The Future State Map

- The purpose of value stream mapping is to highlight sources of waste and eliminate them by implementation of a future value stream that can become reality within a short period of time.
- The goal is to build a chain of production where the individual processes are linked to their customers flow or pull, and each process gets as close as possible to producing only what its customers need when they need it.

Key Questions for the Future State

1. What is the takt time? based on the available working time of the downstream processes that are closest to the customer.
Key Questions for the Future State

2. Will you build a finished goods supermarket from which the customer pulls or directly to shipping? (The answer to this question depends on several factors such as customer buying patterns, the reliability of your processes, and the characteristics of your product. Building directly to shipping will require either a reliable, short lead time, order-to-delivery stream or more safety stock. Fortunately your order-to-delivery lead time involves only those processes from the pacemaker process downstream to delivery.)

Key Questions for the Future State

3. Where can you use continuous flow processing?

4. Where will you need to use supermarkets pull systems? in order to control production of upstream processes.

Key Questions for the Future State

5. At what single point in the production chain (the pacemaker process) will you schedule production? (Remember that all material transfers downstream of the pacemaker process need to occur as a flow.)
Key Questions for the Future State

6. How will you level the production mix at the pacemaker process?

7. What increment of work will you consistently release? and take away at the pacemaker process

Key Questions for the Future State

8. What process improvements will be necessary for the value to flow as your future-state design specifies? (This is the place to note any equipment and procedural improvements that will be necessary, such as reducing changeover time or improving machine uptime. We use the kaizen lightning burst to indicate these points in the process.)

Drawing the Future State Map

• What problems can be noted from the current state map of Acme’s steering column bracket?

• Perhaps the most striking problem is the large amounts of unconnected inventory, the unconnected processes (each producing to its own schedule) pushing their output forward, and the long lead time in comparison to the short processing time.
QUESTION 1

What is the takt time for the chosen product family?

• The takt time calculation starts with the available working time for one shift of the assembly area, which is 28,800 seconds (8 hours). From this you subtract any non-working time, which is two 10 minute breaks per shift. The customer demand of 460 units per shift is then divided into the available working time to give a takt of 60 seconds.

Available working time: 28 800 - 1200 = 27 600 secs / shift

Available Working time 27 600 sec / 460 units per shift
Customer Demand

Acme steering Bracket Assembly Takt Time = 60 secs

• What this takt time number means is that in order to meet customer demand within its available time, Acme needs to produce a steering bracket every 60 seconds in its assembly process.
• This number includes no time for equipment downtime, changeovers, or for producing scrap.
• Acme may decide to cycle assembly faster than takt, if it cannot immediately eliminate downtime problems for example, but the takt time is a reference number defined by the customer and cannot be changed by Acme Stamping.
Note

- Try to cycle your pacemaker process as close as possible to the takt time.
- A significant gap between takt time and cycle time indicates the existence of production problems that cause unplanned downtime.
- When you compensate for production problems by cycling much faster than takt, the incentive to eliminate those problems evaporates.
- If you cycle faster than takt there should be a plan for closing the gap!

QUESTION 2

Should the company build steering brackets to a finished goods supermarket or directly to shipping?

- At Acme, steering brackets are small (easy to store) parts that have only two varieties.
- The customer's demand rises and falls unpredictably, and Acme are uncertain about reliability of future-state changes to be made.
- So Acme has opted to begin with a finished goods supermarket and to move closer to “produce to shipping” in the future.
• Acme can use the customer’s thirty day forecast to determine the amount of production capacity needed in the period immediately ahead. (Lean plants periodically adjust the number of operators in assembly - and redistribute the work elements - to match output to changes in demand)

• Acme will determine actual production by means of kanban coming back upstream to the weld/assembly cell from the finished goods supermarket.

• Since the customer buys in multiples of 20-bracket trays, this is the simple choice for kanban size.

• That is each tray of twenty left drive or right drive brackets in the finished goods supermarket has on it one production kanban.

• As the shipping department withdraws trays from the supermarket to stage them for delivery, the kanban from those trays are sent back to assembly.

• This is a signal to make 20 more left drive (or right drive) brackets

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Example: Building to a Supermarket
The supermarket schedules assembly (Acme’s choice)
Example: Building directly to Shipping
Production Control schedules assembly

QUESTION 3
Where can Acme introduce continuous flow?

- The operator balance chart summarises the current cycle times for each process.
- The stamping operation cycles very quickly and changes over to serve several production lines.
- So incorporating it into continuous flow, which would mean slowing its cycle time to near the takt time and dedicating it to the steering bracket product family is not practical.
- That would result in a vastly under-utilised press and the need to buy another press for Acme’s other product lines!
- It makes sense to run Acme’s stamping press as a batch operation and control its product with a supermarket based pull system.
• Notice that that cycle times of the two assembly workstation are not far apart and also near the takt time.
• These workstations are already dedicated to the steering bracket family, so continuous flow in assembly certainly is possible.
• The same is true of the two welding stations, where work could also pass directly from one welding step to the next in a continuous flow.
• There is nothing to prevent Acme from using continuous flow all the way from welding through assembly, a condition with no inventory (or a maximum of one piece at automated process) between steps.
• The lean approach is to place these four processes immediately adjacent to each other (typically in a cellular arrangement) have operators carry or pass parts from one process step to the next and distribute the work elements so that each operator's work content is just below the takt time.
• Dividing the total welding and assembly work content by the takt time (187 /60) reveals that 3.12 operators would be needed to run welding and assembly in a continuous flow at takt.
• Four operators would be under-utilised, but a redistribution of work elements will not be sufficient to eliminate the need for a fourth operator.

• Our next option is to eliminate waste through kaizen to bring the work content under the takt time. A kaizen target might be to reduce each operator’s work content to 56 seconds or less (or ≤ 168 seconds total work content).
• If that fails, use of some overtime may be necessary.
• With either approach, the fourth operator and the material handler who currently moves parts between isolated processes can be reassigned to other activities that actually create value.

• To allow production to takt time and mix levelling, a pacemaker process should ideally incur little or no changeover time and change over very frequently.
• So the left-drive to right-drive fixture changeover time will need to be reduced from the current ten minutes to a few seconds.
• Focussed attention on improving the reliability of the second spot welder (perhaps through an improved maintenance approach) will also be needed.
Acme Stamping - weld /assembly cell cycle time after process kaizen

- Notice that on the future state map the four welding and assembly process boxes have been combined into one process box to indicate continuous flow.
- A small schematic sketch of a cell inside the process box also indicates the cellular manufacturing idea.

First View of the Future State Map Showing Takt Time, Weld/Assembly Cell, and the Finished Goods Supermarket.
QUESTION 4

Where will Acme need to use supermarket pull systems?

• Acme have decided to produce steering brackets to a finished-goods supermarket.
• Two additional supermarkets are also required - one for stamped parts and one for coils.
Stamped Parts

• Pull system design begins with customer requirements and stamping's customer is the weld/assembly process. The cell currently requires approximately 600 LH and 230 RH stamped parts per day.
• Containers for the stamped parts should be sized to allow for close to the fingertips placement in the cell (for example gravity fed bins near the operator).

• Small containers allow Acme to keep both LH and RH stamped parts in the cell at all times.
• This further reduces LH-RH changeover time at the pacemaker process, where frequent changeovers (levelling the mix) is a key lean objective.
• Each container in the cell - for example a bin that holds 60 stamped parts, or about one hour of current steering bracket assembly - will have a withdrawal kanban with it.

• When a cell operator begins taking parts out of another bin, its withdrawal kanban is given to the to the material handler so that he knows to go to the stamping supermarket and withdraw another bin of parts.
• Withdrawal kanban trigger the movement of parts. Production kanban trigger the production of parts.
• Acme can attach a production kanban to each bin of 60 stamped parts in the supermarket.
• Every time the material handler removes a bin from the supermarket a kanban is sent to the stamping press.
• This instructs stamping to produce 60 parts, place them in a bin, and move to a specified location (the market address) in the stamping supermarket.
• Now stamping no longer receives a schedule from production control.

• However there is a problem with this pull system.
• With a cycle time of one second per piece and a changeover time of one hour, stamping would take one hour to set up to run only 60 seconds (60 pieces) of production.
• Until changeover time on the stamping press is greatly reduced, replenishing what is withdrawn from the stamping supermarket on a bin-for-bin basis is not practical.
• Due to changeover time, stamping needs to produce batches larger than 60 pieces between changeovers.
• With the initial goal of "every part every day" stamping’s target batch size would be approximately 600 LH and 320 RH pieces (which will still require changeover reduction)
• Stamping will keep 1.5 days of parts in its supermarket one half day extra to allow for replenishment delay and stamping problems.

• So Acme will use a signal kanban to schedule stamping. In this case the kanban (often a metal triangle) for left and right hand parts is brought from the supermarket to the stamping press whenever the number of bins remaining in the supermarket drops to a trigger ("minimum") point.
• When a triangle kanban arrives at the stamping press’ scheduling board, it initiates a changeover and production of a predetermined batch size of a specific part.
• Stamping still does not receive a schedule from production control.

The stamped parts supermarket, withdrawal and signal kanban flows (dotted lines) are drawn on the future state map.
Coils

- To build a plant-level lean value stream the suture state map must also show a third supermarket at the receiving dock, which holds coils of steel.
- Even though Acme's steel supplier is not ready to receive kanban and produce according to them, Acme can still attach an internal withdrawal kanban whenever a coil is used.

- Production control can then order coils based on actual usage, instead of based on MRP's best guess of what future usage will be. (MRP may still be used for capacity planning forecast for the coil supplier, but day-to-day orders should be based on pull)
- Once production control has made the days order for coils, the corresponding kanban can be placed in kanban slots at the receiving dock.
- These indicate the day that coils should arrive.
- If there are kanban still left in yesterdays receiving slot, then something is wrong at the supplier.

- Currently the steel supplier is shipping coils weekly.
- By lining up customers along a "milk run" delivery, it may be possible to get necessary amounts of steel on a daily basis, even if the steel supplier does nothing to reduce its minimum batch size by slitting coils.
- Moving to daily delivery eliminates 80% of the inventory at Acme, while providing smooth, steady demand for the steel supplier.
The Story So Far

- We have now proposed a cell of the type many firms have implemented in the past few years, the introduction of pull to control stamping production and coil delivery, "every part every day" in stamping and instituting milk runs for delivery form the raw material suppliers to Acme.

Acme Stamping Lead Time Improvement

<table>
<thead>
<tr>
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<th>Stamped Parts</th>
<th>Weld/Assemble WIP</th>
<th>Finished Goods</th>
<th>Production Lead Time</th>
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</tr>
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<tbody>
<tr>
<td><strong>Before</strong></td>
<td>5 days</td>
<td>7.6 days</td>
<td>6.5 days</td>
<td>4.5 days</td>
<td>23.6 days</td>
<td>10</td>
</tr>
<tr>
<td><strong>So Far</strong></td>
<td>2 days</td>
<td>1.5 days</td>
<td>0</td>
<td>4.5 days</td>
<td>8 days</td>
<td>30</td>
</tr>
</tbody>
</table>

Second View of the Future State Map Showing Stamping and Raw Material Supermarkets
Information Flow & Toyota

- How can we flow information so that one process will make only what the next process needs when it needs it?
- Years ago, Toyota discovered a very different method of managing schedules: stop trying to guess what the customer will want.
- Instead shorten the lead time within production and install supermarkets with small inventories of each product between processes that cannot be coupled to one another.
- These will permit upstream processes to replace in the supermarket what downstream processes have just withdrawn.
- Then instead of sending customer information to a centralised MRP system, which then sends instructions to each production activity, level the customer orders and send them only to one place - either directly to the pacemaker process, where the requested products will be produced in time for shipment, or to a finished goods supermarket, where requested products will be withdrawn and staged for shipping.
Information Flow & Acme

• Currently the customer is sending by fax a ninety day forecast revised once a month and frozen for thirty days.

• In addition, it is sending a daily release during the night by EDI (phone line) to Acme's scheduling computer for the next day's shipping requirement.

• Finally there are occasional revisions in shipping requirements on an emergency basis.

• These are sent by phone from the customer's material handling department to Acme's shipping department during the day as the assembly plant discovers that needed parts are not on hand for whatever reason.

• What happens to the information sent from the customer once it reaches Acme?

• Currently the weekly schedule is fed over the weekend into the computerised MRP which then sends instructions by Monday morning to each department - stamping welding I & II and assembly I & II - about what to make the coming week.

• Then, as additional information is received each night and as each department reports back periodically to the MRP on what it actually did that day (because production does not go as scheduled), the daily production schedules are continually adjusted to bring what Acme is making into synchronisation with what the customer wants.

• If this sounds complicated, it is - because trying to run operations from MRP systems doesn't work well.

• There will be a frequent need for humans to override the system to avoid shortages and take into account emergency orders at various stages of production.
QUESTION 5

What single point in the production chain (the pacemaker process) should Acme schedule?

• Since all the process steps downstream of the pacemaker process need to occur in a flow, in the Acme example the scheduling point is clearly the welding/assembly process.
• We cannot schedule any further upstream (at the stamping process because we are planning to introduce a pull system between stamping and weld/assembly.
• This single scheduling point will regulate Acme’s entire steering-bracket value steam.

QUESTION 6

How should Acme level the production mix at the pacemaker process?
• When the daily delivery is made to the assembly plant, 30 trays of left-drive brackets (600 pieces) and 16 trays of right-drive brackets (320 pieces) are typically staged and loaded onto the truck at one time.
• If we are not careful, the 46 production kanban removed from these trays before loading will be sent back to the weld assembly cell in a batch, as shown on the future state map so far.
• If this happens the weld assembly cell will probably batch produce these parts.

• The cell will produce all 30 trays of left-drive brackets, and then change over to make the 16 trays of right brackets, which would look like this:

<table>
<thead>
<tr>
<th>1st shift</th>
<th>2nd shift</th>
</tr>
</thead>
<tbody>
<tr>
<td>LLLLLLLLLLLLLLLLLLLLLLLLLLLLLRRRRRRRRRRRRRRRR</td>
<td></td>
</tr>
</tbody>
</table>

• From the cell’s perspective this seems to make sense because it minimises the number of required weld-fixture changes.
• However, from a value stream perspective batching is the wrong way to go.
• Batch producing brackets in assembly will increase the impact of problems, lengthen the lead time and mean that the stamped-parts supermarket has to be ready to meet sudden demand surges.
• “Being-ready” means keeping more stamped parts inventory in the supermarket, which again increases lead time, obscures stamping quality problems and in general causes overproduction (waste).
• Instead, if the weld/assembly cell levels the mix of brackets it produces evenly over the shift, then the stamping press (with a shortened set-up time) will have plenty of time to react to the cell’s pulls for left-drive and right-drive parts.
• It will have time to replenish what was taken away without the need for so much inventory in the stamping supermarket.

• With levelling, which requires much more frequent changeovers, the cell’s production mix of trays of brackets would look like this:

1st shift  2nd shift
RLLRLLRLLRLLRLLRLLRLLRLLRLLRLLRLLRLLRLLRLLRLLR

Note

• Enabling such frequent changeovers in the cell will probably require keeping all fixtures and component varieties ready, near the operator’s fingertips.
• However, when all components are kept on the line you may need some failsafe devices to prevent the wrong ones from being assembled.
Here the benefit of a value stream should become evident.

By levelling the production mix at the pacemaker process, which may seem unnatural at that location, the entire value stream will show improved lead time, quality and cost.

These benefits are amplified in the value streams that are longer and more complex.

How can we ensure that kanban coming back to the weld assembly cell, which are the production instructions, come back in a sequence that levels the mix of products over the shift?

At Acme there are two places where the batch of kanban can be intercepted and this levelling takes place.

We will assume that Acme has decided to use a load-levelling box to help maintain a level production mix, paced withdrawal and genuine pull.

**Option A**

Production control can place withdrawal ("move") kanban corresponding to the customer order in a load levelling box near the shipping dock in a mixed, left drive/right drive sequence.

A material handler then pulls these kanban out of the levelling box one-by-one at the pitch increment (20 minutes in this case) and moves trays of brackets from the finished goods supermarket to the staging area one-by-one according to the withdrawal kanban.
• As each tray is pulled from the supermarket, the production kanban on those trays are brought to the cell in time increments and a left-drive/right drive pattern that mirrors exactly the mix and pitch increment that production control has set up.

  • (This levelling option is the one shown in Acme’s future state map.)

**Option B**

• Production control can send today’s customer demand to the material handler, who pulls all the corresponding trays out of the finished goods market at once and stages them for shipment.

• Pulling the trays produces a batch of production kanban, which are placed in a load levelling box near the cell, in a mixed, left-drive/right-drive sequence.
• The weld/assembly material handler then pulls production kanban out of the levelling device one at a time at the pitch increments and as a result assembly produces in a left drive right drive mixed pattern.

• The drawback of Option B us that an entire batch of finished good is moved to shipping at once.
• Lean manufacturing strives to avoid or minimise batching as much as possible, always getting closer and closer to continuous flow.
• Also if Acme is eventually able to shrink its finished goods supermarket to less than one day of inventory withdrawing a one day quantity all at once will not be possible.
• However Option A requires someone to repeatedly move one tray at a time (at the pitch increment), from the weld/assembly cell to the finished goods supermarket, and from finished goods to the shipping dock.
QUESTION 7

What consistent increment of work should Acme release and take at the pacemaker process?

- How will Acme provide takt image to the weld/assembly cell, and how frequently will it check production there?
- Returning all 46 kanban (two shifts worth) to the cell at once would provide no takt image to the cell.
- Batching the volume of work instruction like this must be avoided.
- A natural increment of welding/assembly work in Acme’s case is the 60 second takt time x 20 pieces per tray = 20 minutes. This is the steering bracket pitch, which corresponds to one kanban for one tray of 20 steering brackets.

- This does not mean that every 20 minutes someone walks over to the weld/assembly and asks how are things going on?
- Not exactly!
- What this means is that Acme will practice paced release of work instruction, one kanban at a time and paced withdrawal of finished goods at its weld/assembly cell.
• Each column in Acme’s steering bracket load levelling box represents a 20 minute pitch increment.
• The two rows are designated for left-drive and right-drive kanban.
• Every 20 minutes, a material handler brings the next kanban (the next increment of work) to the weld/assembly call and moves the just-finished tray of brackets to the finished goods area.
• If a tray is not finished at the 20 minute pitch increment, then Acme knows there is a production problem that needs attention.

Load-Levelling Box for Steering Brackets

Weld/assy cell gets kanban from left to right pitch increment

One row per product type

QUESTION 8

What process improvements will be necessary for Acme’s value stream to flow as the future-state design describes?
Achieving the material and information flows we envisage for Acme Stamping requires the following process improvements:

- Reduction in changeover time and batch sizes at the stamping process to allow faster response to downstream usage. The goals are "every part every day" and then "every part every shift".
- Elimination of the long time (10 minutes) required to change between left-drive and right-drive fixtures in welding, to make possible continuous flow and mixed production from welding through assembly.

We mark these items on our future-state nap with the kaizen lightening burst icon.

- Improvement in on-demand uptime of the second spot-weld machine, as it will now be tied to other processes in a continuous flow.
- Elimination of waste in the weld/assembly cell, to reduce total work content down to 168 seconds or less. (Which allows use of 3 operators at the current level.)

We should also figure out how to use existing stamp technology - designed to produce stampings in much higher volume than the customer for this product desires - in a less wasteful way.

- The secret here is to have the stamping press, which also stamps parts for other product families in the plant, make smaller batches of the two parts our value stream needs and make them more frequently.
- The will require additional reduction in changeover time.
• In fact, methods to reduce set-up times on a stamping press are well known and a reduction time to less than 10 minutes per setup can be achieved quickly.
• With that the press can make only about 300 left-drive stampings and 160 right-drive stampings (the per shift production need) then produce parts for other value streams: then make more lefts and rights on the next shift.
• EPE will now equal every part every shift.
• This way the amount of inventory stored between the stamping process and the weld/assembly cell would be reduced by 85%.

The Future State Map
The beauty of asking Question 8 last is that your process improvement efforts become subordinate to the overall value stream design as opposed to vague, stand-alone improvement activities. Teams can now be dispatched to work on these process improvements with a clear understanding of why they are making these improvements.

However be sure to kick-off improvement projects by creating a “pull” for the improvements. That is instead of “pushing” a team to reduce set up time on the stamping process, begin instead by stating that in 30 days the batch sizes on the stamping process will be reduced to 300 and 160 pieces. This creates a sense of urgency about making the process improvement. Likewise stating that in 14 days the welding and assembly will be placed into a continuous flow will pull the elimination of weld-fixture design.

Summing Up
When we compare the summary statistics for Acme’s current state and its future state the results are quite striking. In particularly levelling production in the weld/assembly cell and developing the ability to stamp every part every shift will allow Acme to further reduce the amount of coils and stamped parts held in its supermarkets. However this puts great pressure on maintaining equipment reliability and predictability for production to takt.
Summing Up

- With shortened production lead time through its shop floor, the pacemaker process operating consistently to takt time and fast response to problems, Acme can comfortably reduce the amount of finished goods inventory it holds to two days worth (1200 LH, 640 RH.)

- (If Acme's customer were to level its schedule, this finished goods inventory could be reduced further.)

Summing Up

- Compared with the interim improvements, levelling production at Acme has further reduced production lead time by another 3.5 days and nearly doubled inventory turns.

Acme Stamping Lead Time Improvement

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