<td>8.9</td>
<td>89%</td>
<td>10 Min</td>
<td>100%</td>
<td>98%</td>
<td>168 hr</td>
</tr>
</tbody>
</table>

- **Similar equipment in parallel**
  - If nearly identical, show as one process box, noting the number of machines in parallel.
  - If different, in a way that impacts flow, show each machine.
**PARALLEL EQUIPMENT WITH DIFFERENT CAPABILITY**

**SLITTING**
- **Invtry Days #:**
  - SKUs: 4000 - 7
  - SKUs: 1000 - 7 Days
  - TAKT: 10 Min
  - Utilization: 89%
  - Lead time: 10 Min
  - Yield: 100%

**UNIVERSAL CHOPPER**
- **Invtry Days #:**
  - SKUs: 2000 - 8 Days
  - SKUs: 1000 - 16 Days
  - TAKT: 16
  - Utilization: 80%
  - Lead time: 10 Min
  - Yield: 100%

**NARROW ROLL CHOPPER**
- **Invtry Days #:**
  - SKUs: 5
  - TAKT: 9
  - Utilization: 70%
  - Lead time: 10 Min
  - Yield: 98%

**WRAPPING PACKAGING LABELING**
- **Invtry Days #:**
  - SKUs: 2000 - 8 Days
  - SKUs: 1000 - 16 Days
  - TAKT: 120
  - Utilization: 60%
  - Lead time: 8 Min
  - Yield: 100%
  - Reliability: 98%

**EFFECTIVE CAPACITY**
- SLITTING: 10.3
- UNIVERSAL: 20
- NARROW ROLL: 9
- WRAPPING PACKAGING LABELING: 200

**BATCH SIZE**
- SLITTING: 1 roll
- UNIVERSAL: 1 Cut Roll

**AVAIL TIME**
- SLITTING: 168 hr/wk
- UNIVERSAL: 168 hr/wk

**SHIFT SCHED**
- SLITTING: 3 x 8 x 7
- UNIVERSAL: 3 x 8 x 7
Roll Goods Storage & Retrieval System

**Sheet Forming**
- Effective Capacity: 11.8
- TAKT: 9.5
- Utilization: 80%

**Calendaring Bonding**
- Effective Capacity: 8.9
- TAKT: 8.3
- Utilization: 93%

**Slitting**
- Effective Capacity: 10.3
- TAKT: 7.2
- Utilization: 70%
- Lead time: 10 Min

**Chopping**
- Effective Capacity: 29
- TAKT: 24
- Utilization: 83%
- Lead time: 10 Min
LOGICAL DEPICTION ON A VSM

THESE ARE ALL WITHIN THE SAME PHYSICAL INVENTORY STORAGE AREA

IF SHOWN LOGICALLY RATHER THAN GEOGRAPHICALLY IT IS MUCH EASIER TO SEE FLOW
In order to become more lean, you must be able to see the waste in your process

Value Stream Mapping is a proven, effective way to do that

A well constructed VSM will enable you to see the major wastes

And clues to their root cause

The VSM provides a template for all improvement activity

Using all planned improvements to build a Future State VSM insures that all efforts are

Coordinated

Integrated

Moving you toward a more waste-free process
A VSM consists of three key components:

- Material flow (with data boxes)
- Information flow
- A timeline

Integrating material and information flow on the same diagram highlights areas where mishandling of information inhibits smooth flow and creates waste.

Because most sources of waste add time to the process, the timeline focuses attention on these wastes.
The material in this presentation is featured in

*Productivity Press*

*May 2009*
Questions?

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Appendix 1

TAKT TIME & CYCLE TIME
Takt

- A measure of the rate of customer demand
- Takt in German means rhythm, or drum beat
- Goal is to synchronize production to customer needs

**Takt Time** = \( \frac{\text{Total available time}}{\text{Customer demand}} \)

- Units
  - Minutes (per car, per roll, per batch)
  - Also hours or seconds
- A measure of how much time you have to produce a unit and meet customer needs
Available Time

- The time you plan to run, the planned work schedule
  - Number of shifts
  - Hours per shift
  - Deduct time for lunch and breaks

- If a plant runs 16 hours per day, 5 days each week, available time would be 80 hours per week

- If production suspends for an hour each shift for lunch and breaks, available time is 70 hours per week

- Do NOT deduct for equipment downtime

Takt Time $= \frac{\text{Total available time}}{\text{Customer demand}}$
Example

- A lawnmower plant has weekly demand of 2000 for a certain model
- Two eight-hour shifts per day, 5 days per week
- Production continues through lunch, breaks, shift changes
- Available time = 2 x 8 x 5 = 80 hours/week
- Takt = 80 hours / 2000 = 2.4 minutes
- So the plant must produce a completed mower every 2.4 minutes to satisfy customer demand
Takt must be increased to accommodate losses

- If step 4 in the process has a 10% yield loss or scrap rate…
- Steps 1, 2, and 3 must produce at a Takt of 2.2 minutes to match customer needs

\[
\text{Takt Time} = \frac{\text{Total available time}}{\text{Customer demand}}
\]

* Takt is measured in terms of good output
Cycle Time

- If Takt represents customer demand………
- Our process must be able to produce within that time
- Cycle Time measures how long it takes to produce one unit, one lot, one batch, etc.
- If Cycle Time < Takt, we can produce faster than customer needs
- If the cycle time for step 3 in the lawnmower plant is 2 minutes, we can produce faster than needed, with about 10% spare capacity
Cycle Time = Reality

- Cycle time does not represent the best we can expect from our process or a specific step.
- It represents what we should expect under normal conditions, allowing for PMs, unexpected downtime, rate reductions, yield losses, time for product changeovers, etc.

\[
\text{Cycle Time} = \frac{1}{\text{Max Demonstrated Rate (MDR)} \times \text{OEE}}
\]

\[
\text{Cycle Time} = \frac{1}{(\text{MDR} \times \text{UPtime})}
\]

\[
\text{Cycle Time} = \frac{1}{(\text{MDR} \times \% \text{Reliability} \times \% \text{Rate} \times \% \text{Yield})}
\]
Utilization

A measure of how fully occupied a process step is, how busy it is

Utilization = \frac{\text{Cycle Time}}{\text{Takt}}

If Step 3 in the mower plant has a cycle time of 2 minutes, and a Takt of 2.2 minutes……

Utilization = 91%

Utilization is an indication of where there are bottlenecks in process flow
**Takt as a Rate parameter**

- The units for Takt and cycle time can be awkward in a process plant
  - 0.6 seconds/gal vs 100 gal/min
  - 0.15 secs/ft vs 400 feet/min
  - 0.171 secs/bottle vs 350 bottle/min

- Rate based parameters are often used instead of time based units

\[ \text{Takt Time} = \frac{\text{Available time}}{\text{Customer demand}} \]

\[ \text{Takt Rate} = \frac{\text{Customer demand}}{\text{Available time}} \]
Takt as a Rate parameter

- As before, available time is the time we intend to run
  \[ \text{available time} = \text{no of shifts} \times (\text{hrs/shift} - \text{lunch} - \text{breaks}) \]
- In the lawn mower example, Takt rate for Step 5 = 25 mowers/hr
  \[ (= 2000 \text{ mowers/week} / 80 \text{ hrs/week}) \]
- Takt rate is simply the reciprocal of Takt time

\[
\text{Takt Rate} = \frac{\text{Customer demand}}{\text{Available time}}
\]
Effective Capacity

- The reciprocal of Cycle Time is often called Effective Capacity.
- As before, it represents realistic expectations, not perfection.

\[ \text{Cycle Time} = \frac{1}{\text{Max Demonstrated Rate (MDR) } \times \text{ OEE}} \]

\[ \text{Effective Capacity} = \text{Max Demonstrated Rate (MDR) } \times \text{ OEE} \]
Utilization

- A measure of how fully occupied a process step is, how busy it is

Utilization = \( \frac{\text{Takt rate}}{\text{Effective capacity}} \)

- If Step 3 in the mower plant has an effective capacity of 30 parts/min, and a Takt of 27.3 parts/min......
- Utilization = 91%

Everything works out the same, it’s just easier for some people to relate to rate based parameters
Another example ~ Roll forming

Step 4
Yield = 100%
Takt = 55 rolls/hr

Step 5
Yield = 90%
Takt = 50 rolls/hr

Step 6
Avail time = 24 hr/day
Takt = 50 rolls/hr

Demand = 1200 rolls/day
The Takt Rate is calculated using the formula:

\[ \text{Takt Rate} = \frac{\text{Customer demand}}{\text{Available time}} \]

If Available time changes, Takt changes.

Step 4:
- Avail time = 16 hr/day
- Yield = 100%
- Takt = 83 rolls/hr

Step 5:
- Avail time = 24 hr/day
- Yield = 90%
- Takt = 50 rolls/hr

Step 6:
- Avail time = 24 hr/day
- Takt = 50 rolls/hr
- Demand = 1200 rolls/day
TAKT and CYCLE TIME

Utilization = \( \frac{Takt \text{ rate}}{\text{Effective capacity}} \)

Step 4
Avail time = 16 hr/day
Yield = 100%
Takt = 83 rolls/hr
MDR = 120 rolls/hr
OEE = 85%
Eff Capac = 102 rolls/hr
Util = 81%

Step 5
Avail time = 24 hr/day
Yield = 90%
Takt = 50 rolls/hr
MDR = 72 rolls/hr
OEE = 75%
Eff Capac = 54 rolls/hr
Util = 93%

Step 6
Avail time = 24 hr/day
Takt = 50 rolls/hr
MDR = 100 rolls/hr
OEE = 85%
Eff Capac = 85 rolls/hr
Util = 59%

Demand = 1200 rolls/day
To summarize

- Cycle time or effective capacity is a measure of what we can expect from each step in our process under normal operating conditions.
- Take time or take rate is what each step in the process must make to meet customer demand.
- If cycle time and takt time for a process step are exactly equal, that step is perfectly synchronized to customer needs.
- If cycle time exceeds takt, we have a bottleneck.
- If cycle time is less than takt, we have some degree of excess capacity (this is desirable).
- It is up to the user to decide whether time or rate parameters make more sense.