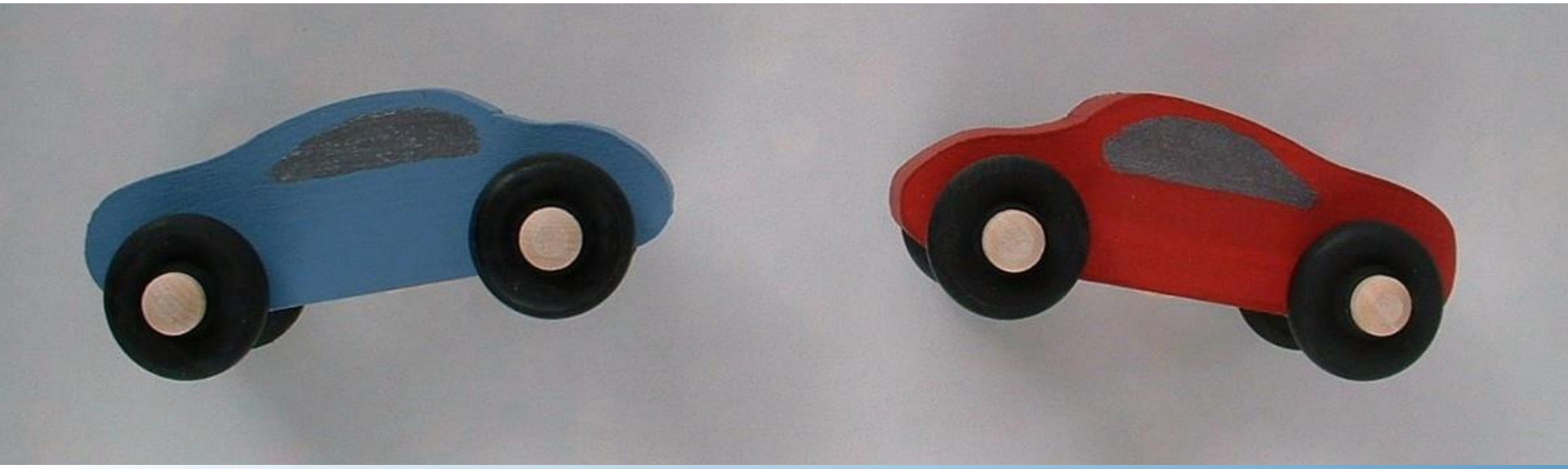
The LeanMan

Lean Factory Simulation Kits

Lean Factory Simulation Kit

4-Event Training Guide



Lean Factory Simulation Kits

WARNING – KIT CONTAINS SMALL PARTS.

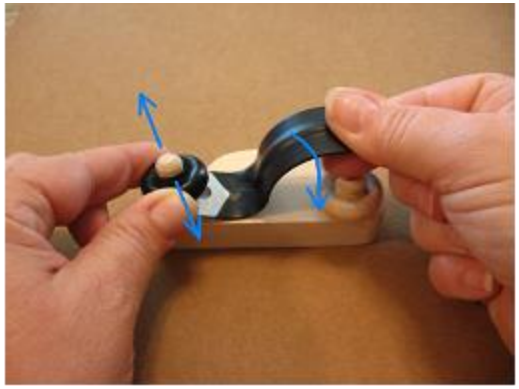
KEEP AWAY FROM YOUNG CHILDREN

A word about safety and ergonomics:

- The simulation exercises use small components to produce toy cars. They are attractive to small children, therefore use caution when storing the components and keep them away from small children to prevent choking.
- The wooden pegs used to mount the wheels are made of a hard wood and should provide stable use over a long time. However, all wood will absorb moisture in high humidity conditions causing a slight swelling of the fibers and resulting is a tight fit of the wheel assembly. If this happens, the pegs may be baked in a 300º F oven for 10 minutes to remove the excess moisture.
- If a tight peg / wheel assembly is difficult to remove, use the wheel extraction tool provided. Follow the instructions as shown.

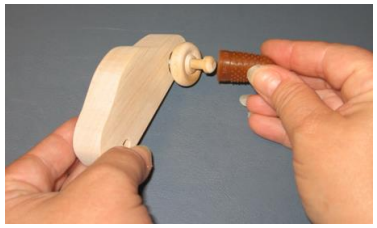
To remove a tight wheel assembly, gently slide the wheel extraction tool under the wheel and around the axle peg.

Slowly pry up against the underside of the wheel or disk, with the tip of the tool centered with the peg, to bring the peg straight out of the hole.



Gently rock the axle back and forth while pressing downward on the extraction tool handle. Use care not to flip the wheel and disk into the air. Do not bend the tool – press slowly and rock the peg loose.

- Use the ergonomic tool provided to grip the peg and prevent finger soreness over the duration of the simulation event. Use the small rubber finger tip grip to hold onto the peg as you turn it. Simply slip the open end of the grip over the peg hub and squeeze with your fingers and turn clockwise with a push to go in, or counter-clockwise with a pull to remove.



Notes for the car material kit:

The kit consists of several car bodies, sets of wheels, axle pegs and disk brakes. The kit provides large plastic containers that may be used for material move totes or point-of-use inventory simulation, plastic bags that are used to pick one piece kits of material when simulating a stockroom operation, and wheel-axle subassembly holding fixtures to simulate shop fixturing activity.

The written material provides some kanban squares which can be printed and used in the simulation when appropriate.

There are two types of quality non-conformance used in the simulation. They are the painted wheel, and the non-rotating wheel.

Car Kit Contents:

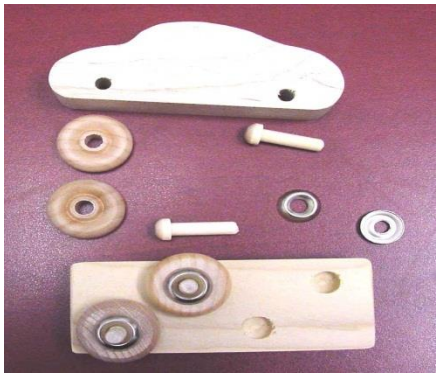
- 2 complete and painted cars
- 20 car bodies unpainted
- 80 wheels unpainted + spares
- 80 axle pegs + spares
- 80 disk breaks + spares
- 8 wheels painted black (quality)
- 5 plastic kit bags (Picked Kit Inv.)
- 5 fixture racks (wheel/axle subassy)
- large plastic containers (POU Inv.)
- small plastic containers (POU Inv.)
- 1 Stopwatch
- 1 organizer with polycarbonate cover
- 1 Participation Event Training Guide
- 1 Wheel Extraction Tool
- 1 Ergonomic peg tool

Kit Features:

The KIT: The stock keeper will pick each KIT, placing all parts for one car into a bag, and place the bags into a container for the batch size of the simulation. To simulate real shop conditions, each bag of parts should be as uniform as possible, i.e., zip-locking each bag will require a consistent amount of time, and will keep the metrics accurate.

The TOTE Batch Container: the role of the batch container in the exercise is to simulate more of the non value-adding steps performed in the shop, such as circulating containers back upstream. The stock keeper eventually has to wait for the containers and bags to return before delivering more kits.

The FIXTURE: the role of the fixture used to hold the subassembly of the wheel & break & axle is another example of non value-adding activity in the shop, particularly when components must travel long distances to their final assembly point. In this exercise, the subassemblies are mounted onto the fixture and passed to the final assembly point. The fixture must then be returned back upstream.

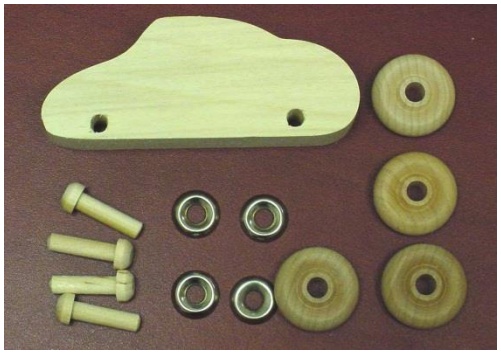


Notes for assembling the car kit:

The axle is inserted through the wheel, through the disk with the flat side toward the wheel, and into the car body. Use a clock-wise rotation of the axle as it is inserted into the car body. Inserting the axle too far will press the round side of the disk to the car body and act as a break, preventing the wheel from rotating. The non-rotating wheel is a random quality defect caused by workmanship. This naturally occurring non-conformance is used to simulate a learning curve and the value of various inspection techniques.

The disk brake components are included in the kit for two purposes. First, they provide an unwanted random breaking action that simulates a quality defect and thus demonstrates the skill of the assembler. Second, they provide a dexterity barrier for the person picking the material from the container, since they tend to stack together. This feature nicely simulates the natural variability of picking kits of small components.

The painted wheels supplied in the kit are used to inject a quality nonconformance into the material stream. This manual insertion of a nonconformance is usually timed from insertion to replacement to show the NVA activity associated with a bad part from stock. It also provides observers a chance to see the effects of a bad part from stock on WIP inventory levels and throughput for later continuous improvement discussions.



A picked 1-pc kit contains 1 car body, 4 axles, 4 disk brakes and 4 unpainted wheels.

A non-conforming quality defect may be introduced by substituting a painted wheel into the kit.

Participation Events

Use the instructions for events 1 through 4 to reinforce the manufacturing concepts presented in the Power Point Lean Principles presentation The Evolution of Lean (provided with the deluxe kit).

1. The first event, MRP **Batch 'n Queue**, shows the effects of moving large batches of product through several stages. Notice how the downstream team sits and waits for the upstream stage to complete it's task. Notice the NVA activity of returning empty batch containers back upstream. Typical time: One 3-piece batch in 10 minutes.

2. The second event, adding **Continuous Flow PUSH**, shows the effects of overproduction which simply means producing more sooner or faster than the next stage requires. Notice that although all of the team members are more quickly put to work, inventory piles up between stages. Notice work is uneven. Typical time: Three 1-piece kits in 6 minutes, or 40% improvement.

3. The third event, **Continuous Flow PULL**, adds a kanban pull signal to coordinate each team member and to control inventory better, and shows where some obvious balance opportunities exist. Not a bad beginning, but there is still room for continuous improvement. Typical time: Three 1-piece kits in 5 minutes at a 50% improvement.

4. The fourth event, **Lean Flow**, adds local control with point-of-use inventory and built in quality, and shows the advantage of becoming lean. Notice the elimination of NVA activities associated with de-kiting and returning empty containers. Typical time: three cars in under 3 minutes, for a total improvement of 66% over the Batch 'n Queue!

Facilitator note: experiment with batch size in each of the four flow models and run the event for 10 minutes. Try a 5-pc, a 3-pc and a 1-pc and take note of how batch size influences in-line inventory levels, quality defects, delay times between operators, and delivery rates to the customer for each flow type.

Participation Events

Each event can be used to focus on one or more of the elements of lean thinking, and each event can be re-run several times with focus on a new element as your teaching program develops. For example, the element of “learning to see the waste” can be integrated into participation event #1 (or any event) by adding one or more observers whose task will be to sample each active participants’ activity several times throughout the event and record if the person is performing a Value Adding (VA) activity.

To perform the VA test, the observer samples the process activity by watching for several seconds, say 10, at the top of each minute while the process unfolds, and looks to see if anytime during that 10 seconds the person(s) observed added value (need not be adding value continuously during the 10 seconds, but must perform some VA part of the time). Record the total number of people observed during the 10 seconds and the number of those who added value.

When the simulation finally stops, have the observer add together the totals for the number of persons observed and the number of VA for each observation. Calculate the Non Value Adding (NVA) observations (Total - VA). Roughly 25% of the NVA count is considered pure waste, the remaining 75% is considered incidental, or necessary waste.

This 25% opportunity becomes the topic for further discussions and possible redesign of the work flow. Try to implement the changes suggested and repeat the test and compare the results. Repeat until all incidental waste is eliminated (no NVA). This is the basis for continuous improvement.

Participation Events

For variation in the events, instead of limiting production to 4 minutes, run continuously for 10 minutes and watch what happens to work in process (WIP) inventory at each stage, the number of quality rejects, and number of cars completed in finished goods. Or add a customer delivery requirement, such as ship when a complete set of three cars is available, to explore effects of batch size on inventory. You might produce two types of cars, one with black wheels and one with unpainted wheels for mixed-mode flow. Try using some of your own company's constraints, such as a quality practice which requires the inspector to stop inspecting after the first nonconformity is found and lot reject the entire batch. Use a reject card to simulate quality paperwork and control.

Once the fundamental flow from each event is understood, the simulation kit becomes valuable for exploring the various types of kanban signals available. Instead of the min/max kanban square signal used in event #4, try substituting a supermarket inventory for wheel/axle/disk subassemblies with a trip-point reorder kanban signal, such as the kanban flag, to the supplier stage for replenishment. Add a production control planner into the scenario and use an order form to place orders at the final assembly stage in a pull-demand flow. Add a customer requirement to ship in batches of three cars every 4 minutes and run the simulation continuously and watch what happens.

The LeanMan Factory Simulation Kit is also a useful tool for exploring Value Stream Mapping techniques. A sample current state VSM is included for participation event #1 showing the 3-piece batch 'n queue MRP push method. The use of VSM techniques is explored further in the Power Point VSM Continuous Loop Presentation included with the Deluxe *PLUS* version of the LeanMan Factory Simulation Kit. VSM is truly one of the most powerful techniques for implementing lean manufacturing, and an essential tool for learning to see the waste.

Participation Events

One final point. Don't overlook the importance of the little things that impact flow, and use the items included in the kit to simulate those elements.

For instance, in event #1 the supplied plastic bags are used to pick each kit, and then three kit bags are packed into a tote, i.e., one of the large plastic containers in the kit. Don't forget to "zip lock." These items are included to simulate the real life elements of kiting and de-kiting material, moving empty totes and containers around the shop and back to their home, and provides some of the fumbling and frustration material movers have in their jobs. Notice also there are only five bags – so the next 3-piece kit is held waiting for returned materials from the down-stream process. It's these little time consumers that highlight the NVA. As the events become more lean, notice how some of these containers, holding fixtures, and kit bags disappear!

The small metal disks used to simulate disk breaks increase the simulation of real life frustrations. The disks stack together naturally, and cause extra parts to be included along with lots of fumbling as the kit is picked, simulating the natural variation of picking real kits.

Some companies have as much paperwork that travels along with the assemblies as there are components. Try adding a version of your company's work order router along with the car kit, and have the participants "sign-off" each operation step. Explore the time required for the paperwork versus the assembly touch time and discuss the relative value to your enterprise.

Note also the slip-fit of the axle pin into the car body requires a technique to ease insertion and removal. Just as real assemblies have a learning curve associated with them, so does this simulation kit. Because of these features, it is often best to change the participants from one event to the next. This gives everyone a chance to participate hands-on, and keeps the "experience level" a bit more evenly distributed for accurate metrics.

NOTE: axle peg diameters vary slightly, causing uneven insertion and removal pressures. Use the ergonomic grip tool supplied with the pegs to prevent hand and wrist discomfort on tight pegs.

Event #1

Batch Mode – Three piece Batch ‘n Queue PUSH Method

The LeanMan Factory is a final assembly point for Zoom-Zoom Cars. The factory process consists of a three piece batch assembly that begins with a set of components picked by the material warehouse into a series of 3-piece kits. Each kit passes through two assembly stages, the first stage assembles all of the wheel, axle and disk subassembly components together, and then passes the entire batch to the second stage for attachment of four each of the subassemblies to each of the three car bodies. The batch of assembled cars then passes to final inspection and then to the finished goods warehouse. The Value Stream Map #1 for this “current state” is shown on the next slide. Customer demand: 3 cars every 4 minutes (TAKT = 1.33 minutes)

Step 1: STOCK KEEPER: pick a 3 pc KIT, place all parts for one car into a bag and place three bags into a container. Container is moved to step 2. Quality Control: substitute a black wheel into one of the three kits. Repeat the process as fast as you are able, but you will need the bags and tote returned from step 1. **Note: a conveyance person to move materials between operation stages is recommended when exercise space permits.**

Step 2: ASSEMBLER 1: unpack kits and return containers to step 1. Assemble all wheel & break & axle subassemblies, place on holding rack. When all subs are complete, the sub assys and remaining kit parts (car bodies) move as a batch to step 3. Note: build using the painted wheel if supplied.

Step 3: ASSEMBLER 2: unpack subassemblies and return container to step 2. Assemble the 4 wheel subs to each car body. All cars move as a batch to step 4 after the last car is complete. If a reject car is returned, repair it. Ask the stock keeper for any necessary new (unpainted) parts. Move the car(s) to step 4 after repair.

Step 4: QUALITY INSPECTOR – all four wheels must rotate freely, all wheels plain (not painted). If any cars are reject, identify the reject car and move it back to step 3 for repair. Once all cars pass inspection, move the batch to Finished Goods. Variation – lot reject entire batch to step 3 upon 1st reject condition (without further inspection of remaining cars in the batch). Keep track of the number of rejects.

Timekeeper: record the start and stop time; the time the 1st batch of 3 reaches finished goods (also the time for the first delivery of 3). Run the simulation for 4 minutes. It is permissible to run up to an additional 4 minutes of overtime if needed to deliver the first batch to the customer. Observe the impact to flow time for the quality defect (painted wheel).

Metrics: Complete the metrics chart.

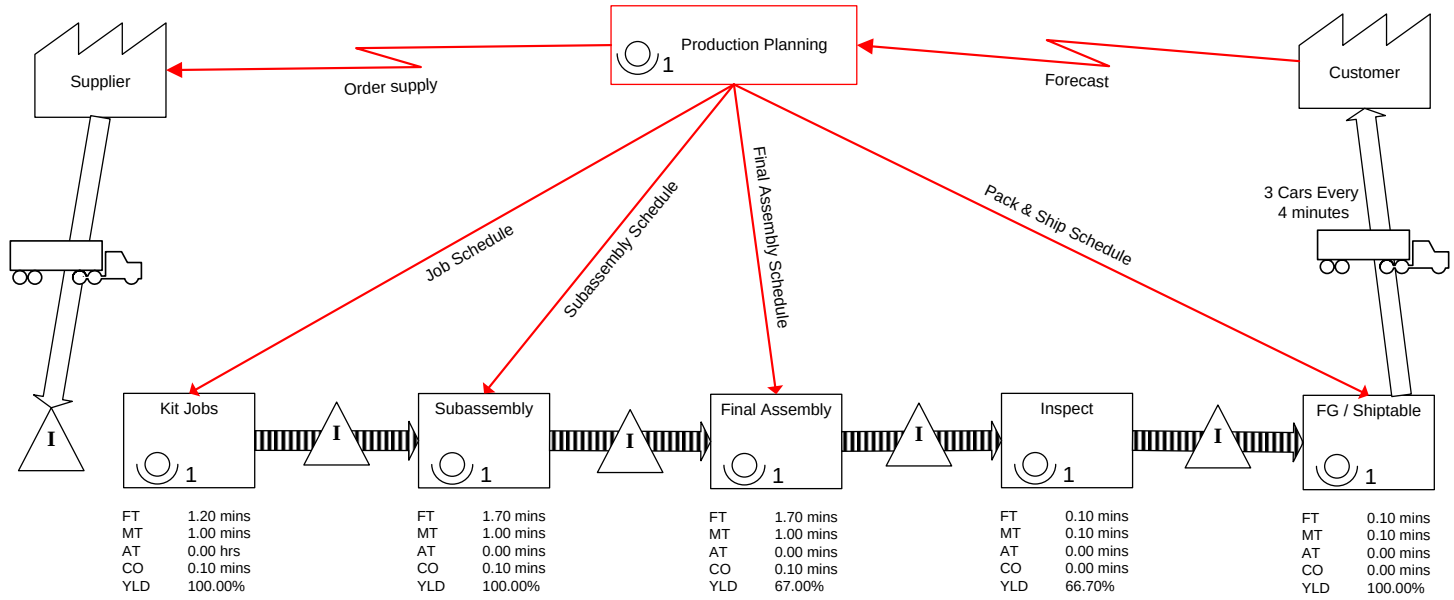
The LeanMan

Current State
3-pc batch 'n queue
Simulation exercise

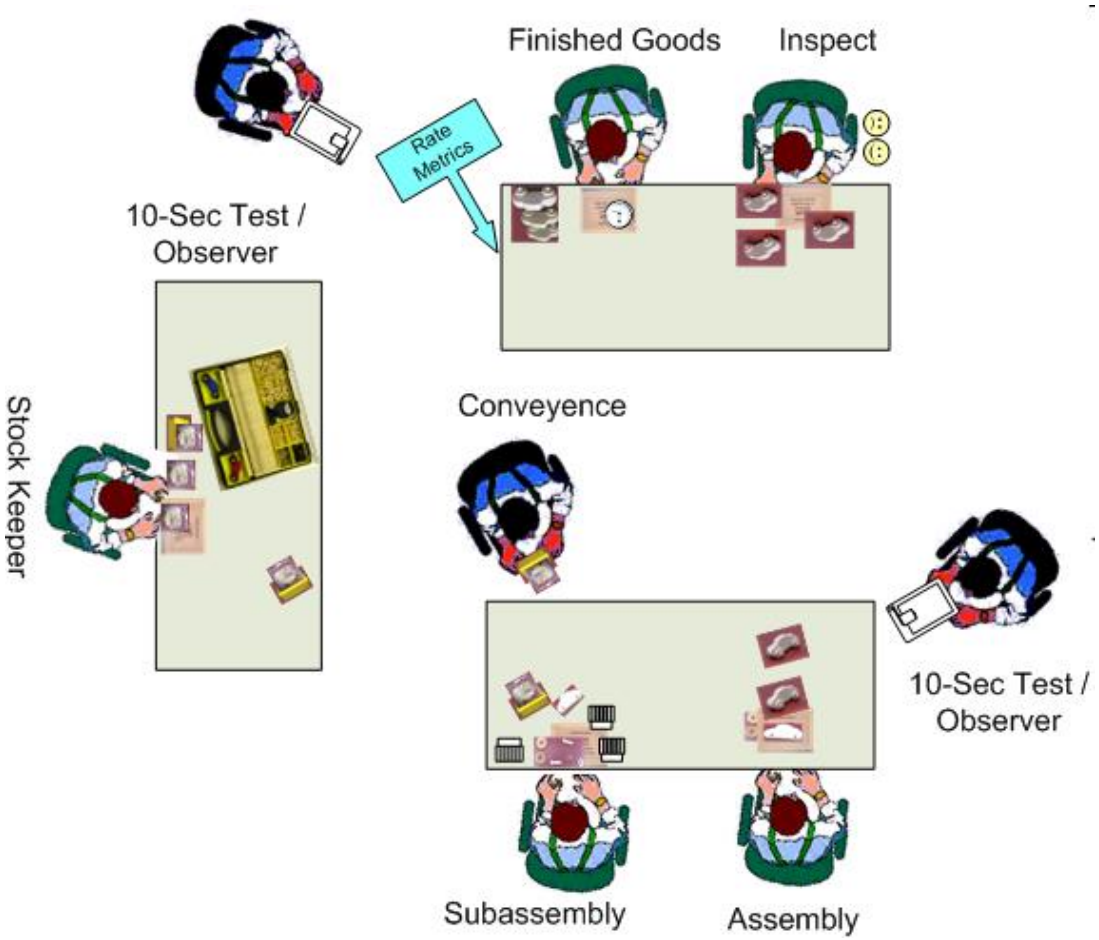
Value Stream Map #1

Business Case	Value Statement	Key Requirements	Measurements	Ideal State
• Losing Business to competitors due to long lead times and late deliveries.	• Improve lead time performance by synchronizing production with customer demand.	• 1) Reduce flow time to meet customer demand. • 2) Reduce RAW, WIP and FGI levels.	• 1) Total flow time • 2) Inventory levels • 3) ROKA and EBIT performance.	• On-Demand • Defect Free • 1-By-1 • Lowest Cost

Customer	LeanSim Factory
Product	Zoom Zoom Cars
Demand	3/4.00mins
TAKT	1.33 mins



Event #1 Setup



Lean Factory Simulation – Exercise #1 3-PC Batch 'n Queue PUSH

Event #2

Cellular Flow Mode – 1 pc flow push method (3 pc order)

The Zoom-Zoom car factory wants to use a work cell with a 1-pc flow process. Move the participants into a work cell arrangement and change the batch size to pick a series of 1-piece kits of components. The kit passes through two assembly stages, the first stage assembles all of the wheel, axle and disk subassembly components together, and then passes to the second stage for attachment of four each of the subassemblies to the car body. The assembled car then passes to final inspection and then to the finished goods warehouse. The Value Stream Map #2 for this "future state" is shown on the next slide. Customer demand: 3 cars every 4 minutes (TAKT = 1.33 minutes)

Step 1: STOCK KEEPER: pick a 1 pc KIT of complete car parts into a bag and move bag to step 2 as soon as it is complete. Repeat for all 3 car kits. Quality Control: insert a black wheel into the 3rd kit.

Step 2: ASSEMBLER 1: unpack the kit and return the package to step 1. Assy 4 wheel & break & axle subs, place on holding rack and move the rack along with the remaining kit part (car body) to step 3. Repeat for each KIT presented, moving the material as soon as it is assembled.

Step 3: ASSEMBLER 2: Assy 4 wheel subs to the car body and move the car to step 4. Return the holding rack to step 2. Repeat for each car kit presented, moving the car as soon as it is assembled.

Step 4: QUALITY INSPECTOR – all four wheels must rotate freely, all wheels plain (not painted). If any cars are reject, identify the reject car and move it back to step 3 for repair. Once a car passes inspection, move it to Finished Goods. Repeat until all cars are in Finished Goods. Keep track of the number of rejects.

Timekeeper/Shipper: record the start and stop time; the time the 1st car reaches finished goods; and the time for the first delivery of 3 to the customer. When finished goods level reaches 3 cars, "ship" them to the customer. Note: you must wait until there are 3 cars in finished goods before you can make the delivery. Observe the impact to flow time for the quality defect (painted wheel). Run the simulation for 4 minutes. It is permissible to run up to an additional 4 minutes of overtime if needed to deliver the first batch to the customer.

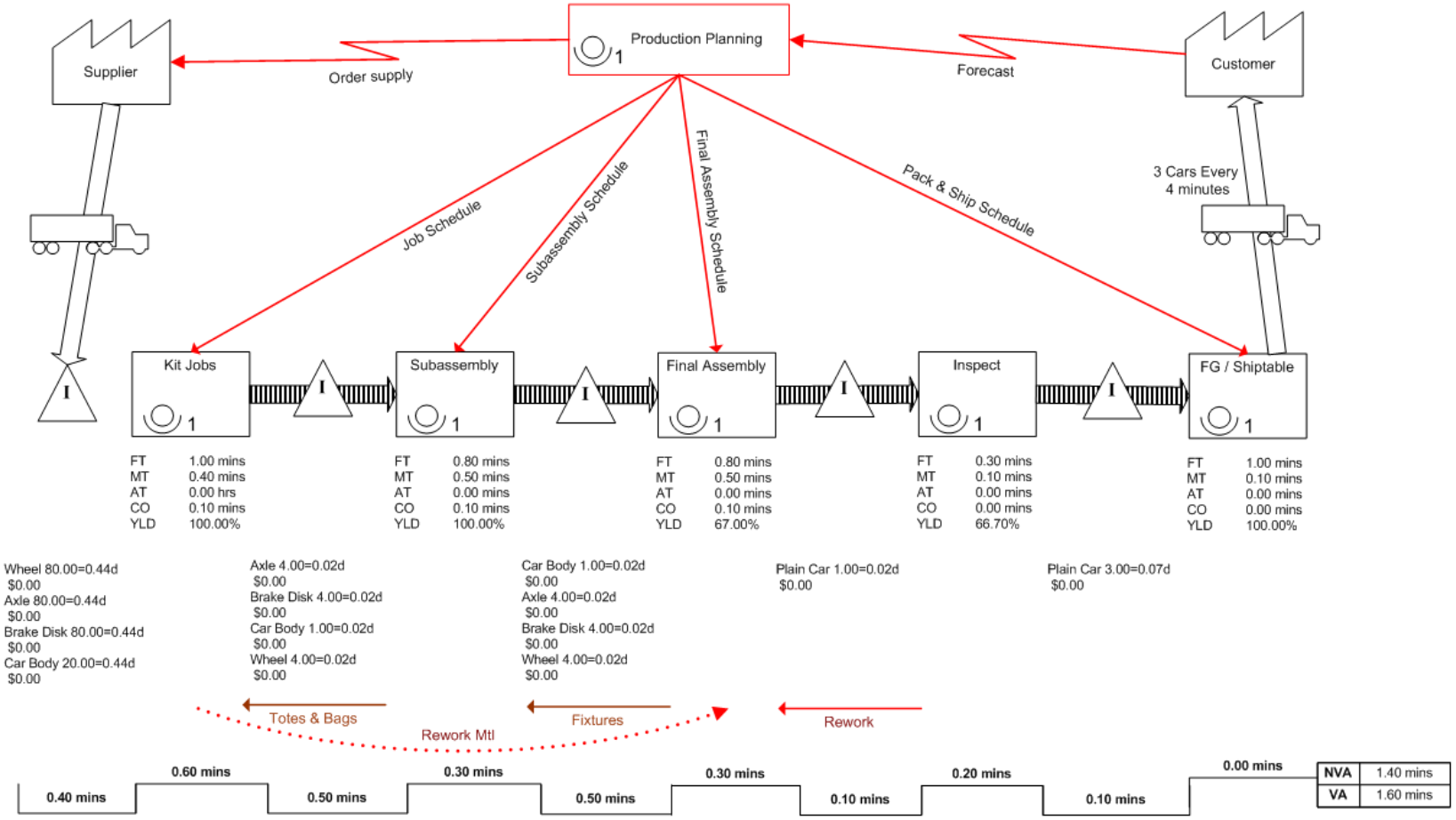
Metrics: Complete the Financial Metrics chart to compute earned value.

The LeanMan

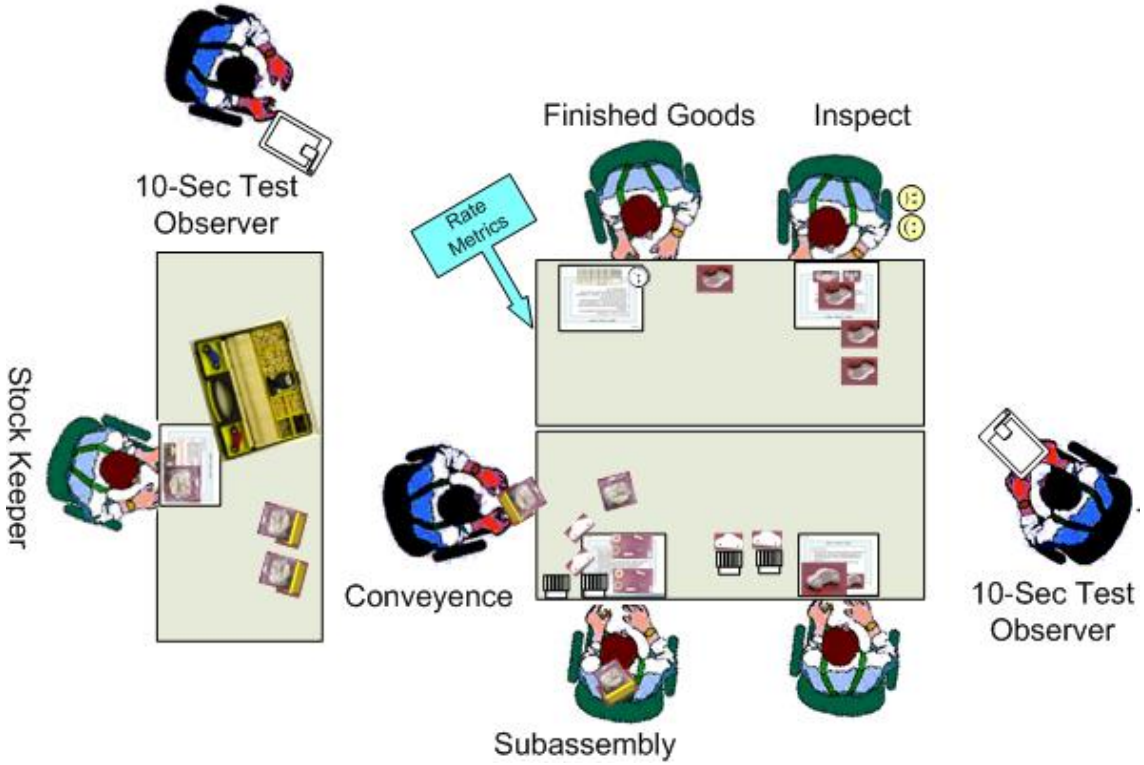
Future State
1-pc Cellular Flow PUSH
Simulation exercise

Value Stream Map - #2

Customer	LeanSim Factory
Product	Zoom Zoom Cars
Demand	3/4.00mins
TAKT	1.33 mins



Event #2



Lean Factory Simulation – Exercise #2 Cellular Flow 1-pc PUSH

Event #3

Continuous Flow Mode – 1 pc flow Pull method with *kanban* signal

The Zoom-Zoom car factory wants to use a work cell with a 1-pc flow process, and add a pull mechanism to draw the cars into finished goods. The participants keep the same work cell arrangement and 1-pc picked kits from event #2, but this time add a kanban square signal between each process step to regulate flow.

Prepare the shop by placing a kanban square between each of the 4 steps, with the 4th square being Finished Goods. This general rule applies for each of the 4 steps: If the output (down-line) kanban square is empty, then perform your process operation and move the product into the output square. If the square is occupied, you must wait until it is empty to move another into that square.

Hint: you may perform your own process step on just one more product and hold it in place until your output square becomes empty allowing you to move it along. No more than one product may be held in place at any one time. (where "product" is the result of your process i.e. picked kit, subassembly, assembly, inspected car etc)

You may pull product from your input kanban square only if you are ready to work on it. Do not create a stockpile of untouched inventory in your work area. The Value Stream Map #3 for this "future state" is shown on the next slide. Customer demand: 3 cars every 4 minutes (TAKT = 1.33 minutes)

Step 1: STOCK KEEPER: pick a complete 1 pc KIT of car parts into a bag and move it to step 2 ONLY if the kanban square is empty. You may pick another kit and hold it until you are able to move it to the square, repeating the operation as long as the down-line square remains empty. Quality Control: insert a black wheel into every 3rd kit.

Step 2: ASSEMBLER 1: unpack the kit and return the container to step 1. Assemble 4 wheel & break & axle subs, placing them onto the fixture rack and move the rack along with the car body to step 3 as soon as your output square is empty. Repeat for each KIT presented into your input square, and make sure only one set of material occupies your output square at any one time.

Continued on next page...

Event #3

Continuous Flow mode – 1 pc flow Pull method with *kanban* signal

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Step 3: ASSEMBLER 2: Assemble the 4 wheel subs to the car body and move the car to step 4 as soon as your output square is empty. Return the holding rack to step 2. Repeat for each set of material presented, making sure only one car occupies the output square at any one time (except for rejected cars returned for rework). All reject cars returned to your output square are given priority for rework before any new car kit is to be pulled from the input-square, and the reworked car is moved into the down-line square when it next becomes empty. If rework requires it, order a new part from the stock keeper.

Step 4: QUALITY INSPECTOR – all four wheels must rotate freely, all wheels plain (not painted). If any cars are reject, identify the reject car and move it back to step 3 for repair. Once a car passes inspection, move it to the Finished Goods square. Keep track of the number of rejects.

Timekeeper/Shipper: record the start and stop time; the time the 1st car reaches finished goods; and the time for the first delivery of 3 to the customer. When finished goods level reaches 3 cars, “ship” them to the customer. Note: you must wait until there are 3 cars in finished goods before you can make the delivery. Observe the impact to flow time for the quality defect (painted wheel). Run the simulation for 4 minutes. It is permissible to run up to an additional 4 minutes of overtime if needed to deliver the first batch to the customer.

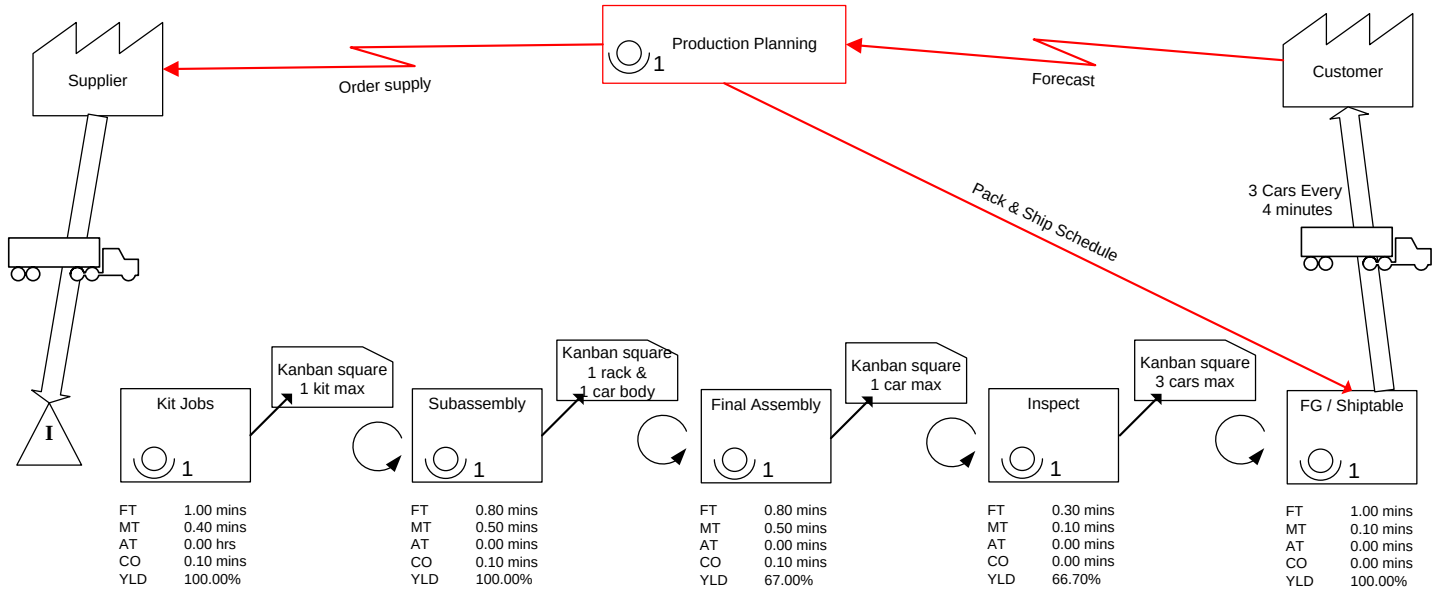
Metrics: Complete the Financial Metrics chart to compute earned value.

The LeanMan

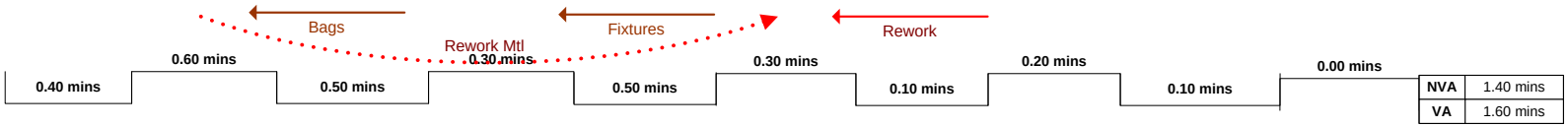
Future State
1-pc Cellular Flow PULL
Simulation exercise

Value Stream Map - #3

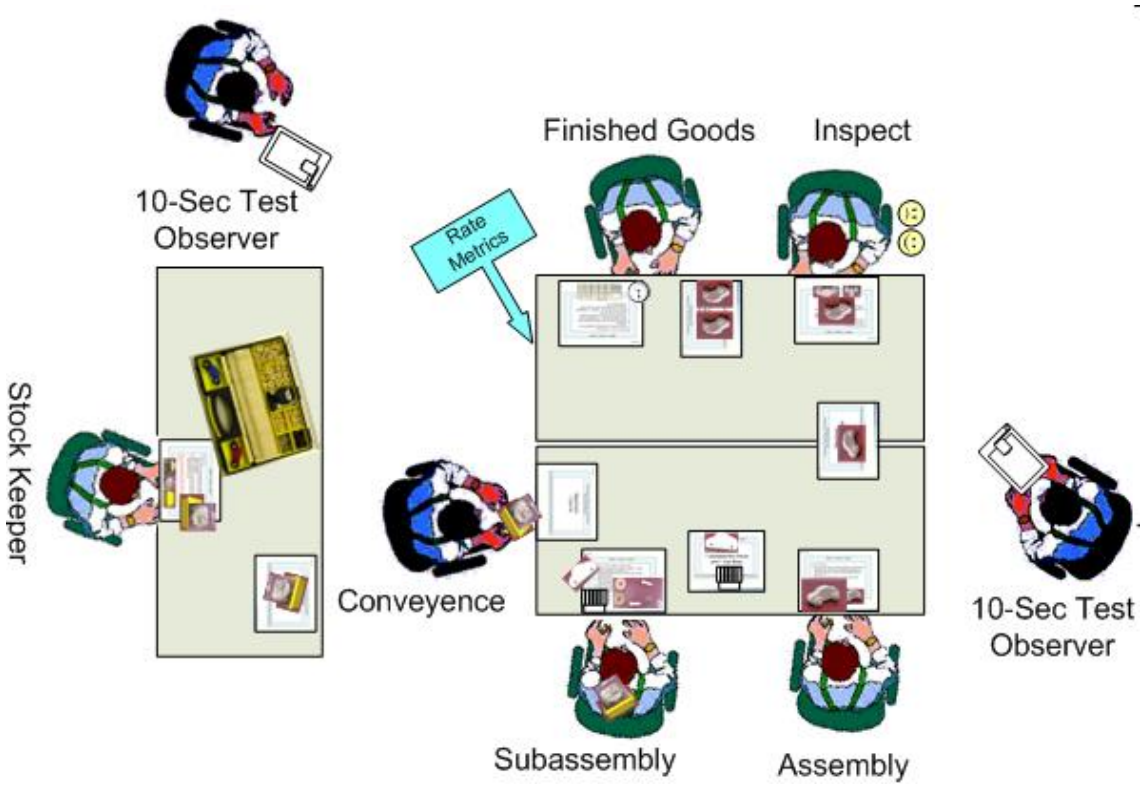
Customer	LeanSim Factory
Product	Zoom Zoom Cars
Demand	3/4.00mins
TAKT	1.33 mins



Wheel 80.00=0.44d
$0.00
Axle 80.00=0.44d
$0.00
Brake Disk 80.00=0.44d
$0.00
Car Body 20.00=0.44d
$0.00



Event #3



Lean Factory Simulation – Exercise #3 Cellular Flow – 1-PC PULL

Event #4

Lean Mode – 1 pc Lean Flow (Point Of Use material, Certified Inspector)

The Zoom-Zoom car factory wants to use a lean work cell with 1-pc flow process, customer pull-demand, and two lean concepts of point of use (POU) inventory and certified assemblers who can perform inspection as well as build the product. The participants rearrange the work cell to move assembly step 1 next to assembly step 2 with a kanban square between them, and we will add POU material at each assembly process step. In this exercise, the STOCK KEEPER & QUALITY INSPECTOR positions not needed.

Mix the black painted wheels into the container with plain wheels and place the containers of wheels, axles, and breaks into a point of use area next to step 1. Place the container of car bodies in a POU area next to step 2. Train (certify) the Assembler 1 and 2 participants to inspect for and reject any black painted wheels during the picking process, and to repair non-rotating wheels before passing any assembled car to the next step.

Step 1: CERTIFIED ASSEMBLER 1: Pick your material as needed from the POU containers. Look at the item as it is picked and reject any defect (black wheel). Assemble a wheel & break & axle subassembly and place it into your output kanban square only if it contains less than 4 subassemblies. Repeat, trying to maintain 4 of the subs in the kanban square as assembly step 2 is withdrawing them for use.

Step 2: CERTIFIED ASSEMBLER 2: Look at the subassembly material as it is pulled from your input kanban square and reject any defect (black wheel) to assembler 1. Pull and assemble 4 of the wheel subs onto a car body. Perform final inspection - the four wheels must rotate freely and all wheels plain (not painted). Adjust as required. Once a car passes inspection, move it to the Finished Goods kanban only if it holds less than 3 cars.

Timekeeper/Shipper: record the start and stop time; the time the 1st car reaches finished goods; and the time for the first delivery of 3 to the customer. When finished goods level reaches 3 cars, “ship” them to the customer. Note: you must wait until there are 3 cars in finished goods before you can make the delivery. Observe the impact to flow time for the quality defect (painted wheel), if any. Run the simulation for 4 minutes. It is permissible to run up to an additional 4 minutes of overtime if needed to deliver the first batch to the customer.

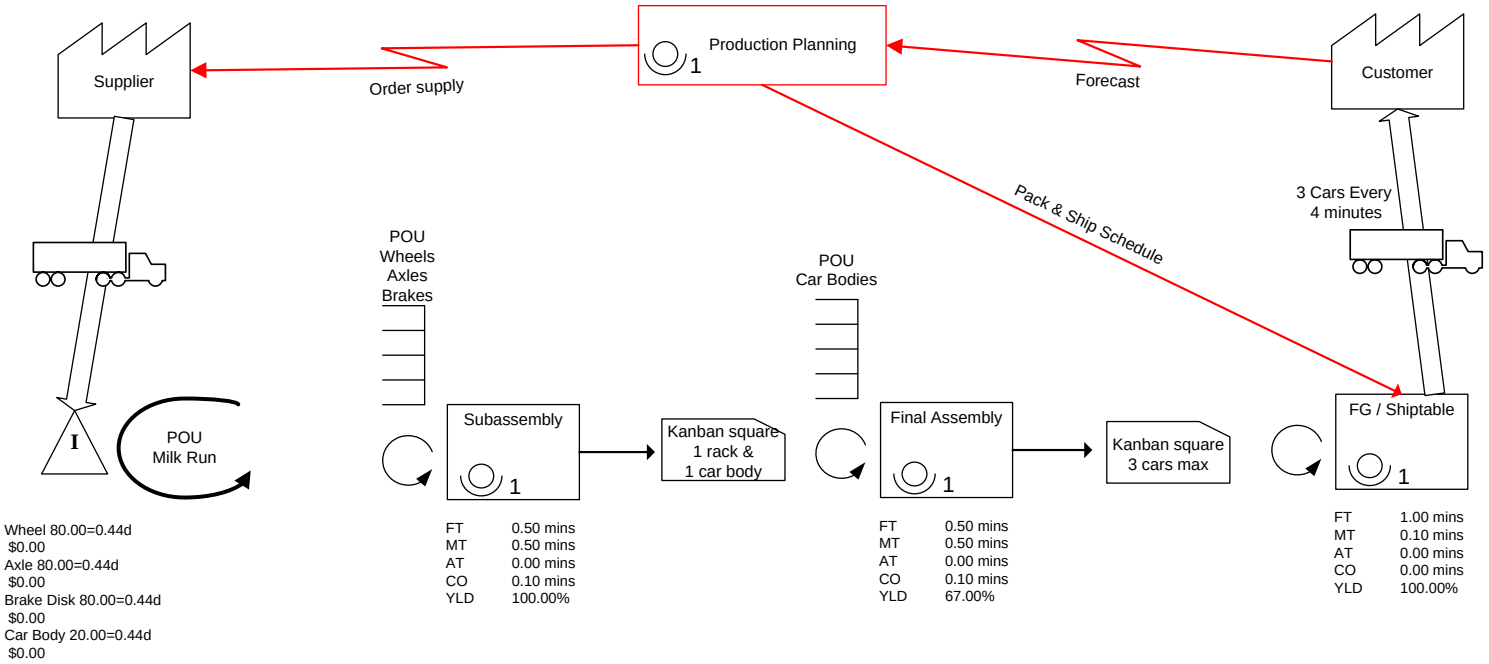
Metrics: Complete the Financial Metrics chart to compute earned value

The LeanMan

Future State
1-pc Lean Flow
Customer Pull
Simulation exercise

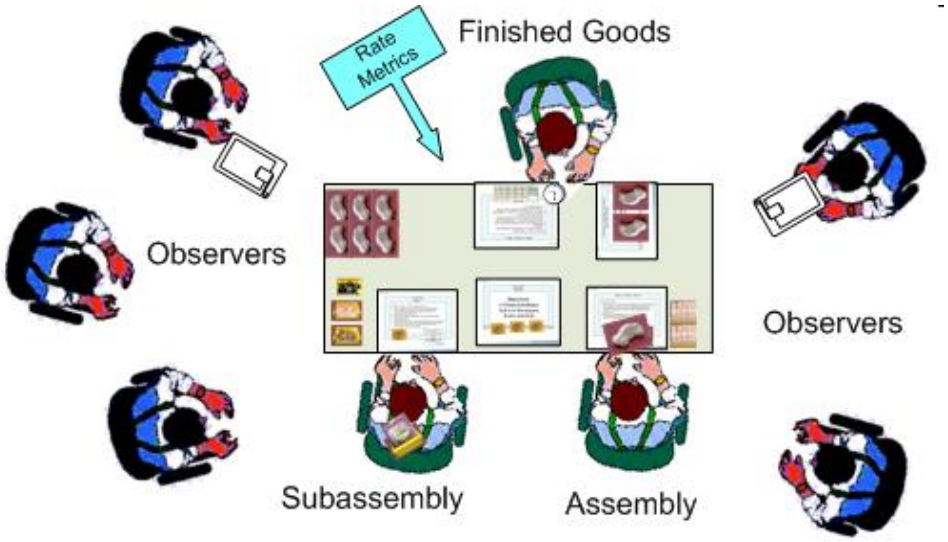
Value Stream Map - #4

Customer	LeanSim Factory
Product	Zoom Zoom Cars
Demand	3/4.00mins
TAKT	1.33 mins



The LeanMan

Event #4



Lean Factory Simulation – Exercise #4 Lean Flow – 1-PC PULL

Financial Chart LeanMan Car Factory	Event #1 Batch 'n Queue		Event #2 Cellular Flow - PUSH		Event #3 Cellular Flow - PULL		Event #4 Lean Flow	
		$	#	$	#	$	#	$
# Cars delivered x $500 ea = **Total Sales =**								
Cost of Goods Sold								
Sales Material = # cars sold x $100 ea								
Labor = # workers x $165 ea								
Labor OT = # minutes OT x $40 ea worker								
Overhead = # Chairs used x $10 ea								
Scrap = # nonconforming cars x $100 each								
Total of COGS =								
Capital Charges								
Work in Process								
Stockroom = # undelivered kit bags picked x $100 ea								
Wheel/Axle/Brake Subassy = # Subassembly Items built x $10 ea								
Car Assy = # Undelivered cars built x $60 ea								
Inspection = # Cars in inspection x $100 ea								
Ship = # Cars in Finished Goods x $100 ea								
Facilities								
# Tables used x $15 ea								
# Fixtures used x $10 ea								
Total Capital Charge =								
Sales – COGS – Capital Charges =**EVA =**								
Production Velocity (4 minute run plus OT)								
Number of Minutes Worked plus OT								
Number of Cars Produced (sold + FG Inv)								
Production Rate =								

Note: Workers are Stockkeeper, Subassembler, Assembler, Inspector, Shipper, Conveyence

Financial Chart is available as an Excel File on the CD

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