

Value Stream Mapping and Calendar Time Conversion Instructions

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Value Stream Mapping and Calendar Time Conversion

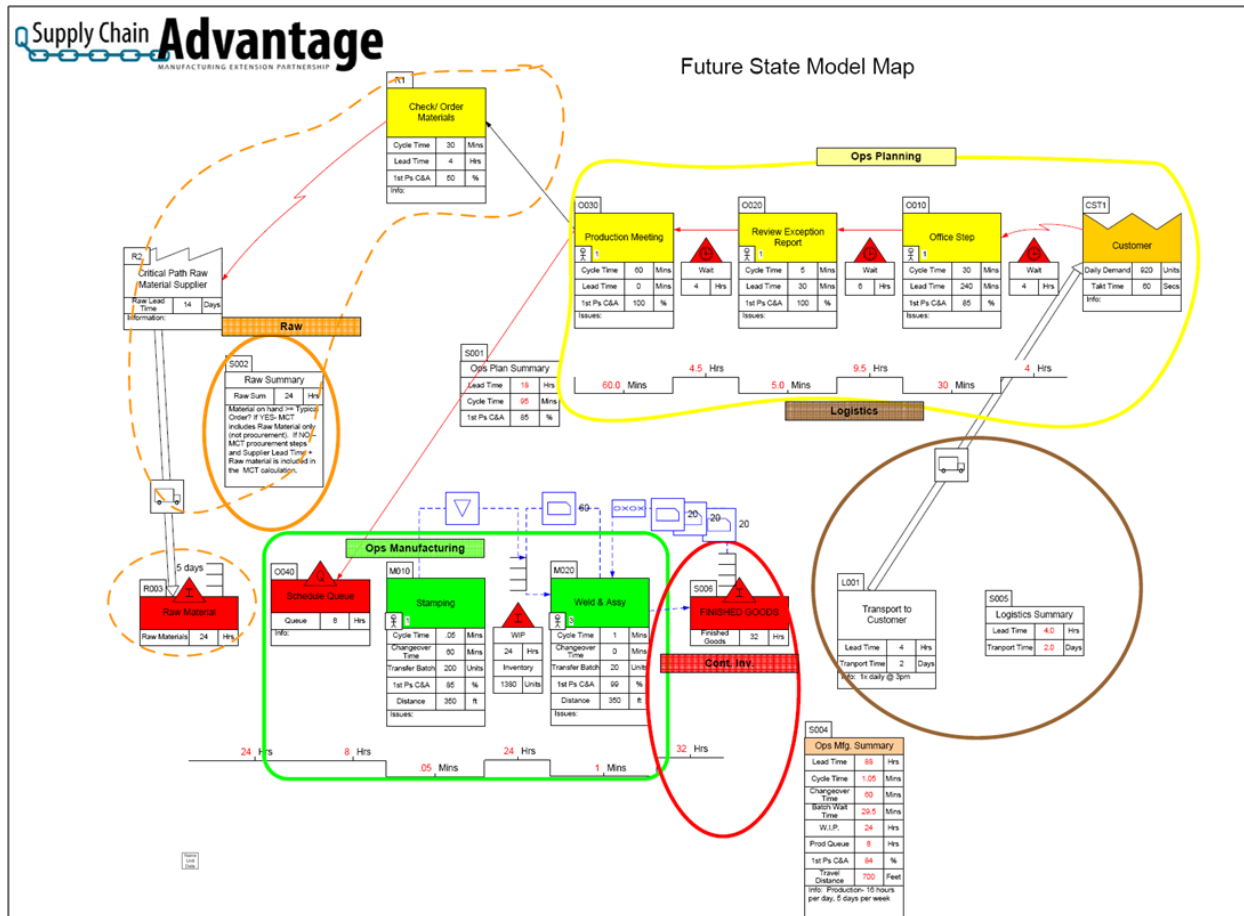
Introduction

Note: To download a printer-friendly version of the **Value Stream Mapping and Calendar Time Conversion** topics, go to: www.wmep.org.

Also Note: To view online instructional videos that demonstrate the Value Stream Mapping and Calendar Time Conversion tools, go to www.wmep.org.

The Accelerate process introduces small-to-medium sized manufacturing businesses to a simple process they can use to identify, implement, and measure improvements to their entire production process. Two powerful tools are used in this process:

- **Value Stream Mapping (VSM):** VSM depicts the flow of information and materials required to process an order, procure materials, produce the product, and ship the product back to the customer. The data associated with each icon in the map allows everyone to easily identify and discuss opportunities for improvement.
- **Manufacturing Critical-path Time (MCT) metric:** MCT quantifies VSM's true lead time in calendar days, which represents the customer viewpoint.



Although the Value Stream Mapping and the Manufacturing Critical-path Time (MCT) tools can be used independently, when these tools are used in combination, a synergistic effect is unleashed. For example, in order to interface with MCT, the Value Stream Map must collect data regarding batch size and the order entry process, resulting in a more robust understanding of the value stream. Likewise, by providing a true calendar time representation of the value stream, when it comes to planning improvements, the MCT calculations benefit from the more robust visual depiction of the process provided by the Value Stream Map.

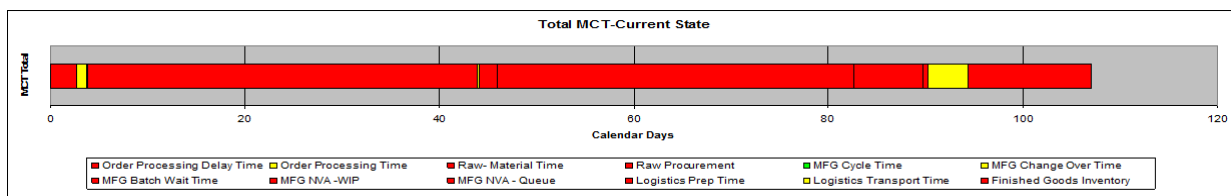
Work Time vs. Calendar Time

When it comes to the standard VSM timeline and Manufacturing Critical-path Time metric, you must keep in mind the following measurement differences:

- VSM measures everything relative to the work time available and does not take weekends or shift downtime into account.
- Manufacturing Critical-path Time (MCT) provides an easily understood metric that measures everything in calendar time.

There are several benefits to calendar time:

- MCT is valuable as a measurement supply chain order fulfillment, providing both suppliers and customers a measurement of current capabilities and a common focus for improvement efforts.
- Calendar days provide a consistent measurement for firms, no matter how widely they may differ with respect to the products they produce or their production work-time-availability.
- MCT represents the viewpoint of the customer, and as such, provides an essential perspective in the world of supplier/customer interface and lean improvements.



For these reasons, the MEP network has adopted VSM as a standard tool and integrated the use of the MCT metric into the VSM process through the Calendar Time Conversion Calculator. The information presented here has been developed to support the consistent combined use of VSM with the Calendar Time Conversion Calculator.

Preparing the Value Stream Map for MCT Conversion

Overview

Note: To download a printable example of an Accelerate Value Stream Map, go to www.wmep.org.

The instructions provided in this section supplement and support the standard Value Stream Mapping process as presented in the book **Learning to See** by Mike Rother and John Shook. This section provides an explanation of the Value Stream Mapping template deployed in the Accelerate process, which in turn supports the use of the Calendar-Time Conversion Calculator.

Although complex Value Streams that involve multiple components can be fully represented on a Value Stream Map, the essential mapping calculations are those which are part of the critical path (the path that represents the longest lead time). If you have multiple parallel paths of material or information flow, the longest path is the critical path and should be the basis for the Value Stream Map timeline and subsequent MCT calculations.

All measurements on the Value Stream Map should be recorded relative to the work time available, not actual calendar time. In other words, on the Value Stream Map, hours should be normal working hours available per week and days should be normal work days.

How to Convert Inventory Into Time

Value Stream Mapping converts inventory into "time relative to work days available" by performing the following steps:

1. Identify the **average customer demand per month**
2. Identify the **work days available per month**
3. Identify the **average daily demand** by dividing the **average customer demand per month** by **work days available per month**.
4. Identify the **work in progress (WIP)** by dividing the **observed pieces of inventory** by the **customer demand rate**.

Example

1. Average customer monthly demand = 18,400
2. Work days available per month = 20 (no weekends or holidays are used in this example)
3. Average daily demand = 920 pieces per available work day ($18,400 / 20$)
4. 2,500 pieces of work in progress (WIP) = 2.72 work days of WIP ($2500 / 920$)

VSM Loops

To better manage the Value Stream Mapping data, it is important to summarize the data according to the major sections (or "loops") of the Value Stream Map. The Value Stream Map is divided into the following five loops:

- [Operations Planning \(Office\) loop](#)
- [Raw Material and Procurement loop](#)
- [Operations Manufacturing loop](#)
- [Logistics loop](#)
- [Contingency Inventory loop](#)

Operations Planning (Office) Loop

The Operations Planning Loop begins from the point of the customer release of the order. It follows the information flow until a production order is released to Manufacturing Operations. It does not include material procurement activities.

Ops Plan Summary Table

S001	Ops Plan Summary	
Order Delay Time	16	Hrs
Order Process Time	331	Mins
1st Ps Prfct	85.4	%

- **Order Delay Time:** Is the total of all non-value add office activity, including: Wait Time, Queue Time, and Batch Wait Time. It begins with the customer order and follows the information flow through issuance of the production order to the floor.
To compute: Add the Wait Time and Queue Time between each step, and also add the additional Batch Wait Time that is part of the step (if it's different than the required cycle time).
- **Order Processing Time:** Is the total of all necessary touch time to move information from the customer to Manufacturing Operations.
To compute: Add the step touch times.
- **1st Pass Perfect:** Is the total overall percentage of orders that go through the processing step without a delay due to incomplete or inaccurate information or processing.
To compute: Multiply the entire 1st Pass Perfect In and Through measurements for all the production steps. For example: $96\% \times 85\% \times 100\% \times 100\% \times 50\% = 40.8\%$ 1st Pass Perfect In and Through.

Raw Material and Procurement Loop

The Raw Material Loop includes all procurement activities, the supplier lead time, and the raw material held on hand that pertains to the critical production path. The Raw Material Loop consists of two parts:

- **Raw Procurement:** Includes the purchasing activities and raw material supplier lead time for the critical path component in a non-expedited disposition. This is not part of the VSM time-line.
- **Raw Material:** Includes all raw materials on hand for the critical path component.

Raw Material Summary Table

Raw Material includes:

- The time represented by the raw material for the critical path component
- The time represented by any kitted material
- The total procurement time for the critical path component

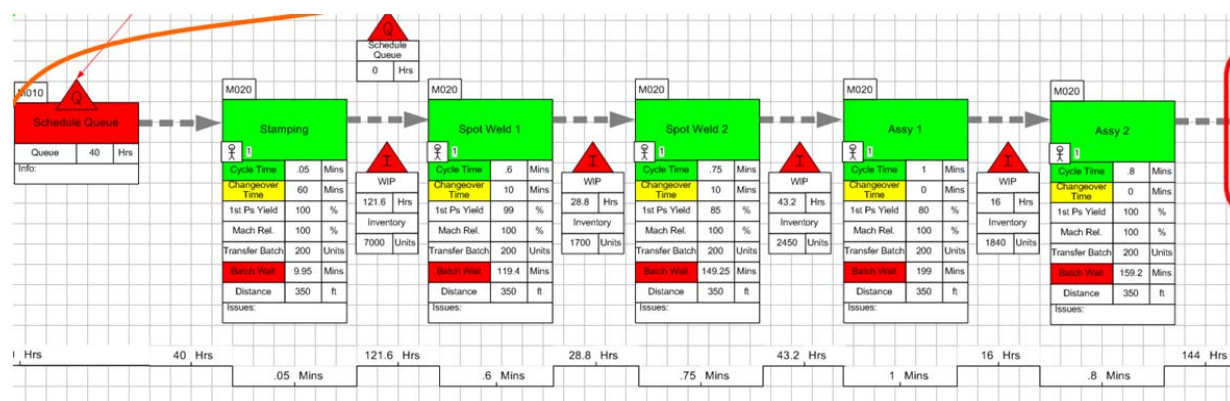
S002		
Raw Mat'l Summary		
Raw Inv	80	Hrs
Kitted Inv	0	Hrs
Total Procure Time	15.02	Days
Total Procure Time= Supplier Lead Time + office procurement Time + materials handling/receiving		

Operations Manufacturing Loop

The Operations Manufacturing Loop includes all non-value and value-added activity from the Raw Material loop through the critical production path until a finished product has been produced. This includes:

- The production schedule queue
- The cycle time for all the production steps, as well as the change over times
- The batch wait times
- The time represented by the Work in Process Inventory (WIP)
- The queue time waiting on shared resources

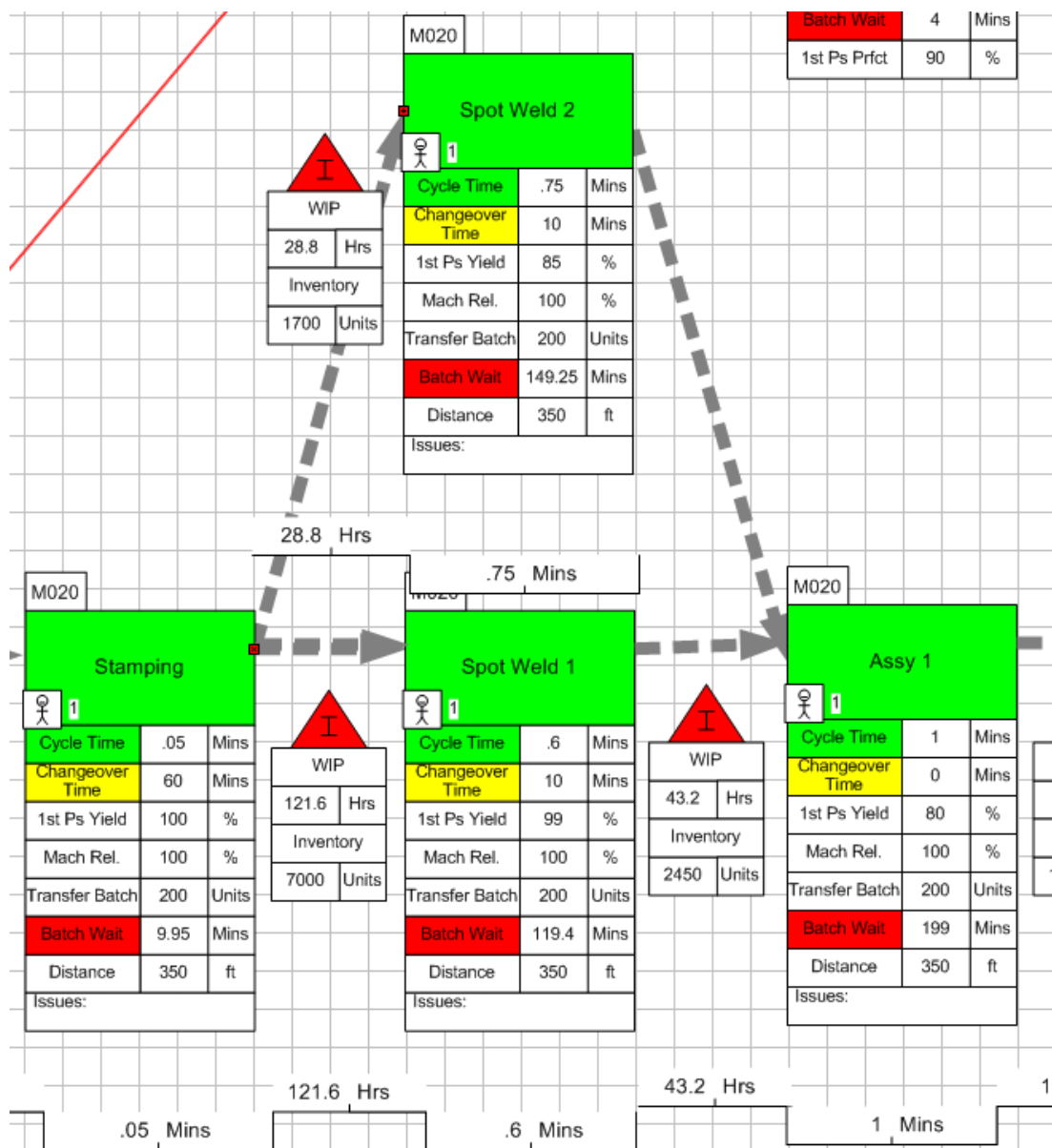
The Operations Manufacturing Loop does not include packing, shipping or finished goods inventory.



Determine the Critical Path of Production

If more than one production path exists, the critical path is the path with the longest lead time.

In the example provided here, Spot Weld 1 and 2 are running in parallel and both feed into Assembly 1. Spot Weld 2 has 28.8 hours of WIP and a .75 minute cycle time, whereas Spot Weld 1 has 121.5 hours of WIP and a .6 minute cycle time. Spot Weld 1 is the longest path and thus the critical path.



Operations Manufacturing Summary Table Calculations

This section provides an explanation of the components that make up the Operations Manufacturing Summary table.

- **Lead Time:** Total of all NVA (non-value add) activity in the critical production path, including Raw Material Inventory, and the WIP and Queue between production steps, through the completing of a finished product. This is a standard VSM measurement.
- **Cycle Time:** Total of all the Cycle Time in the critical production path. This is also a standard VSM measurement.
- **Changeover Time:** Total of all the change over time in the critical production path.
- **Batch Wait Time:** For each production step, multiply the number of units in the transfer batch size minus 1 times the cycle time for that step to get the batch wait time for this step.

Example: Transfer batch of 200-1=199 x .05 min= Batch wait of 9.95 minutes.

To get the total Batch Wait Time, add the batch wait time for each step to get the total batch wait time for the critical production path.

- **W.I.P.:** Add the total of the manufacturing non-value add values that are due to WIP in the production loop.
- **Queue:** Add the total of the manufacturing non-value add values that are due to Queue times in the production loop.
- **1st Pass Quality Yield:** Multiply all the 1st Pass Yield measurements for all the production steps.

Example: 96% x 85% x 100% x 100% x 50% = 40.8% 1st Pass Yield.

This gives you the overall percentage of parts that go through the value stream without defects, scrap, or rework on the first pass.

- **Machine Reliability:** Multiply all the machine reliability measurements for all the production steps in the same manner as 1st Pass Quality Yield. This gives you the total percent of time that all machines required for this value stream are in proper working order.
- **Travel Distance:** Add the distance traveled (in feet) by the material from Raw Material to Finished Goods.

S004		
Ops Mfg. Summary		
Lead Time	433.6	Hrs
Cycle Time	3.2	Mins
Changeover Time	1.3	Hrs
Batch Wait Time	642	Mins
W.I.P.	209.6	Hrs
Queue	40	Hrs
1st Ps Yield	67.3	%
Mach Rel.	87%	%
Travel Distance	1750	Feet

VSM Production Timeline

The non-value add values in the VSM production timeline are made up of WIP and Queue Time. Do not include raw material, kitted material, or finished goods inventory in WIP or Queue totals since they are included in their respective categories.



Logistics Loop

The Logistics Loop includes all the wait time and activities in the shipping of a finished product. This includes:

- Packing
- Waiting on the shipping dock
- Transport time through physical receipt of the goods by the customer.

The legal transfer of ownership is irrelevant to this mapping exercise, which focuses on the physical flow of goods.

Logistics Summary Table

- **Logistics Prep Time:** The typical time the finished product is awaiting shipment, including packing activities, waiting, and loading.
- **Transport Time:** Time required to transport the finished goods from the supplier dock to the customer dock.

L030		
Transport To Customer		
Prep Time	4	Hrs
Transport Time	2	Days
Info: 1x daily @ 3pm		

Contingency Inventory Loop

The Contingency Inventory Loop refers to all finished goods inventory as distinct from WIP.

The Contingency Inventory is part of the Value Stream Mapping Production Lead time calculation, but for the purposes of MCT is considered a separate loop distinct from the Operations Manufacturing Loop. The Contingency Inventory does not require a summary table since it is a stand alone measure.

Calculating the MCT Measurement

Calculating the MCT Measurement

Entering VSM Values into Calendar Time Conversion Sheet

Use your completed value stream map to make the required entries to the calendar time conversion sheet. The MCT calculation requires 14 step entries from the Value Stream Map. After completing the 14 steps the final calculations are [displayed on the conversion sheet](#).

Step 1 - Order Processing Delay Time

From the Ops Plan Summary Table on your VSM, enter the Order Processing Delay Time onto the Calendar Time Conversion spreadsheet. Then enter the work hours per day and the work days per week (e.g. 8 hours, 5 days per week). You'll do this for each step.

Calculating the MCT Measurement: Steps 2 and 3

Step 2 - Order Processing Time

From the Ops Plan Summary Table on your VSM, enter the Order Processing Time. Then enter the work hours per day and the work days per week (e.g. 8 hours, 5 days per week).

S001	Ops Plan Summary		
Order Delay Time	16	Hrs	
Order Process Time	331	Mins	
1st Ps Pnct	85.4	%	

CALENDAR TIME CONVERSION SHEET						CURRENT STATE		
CRITICAL PATH				Step Duration Entries in Work time Available		Work Hours Per Day	Work Days per Week	MCT
Step	VSM Summary Metric Name	Days	Hours	Mins				
1	Order Processing Delay Time		16		8	5		2.80
2	Order Processing Time		5	31	8	5		0.97
3	Raw- Material Time	0	80		8	5		14.00
4	Raw Procurement	0	0		8	7		0.00

R010	Raw Material		
Raw Materials	80	Hrs	
Raw Materials	1297	Units	

Step 3 - Raw Material Time

From your VSM, enter the time for the Raw Material Inventory on Hand. Then enter the work hours per day and the work days per week (e.g. 8 hours, 5 days per week). Raw Material uses the same work hours per day and work days per week as the Manufacturing Loop. Kitted Raw Material is included in Raw Material on Hand, not WIP. Time for kitting activities (but not material) is included in the production loop.

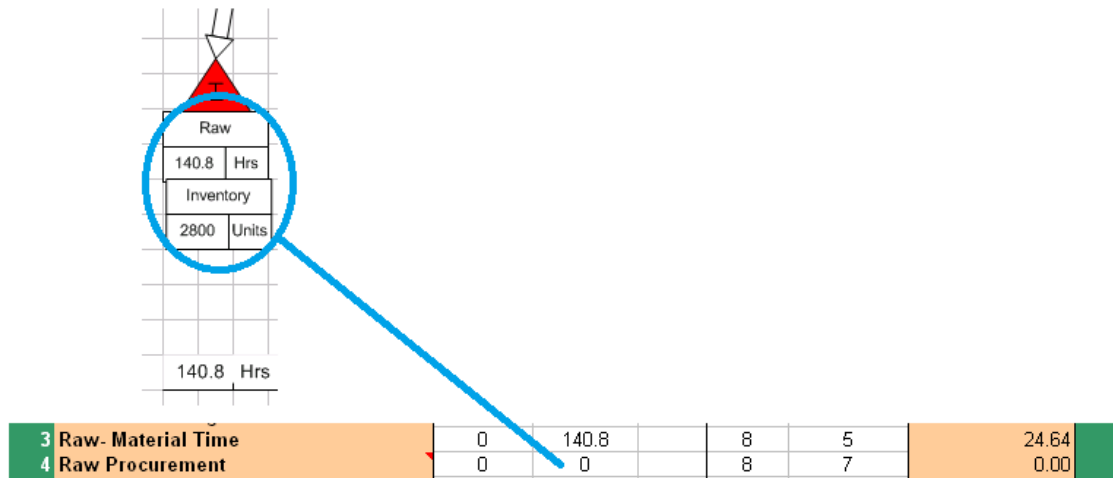
Calculating the MCT Measurement: Step 4

Raw Procurement

Raw procurement time is not always part of the Manufacturing Critical-path Time, and therefore is not always entered in the Calendar Time Conversion spreadsheet.

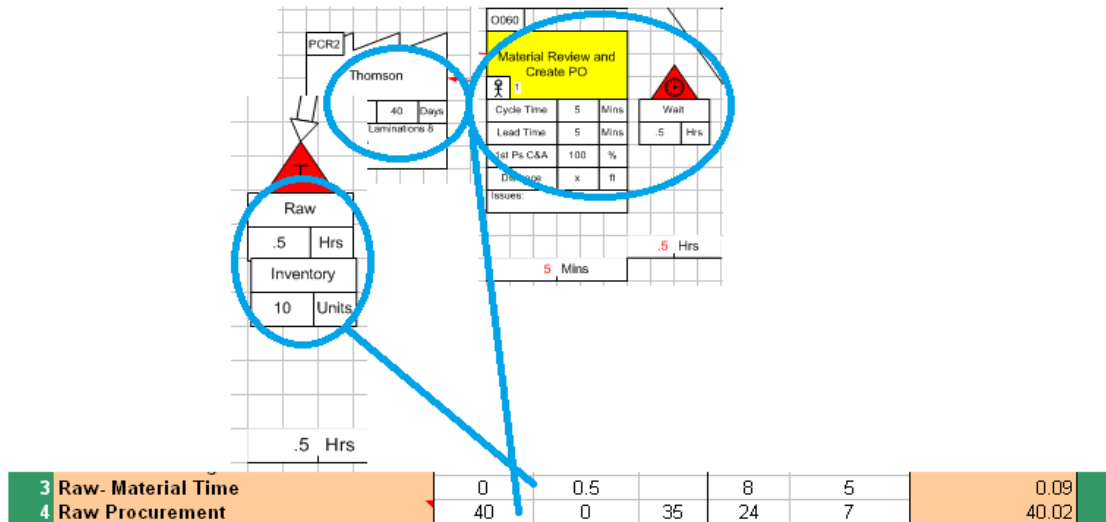
- If the Raw Material on Hand ***is*** sufficient for a typical customer order quantity, you ***do not*** enter the procurement time. Enter 0 for Raw Material procurement Lead Time and go on to line 5, MFG. Cycle Time.
- Typical order quantity is best selected by reviewing previous orders and selecting a typical quantity. Compare that quantity to the amount of raw material on hand.

For example, if your typical customer order quantity is 1000 pieces, and your Raw Material on hand is 2800 units, enter the time value (140.8 hours) for line 3. Leave line 4 as 0 and go to line 5.



- If the Raw Material On Hand ***is not*** sufficient for a typical customer order quantity, enter the Raw Procurement Lead Time and Cycle Time (in addition to any Raw Material on Hand). This would include the total time of the procurement activities and the supplier lead time in a non-expedited disposition.

For example, if your typical customer order quantity is 1000 pieces, and your Raw Material on hand is 10 units, enter the time value (.5 hrs) for line 3. Then add the time for procurement activities and the supplier lead time in line 4. In the example below, you would enter 40 days and 35 minutes (.5 hour wait and 5 minutes of procurement cycle time and 40 days of supplier lead time.) Enter the work hours and work days per week at which the Raw Procurement activities are factored. Typically the supplier lead time is already in true calendar time. In this case, enter 24 hours and 7 days for the conversion factor.



Calculating the MCT Measurement: Step 5

MFG Cycle Time

From the Ops Mfg. Summary Table on your VSM, enter the Cycle Time Total. This is the total of the Value Added Time for one piece in production through the critical path. Then enter the normal work hours per day and the work days per week for the manufacturing floor. If different departments have differing work hours and work days per week, take the smaller working period as the conversion factor.

Example: Plant ABC runs production on a 2 shift 6 days per week, but the welding department only runs 8 hours per day 5 days per week. Enter 8 hours per day and 5 days per week as the conversion factor for the production steps.

Calculating the MCT Measurement: Steps 6, 7, 8, and 9

Step 6: MFG Change Over Time

From the Ops Mfg. Summary Table on your VSM, enter the Changeover Time total. This is the total of all the change-overs for all production steps through the critical path of production.

Step 7: Batch Wait Time

From the Ops Mfg. Summary Table on your VSM, enter the Batch Wait Time total for the critical production path.

Step 8: MFG NVA- WIP

From the Ops Mfg. Summary Table on your VSM, enter the Total Production NVA- WIP (non-value add work-in-process)

Step 9: MFG NVA Queue

From the Ops Mfg. Summary Table on your VSM, enter the Total Production NVA- Prod Queue

S004							
Ops Mfg. Summary							
Lead Time	433.0	Hrs					
Cycle Time	3.2	Mins					
Changeover Time	1.3	Hrs					
Batch Wait Time	642	Mins					
W.I.P.	209.6	Hrs					
Queue	40	Hrs					
1st Ps. Hold	63.6	%					
Mach Rel.	87%	%					
Travel Distance	1750	Feet					

5	MFG Cycle Time	0	0	3.2	8	5	0.01
6	MFG Change Over Time	0	1.3	0	8	5	0.23
7	MFG Batch Wait Time	0	0	642	8	5	1.87
8	MFG NVA -WIP	0	209.6		8	5	36.68
9	MFG NVA - Queue	0	40	0	8	5	7.00

Calculating the MCT Measurement: Step 10

Logistics Prep Time

From the Logistics Summary Table on your VSM, enter the Logistics Lead time in your conversion table. Enter work hours per day and the work days per week of the shipping department.

		L030					
				Transport To Customer			
		Prep Time		3	Hrs		
		Transport Time		3	Days		
		Info: 1x daily @ 3pm					

10	Logistics Prep Time		3	0	8	5	0.53
11	Logistics Transport Time	3			24	5	4.20

Calculating the MCT Measurement: Steps 11 and 12

Step 11 - Logistics Transport Time

From the Logistics Summary Table on your VSM, enter the Transport time in your conversion table. Enter 24 hours per day and the work days per week that material is received for the conversion factor for this step.

Step 12 - Finished Goods Inventory

If present, enter the Contingency Inventory (All Finished Goods) from your VSM into your conversion table. Use the work hours per day and work days per week of your production loop for the conversion factor for this step.

Distance traveled and Mfg 1st Pass Perfect do not affect the calendar time calculation, but are included on the calendar time conversion sheet to track improvements in these areas relative to the value stream.

F010		I		FINISHED GOODS		
Finished Goods	8280	Units				
Finished Goods	144	Hrs				

12 Finished Goods Inventory	0	144	16	5	12.60
Total					59.69
MFG Distance Traveled	1750 Feet				
MFG 1st Pass Quality Yield%	67.3 %		Response 46.62		

Calculating the MCT Measurement: Steps 13 and 14

Step 13 - Distance Traveled

Enter the total number of feet the material travels from raw material through shipment of finished goods.

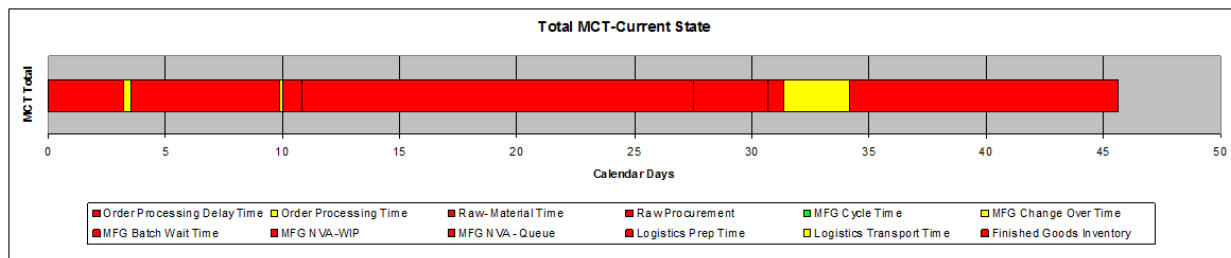
Step 14 - Mfg 1st Pass Quality Yield

Enter the total 1st Pass Quality Yield measurement for the [critical production path](#).

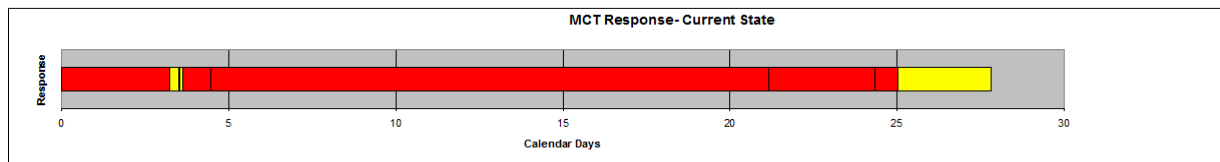
Understanding the Calendar Time Calculations

After completing the 14 MCT measurement steps, the following calculations are displayed on the Calendar Time Conversion Sheet:

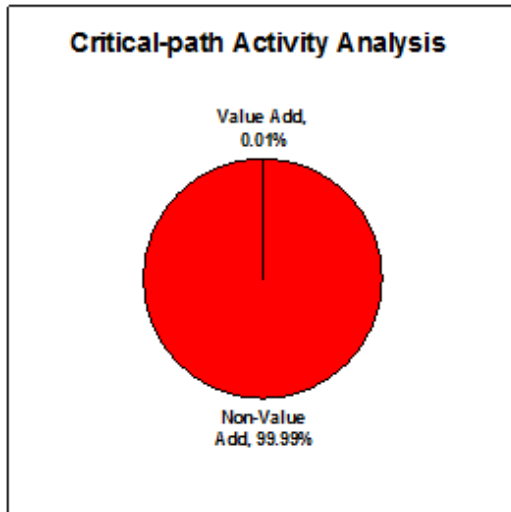
MCT Total: This is the total true lead time for the critical path of the value stream in calendar days in a non-expedited, First In, First Out flow.



MCT Response: This is a subset of the MCT total, excluding Raw Material and Finished Goods on hand. It measures the activities associated with order fulfillment. This metric is especially relevant to operational flexibility and order fulfillment capabilities.

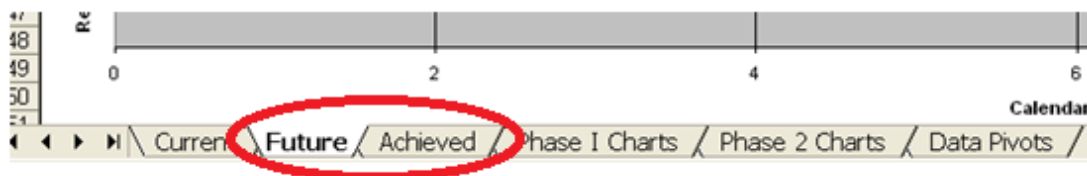


Critical-path Activity Analysis: This compares the amount of "value added activity" to "non-value added activity" relative to the first piece of an order. As in the Value Stream Map, Value Add is taken from the viewpoint of the first single piece.



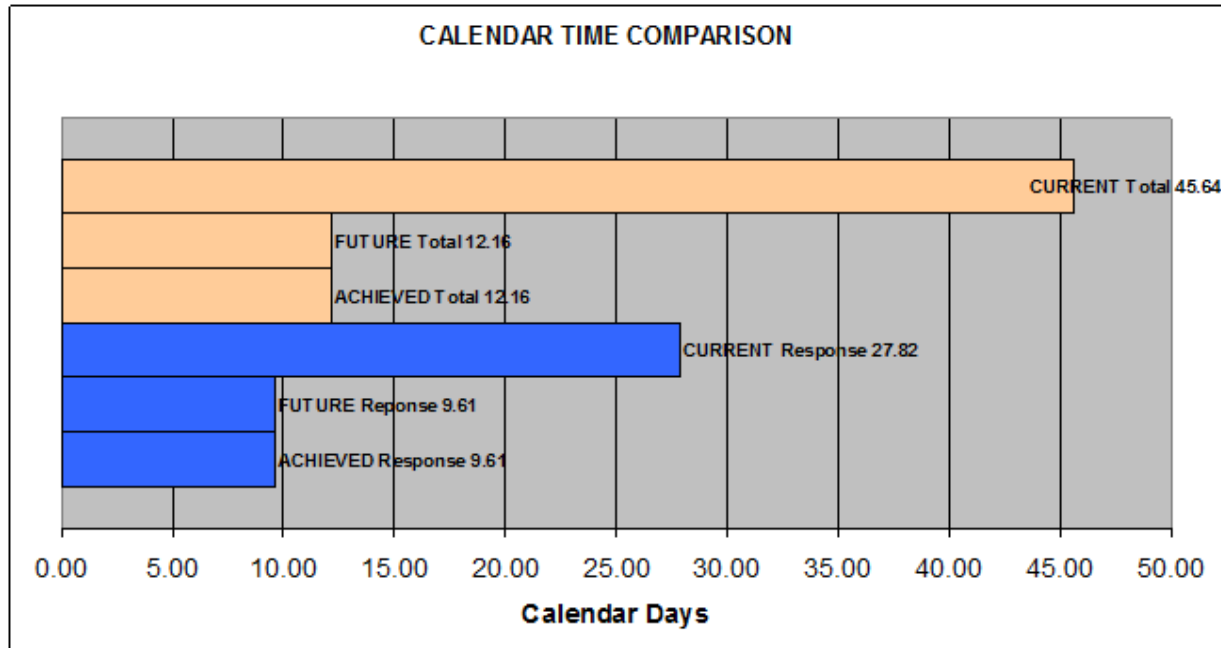
Comparison Charts

Once the current state is completed, additional “future” and “achieved” calculations can be created by selecting and completing these respective sheets.



Whenever future or achieved state are completed, charts comparing the data from these sheets to the Current sheet are automatically generated.

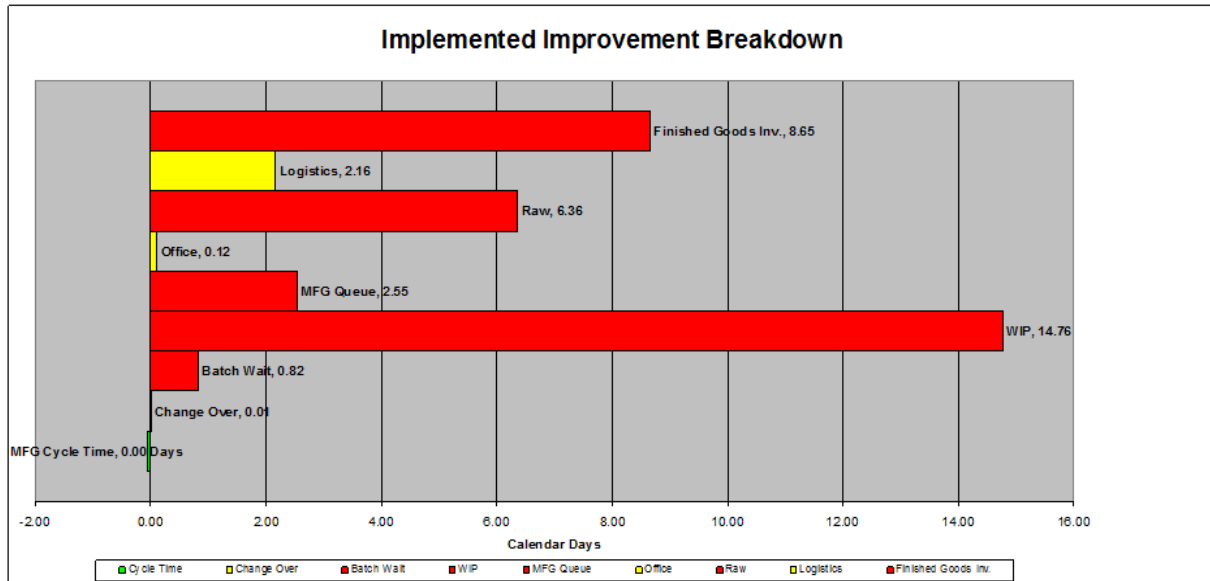
These Calendar Time Comparison charts can be viewed by selecting the **Phase I Charts** tab, which compares Current and Future, or by selecting the **Phase II Charts** tab, which compares Current and Achieved.



Below the Calendar Time Comparison charts, a detailed **Improvement Breakdown** chart is also generated. It is based on a comparison between the Total MCT values of the Current / Future states or the Current / Achieved states. The Improvement opportunity is stated both in Calendar days and as a percentage of improvement compared to the current state as the “baseline.”

This analysis chart is presented in order to visually display the amount of improvement in the various segments of the Value Stream. This chart breaks down the number of calendar days of improvement in the following specific categories:

- Contingency inventory (finished goods)
- Logistics
- Raw material
- Office processing
- Mfg. queue time
- WIP inventory
- Batch wait time
- Change over
- Mfg. cycle time



Finally, below the Improvement Breakdown chart, improvement in the distance traveled and the 1st Pass Quality at the source are displayed. These charts can be effective tools to track and communicate the areas of improvement recognized through the mapping process.

Frequently Asked Questions

Question

What should I do when I have a number of different raw materials coming into the value stream at different points and being assembled?

Answer

Track each one on the value stream map. For the summary totals and calendar time conversion, use the values for the items and processes that represent the critical-path (the longest lead time).

Question

What should I do with kitted raw material that is separate from raw material inventory?

Answer

Even if the raw material is kitted, it should be considered raw material for the sake of MCT mapping.

In this example, 80 hours worth of raw material is in inventory, and 10 hours of raw material has been kitted. Step 3 in the Calendar Time Conversion Spread sheet should be 90 hours for Raw Material Time.

S002

Raw Mat'l Summary

Raw Inv	80	Hrs
Kitted Inv	10	Hrs
Total Procure Time	14.02	Days

Total Procure Time =
Supplier Lead Time + office
procurement Time +
materials handling/receiving

3	Raw- Material Time	0	90	12	5	10.50
4	Raw Procurement	0	0	24	7	0.00

Question

Where should I include the material receiving and inspection activities prior to the receiving of raw materials into inventory?

Answer

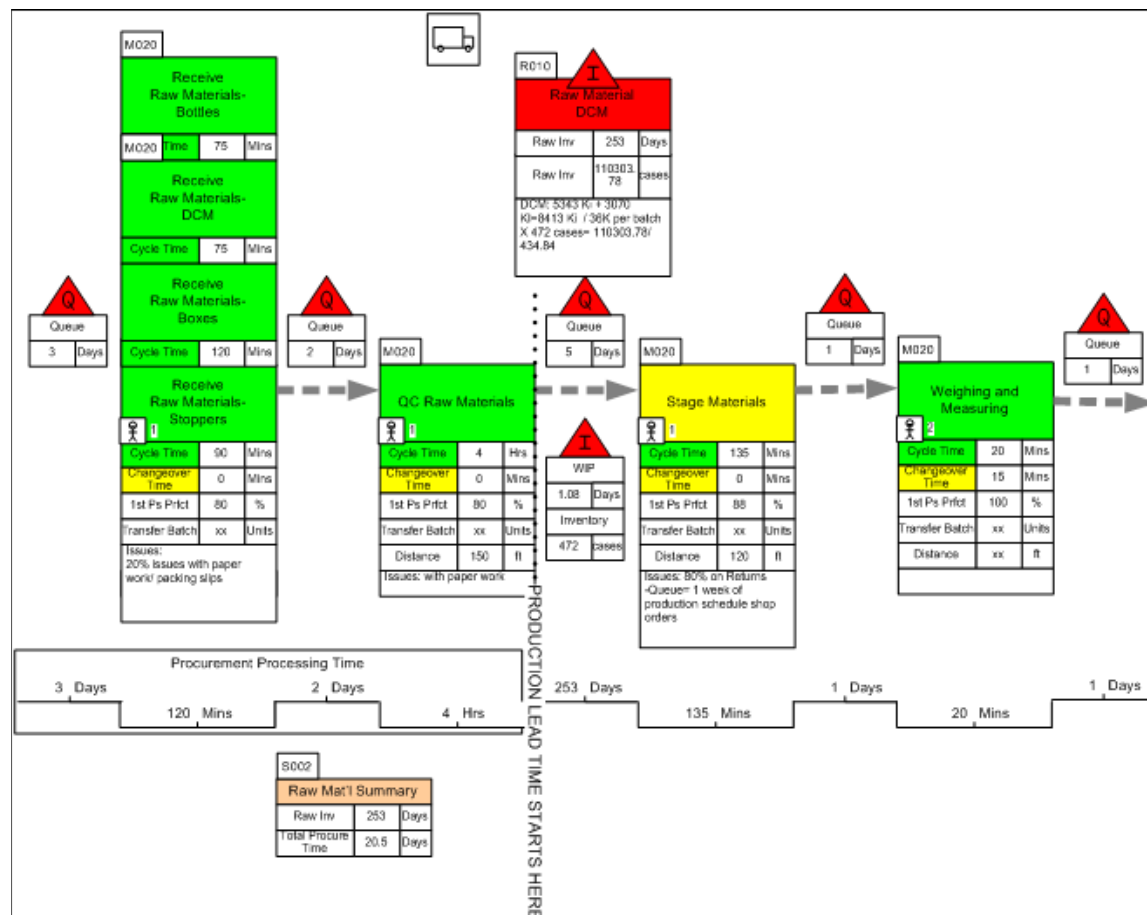
While these activities can be depicted on the Value Stream Map as “production processes” and often represent improvement opportunities, these activities are actually part of the procurement process. The time for these activities should be captured as part of the total procurement time and not included in the production time-line.

Consequently, these activities would not be included in the MCT calculation unless raw material procurement time is included ([see MCT Measurement: Step 4](#)).

In the example below, significant time was spent receiving and inspecting raw materials before it was put into storage. These activities, while captured on the VSM, are not included in the production time-line.

The time for these activities is part of the total procurement time in the Raw Material Summary.

Production lead time begins with raw material inventory, represented by the dotted line.



Question

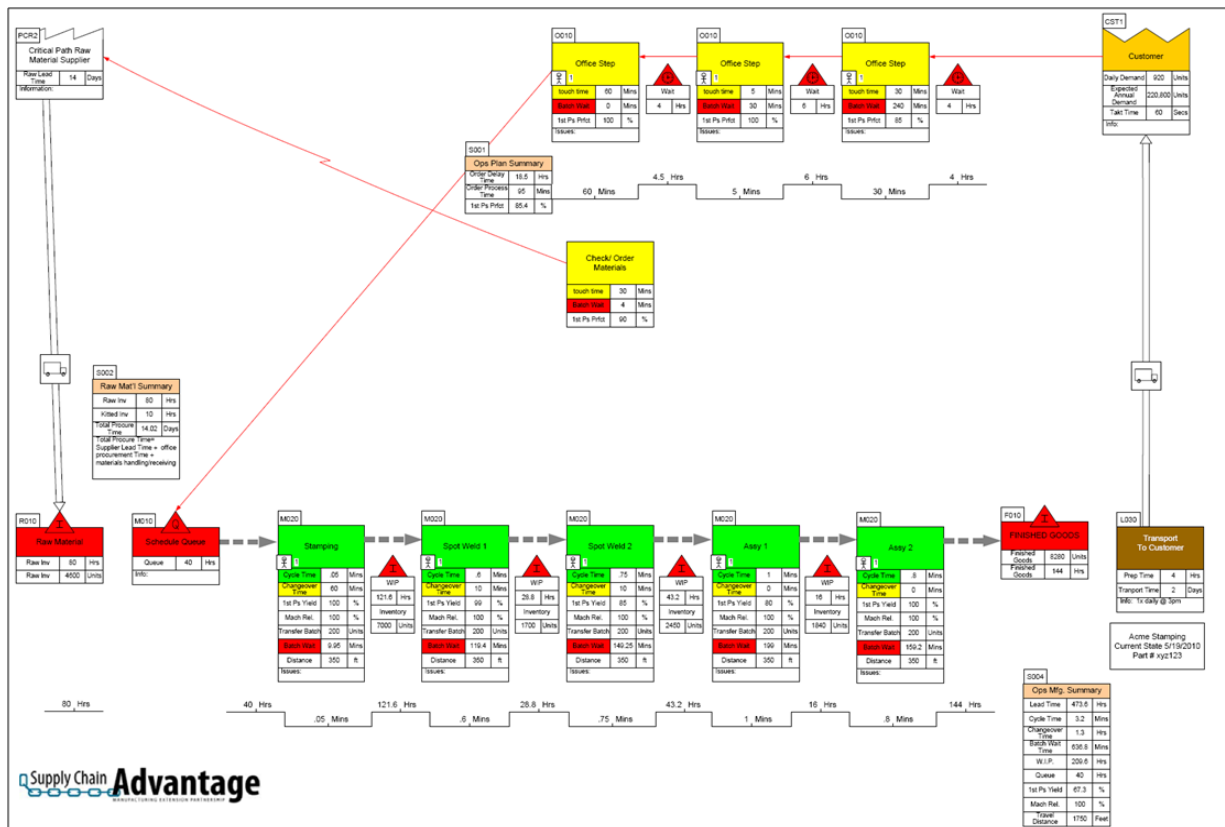
Where should I include time for activities after the product is finished, such as inspection, material handling, packing, and shipping?

Answer

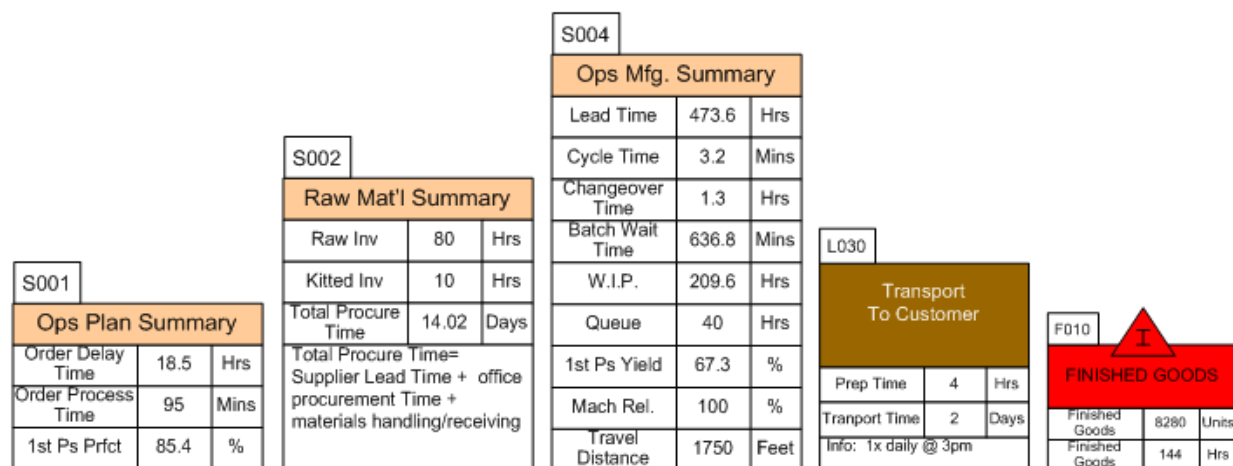
These activities are depicted on the Value Stream Map as separate steps or included under the “logistics prep” time. The typical depiction is captured in the table below:

Activity	Shown on VSM	Included In VSM Timeline?
Finished Goods Inspection	Yes, as separate step	Yes, normally part of production time
Moving material into FG storage	Yes, as separate step	Yes, normally part of production time
Finished Goods Inventory	Yes, as inventory	Yes. Adds to production time
Pulling material out of FG storage	No, include in logistics prep	No. Part of Logistics prep time
Packing to ship	Usually not; included in logistics prep.	No. Part of Logistics prep time
Loading onto Truck	No	No. Part of Logistics prep time

Sample Value Stream Map



Summary Boxes from the Sample Value Stream Map



Corresponding Calendar Time Conversion Sheet

CALENDAR TIME CONVERSION SHEET					CURRENT STATE			
CRITICAL PATH		Step Duration Entries in Work time Available			Work Hours	Work Days		
Step	VSM Summary Metric Name	Days	Hours	Mins	Per Day	per Week	MCT	
1	Order Processing Delay Time		18.5		8	5	3.24	
2	Order Processing Time		0	95	8	5	0.28	
3	Raw- Material Time	0	4		12	5	0.47	
4	Raw Procurement	0	0	0	24	7	0.00	
5	MFG Cycle Time	0	0	3.2	12	5	0.01	
6	MFG Change Over Time	0	1.3	0	12	5	0.15	
7	MFG Batch Wait Time	0	0	636.8	12	5	1.24	
8	MFG NVA -WIP	0	209.6	0	12	5	24.45	
9	MFG NVA - Queue	0	40	0	12	5	4.67	
10	Logistics Prep Time		4	0	8	5	0.70	
11	Logistics Transport Time	2		0	24	5	2.80	
12	Finished Goods Inventory	0	144		12	5	16.80	
						Total	54.80	Days
MFG Distance Traveled		1750		Feet				
MFG 1st Pass Quality Yield%		67.3		%	Response 37.53 Days			
Company:	Acme Stamping				Value Add	0.01%		
Product:	xyz123 part							
Date:	5/19/2010				Non-Value Add	99.99%		