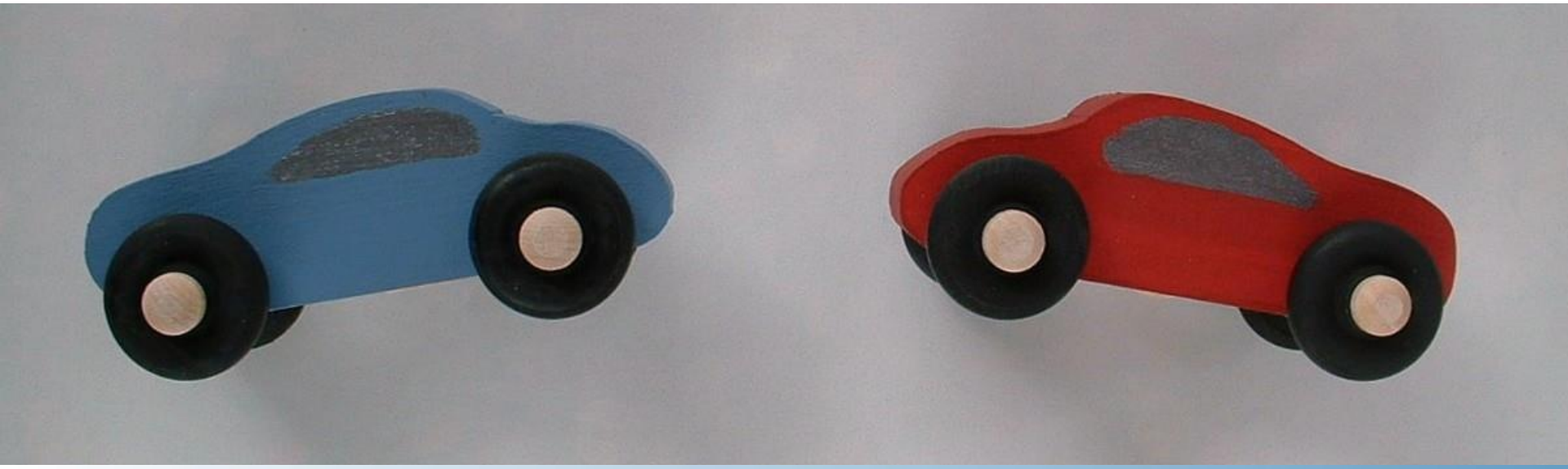
The LeanMan

Lean Factory Simulation Kits

Lean Car Factory Simulation

Facilitator Guide

Simulation Exercise for Large Groups



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Lean Factory Simulation Kits

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WARNING – KIT CONTAINS SMALL PARTS.

KEEP AWAY FROM YOUNG CHILDREN

CAUTION: 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 reconditioned to remove the excess moisture by following the process provided on the Car Kit CD.

Facilitator Instructions:

The large group exercises should be held in a training room with sufficient space to hold the tables and chairs for the hands-on participants. Additional participants may form an observation team, and stand near and around the tables behind the seated operators. Their job is to make observations about the process, the material flow, the occurrence of value-adding and non value-adding activities, and in general work with the facilitator to gather information to be used after the simulation for further discussion of key points.

Each of the exercise events is intended to be run in sequence, and the facilitator's notes key off each other in that sequence. The transition from Taylor's division of labor principles as demonstrated in the Batch 'n Queue event, the Work Cell concepts explored in the 1-pc Push followed by the Continuous Flow 1-pc Pull, and the final Lean Flow event are a representation of how the implementation of Lean principles tends to follow these same steps as company's take small incremental improvement in their design of operations.

The greatest lesson to be learned from these simulation events is that not all change is lean, and that without keeping an eye on the whole value stream, you may end up with isolated islands of perfection (work cells) linked by systems that are optimized for their own self interest (purchasing, receiving, stockroom, inspection, etc.) without concern for your "island's" needs. Understanding the value stream is essential to prevent such unwanted and wasteful results.

The facilitator's talking points are things to look for, and point out as they happen during the simulation exercise. The facilitator should move about the class room and talk about each process type as it is being simulated, and again after each simulation. The talking points are not all inclusive, but are a start. Adlib your own comments about what is happening, and try to inject humor.

The observers should be taking notes for later discussion. After each event the team should discuss the observed notes and the participant's learned reactions.

The placemats for each hands-on participant and the kanban squares should be printed and located at the participant tables. They will greatly aide the timing of the exercise and provide a level of comfort for hesitant participants. Do not run the exercise without them. Feel free to edit them with your company's own logo. And of course, you should customize the exercises to include any of your company's process methods you wish to emphasize.

The Deluxe Kit comes with the Lean Principles Training Guide: Learning to See the Waste. On it you will find forms and instruction for the 10-Second Test and the 15-Minute Observation. They provide an excellent method for teaching your employees to develop lean eyes, and work well with the simulation exercises.

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Large Group Simulation (up to 39 participants)

Material Requirements:1 kit = 13, 2 kits = 26, 3 kits = 39

3 Car Factory Kits (combination of 1 Deluxe and 2 Companion Kits, or 1 Deluxe *Plus* VSM Package and 1 Companion Kit)

The 3 kits will provide 60 sets each of plain car bodies, plain wheels, axle pegs and disk brakes. The 3 kits also contain 6 painted car bodies and 48 black wheels. Materials from each kit are divided equally between the teams.

You will need 2 or 3 of the large plastic containers to be used for material move totes for each stock keeper, 2 or 3 plastic zip-loc bags to pick kits of material for each stock keeper, and 2 or 3 wheel-axle subassembly holding fixtures for each sub-assembly participant.

Detail Department. This additional process point can be added to the simulation event by purchasing small round stick-on dots from an office supply store such as Office Max or Staples. Use yellow for headlights and red for tail lights.

The Deluxe *Plus* VSM Package provides these additional materials for flow control. Add them into the flow simulations as desired.

- 6 Kanban Signal Flags
- 16 Job Ticket Order Cards
- 16 Heijunka Cards
- 16 Material Requisition Cards
- 16 Nonconforming Material Cards

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
- 5 plastic kit bags
  - large plastic containers
  - small plastic containers
- 5 fixture racks (wheel/axle subassy)
- 1 Stopwatch
- 1 organizer with polycarbonate cover

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Kit Features:

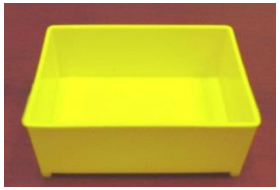
The KIT: The stock keeper will pick each KIT, placing all parts for one car into a bag, and place the bags into a container for the batch size of the simulation. To simulate real shop conditions, each bag of parts should be as uniform as possible, i.e., zip-locking each bag will require a consistent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

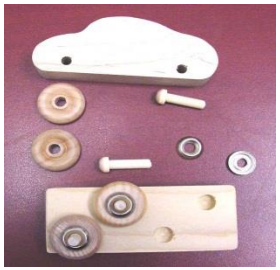
The TOTE Batch Container: the role of the batch container in the exercise is to simulate more of the non value-adding steps performed in the shop, such as circulating containers back upstream. The stock keeper eventually has to wait for the containers and bags to return before delivering more kits.

The FIXTURE: the role of the fixture used to hold the subassembly of the wheel & brake & 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.

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 brake, 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 braking 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.





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.

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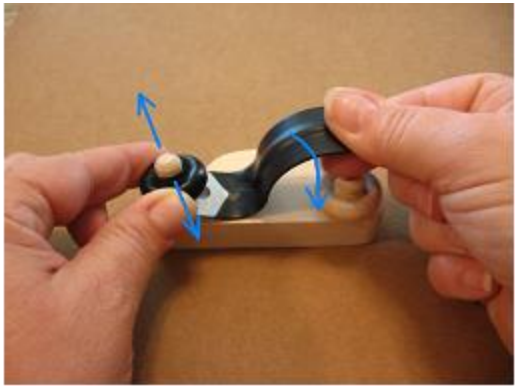
A word about safety and ergonomics:

- 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 reconditioned to remove the excess moisture by following the process **Instructions for microwave drying wooden pegs.doc** provided on the CD.
- 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.

- When inserting the wheel / peg assembly onto the car body, use a slight clockwise twist of the peg to ease insertion. Use the ergonomic tool provided to grip the peg and prevent finger soreness over the duration of the simulation event.

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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). This event is designed for large groups up to 39 participants sharing up to 3 Car Factory Kits of material. Sharing places limits on batch size and the length of time the exercise can run. For small groups, use the standard simulation exercises provided with the kit.

1. The first event, MRP **Batch 'n Queue**, shows the effects of moving large batches of product through several stages as quickly as possible. 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. Time allowed for the simulation is 8 minutes. Overtime of 2 minutes is allowed if no batch has reached Finished Goods in the 8 minute period.

2. The second event, adding **Cellular 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 in the Work Cell, but inventory still piles up between stages. Notice work is uneven. Time allowed for the simulation is 8 minutes. Overtime of 2 minutes is allowed if no batch has reached Finished Goods in the 8 minute period.

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. Time allowed for the simulation is 8 minutes. Overtime of 2 minutes is allowed if no car has reached Finished Goods in the 8 minute period.

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. Time allowed for the simulation is 8 minutes. Overtime of 2 minutes is allowed if no car has reached Finished Goods in the 8 minute period.

   Complete the Financial Calculation metric sheet (also available as excel file on CD). Compare the bottom line improvement with each change in flow method.

Facilitator note: experiment with batch size in each of the four flow models and run the event for 8 minutes. Try a 3-pc Job in each event and take note of how batch size influences in-line inventory levels, quality defects, delay times between operators, and delivery rates to the customer.

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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. Use the laminated 10-Second Test form, or the excel file on the CD.

To perform the VA 10-Second Test, the observer samples the process activity by watching for 10 seconds at two minute intervals 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.

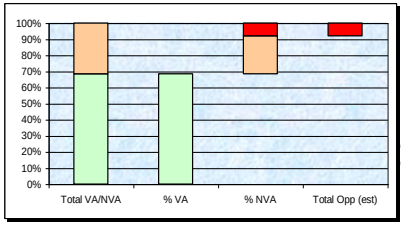
This 25% opportunity becomes the topic for further discussions and possible redesign of the work flow. Try to implement the changes suggested and repeat the test and compare the results. Repeat until all incidental waste is eliminated (no NVA). This is the basis for continuous improvement.

The LeanMan, LLC — **10 Second Test** — The LeanMan Production System

Area

Test #	# Observed		VA (qty)		NVA (qty)		Running % NVA
	Input No. of Persons Observed		Input No. of Persons Doing VA Work				
1	4		4		0		0%
2	3		2		1		33%
3	4		4		0		0%
4	3		3		0		0%
5	4		3		1		25%
6	2		0		2		100%
7	4		2		2		50%
8	4		1		3		75%
9	4		3		1		25%
10	3		2		1		33%
Totals	**35**		**24**		**11**		**31%**

Total Observed	35
Total Observed VA	24
Total Observed NVA	11
% Activity NVA	31%
Est Opportunity (%)	**8%**
(Shown in Red)	



Lean Thinking - developing an "eye for waste"

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Participation Events

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 the batch number of 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 batch job 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 with small parts. Encourage participants to experiment with ways of improving their task. For example, by dropping a few disks on the table most will flip with the round side down and separate, thus they become easy for the fingers to grasp and pick up.

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 rotate seats or 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.

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Car Factory Simulation Exercises

Large Group Simulation Parameters: This simulation is designed to operate with variable sized groups of participants using up to 3 Car Factory Kits of material, and can be adjusted as needed to accommodate from 5 people to 39 people. Simulation is limited to 10 sets of car material when a single kit is shared between two teams. Adding a disassembly person as the Customer can alleviate some of this limitation as materials can be put back into the stockroom from the delivered cars. This may be recommended for the Demand-Pull simulation events # 3 and # 4 where material moves at a higher production velocity. This same person might help perform as a second Stockkeeper in events #1 and #2. The person would not be counted as part of the simulation metrics when doing disassembly.

The 5 main process points are Stockroom, Subassembly, Final Assembly, Inspection, and Finished Goods. Conveyance is an option if there is space in the training room to place the process points at some distance from each other. This distance spacing is highly recommended because it more accurately simulates a real production shop. The Detail Department is optional, increasing the minimum participant count to 6 people per team if used. Each kit of material can support two teams operating in parallel (up to 13 participants) as shown, and the three kits together can support up to 39 participants when six teams are operating in parallel with a full complement of participants.

Basic process points in the simulation exercise with two parallel teams and one Car Factory Kit

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Lean Factory Simulation Kits

Lean Principles

Facilitator Instructions

Lean Car Factory Simulation

Event #1 Batch ‘n Queue

Large Group Version

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Event #1

Batch Mode – Two piece Batch ‘n Queue PUSH Method

The LeanMan Factory is a final assembly point for Zoom-Zoom Cars. See setup for event #1 for suggested table arrangement and participant seating.

Department #1 The factory process begins with sets of components picked by a Stockkeeper into a series of 1-pc kit bags, each packed into a yellow tote container to make up the batch job. The batch job moves to department #1’s output shelf and the Stockkeeper calls out “Conveyance.” Repeat the process as fast as you are able, but you may be delayed waiting for bags and totes returned from Dept 2. Batch size is 2. Recommendation: Experiment with different batch sizes to observe the effect on flow.

Conveyance hears the call, picks up the batch job and delivers it into the input of sub-assembly department #2. Any empty totes or bags are returned back to the stockroom department #1.

Department #2 The batch job passes through Sub Assembly where the wheel, axle and disk components are assembled together, 4-each mounted onto a holding fixture. Empty Totes and Bags are quickly placed on the output shelf and “Conveyance” called out. The completed batch job of “fixtures and a tote of car bodies” is moved to the output shelf and “conveyance” is called out.

A Conveyance person hears the call and delivers the batch job to the input of department #3. Any empty fixtures or totes are also picked up and returned back upstream (totes to department #1 and fixtures to department #2).

Department #3 The job order passes through Final Assembly where the subassembly components are removed from the fixture and attached to the car body. *Be sure to use the ergonomic tool.* If a reject car is returned from inspection, repair it. Ask the Stockkeeper for any necessary parts and call “conveyance” to deliver them. Empty totes and fixtures are placed on the output shelf where conveyance will pick them up and return them to Department #2. The completed batch job is moved to department #4’s output shelf and “conveyance” is called out.

Department #4 Each assembled car passes to the Detail stage, if this position is used, where headlights and tail lights are applied (or verified if a rework occurred). (Small yellow or red stick-on dots available from Office Max or Office Depot.) The batch job is moved to the output shelf and “conveyance” is called out.

Department #5 The batch job moves to Final Inspection where the wheel rotation and wheel color match is verified. Rejected cars are placed in the reject shelf and conveyance is called to return them to department #3 for rework. If all are acceptable, the batch job is moved to department #5’s output shelf and “conveyance” is called out. All cars move as a batch job. Do not split off good cars from the rework cars.

Department #6 The batch job moves to the finished goods warehouse where cars are grouped into customer order quantities and delivered according to the delivery schedule. Customer demand is 3 cars every 4 minutes (TAKT = 1.33 minutes). Do not deliver early, deliver only complete sets of 3, and record the time off the stopwatch when actually shipped.

Timekeeper: record the event start and stop time; the time the 1st job reaches finished goods, and the time for the first delivery of 3 to the customer. Run the simulation for 8 minutes. It is permissible to run up to an additional 2 minutes of overtime if needed to deliver the first batch to the customer. Call out “we are on over time” if this occurs. Complete the Financial Metrics chart with the help of the team.

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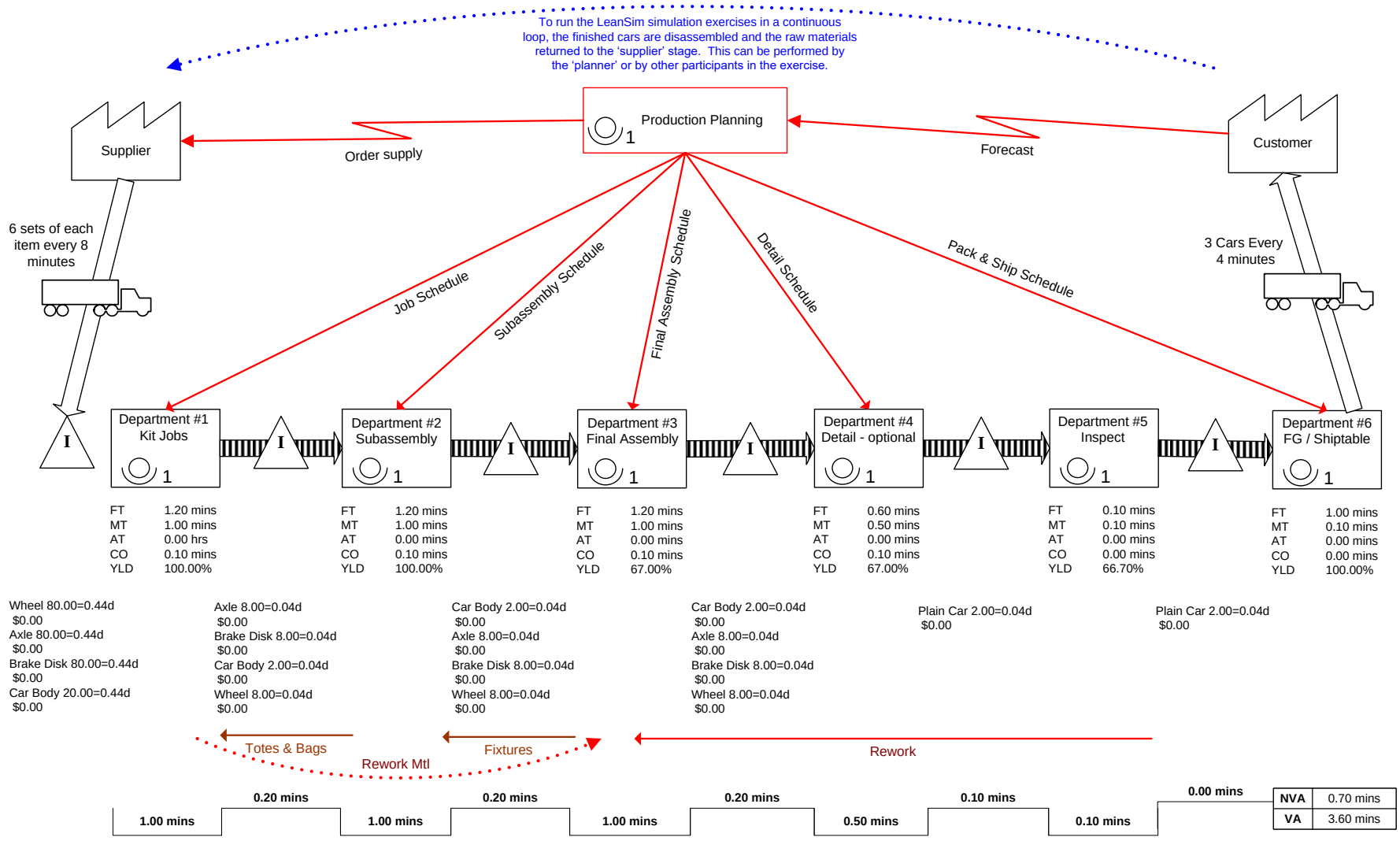
Value Stream Map – Event #1

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

Current State
2-pc batch 'n queue
Simulation exercise

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



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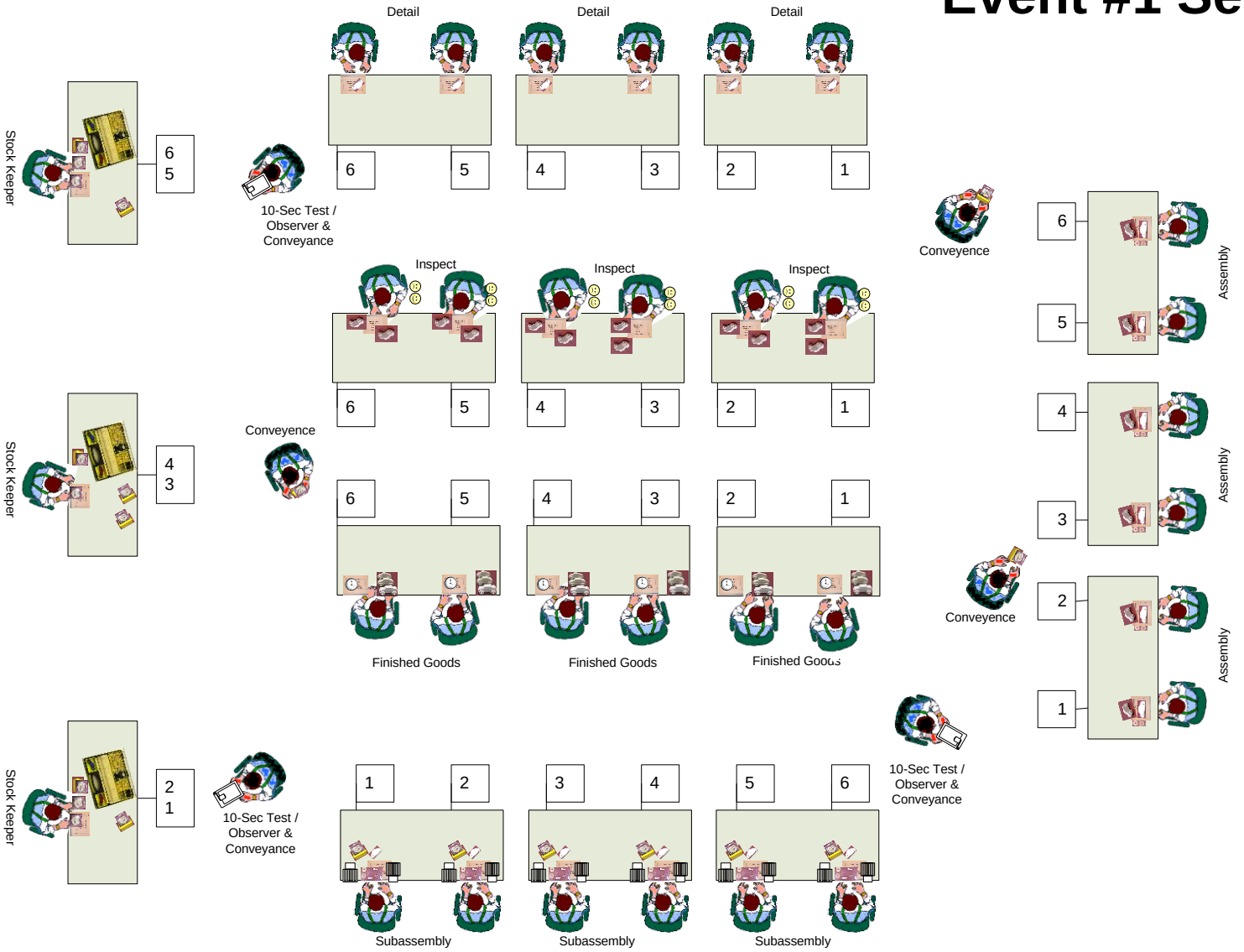
Event #1 Setup



Factory Simulation – Exercise #1 2-PC Batch 'n Queue PUSH

Six teams organized traditionally by functional department

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Event #1 Metrics

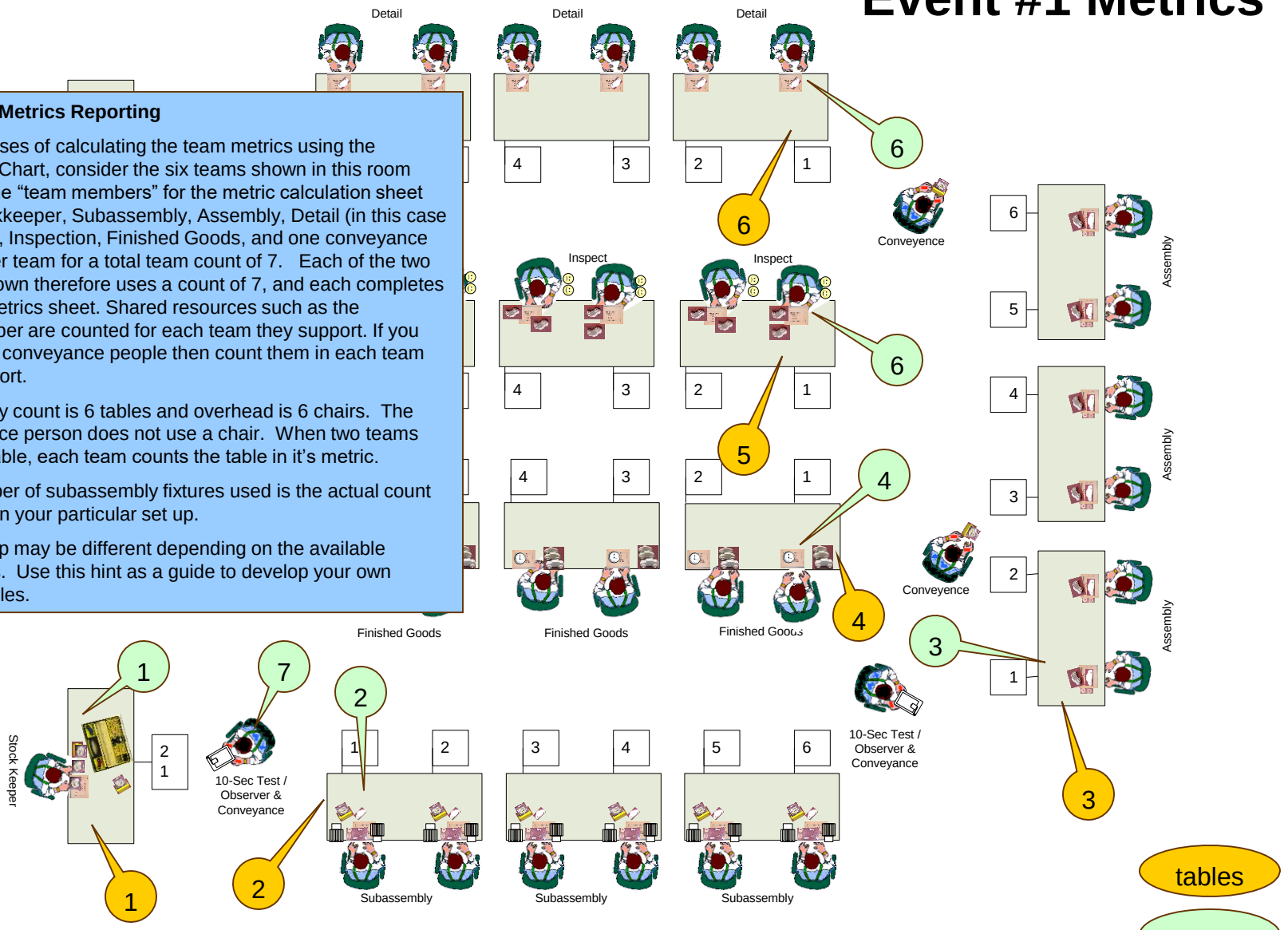
Hints on Metrics Reporting

For purposes of calculating the team metrics using the Financial Chart, consider the six teams shown in this room setup. The "team members" for the metric calculation sheet are: Stockkeeper, Subassembly, Assembly, Detail (in this case it is used), Inspection, Finished Goods, and one conveyance person per team for a total team count of 7. Each of the two teams shown therefore uses a count of 7, and each completes its own metrics sheet. Shared resources such as the Stockkeeper are counted for each team they support. If you add more conveyance people then count them in each team they support.

The facility count is 6 tables and overhead is 6 chairs. The conveyance person does not use a chair. When two teams share a table, each team counts the table in it's metric.

The number of subassembly fixtures used is the actual count provided in your particular set up.

Your setup may be different depending on the available resources. Use this hint as a guide to develop your own metrics rules.



Factory Simulation – Exercise #1 2-PC Batch 'n Queue PUSH

Six teams organized traditionally by functional department

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Facilitator Instructions:

Event Number 1 - Batch ‘n Queue - Taylor’s Division of Labor.

Facilitator talking points:

Note: roam around the room and between all teams of the Large Group Simulation

Department # 1: STOCKKEEPER: pick a 2-pc job: place all parts for one car into a bag and place two bags into a large yellow container. Container is moved to Dept #2. Quality Nonconforming: substitute a black wheel into one of the two kits for each of the batch jobs delivered to each team and observe the affect on flow. Discontinue using the black wheels for any team that tells you to stop.

1. Notice when the factory starts up, no one down stream is working.
2. Everyone except the Stockkeeper starts out the “day” idle, even though the 2-piece batch may be optimum for someone picking kits, it’s not optimum for the value stream (everyone else). The usual result in the real shop is a need to buffer kits by picking them a day or two ahead.
3. Notice how the upstream process stops when waiting for totes and bags to return from downstream. This type of problem will cause the real shop to buy more totes and fixtures to accommodate all of the excess material the system is pushing through the shop.
4. Notice how each of the two teams fed by the stock room must wait for the Stockkeeper to become available to service their line.
5. Picking kits into bags and then into totes and then de-kiting right away at the next step is a lot of double handling of material
6. What effect did the requirement to move the entire set of kits as a batch job have on delivery to the shop? Did the Stockkeeper hold any completed kit bags waiting for a tote before moving them on to the next step?
7. How is the work load of the Stock Keeper in a Batch ‘n Queue method? Can the stock keeper easily keep up with demand?
8. Could this same stock keeper also pick batch kits for a few other production lines and still keep up with demand? If this same stock keeper were picking kits for all 6 production lines, would each line be satisfied with their batch flow?
9. What is the effect of distance between the stockroom and the work area? How well did the Conveyance Person keep up with flow? Did you need two people?

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Facilitator Instructions:

Event Number 1 - Batch ‘n Queue - Taylor’s Division of Labor.

- **Facilitator talking points**:

  Department # 2: SUBASSEMBLY: unpack kits and return containers to Dept # 1. Assemble all wheel & break & axle subassemblies, place on holding rack (rack is small wood block with four depressions to hold the subassembly). When all subs are complete, the subs and remaining kit parts (car bodies) move as a batch to Dept # 3.

  1. Note: build using the painted wheel if supplied, since you are not trained to inspect.
  2. Note: all movement between departments is accomplished by placing material in the department’s output area and calling out “conveyance.” The Conveyance person will pick up the material and deliver it where needed.

1. Notice as the factory starts to run, few down stream are working. Gradually activity will pick up as material is pushed into the system. What are the 10-Second Test observers seeing during the first half of the “8 minute day” ?
2. Notice how the upstream process work is constrained by the reverse flow of containers and bags. Work stops when no totes and bags are returned from downstream. What is uppermost in the mind of the Subassembler? Returning totes and bags, or building subassemblies? The work focus is definitely blurred. Different people performing this simulation will make their own unique decisions on what to do first. When there is distance between functional departments, what options do the participants have in expressing their needs between the departments? What does this do in optimizing each department for their own best process? Are their internal customer’s concerns likely to be considered?
3. Picking kits into bags and then into totes and then de-kiting right away at the next step is a lot of double handling of material.
4. Notice the non-conforming quality defect passes right through this process, since the assembler isn’t expected to inspect. Taylor’s division of labor says a second person somewhere downstream will be better qualified to inspect.
5. Notice any other workmanship quality defect, watch for wheels facing inward, or disks placed on backwards. Did this person read the instruction process placemat? Or did this person assume an understanding of the process.
6. Did this person hold all racks of subassemblies in the batch job before moving any on to the next step?

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Facilitator Instructions:

Event Number 1 - Batch ‘n Queue - Taylor’s Division of Labor.

- **Facilitator talking points:**

  Department # 3: ASSEMBLY: unpack subassemblies and return fixture rack to Dept # 2. Assemble the 4 wheel subs to each car body. All cars move as a batch to Dept # 4 after the last car in the batch job is complete. If a reject car is returned from Inspection, repair it. Ask the Stockkeeper for any necessary new (unpainted) parts (call a conveyance person to obtain the part). Move the cars to Dept # 4 after repair.

  1. Note: build new cars using the painted wheel subassembly if supplied, since you are not trained to inspect.
  2. Note: install the subs onto the car body following the process instruction closely. Do not interpret beyond the instruction provided. Remember, you are not trained to inspect, so let the inspection department do it’s own work.
  3. Note: all movement between departments is accomplished by placing material in the department’s output area and calling out “conveyance.” The Conveyance person will pick up the material and deliver it where needed. You may also call conveyance to request material be obtained from stock or send messages to other departments.

1. Notice as the factory continues to run, there are still people down stream not working.
2. Fixture and tools to hold material and subassemblies is typically necessary when the material or subassembly must travel some distance to the next assembly point, or must wait in queue for some period of time waiting to be used. It’s a lot of double handling of material and equipment.
3. Notice the non-conforming quality defect passes right through this process as well, since the assembler isn’t expected to inspect.
4. Notice any other workmanship quality defect, such as wheels that won’t rotate.
5. When a nonconforming car is returned from inspection, what did it do to the flow? What decisions were made by the assembler concerning when to do new work versus old repair? Now many nonconforming wheels were in WIP before the inspector returned the first one?
6. Did this person read the instruction process placemat? Or did this person assume an understanding of the process. Did this person hold the batch together before moving any car on to the next step?
7. How has standard work been defined in this Batch ‘n Queue? Is the touch labor required to assemble the car consistent throughout the exercise?
8. Was a Conveyance Person assigned to move materials between Assembly and Inspection? How did the batch move of rejected material affect this person work load?

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Facilitator Instructions:

Event Number 1 - Batch ‘n Queue - Taylor’s Division of Labor.

- **Facilitator talking points:**

Department # 4: DETAIL – an optional process step. The Detail person adds headlights and tail lights to the car by applying small yellow and red stick-on dots (3/16” round dots are available from an office supply store).

1. Notice now the factory is running at each stage. Are there still periods when people upstream are not working?
2. How is the flow of bags, containers, and fixture racks back upstream working out? Any work stoppages?
3. What does the WIP look like? Are piles of material sitting idle along the flow? How is the balance of worker time?
4. How is the balance of worker time at each department. Is there an obvious bottleneck operation?

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Facilitator Instructions:

Event Number 1 - Batch ‘n Queue - Taylor’s Division of Labor.

- **Facilitator talking points:**

  Department # 5: QUALITY INSPECTOR – all four wheels must rotate freely, all wheels plain (not painted). If any cars are reject, return the entire batch of cars back to Dept # 3 for repair. Once all cars in the batch pass inspection, move the batch to Dept #6 Finished Goods. Keep track of the number of rejected cars (only count the nonconforming cars in the batch). Upon receipt of the first nonconforming painted wheel, call “conveyance” and send a message to the Stockkeeper to stop using painted wheels.

1. Notice how the rejection of a batch interrupts the flow. Many quality organizations use this lot reject method of rejecting the entire batch upon first discovery of a nonconforming part, usually without inspecting the entire batch. Experiment with variations to the quality rules. Try just rejecting the ones that are bad and letting the partial batch of good cars continue on their way. How does this impact customer delivery?
2. What does the WIP look like? Are there piles of material sitting idle along the flow? How is the balance of worker time affected by quality problems?
3. What has been the effect of non-conforming quality defects passing through assembly to inspection? Do you agree with Taylor - that a dedicated inspector is the “one best way” process?
4. Notice any other workmanship quality defect, such as wheels that won’t rotate. Are inspectors allowed to do minor rework at your company? Or do they push the defect back upstream for rework? For fun, have your inspector fill out your company’s non-conforming material report form, and have a “quality manager” sign it before processing the rework (have the facilitator sign the form). How would this affect the flow?
5. Did this person read the instruction process place mat? Or did this person assume an understanding of the inspection process?

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Facilitator Instructions:

Event Number 1 - Batch ‘n Queue - Taylor’s Division of Labor.

- Facilitator talking points:

Department # 6: FINISHED GOODS / Timekeeper: Time the simulation and complete the time metric form. Control the start and stop time and the stopwatch, and record the time the 1st batch reaches finished goods, the time the 1st delivery is made to the customer, and the time the 2nd delivery is made. If possible, record the time for the quality defect (painted wheel) to travel the line from injection into the stream to repair. **Call STOP when 8 minutes are up if a delivery has been made, or call “Overtime” and allow up to 2 more minutes to attempt a delivery.**

1. **Large Group Constraint: if the single kit stopwatch is shared between two teams, then a single timekeeper controls the watch and calls out start and stop and OT. The second team’s timekeeper will record the time metrics by asking for the time. The two participants should be located near each other.**
2. Metrics: Complete the Financial Calculation Metrics Form with the facilitator and team.
3. ***10-Second Test Form:***
    1. ***Observers complete the 10-Second Test form with the VA/NVA observations. Plot the results or use the excel spreadsheet provided if a laptop is available (built in calculations and plots). What percentage of time was pure waste?***
    2. ***Record NVA observations on flow for later comparison.***
    3. ***Have the observation team question the participants on any part of the process to confirm the observations.***
    4. ***Hold a Kaizen event with all of the participants and observation teams from the large group to discuss how they would improve the batch ‘n queue process (stay with batch ‘n queue methods for purposes of this exercise, and see how much improvement can be made)***
    5. ***Reset one production line and with all large group participants present, run the single line for 8 minutes and determine if the improvements were sufficient to satisfy the customer’s on-time delivery requirement.***

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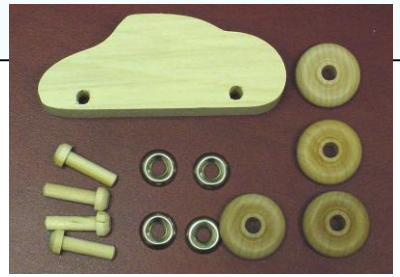
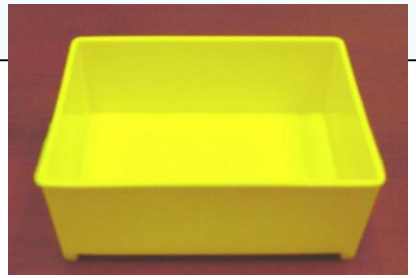
Department #1
Batch ‘n Queue

Stockkeeper:

1 Pick 2 kits, placing material for each car into a plastic bag, zip lock the bag and place the 2 bags into large yellow container.
2 Move the batch of 2 cars to the output and call “conveyance.” When supporting two teams, alternate delivery to each team in a round-robin fashion.
3 Repeat the operation as quickly as possible, but you may need to wait for the return of empty containers.

NOTE: insert one painted wheel into 1 of the 2 kit bags in each batch job for each team until told to stop by the team’s inspection person (via conveyance).





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Department #2

Batch ‘n Queue

Wheel / Axle / Brake Subassembly:

1 Remove material from plastic container. Place empty containers in Dept output for return.

2 Assemble wheel onto axle, curved side of wheel toward axle hub.

3 Slip disk brake onto axle, flat side to wheel’s flat side. Place sub assembly onto fixture by pressing the rounded hub into the fixture’s recessed hole.

4 Place 4 subassemblies onto each fixture.

5 Place the car bodies into a tote and place with the set of loaded fixtures into the output and call “conveyance.”

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Department #3
Batch ‘n Queue

Car Assembly:

1 Remove each wheel subassembly from holding fixture and attach to car body, use clockwise twist as you insert the axle peg. Place empty holding fixture in department output area.
2 Move the completed batch of cars to the Dept output and call “conveyance”
3 If a car is returned for repair, determine the rework (loosen the wheel or replace a black wheel with a new plain wheel from stock – call conveyance to obtain a wheel)


Ergonomic Assembly Tool

Use of the tool is highly encouraged to prevent sore fingers over the duration of the simulation event.

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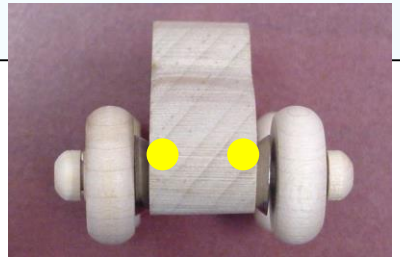
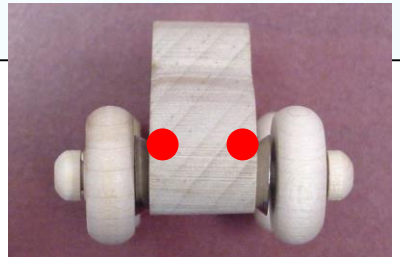
Department #4

Batch ‘n Queue

Car Detail:

1 Apply two yellow stick-on dots to the front of the car as headlights.
2 Apply two red stick-on dots to the back of the car as tail lights.
3 Move the completed batch of cars to the dept output and call “conveyance”





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Department #5

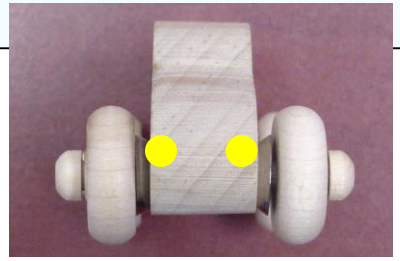
Batch ‘n Queue

Inspection Criteria:

1 All 4 wheels rotate freely.

2 All 4 wheels unpainted. Return any rejected cars to Dept #3 Assembly for repair, ***and tell the stock keeper to stop using painted wheels.***
(the conveyance person carries the message)

3 If the batch is acceptable, pass completed cars to the dept output to be delivered to Dept #6 Finished Goods. Call “conveyance.”



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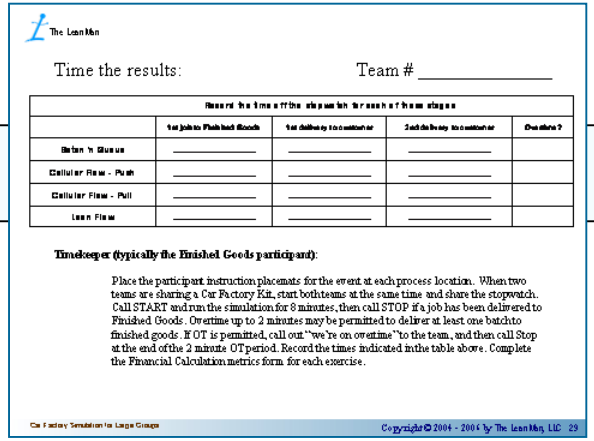
Department #6
Batch ‘n Queue

Finished Goods / Timekeeper

1 Start the exercise by starting the stopwatch and calling go.
2 Deliver cars in sets of 3, the first at 4.0 minutes and the 2nd at 8.0 minutes. Do not deliver early.
3 Record the metrics in the spaces provided on the *time the results* form for event 1. Follow the instructions on the form for event timing requirements.
4 Complete the Financial chart with the help of the facilitator and the team.



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Time the results: Team # _____

Record the times of the stopwatch for each of these stages				
	1st job to Finished Goods	1st delivery to customer	2nd delivery to customer	Overtime?
Batch ‘n Queue	_____	_____	_____	
Cellular Flow - Push	_____	_____	_____	
Cellular Flow - Pull	_____	_____	_____	
Lean Flow	_____	_____	_____	

Timekeeper (typically the Finished Goods participant):

Place the participant instruction placemats for the event at each process location. When two teams are sharing a Car Factory Kit, start both teams at the same time and share the stopwatch. Call START and run the simulation for 8 minutes, then call STOP if a job has been delivered to Finished Goods. Overtime up to 2 minutes may be permitted to deliver at least one batch to finished goods. If OT is permitted, call out "we're on overtime" to the team, and then call Stop at the end of the 2 minute OT period. Record the times indicated in the table above. Complete the Financial Calculation metrics form for each exercise.

Car Factory Simulation for Large Groups

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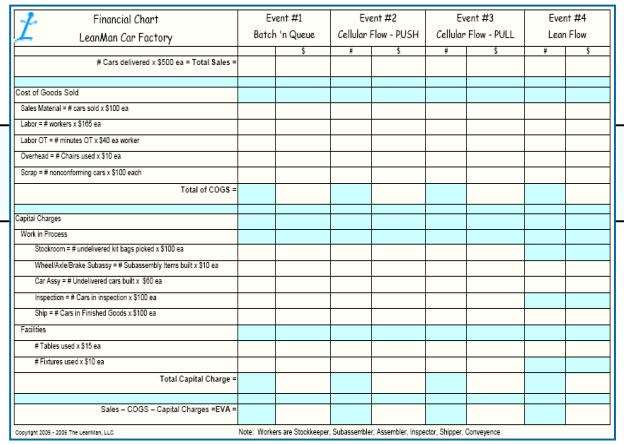

Financial Chart — LeanMan Car Factory	Event #1 Batch 'n Queue		Event #2 Cellular Flow - PUSH		Event #3 Cellular Flow - PULL		Event #4 Lean Flow	
	#	$	#	$	#	$	#	$
# Cars delivered x $500 ea = Total Sales =								
Cost of Goods Sold								
Sales Material = # cars sold x $100 ea								
Labor = # workers 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 =								

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

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Event #1 Post Discussion

Facilitator Instructions:

At the end of the Batch 'n Queue exercise, discuss team observations and draw some conclusions.

What did we observe?

How well were work balance and inventory distribution managed in this exercise?

Did we make the customer happy? What was the on-time delivery metric? Quality metric?

Discuss how the 8 wastes were apparent:

Overproduction –
Waiting –
Conveyance –
Over processing –
Excess Inventory –
Unnecessary Motion –
Defects –
Human Creativity –

Best Practice

The 4th step in 5S is to standardize work based on team participation in documenting best practices. Before moving on to event #2, have the team review the process for event #1. Stay within the Batch 'n Queue parameters: 2-pc batch, all material must move as a batch, and all departments remain intact (no combining or eliminating functions) and list improvements that would improve the final metrics in this type of flow.

Use just one of the team setups and implement as many creative improvements to the flow as the students can think of to improve the flow, work balance, quality, inventory management and on-time delivery. Be sure to stay within the constraints of the Batch 'n Queue technology (functional departments each optimized for their own best interest without regard for internal supplier or internal customer needs). Run the simulation again to verify the new process and compare the results to the recorded metrics chart for event #1. Would the customer be happier with these improvements?

Many companies spend vast amounts of resource on attempting to make improvements to their Batch 'n Queue flows rather than advance to the newer concepts that became popular in the 1980's: Work Cells. In the next event we will advance to see how work cells changed the face of manufacturing.

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Lean Factory Simulation Kits

Lean Principles

Facilitator Instructions

Lean Car Factory Simulation

Event #2 Cellular Flow (push)

Large Group Version

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Event #2

Cellular Flow Mode – Two-Piece Batch Job with One-Piece Flow PUSH Method

The Zoom-Zoom car factory wants to use a work cell arrangement with a 1-pc flow process at assembly. See setup for event #2 for suggested table arrangement and participant seating.

Department #1 The factory process continues with sets of components picked by a Stockkeeper into a series of 1-pc kit bags, each packed into a yellow tote container to make up the batch job. The batch job moves to department #1's output shelf and the Stockkeeper calls out "Conveyance." Repeat the process as fast as you are able, but you may be delayed waiting for bags and totes returned from Dept 2. Batch size is 2 to optimize this department's use of resources, but flow is 1-pc inside the work cell.
Recommendation: Experiment with different batch sizes to observe the effect on this flow.

Conveyance hears the call, picks up the batch job and delivers it into the input of Work Cell department #2. Any empty totes or bags are returned back to the warehouse department #1.

Department #2 The batch job passes through the assembly Work Cell where the wheel, axle and disk components are assembled together, 4-each mounted onto a holding fixture. Empty Totes and Bags are quickly placed on the output shelf and "Conveyance" called out. The 1st completed fixture and 1st car body is slid over to the final assembly person and the 2nd set is started. The Final Assembly person removes the subassemblies from the fixture and attaches each to the car body. *Be sure to use the ergonomic tool.* If a reject car is returned from inspection, repair it. Ask the Stockkeeper for any necessary parts and call "conveyance" to deliver them. The assembled car then passes to the Detail stage, if this position is used, where headlights and tail lights are applied. The car is moved to the output shelf and when all cars on the batch job are ready, "conveyance" is called out to deliver the batch to department #5.

The Conveyance person hears the call and delivers the batch job to the input of department #5. Any empty bags or totes are also picked up and returned back upstream to department #1

Department #3 – combined with #2
Department #4 – combined with #2

Department #5 The cars are together as a batch again, and the batch job moves to Final Inspection where the wheel rotation and wheel color match is verified. Rejected cars are placed in the reject shelf and conveyance is called to return them to department #2 for rework. If all are acceptable, the batch job is moved to department #5's output shelf and "conveyance" is called out. Move as a batch - do not split off good cars from the reject cars.

Department #6 The batch job moves to the finished goods warehouse where cars are grouped into customer order quantities and delivered according to the delivery schedule. Customer demand is 3 cars every 4 minutes (TAKT = 1.33 minutes). Do not deliver early, and record the time from the stopwatch when actually shipped.

Timekeeper: record the event start and stop time; the time the 1st job reaches finished goods, and the time for the first delivery of 3 to the customer. Run the simulation for 8 minutes. It is permissible to run up to an additional 2 minutes of overtime if needed to deliver the first batch to the customer. Call out "we are on over time" if this occurs. Complete the Financial Metrics chart.

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Value Stream Map – Event #2

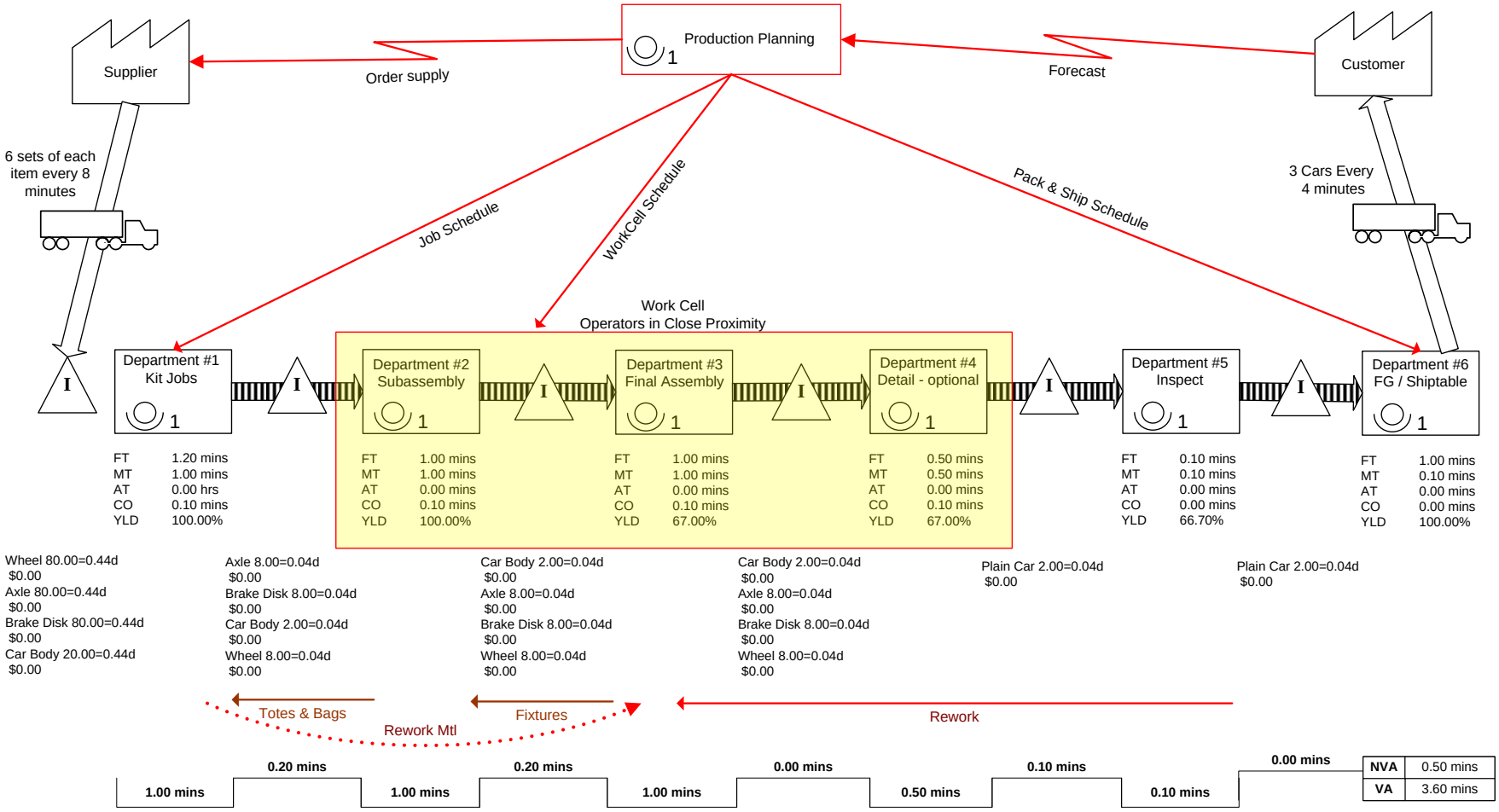
Customer	LeanMan Factory
Product	Zoom Zoom Cars
Demand	3/4.00mins
TAKT	1.33 mins

Improvement

- Some NVA eliminated by reducing conveyance inside the work cell. NVA of 0.7 dropped to 0.5
- VA time unchanged

Future State
2-pc MRP Push
1-pc flow Work Cell
Simulation exercise

To run the LeanSim simulation exercises in a continuous loop, the finished cars are disassembled and the raw materials returned to the 'supplier' stage. This can be performed by the 'planner' or by other participants in the exercise.



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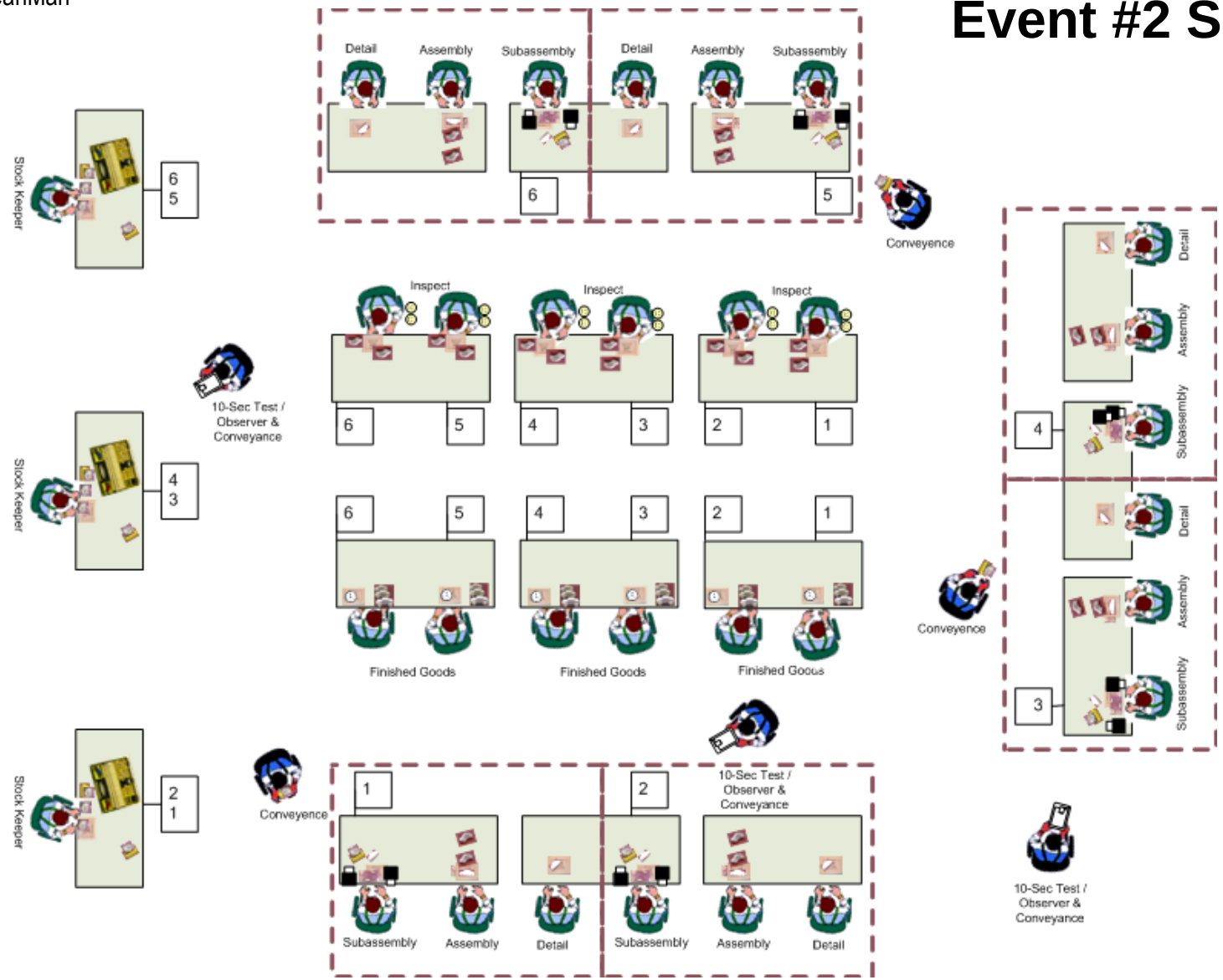
Event #2 Setup



Factory Simulation – Exercise #2 2-PC Batch and 1-pc Work Cell PUSH

Six assembly teams organized in work cells, supported by functional departments

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Facilitator Instructions:

Event Number 2 – Cellular Flow Push with 1-pc flow in the cell.

Facilitator talking points:

Department # 1: STOCKKEEPER: pick a 2-pc job the same as in event #1: place all parts for one car into a bag and place two bags into a large yellow container. Container is moved to step 2. Quality Nonconforming: substitute a black wheel into one of the two kits for each of the batch jobs delivered to each team and observe the affect on flow. Discontinue using the black wheels for any team that tells you to stop.

Below are the same observations from Event #1 – will the assembly work cell make a difference?

1. Notice when the factory starts up, no one down stream is working.
2. Everyone except the Stockkeeper starts out the "day" idle, even though the 2-piece batch may be optimum for someone picking kits, it's not optimum for the value stream (everyone else). The usual result in the real shop is a need to buffer kits by picking them a day or two ahead.
3. Notice how the upstream process stops when waiting for totes and bags to return from downstream. This type of problem will cause the real shop to buy more totes and fixtures to accommodate all of the excess material the system is pushing through the shop.
4. Notice how each of the two teams fed by the stock room must wait for the Stockkeeper to become available to service their line.
5. Picking kits into bags and then into totes and then de-kiting right away at the next step is a lot of double handling of material
6. What effect did the requirement to move the entire set of kits as a batch job have on delivery to the shop? Did the Stockkeeper hold any completed kit bags waiting for a tote before moving them on to the next step?
7. How is the work load of the Stockkeeper when a Cellular Flow assembly method is used? Can the stock keeper easily keep up with demand?
8. Could this same Stockkeeper also pick batch kits for a few other production lines and still keep up with demand? If this same stock keeper were picking kits for all 6 production lines, would each line be satisfied with their batch flow?
9. What is the effect of distance between the stockroom and the work area? How well did the Conveyance Person keep up with flow? Did you need two people?

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Facilitator Instructions:

Event Number 2 – Cellular Flow Push with 1-pc flow in the cell.

- **Facilitator talking points**:

  Department # 2 (now the Work Cell): SUBASSEMBLY: unpack kits and return containers to Dept # 1. Assemble all wheel & break & axle subassemblies, place on a holding rack. When all 4 subs are complete, the subs and the car body are moved (slid over) to Assembly. Continue with the second set of subs and repeat.

  1. Note: build using the painted wheel if supplied, since you are not trained to inspect.
  2. Note: all movement between internal work cell steps are by 1-pc flow and "slid over" to the next person. Movement between external departments is accomplished by placing material in the Work Cell's output area and calling out "conveyance." The Conveyance person will pick up the material and deliver it where needed.

1. Notice as the factory starts to run, few down stream are working. Gradually activity will pick up as material is pushed into the system. What are the 10-Second Test observers seeing during the first half of the "8 minute day" ? What changes in WIP and Flow are evident with the use of a Work Cell? What remains the same?
2. Notice how the upstream process work is still constrained by the reverse flow of containers and bags. Work stops when no totes and bags are returned from downstream. What is uppermost in the mind of the sub-assembler? Returning totes and bags, or building subassemblies? The work focus is definitely blurred. Different people performing this simulation will make their own unique decisions on what to do first. When there is distance between functional departments and the Work Cell, what options do the participants have in expressing their needs between the departments? What does this do in optimizing each department for their own best process? Are their internal customer's concerns likely to be considered?
3. Picking kits into bags and then into totes and then de-kiting right away at the next step is still a lot of double handling of material.
4. Notice the non-conforming quality defect passes right through this process, since the assembler isn't expected to inspect. Taylor's division of labor says a second person somewhere downstream will be better qualified to inspect.
5. Notice any other workmanship quality defect, watch for wheels facing inward, or disks placed on backwards. Did this person read the instruction process placemat? Or did this person assume an understanding of the process.
6. Did this person hold all racks of subassemblies in the batch job before moving any on to the next step?

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Facilitator Instructions:

Event Number 2 – Cellular Flow Push with 1-pc flow in the cell.

- **Facilitator talking points:**

  Department # 3 (now the Work Cell): ASSEMBLY: unpack subassemblies and return fixture rack to the subassembly person. Assemble 4 wheel subs to a car body and move the car to the Detail person. Continue assembling the next car. If a rejected car is returned from Inspection, repair it. Ask the Stockkeeper for any necessary new (unpainted) parts (call a conveyance person to obtain the part). Move the cars to Dept # 4 after repair.

  1. Note: build new cars using the painted wheel subassembly if supplied, since you are not trained to inspect.
  2. Note: install the subs onto the car body following the process instruction closely. Do not interpret beyond the instruction provided. Remember, you are not trained to inspect, so let the inspection department do it's own work.
  3. Note: all movement between internal work cell steps are by 1-pc flow and "slid over" to the next person. All movement between departments is accomplished by placing material in the department's output area and calling out "conveyance." The Conveyance person will pick up the material and deliver it where needed. You may also call conveyance to request material be obtained from stock or send messages to other departments.

1. Notice any other workmanship quality defect, such as wheels that won't rotate.
2. When a nonconforming car is returned from inspection, what did it do to the flow? What decisions were made by the assembler concerning when to do new work versus old repair? Now many nonconforming wheels were in WIP before the inspector returned the first one?
3. Did this person read the instruction process placemat? Or did this person assume an understanding of the process. Did this person hold the batch together before moving any car on to the next step?
4. How has standard work been defined in this mixed flow? Is the touch labor required to assemble the car consistent throughout the exercise?

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Facilitator Instructions:

Event Number 2 – Cellular Flow Push with 1-pc flow in the cell.

- **Facilitator talking points:**

  Department # 4 (now the Work Cell): DETAIL – an optional process step. The Detail person adds headlights and tail lights to the car by applying small yellow and red stick-on dots (3/16" round dots are available from an office supply store). When complete, the car is placed into the work cell output. When all cars of the batch job are in the output "conveyance" is called to move the batch job to the next department.

1. Notice how batch jobs flow between functional departments as a complete batch of material, but are often passed through a work cell as 1-pc flow. Is there any advantage to 1-pc flow inside the work cell when flow outside is still in batches?
2. Notice now the factory is running at each stage. Are there still periods when people upstream are not working?
3. How is the flow of bags, containers, and fixture racks back upstream working out? Any work stoppages? Has the use of holding fixtures inside a work cell taken on any advantage or disadvantage from their use in a full batch flow?
4. What does the WIP look like? Are piles of material sitting idle along the flow? How is the balance of worker time in the cell? Did the work cell change anything from Batch 'n Queue flow?
5. How is the balance of worker time at each department. Is there an obvious bottleneck operation?

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Facilitator Instructions:

Event Number 2 – Cellular Flow Push with 1-pc flow in the cell.

- **Facilitator talking points:**

  Department # 5: QUALITY INSPECTOR – all four wheels must rotate freely, all wheels plain (not painted). If any cars are reject, return the entire batch of cars back to the Work Cell for repair. Once all cars in the batch pass inspection, move the batch to Dept #6 Finished Goods. Keep track of the number of rejected cars (only count the nonconforming cars in the batch). Upon receiving the first nonconforming reject due to painted wheel, call "conveyance" and send a message to the Stockkeeper to stop using painted wheels.

1. Notice how the rejection of a batch interrupts the flow inside the Work Cell. How does the use of a Work Cell and handling of quality problems impact customer delivery?
2. What does the WIP look like? Are there piles of material sitting idle along the flow? How is the balance of worker time affected by quality problems?
3. What has been the effect of non-conforming quality defects passing through assembly to inspection? Do you agree with Taylor - that a dedicated inspector is still the "one best way" process?
4. Notice any other workmanship quality defect, such as wheels that won't rotate. Are inspectors allowed to do minor rework at your company? Or do they push the defect back upstream for rework? For fun, have your inspector fill out your company's non-conforming material report form, and have a "quality manager" sign it before processing the rework (have the facilitator sign the form). How would this affect the flow?
5. Did this person read the instruction process place mat? Or did this person assume an understanding of the inspection process?

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Facilitator Instructions:

Event Number 2 – Cellular Flow Push with 1-pc flow in the cell.

- **Facilitator talking points**:

  Department # 6: FINISHED GOODS / Timekeeper: Time the simulation and complete the time metric form. Control the start and stop time and the stopwatch, and record the time the 1st batch reaches finished goods, the time the 1st delivery is made to the customer, and the time the 2nd delivery is made. If possible, record the time for the quality defect (painted wheel) to travel the line from injection into the stream to repair. **Call STOP when 8 minutes are up if a delivery has been made, or call "Overtime" and allow up to 2 more minutes to attempt a delivery.**

1. **Large Group Constraint: if the single kit stopwatch is shared between two teams, then a single timekeeper controls the watch and calls out start and stop and OT. The second team's timekeeper will record their time metrics by asking for the time. The two participants should be located near each other.**
2. Metrics: Complete the Financial Calculation Metrics Form with help from the facilitator and the team.
3. ***10-Second Test Form:***
   1. ***Observers complete the 10-Second Test form with the VA/NVA observations. Plot the results or use the excel spreadsheet provided if a laptop is available (built in calculations and plots). What percentage of time was pure waste?***
   2. ***Record NVA observations on flow for later comparison.***
   3. ***Have the observation team question the participants on any part of the process to confirm the observations.***
   4. ***Hold a Kaizen event with all of the participants and observation teams from the large group to discuss how they would improve the Work Cell Push process (stay with cellular flow push methods for purposes of this exercise, and see how much improvement can be made)***
   5. ***Reset one production line and with all large group participants present, run the single line for 8 minutes and determine if the improvements were sufficient to satisfy the customer's on-time delivery requirement.***

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Department #1

Cellular Flow - Push

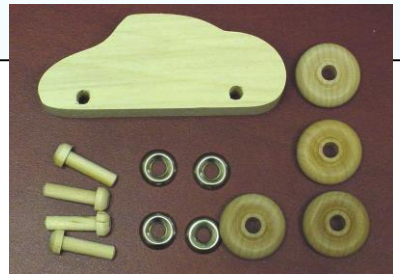
Stockkeeper:

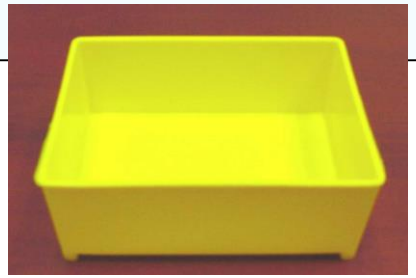
1 Pick 2 kits, placing material for each car into a plastic bag, zip lock the bag and place the 2 bags into large yellow container.

2 Move the batch of 2 cars to the output and call "conveyance." When supporting two teams, alternate delivery to each team in a round-robin fashion.

3 Repeat the operation as quickly as possible, but you may need to wait for the return of empty containers.

NOTE: insert one painted wheel into 1 of the 2 kit bags in each batch job for each team until told to stop by the team's inspection person (via conveyance).





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Department #2

Cellular Flow - Push

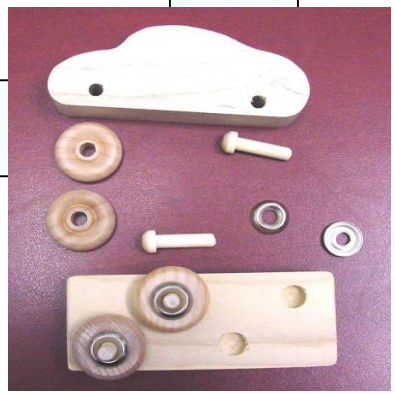
WORK CELL - SUBASSEMBLY:

1 Remove material from plastic container. Place empty containers in Work Cell output for return and call “Conveyance.”

2 Assemble wheel onto axle, curved side of wheel toward axle hub, slip disk brake onto axle, flat side to wheel’s flat side, and place sub assembly onto fixture by pressing the rounded hub into the fixture’s recessed hole.

3 Place 4 subassemblies onto a fixture. And slide the loaded fixture and a car body to the Assembly person.

4 Repeat for the next set of material in the batch.



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Department #3

Cellular Flow - Push

WORK CELL - ASSEMBLY:

1 Remove 4 wheel subassemblies from holding fixture and attach to car body, use clockwise twist as you insert the axle peg. Slide empty holding fixture back to the subassembly area in the cell.

2 Move the completed cars to the Detail area in the cell output and repeat for the next car in the batch.

3 If a reject batch is returned from inspection, correct any non-rotating wheels or replace any painted wheels. Call conveyance to obtain a new wheel from stock.

Ergonomic Assembly Tool

Use of the tool is highly encouraged to prevent sore fingers over the duration of the simulation event.

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Department #4

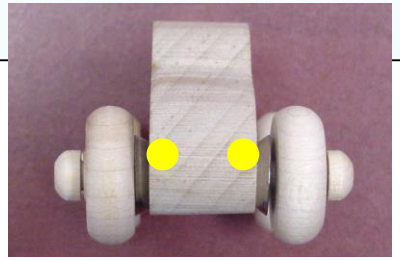
Cellular Flow - Push

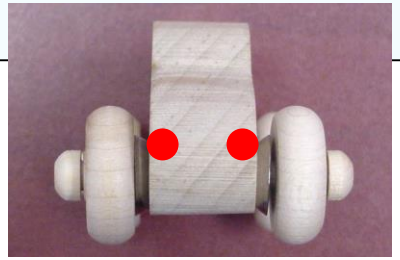
WORK CELL DETAIL:

1 Apply two yellow stick-on dots to the front of the car as headlights.

2 Apply two red stick-on dots to the back of the car as tail lights.

3 Move the completed car into the dept output. Repeat the process for each car in the batch job. When all cars are complete, call “conveyance” to move the batch to the next department.





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Department #5

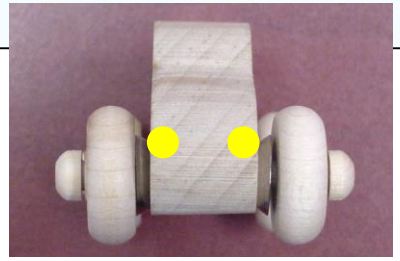
Cellular Flow - Push

Inspection Criteria:

1 All 4 wheels rotate freely.

2 All 4 wheels unpainted. Return any rejected cars to the Work Cell for repair, ***and tell the stock keeper to stop using painted wheels.***
(the conveyance person carries the message)

3 If the batch is acceptable, pass completed cars to the dept output to be delivered to Dept #6 Finished Goods. Call "conveyance."



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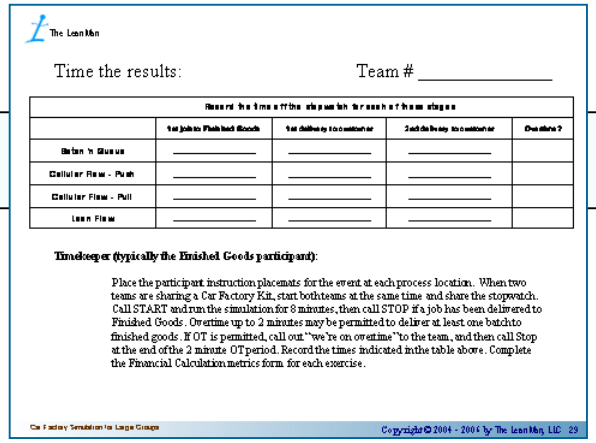
Department #6

Cellular Flow - Push

Finished Goods / Timekeeper

1. Start the exercise by starting the stopwatch and calling go.
2. Deliver cars in sets of 3, the 1st at 4.0 minutes and the 2nd at 8.0 minutes. Do not deliver early.
3. Record the metrics in the spaces provided on the *Time the results* form for event 2. Follow the instructions on the form for event timing requirements.
4. Complete the Financial chart with the help of the facilitator.



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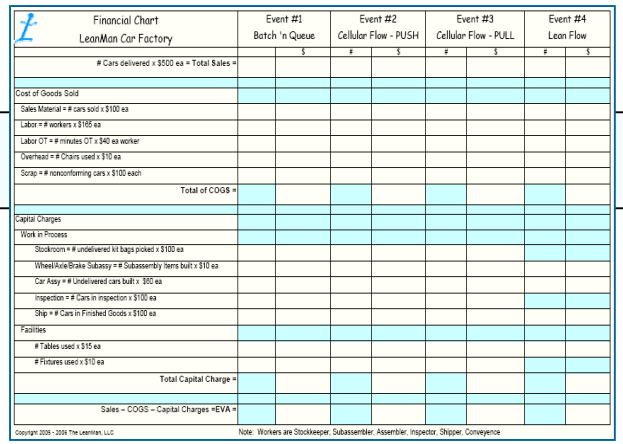
Time the results: Team # _____

	Record the times of the stopwatch for each of these stages			
	1st job to Finished Goods	1st delivery to customer	2nd delivery to customer	Overtime?
Batch 'n Queue	_____	_____	_____	
Cellular Flow - Push	_____	_____	_____	
Cellular Flow - Pull	_____	_____	_____	
Lean Flow	_____	_____	_____	

Timekeeper (typically the Finished Goods participant):

Place the participant instruction placemats for the event at each process location. When two teams are sharing a Car Factory Kit, start both teams at the same time and share the stopwatch. Call START and run the simulation for 8 minutes, then call STOP if a job has been delivered to Finished Goods. Overtime up to 2 minutes may be permitted to deliver at least one batch to finished goods. If OT is permitted, call out "we're on overtime" to the team, and then call Stop at the end of the 2 minute OT period. Record the times indicated in the table above. Complete the Financial Calculation metrics form for each exercise.

Car Factory Simulation for Large Groups — Copyright © 2004 - 2006 by The LeanMan, LLC 29



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 =								

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

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Event #2 Post Discussion

Facilitator Instructions:

At the end of the Cellular Flow - Push exercise, discuss team observations and draw some conclusions.

What did we observe?

How well were work balance and inventory distribution managed in this exercise?

Did we make the customer happy? What was the on-time delivery metric? Quality metric?

Discuss how the 8 wastes were apparent:

Overproduction –
Waiting –
Conveyance –
Over processing –
Excess Inventory –
Unnecessary Motion –
Defects –
Human Creativity –

Best Practice

Before moving on to event #3, have the team review the process for event #2. Stay within the Work Cell parameters: 2-pc batch input and 1-pc flow internal to the cell, all material must move as a batch outside the work cell. List improvements that would improve the final metrics in this type of flow.

Use just one of the team setups and implement as many creative improvements to the flow as the students can think of to improve the flow, work balance, quality, inventory management and on-time delivery. Be sure to stay within the constraints of the Work Cell technology (external functional departments each optimized for their own best interest, and 1 pc flow internal to the cell). Run the simulation again to verify the new process and compare the results to the recorded metrics chart for event #2. Would the customer be happier with these improvements?

Many companies attempted to make improvements to their flows by creating work cells without changing from the MRP Push methods, and without realizing that improving a pointy process often has little impact to the bottom line financial metrics. In the next event we will advance the work cell concept to disconnect from MRP and use a 1-pc pull system.

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Lean Factory Simulation Kits

Lean Principles

Facilitator Instructions

Lean Car Factory Simulation

Event #3 Continuous Flow (pull system)

Large Group Version

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Event #3

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

The Zoom-Zoom car factory wants to continue to use a work cell with a 1-pc flow process, but wants 1-pc flow all the way through the process stream. The factory also wants to regulate work in process (WIP) inventory, and wants to add a pull mechanism to draw the cars into finished goods. The participants keep the same work cell arrangement, but now inspection is added as part of the work cell. The picked kit batch size to set to1. A kanban square signal between each process step is used to regulate flow.

Prepare the shop by moving the inspection station into the work cell. Place a kanban square between each of the process steps, with 1 pc max at each square, except set 4 subassemblies max at the input to final assembly and set the input kanban square to 3 cars at Finished Goods. This general rule applies for each of the process steps: If the downstream input kanban square is below it's set point, then perform your process operation and move the product into the next process input square. If the square holds its max limit, you must wait until it drops below the max limit to move another piece into that square.

Hint: you may perform your own process step on just one more item and hold it in place until the downstream input square drops below it's max limit allowing you to move the item along. No more than one item may be held in place in WIP at any one time. (where "item" is the result of your process i.e. picked kit, subassembly axle, assembled car, detailed car, inspected car etc)
Recommendation: try this flow by first wetting the line, e.g., fill up the kanban squares to the max limit at each process point, and include the 3 cars in the finished goods input kanban as well as the 3 cars in the warehouse waiting for delivery at 4 minutes. What happens to flow during the first 4 minutes?

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 provided. Customer demand: 3 cars every 4 minutes (TAKT = 1.33 minutes)

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Event #3

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

The Zoom-Zoom car factory wants to continue to use a work cell arrangement, and wants to implement a Pull-Demand system with kanban control from Finished Goods to regulate the 1-pc flow. See setup for event #3 for suggested table arrangement and participant seating.

Department #1 The factory process continues with sets of components picked by a Stockkeeper into a series of 1-pc kit bags, each packed into a yellow tote container to make up the batch job. The batch job moves to department #1's output kanban square and the Stockkeeper calls out "Conveyance." Note: use one output kanban square for each assembly line you support. Repeat the process as fast as you are able, but you may not hold more than one kit in the output kanban at any one time. You may also be delayed waiting for bags and totes returned from Dept 2. Batch size is 1. Recommendation: Experiment with different batch sizes to observe the effect on this flow with the kanban regulator in place. Experiment with the max limits of the kanban regulators and observe the impact on WIP.

Conveyance hears the call, checks the input kanban square at department #2 and, if empty, picks up the job from department #1 and delivers it into the input kanban of Work Cell department #2. If department #2's input kanban still holds a kit then the new job is left in the output of department #1 until able to be moved. Any empty totes or bags are returned back to the warehouse department #1.

Department #2 / Work Cell The job is removed from the input kanban square and passes through the assembly Work Cell where the wheel, axle and disk components are assembled together. Each subassembly is placed into the downstream kanban square as soon as it is completed, but no more than a maximum of 4 at any one time. Car bodies are also placed into the kanban. Empty Totes and Bags are quickly placed on the output shelf and "Conveyance" called out. The Final Assembly person removes the subassemblies from the kanban and attaches each to the car body. *Be sure to use the ergonomic tool.* If a reject car is returned from inspection, repair it. Ask the stock keeper for any necessary parts. The assembled car then passes to the Detail stage input kanban (1 car maximum) where headlights and tail lights are applied. The car is next moved into the input kanban for inspection. Final Inspection checks the wheel rotation and wheel color match is verified. A rejected car is returned to the final assembly input kanban for rework. If acceptable, the car is moved to the output and "conveyance" is called out.

The Conveyance person hears the call and checks the input kanban at department #6. If below the max limit the car is delivered to the input kanban of department #6. Any empty bags or totes are also picked up and returned back upstream to department #1

Department #5 – combined with #2

Department #6 The car moves to the finished goods warehouse input kanban (3 cars maximum) where cars are grouped into customer order quantities and delivered according to the delivery schedule. Customer demand is 3 cars every 4 minutes (TAKT = 1.33 minutes) as defined on the ON Time Delivery chart at shipping. Do not deliver early, and record the time from the stopwatch when actually shipped.

Timekeeper: record the event start and stop time; the time the 1st job reaches finished goods, and the time for the first delivery of 3 to the customer. Run the simulation for 8 minutes. It is permissible to run an additional 2 minutes of overtime if needed to deliver the first batch to the customer. Call out "we are on over time" if this occurs. Complete the Financial Metrics chart.

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Value Stream Map – Event #3

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

Improvement

- NVA changed because fixture handling is eliminated and inspection is moved into the cell. Drops from 0.5 to 0.2
- Quality nonconforming material still poses a threat to flow
- VA time reduced from 3.6 to 3.05

Future State
1-pc Pull w/ kanban control Work Cell
Simulation exercise

To run the LeanSim simulation exercises in a continuous loop, the finished cars are disassembled and the raw materials returned to the 'supplier' stage. This can be performed by the 'planner' or by other participants in the exercise.

Supplier

Order supply

Production Planning 1

Forecast

Customer

6 sets of each item every 8 minutes

Pack & Ship Schedule

3 Cars Every 4 minutes

I

Work Cell
Operators in Close Proximity

Department #1 Kit Jobs 1

FT	0.20 mins
MT	0.50 mins
AT	0.00 hrs
CO	0.10 mins
YLD	100.00%

1 Kit Max Withdrawal

Department #2 Subassembly 1

FT	0.30 mins
MT	0.30 mins
AT	0.00 mins
CO	0.10 mins
YLD	100.00%

4 Subs Max 1 car body Withdrawal

Department #3 Final Assembly 1

FT	0.30 mins
MT	0.30 mins
AT	0.00 mins
CO	0.10 mins
YLD	67.00%

1 Car Max Withdrawal

Department #4 Detail - optional 1

FT	0.50 mins
MT	0.50 mins
AT	0.00 mins
CO	0.10 mins
YLD	67.00%

1 Car Max Withdrawal

Department #5 Inspect 1

FT	0.05 mins
MT	0.05 mins
AT	0.00 mins
CO	0.00 mins
YLD	66.70%

3 Cars Max Withdrawal

Department #6 FG / Shiptable 1

FT	1.00 mins
MT	0.10 mins
AT	0.00 mins
CO	0.00 mins
YLD	100.00%

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

Totes & Bags

Rework Mtl

Rework

0.50 mins	0.20 mins	1.00 mins	0.00 mins	1.00 mins	0.00 mins	0.50 mins	0.00 mins	0.05 mins	0.00 mins

NVA	0.20 mins
VA	3.05 mins

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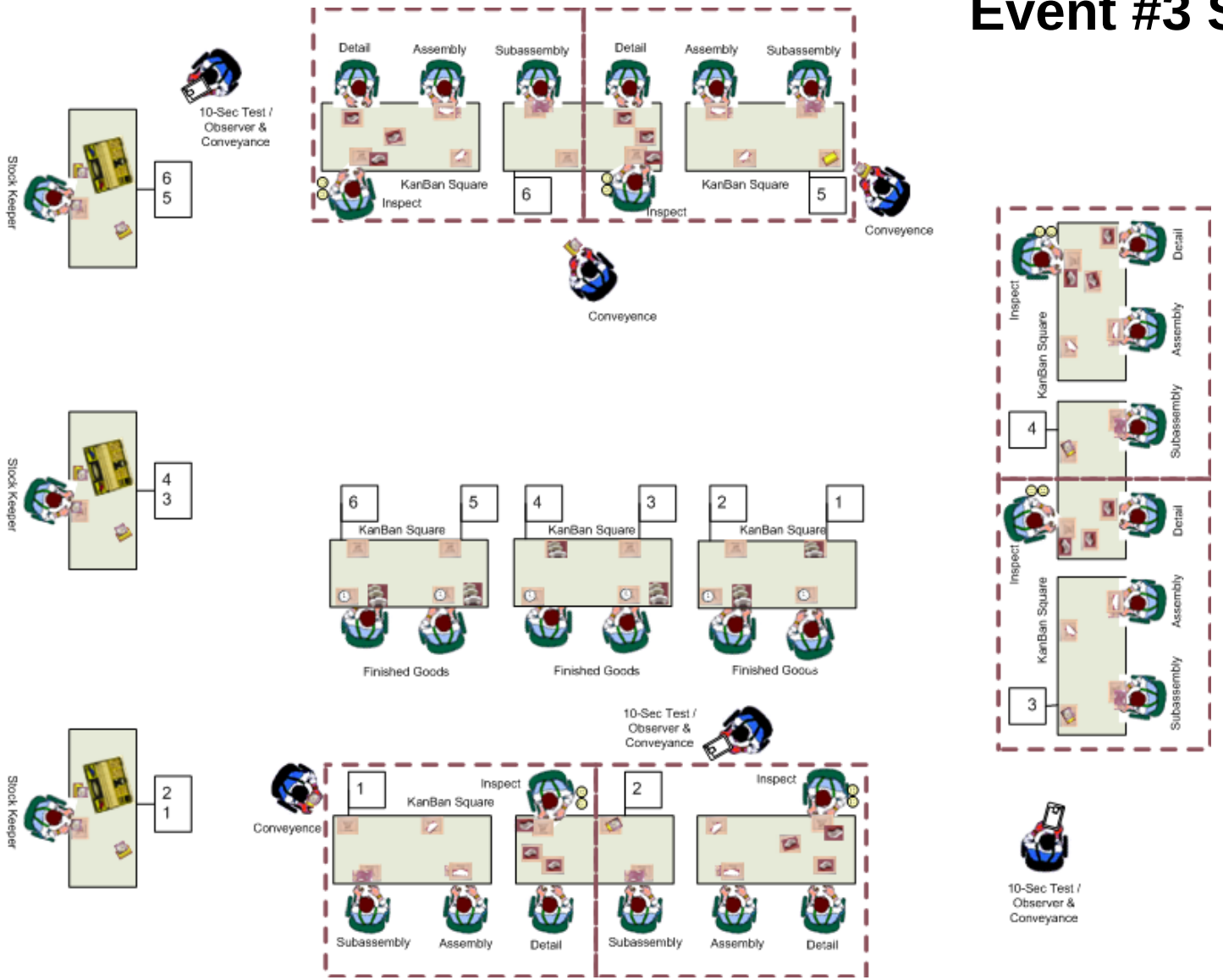
Event #3 Setup



Factory Simulation – Exercise #3 1-PC PULL

Six assembly teams organized in work cells with kanban squares

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Facilitator Instructions:

Event Number 3 – Continuous Flow Pull with kanban flow control.

Facilitator talking points:

Department # 1: STOCKKEEPER: pick a 1-pc job: place all parts for one car into a bag and place the bag into a large yellow container. Container is moved to the output Kanban Square. The kanban square can hold only a maximum number of the kit totes at any given time, so the Stockkeeper must wait to place the next kit into the kanban until the square is below it's max level. In this case, the level is 1 kit. Quality Nonconforming: substitute a black wheel into one of every two kits delivered to each team and observe the affect on flow. Discontinue using the black wheels for any team that tells you to stop.

1. Everyone except the Stockkeeper starts out the "day" idle, although the 1-piece batch may not be optimum for someone picking kits. What affect does this change have on the Stockkeeper's time? What effect is the kanban square having on work load for the Stockkeeper?
2. Is the the upstream process still stopping as often now waiting for totes and bags to return from downstream?
3. Notice how each of the two teams fed by the stock room must wait for the Stockkeeper to become available to service their line, which is also influenced by their own ability to pull a kit from the Stockkeeper's kanban.
4. Picking kits into bags and then into totes and then de-kiting right away at the next step is still a lot of double handling of material
5. What effect did the requirement to move the kits by kanban have on delivery to the shop? Did the Stockkeeper hold any completed kit bag waiting for the kanban to empty? What effect is this having on excess kits being picked at the stock room?
6. Could this same Stockkeeper also pick batch kits for a few other production lines and still keep up with demand? If this same stock keeper were picking kits for all 6 production lines, would each line be satisfied with their flow?
7. What is the effect of distance between the stockroom and the work area? How well does the Conveyance Person keep up with flow when kanban squares are used? Did you need more people?

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Facilitator Instructions:

Event Number 3 – Continuous Flow Pull with kanban flow control.

- **Facilitator talking points**:

  Department # 2 (now the Work Cell): SUBASSEMBLY: unpack the kit and return the containers to Dept # 1. Assemble a wheel & break & axle subassembly and place it in the input kanban square for Assembly. When the max of 4 subs are in the square, wait until one is pulled by the Assembler before placing the next into the square. The car body is also placed into the square with a max level on 1 pc. Continue pulling kits and building subs as fast as the kanban limits allow.

  1. Note: build using the painted wheel if supplied, since you are not trained to inspect.
  2. Note: all movement between internal work cell steps are by kanban square control to the next person. Movement between external departments is accomplished by placing material in the Work Cell's output area and calling out "conveyance." The Conveyance person will pick up the material and deliver it where needed but only if the department's input kanban limit has not been reached.

1. What are the 10-Second Test observers seeing during the first half of the "8 minute day" ? What changes in WIP and Flow are evident with the use of the kanban control system? What remains the same?
2. Notice how the upstream process work is still constrained by the reverse flow of containers and bags. Work stops when no totes and bags are returned from downstream. The work focus should be clearing up a bit since the movement of all material in the line is synchronized to the kanban constraints. When there is distance between functional departments and the Work Cell, how well does the kanban work in "communicating needs" between departments? What does this do in optimizing each department for their own best process? Are their frustration levels increasing because of this control placed over their freedom to produce?
3. Notice the non-conforming quality defect still passes right through this process, since the assembler isn't expected to inspect. Look for any other workmanship quality defect, watch for wheels facing inward, or disks placed on backwards. Does the kanban regulator help improve quality?

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Facilitator Instructions:

Event Number 3 – Continuous Flow Pull with kanban flow control.

- **Facilitator talking points:**

  Department # 3 (now the Work Cell): ASSEMBLY: pull a car body and subs from the input kanban. Assemble 4 wheel subs onto a car body and move the car to the input kanban square for the Detail person, if the limit has not yet been reached. Continue pulling material and assembling car as fast as material is available. If a rejected car is returned from Inspection, repair it. Ask the Stockkeeper for any necessary new (unpainted) parts (call a conveyance person to obtain the part). Move the car to the Detail input kanban after repair.

  1. Note: build new cars using the painted wheel subassembly if supplied, since you are not trained to inspect.
  2. Note: install the subs onto the car body following the process instruction closely. Do not interpret beyond the instruction provided. Remember, you are not trained to inspect, so let the inspection department do it's own work.
  3. Note: all movement between internal work cell steps are by kanban square control to the next person. Movement between external departments is accomplished by placing material in the Work Cell's output area and calling out "conveyance." The Conveyance person will pick up the material and deliver it where needed but only if the department's input kanban limit has not been reached Notice as the factory continues to run, there are still people down stream not working.

1. When a nonconforming car is returned from inspection, what did it do to the flow? What decisions were made by the assembler concerning when to do new work versus old repair? How did the Assembler fit the repaired car into the kanban control?
2. How has standard work been defined in this 1-pc flow with kanban control? Is the touch labor required to assemble the car consistent throughout all the exercises?
3. Was a Conveyance Person assigned to move materials between the work cell and Inspection? How did the rejected material affect this person's work load?

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Facilitator Instructions:

Event Number 3 – Continuous Flow Pull with kanban flow control.

- **Facilitator talking points:**

  Department # 4 (now the Work Cell): DETAIL: The Detail person pulls a car from the input kanban and adds headlights and tail lights to the car by applying small yellow and red stick-on dots (3/16” round dots are available from an office supply store). When complete, the car is placed into the Inspection input kanban square.

1. Notice how material flows under control of the kanban squares. Is flow smooth or intermittent? What would make flow start and stop between process points? How can better work balance help this effect?
2. Notice now the factory is running at each stage. Are there still periods when people upstream are not working?
3. How is the flow of bags and containers back upstream working out? Any work stoppages? Has the elimination of holding fixtures inside the work cell provided any advantage to flow?
4. What does the WIP look like? Are piles of material still sitting idle along the flow? How is the balance of worker time in the cell? Did the kanban change anything from the previous flow methods?
5. How is the balance of worker time at each department. Is there any obvious bottleneck operation?

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Facilitator Instructions:

Event Number 3 – Continuous Flow Pull with kanban flow control.

- **Facilitator talking points:**

  Department # 5 (now the Work Cell): QUALITY INSPECTOR – pull a car from the kanban and inspect that all four wheels rotate freely, all wheels are plain (not painted). If the car is rejected, return the car back to the Assembler in the Work Cell for repair. Once a car passes inspection, move the car to the Work Cell output and call “conveyance” to move it to Finished Goods. Keep track of the number of rejected cars. Upon the first instance of rejecting a painted wheel, call conveyance and send a message to the Stockkeeper to stop using painted wheels.

1. Notice how the rejection of a car inside the Work Cell is less intrusive on flow. How does the use of a Work Cell and handling of quality problems impact customer delivery?
2. Once the Stockkeeper is notified to stop using painted wheels, how long does it take to clear the line? How many additional rejects are counted from the time of notification?
3. What does the WIP look like with kanban control? Are there any piles of material sitting idle along the flow? How is the balance of worker time affected ?
4. Notice any other workmanship quality defect, such as wheels that won’t rotate. Are inspectors allowed to do minor rework at your company? Or do they push the defect back upstream for rework? For fun, have your inspector perform the rework. How would this affect the flow?

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Facilitator Instructions:

Event Number 3 – Continuous Flow Pull with kanban flow control.

- **Facilitator talking points**:

  Department # 6: FINISHED GOODS / Timekeeper: Time the simulation and complete the time metric form. Control the start and stop time and the stopwatch, and record the time the 1st car reaches finished goods, the time the 1st delivery is made to the customer, and the time the 2nd delivery is made. If possible, record the time for the quality defect (painted wheel) to travel the line from injection into the stream to repair. **Call STOP when 8 minutes are up if a delivery has been made, or call "Overtime" and allow up to 2 more minutes to attempt a delivery.**

1. **Large Group Constraint: if the single kit stopwatch is shared between two teams, then a single timekeeper controls the watch and calls out start and stop and OT. The second team's timekeeper will record their time metrics by asking for the time. The two participants should be located near each other.**
2. Metrics: Complete the Financial Calculation Metrics Form with help from the facilitator and the team.
3. ***10-Second Test Form:***
   1. ***Observers complete the 10-Second Test form with the VA/NVA observations. Plot the results or use the excel spreadsheet provided if a laptop is available (built in calculations and plots). What percentage of time was pure waste?***
   2. ***Record NVA observations on flow for later comparison.***
   3. ***Have the observation team question the participants on any part of the process to confirm the observations.***
   4. ***Hold a Kaizen event with all of the participants and observation teams from the large group to discuss how they would improve the Work Cell Pull process (stay with kanban control and 1-pc flow pull methods for purposes of this exercise, and see how much improvement can be made)***
   5. ***Reset one production line and with all large group participants present, run the single line for 8 minutes and determine if the improvements were sufficient to satisfy the customer's on-time delivery requirement.***

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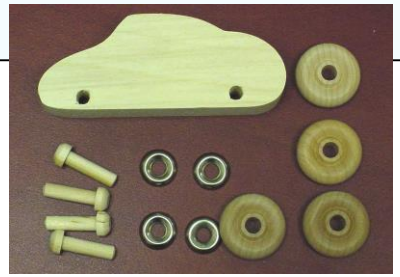
Department #1

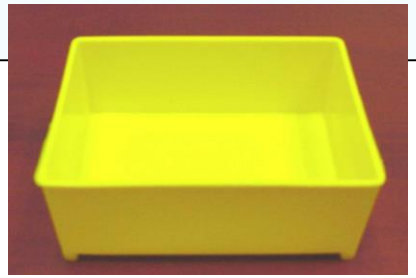
Continuous Flow - Pull

Stockkeeper:

1 Pick a kit for 1 car into a plastic bag, zip lock the bag and place the bag into a large yellow container.
2 Move the job to the output kanban and call "conveyance." When supporting two teams, use a kanban square for each team and keep each at it's max limit if possible.
3 Repeat the operation as quickly as possible, but you do not exceed the kanban limit.

NOTE: insert one painted wheel into every other kit bag for each team until told to stop by the team's inspection person (via conveyance).





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Department #1

Continuous Flow - Pull

Maximum:
1 Job
in this square
at any one time

Place this kanban at output from Stockroom

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Department #2

Continuous Flow - Pull

Maximum:
1 Job
in this square
at any one time

Place this kanban at input to Subassembly

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Department #2

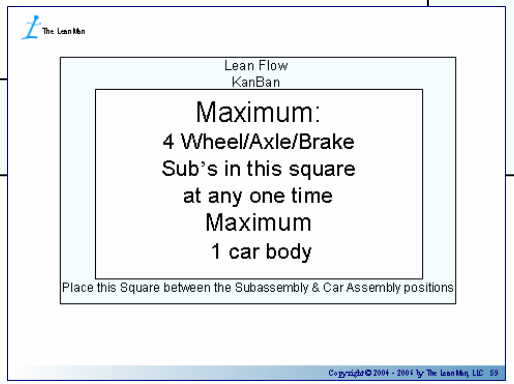
Continuous Flow - Pull

WORK CELL - SUBASSEMBLY:

1 Pull a kit from the kanban input. Remove material from plastic container. Place empty container in Work Cell output for return and call "Conveyance."

2 Assemble wheel/ axle/ brake and place sub assembly into the kanban square. Do not exceed 4 subs at any one time. Place a car body into the kanban

4 Pull and repeat for the next set of material, always keeping the downstream kanban full.



Department #3

Continuous Flow - Pull

Maximum:

4 Wheel/Axle/Brake Sub's in this square at any one time

Maximum

1 car body

Place this kanban between the Subassembly & Assembly positions

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Department #3

Continuous Flow - Pull

WORK CELL - ASSEMBLY:

1 Pull a car body and subs one at a time from the input kanban and attach each to the car body, use clockwise twist as you insert the axle peg.
2 Move the completed car to the input kanban for the Detail person.
3 Pull and repeat for the next set of material, always keeping the downstream kanban full.

Ergonomic Assembly Tool

Use of the tool is highly encouraged to prevent sore fingers over the duration of the simulation event.

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Department #4

Continuous Flow - Pull

Maximum:
1 car
in this square
at any one time

Place this kanban between Assembly and Detail

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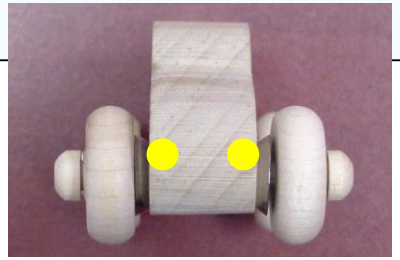
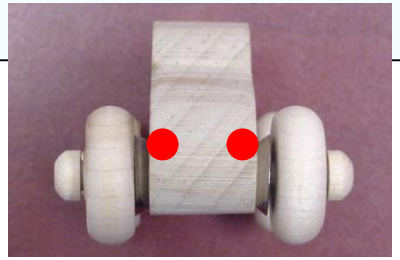
Department #4

Continuous Flow - Pull

WORK CELL DETAIL:

1 Pull the next car from the kanban and apply two yellow stick-on dots to the front of the car as headlights.
2 Apply two red stick-on dots to the back of the car as tail lights.
3 Move the completed car into the Inspection kanban.
4 Pull and repeat for the next set of material, always keeping the downstream kanban full.





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Department #5

Continuous Flow - Pull

Maximum:
1 car
in this square
at any one time

Place this kanban between Detail and Inspection

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Department #5

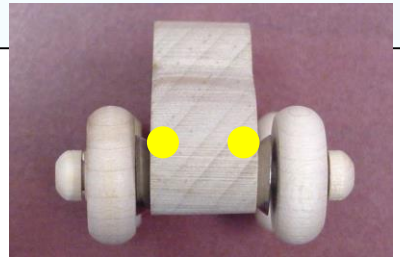
Continuous Flow - Pull

WORK CELL INSPECTION:

1 Pull the next car from the kanban. All 4 wheels must rotate freely.

2 All 4 wheels unpainted. Return any rejected cars to the Assembler for repair, ***and tell the stock keeper to stop using painted wheels.***
(the conveyance person carries the message)

3 If the car is acceptable, place the car in the Work Cell output and call “conveyance.”



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Department #6

Continuous Flow - Pull

Maximum:
3 cars
in this square
at any one time

Place this kanban between Inspection and Finished Goods

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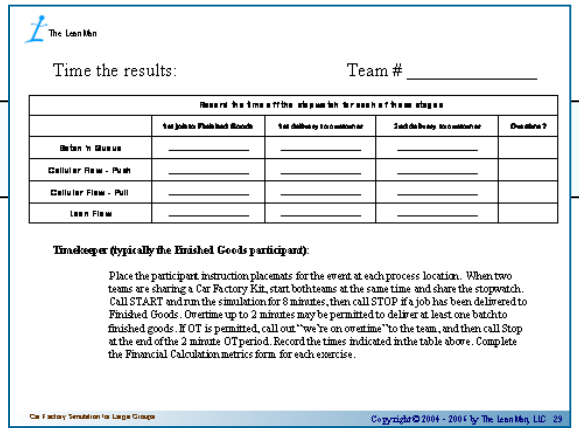
Department #6

Continuous Flow - Pull

Finished Goods / Timekeeper

1. Start the exercise by starting the stopwatch and calling go.
2. Deliver cars in sets of 3, the 1st at 4.0 minutes and the 2nd at 8.0 minutes. Do not deliver early
3. Record the metrics in the spaces provided on the time the results form for exercise 2. Follow the instructions on the form for event timing requirements.
4. Complete the Financial chart with the help of the facilitator.



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Time the results: Team # _____

	1st job to Finished Goods	1st delivery to customer	2nd delivery to customer	Overtime?
Batch 'n Queue	_____	_____	_____	
Cellular Flow - Push	_____	_____	_____	
Cellular Flow - Pull	_____	_____	_____	
Lean Flow	_____	_____	_____	

Timekeeper (typically the Finished Goods participant):

Place the participant instruction placemats for the event at each process location. When two teams are sharing a Car Factory Kit, start both teams at the same time and share the stopwatch. Call START and run the simulation for 8 minutes, then call STOP if a job has been delivered to Finished Goods. Overtime up to 2 minutes may be permitted to deliver at least one batch to finished goods. If OT is permitted, call out "we're on overtime" to the team, and then call Stop at the end of the 2 minute OT period. Record the times indicated in the table above. Complete the Financial Calculation metrics form for each exercise.

Car Factory Simulation for Large Groups

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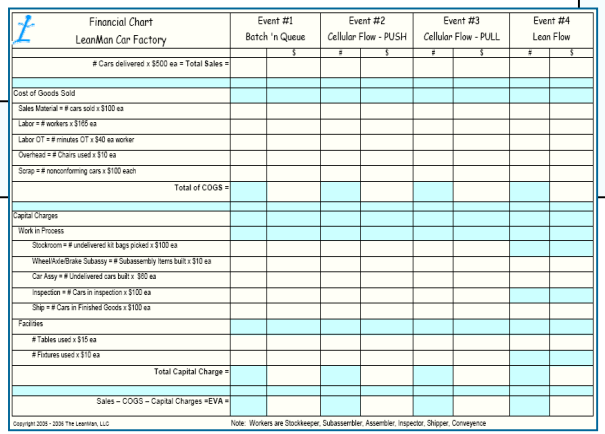

Financial Chart LeanMan Car Factory	Event #1 Batch 'n Queue		Event #2 Cellular Flow - PUSH		Event #3 Cellular Flow - PULL		Event #4 Lean Flow	
	#	$	#	$	#	$	#	$
# Cars delivered x $500 ea = Total Sales =								
Cost of Goods Sold								
Sales Material = # cars sold x $100 ea								
Labor = # workers 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 =								

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

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Event #3 Post Discussion

Facilitator Instructions:

At the end of the Continuous Flow - Pull exercise, discuss team observations and draw some conclusions.

What did we observe?

How well were work balance and inventory distribution managed in this exercise?

Did we make the customer happy? What was the on-time delivery metric? Quality metric?

Discuss how the 8 wastes were apparent:

Overproduction –
Waiting –
Conveyance –
Over processing –
Excess Inventory –
Unnecessary Motion –
Defects –
Human Creativity –

Best Practice

Before moving on to event #4, have the team review the process for event #3. Stay within the same parameters of 1-pc pull using a signal mechanism when the down stream process needs more input. List improvements that would improve the final metrics in this type of flow.

Use just one of the team setups and implement as many creative improvements to the flow as the students can think of to improve the flow, work balance, quality, inventory management and on-time delivery. Be sure to stay within the constraints of the Work Cell technology (external functional departments each optimized for their own best interest, and a pull mechanism to control material movement). Run the simulation again to verify the new process and compare the results to the recorded metrics chart for event #3. Would the customer be happier with these improvements?

Many companies attempt to implement Lean Principles creating work cells, but still have difficulty seeing the need to disconnect the MRP Push system at the shop door. In the next event we will advance the work cell concept to disconnect from MRP and implement a Customer driven demand-pull system. MRP continues to be used to drive raw material to marketing forecast.

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Lean Factory Simulation Kits

Lean Principles

Facilitator Instructions

Lean Car Factory Simulation

Event #4 Lean Flow

Large Group Version

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Event #4

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

The Zoom-Zoom car factory wants to continue to use the work cell arrangement, and wants to implement several additional lean techniques such as a Customer-Pull-Demand system, point of use inventory (POU) and certified inspection assemblers (CI) who can perform inspection as well as build the product. See setup for event #4 for suggested table arrangement and participant seating. Departments #1 and #5 functions are blended into the work cell. Totes, bags and fixtures are not used.

If Finished Goods is physically close to the output of the work cell the conveyance function may be eliminated. If, then continue to call conveyance when a car is ready to be delivered into finished goods.

Divide the 20 pc set of kit materials in half for each team, and 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 Subassembly. Place the container of car bodies in a POU area next to Final Assembly, and if used, place the headlight and tail light dots at the Detail position. Train (certify) the Subassembly and Final Assembly 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.

Department #2 / Work Cell The wheel, axle and disk components are assembled together, inspected, and placed into the downstream kanban square. No more than 4 subassemblies at any one time. The Final Assembly person removes the subassemblies from the kanban one at a time and attaches each to a car body taken from the POU inventory. *Be sure to use the ergonomic tool.* The assembled car is inspected to assure all four wheels rotate freely and all for match in color, repaired as necessary, then the car passes to the Detail stage input kanban (1 car maximum), if this position is used, where head light and tail lights are applied. The car is moved to the output kanban (1 car maximum) and, “conveyance” is called out.

Conveyance hears the call, checks the input kanban square at finished goods department #6 and, if below the maximum of 3 cars, picks up the job from department #2 and delivers it into the input kanban of department #6. If department #6’s input kanban still holds the maximum number of cars the new car is left in the output of department #2 until able to be moved. This conveyance position may be eliminated if the work cell output is located near the finished goods input location.

Department #6 The cars are removed from the input kanban and moved to the finished goods warehouse (3 cars max) where the cars are grouped into customer order quantities and delivered according to the delivery schedule. Customer demand is 3 cars every 4 minutes (TAKT = 1.33 minutes) as defined on the laminated ON Time Delivery chart at shipping. Do not deliver early, and record the time from the stopwatch when actually shipped.

Timekeeper: control the event start and stop time; record the time the 1st job reaches finished goods, and the time for the first delivery of 3 to the customer. Run the simulation for 8 minutes. It is permissible to run up to an additional 2 minutes of overtime if needed to deliver the first batch to the customer. Call out “we are on over time” if this occurs. Complete the Financial Metrics chart.

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Value Stream Map – Event #4

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

Improvement

- NVA changed because externam stock keeper and inspection functions incorporated. Drops from 0.3 to 0
- Quality nonconforming material unlikely to be flow problem
- VA time reduced from 3.6 to 1,1

Future State
1-pc Lean Pull w/ kanban
Control, POU, CI
Simulation exercise

To run the LeanSim simulation exercises in a continuous loop, the finished cars are disassembled and the raw materials returned to the 'supplier' stage. This can be performed by the 'planner' or by other participants in the exercise.

Supplier

Order supply

Production Planning 1

Forecast

Customer

Upon demand

Pack & Ship Schedule

3 Cars Every 4 minutes

Wheel/axle/brake components

Car Body components

Head Light / Tail Light components

Work Cell
Operators in Close Proximity

Milk Run

I

Withdrawal

Axle 40.00=0.22d
$0.00
Brake Disk 40.00=0.22d
$0.00
Wheel 40.00=0.22d
$0.00
Car Body 10.00=0.22d
$0.00

Department #2 Subassembly 1

FT	0.30 mins
MT	0.30 mins
AT	0.00 mins
CO	0.10 mins
YLD	100.00%

4 Subs Max
1 car body

Withdrawal

Department #3 Final Assembly 1

FT	0.30 mins
MT	0.30 mins
AT	0.00 mins
CO	0.10 mins
YLD	67.00%

1 Car Max

Withdrawal

Department #4 Detail - optional 1

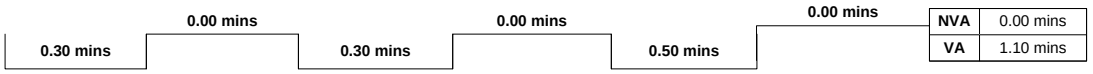
FT	0.25 mins
MT	0.25 mins
AT	0.00 mins
CO	0.10 mins
YLD	67.00%

3 Cars Max

Withdrawal

Department #6 FG / Shiptable 1

FT	1.00 mins
MT	0.10 mins
AT	0.00 mins
CO	0.00 mins
YLD	100.00%



NVA	0.00 mins
VA	1.10 mins

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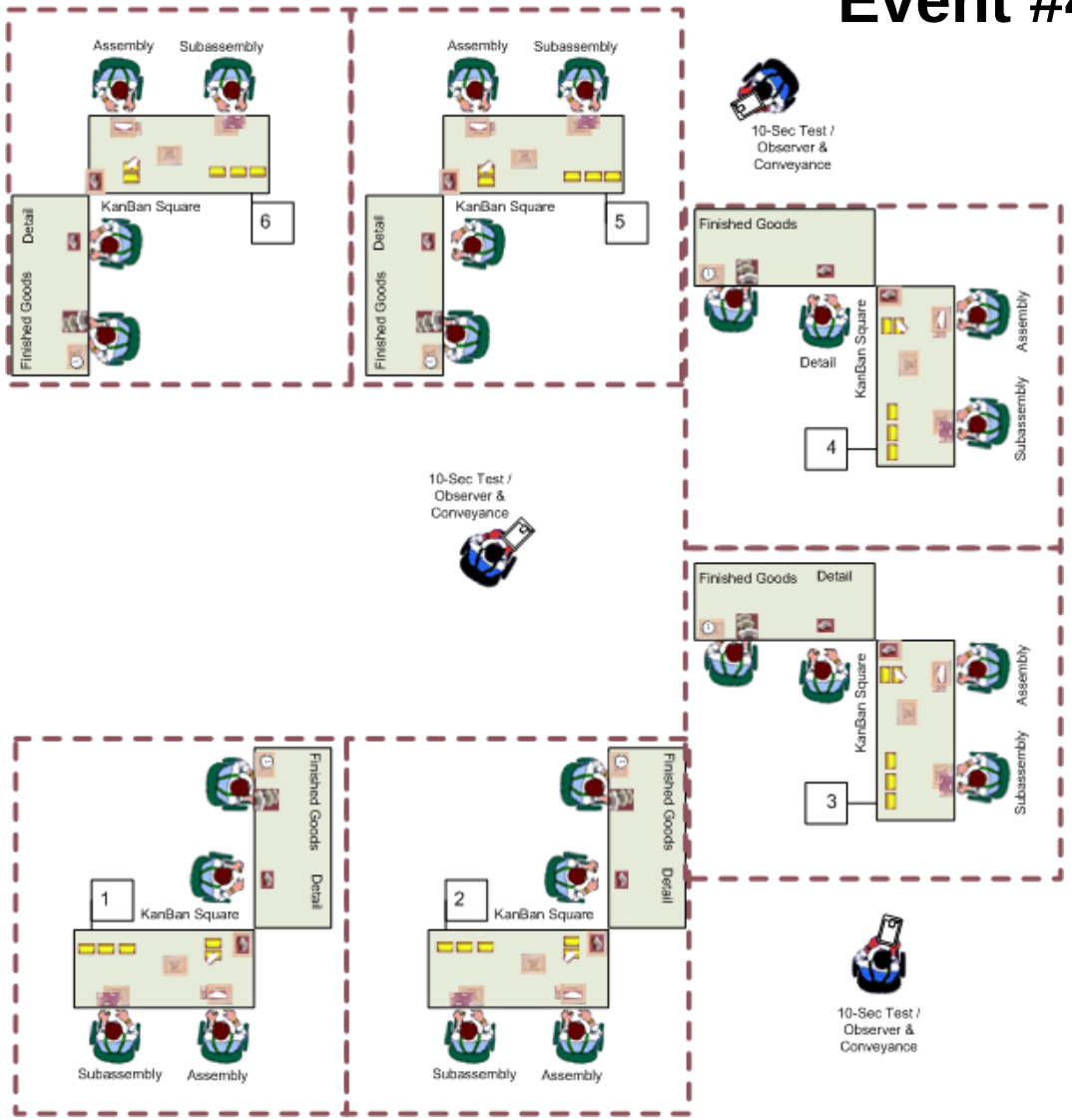
Event #4 Setup



Factory Simulation – Exercise #4 Lean FLOW

Six assembly teams organized in work cells with kanban squares, POU inventory and CI assembly

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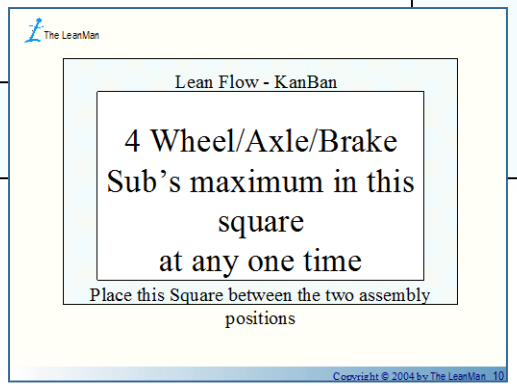
Work Cell
Lean Flow

Subassembly:

1 Pick material from the POU bins, inspecting for nonconforming material (discard and do not use and painted wheel)

2 Assemble wheel onto axle, slip disk brake onto axle, Place sub assembly into the KANBAN square. *No more then 4 at any one time*



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Work Cell

Lean Flow

Maximum:
4 Wheel/Axle/Brake
Sub's in this square
at any one time

Place this kanban between the Subassembly & Car Assembly positions

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Work Cell
Lean Flow

Car assembly:

1 Pick the car body from the POU material and pick each wheel subassembly from the kanban square as needed, inspecting for (and rejecting) any with a painted wheel.

2 Attach each wheel subassembly to the car body, use clockwise twist as you insert the axle peg, and inspect for freely rotating wheel. Adjust as required.

3 Place sub assembly into the kanban square. No more then 1 at any one time

Use of the tool is highly encouraged to prevent sore fingers over the duration of the simulation event.

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Work Cell

Lean Flow

Maximum:
1 car
in this square
at any one time

Place this kanban between the Car Assembly and Detail positions

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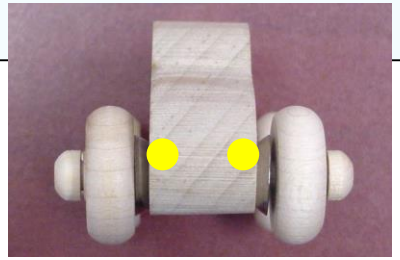
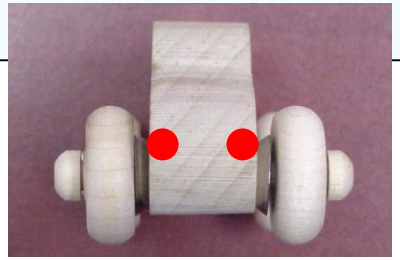
Work Cell
Lean Flow

WORK CELL DETAIL:

1 Pull the next car from the kanban and apply two yellow stick-on dots to the front of the car as headlights.
2 Apply two red stick-on dots to the back of the car as tail lights.
3 Move the completed car into the Inspection kanban.
4 Pull and repeat for the next set of material, always keeping the downstream kanban full.





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Work Cell

Lean Flow

Maximum:
3 cars
in this square
at any one time

Place this kanban between Car Detail and Finished Goods

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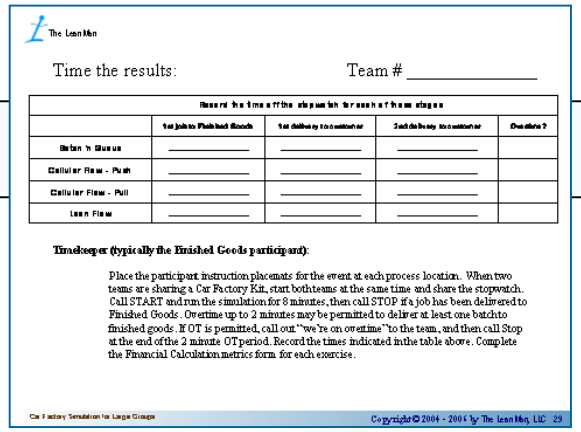
Department #6
Lean Flow

Finished Goods / Timekeeper

1 Start the exercise by starting the stopwatch and calling go.
2 Deliver cars in sets of 3, the 1st at 4.0 minutes and the 2nd at 8.0 minutes. Do not deliver early.
3 Record the metrics in the spaces provided on the time the results form for exercise 2. Follow the instructions on the form for event timing requirements.
4 Complete the Financial chart with the help of the facilitator.


The LeanMan

Time the results: Team # _____

	1st job to Finished Goods	1st delivery to customer	2nd delivery to customer	Overtime?
Batch 'n Queue	_____	_____	_____	
Cellular Flow - Push	_____	_____	_____	
Cellular Flow - Pull	_____	_____	_____	
Lean Flow	_____	_____	_____	

Timekeeper (typically the Finished Goods participant):

Place the participant instruction placemats for the event at each process location. When two teams are sharing a Car Factory Kit, start both teams at the same time and share the stopwatch. Call START and run the simulation for 8 minutes, then call STOP if a job has been delivered to Finished Goods. Overtime up to 2 minutes may be permitted to deliver at least one batch to finished goods. If OT is permitted, call out "we're on overtime" to the team, and then call Stop at the end of the 2 minute OT period. Record the times indicated in the table above. Complete the Financial Calculation metrics form for each exercise.

Car Factory Simulation for Large Groups

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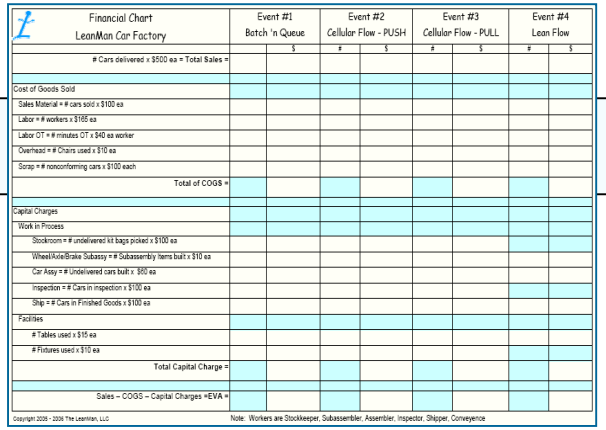
Financial Chart LeanMan Car Factory	Event #1 Batch 'n Queue		Event #2 Cellular Flow - PUSH		Event #3 Cellular Flow - PULL		Event #4 Lean Flow	
	#	$	#	$	#	$	#	$
# Cars delivered x $500 ea = Total Sales =								
Cost of Goods Sold								
Sales Material = # cars sold x $100 ea								
Labor = # workers 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 =								

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

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Event #4 Post Discussion

Facilitator Instructions:

At the end of the Lean Flow – Customer Demand-Pull exercise, discuss team observations and conclusions.

What did we observe?

How well were work balance and inventory distribution managed in this exercise?

Did we make the customer happy? What was the on-time delivery metric? Quality metric?

Discuss how the 8 wastes were apparent:

Overproduction –
Waiting –
Conveyance –
Over processing –
Excess Inventory –
Unnecessary Motion –
Defects –
Human Creativity –

Best Practice

Before ending event #4, have the team review the process for the event. Stay within the same parameters of 1-pc pull using a signal mechanism starting with customer delivery and drawing into the down stream process to fill the void. List improvements that would improve the final metrics in this type of flow.

Use just one of the team setups and implement as many creative improvements to the flow as the students can think of to improve the flow, work balance, quality, inventory management and on-time delivery. Be sure to stay within the constraints of Lean Principles. Run the simulation again to verify the new process and compare the results to the recorded metrics chart for event #4. Would the customer be happier with these improvements?

Many companies still have difficulty with supply chain management. In an optional next step, run just one work cell and use the car kit materials to operate a supply source. Implement signals from each POU inventory area to signal the supplier to send more material when needed. A two-bin kanban works well. Add a Customer function to randomly order quantities of cars. Delivery sequence is at the guaranteed rate of 1.3 minutes per car. Run the Customer driven demand-pull system and observe the results.

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Time the results: Team # _____

Record the time off the stopwatch for each of these stages				
	1st job to Finished Goods	1st delivery to customer	2nd delivery to customer	Overtime?
Batcn 'n Queue	_____	_____	_____	
Cellular Flow - Push	_____	_____	_____	
Cellular Flow - Pull	_____	_____	_____	
Lean Flow	_____	_____	_____	

Timekeeper (typically the Finished Goods participant):

Place the participant instruction placemats for the event at each process location. When two teams are sharing a Car Factory Kit, start both teams at the same time and share the stopwatch. Call START and run the simulation for 8 minutes, then call STOP if a job has been delivered to Finished Goods. Overtime up to 2 minutes may be permitted to deliver at least one batch to finished goods. If OT is permitted, call out “we’re on overtime” to the team, and then call Stop at the end of the 2 minute OT period. Record the times indicated in the table above. Complete the Financial Calculation metrics form for each exercise.

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Financial Chart LeanMan Car Factory Large Group	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								
Car Detail = # Undelivered cars detailed x $10 ea (if used)								
Inspection = # Cars in inspection x $100 ea								
Total WIP Inventory		$ -		$ -		$ -		$ -
FGI = # Cars in Finished Goods x $100 ea (not part of WIP)								
Facilities								
# Tables used x $15 ea								
# Fixtures used x $10 ea								
Total Capital Charge =								
Sales – COGS – Capital Charges =**EVA =**								
Production Velocity (8 minute run plus OT)								
Number of Minutes Worked								
Number of Cars Produced (sold + FG Inv)								
Production Rate =								

Note: Workers are Stockkeeper, Subassembler, Assembler, Detailer, Inspector, Shipper, Conveyence
items in transit are assumed to be at the output where they were picked up by conveyance

Financial Chart is available as an Excel File on the CD

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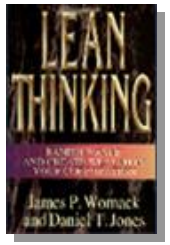
References:

Lean Thinking

Author: Daniel Jones, James Womack
Publisher: Simon & Schuster
Publication Date: 9/9/1996

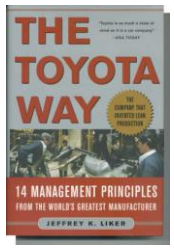


New Manufacturing Challenge: Techniques for Continuous Improvement

Author: Kiyoshi Suzaki
Publisher: The Free Press, a division of Simon & Schuster
Publication Date: 1987

The Toyota Way

Author: Jeffrey K. Liker
Publisher: McGraw-Hill
Publication Date: 2004



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