Heijunka

Leveling the waves

Lean Manufacturing

Lean Manufacturing's objective is to create the physical environment that will allow material to flow from raw material to finished product and on to the customer – when the customer wants it and in the quantity the customer wants. In doing this, Lean eliminates waste and wasteful practices, reduces costs and cuts lead times - while synchronizing all production and purchasing activities.

Its primary components are

- standard work,
- visual management,
- heijunka (hi-e-june-ca),
  - takt time,
  - one-piece flow,
  - kanban,
  - EPEI, (every part every interval)
- and planning.

Establish the work environment

Critical to implementing a continuous improvement program for any product is the establishment of the boundaries of the world in which the product must live. This establishes the uncertainty in which the daily “good” decisions are expected to be made by people at the levels closest to touching the product in the flow, and how robust the process must be to support those decisions made in the face of this uncertainty.

- Material availability and delivery system
- Customer demand logic
- Production build logic
- Product Mix
- Finished Goods Logic

Establish the work environment

- Material availability and delivery system:
  - What is your world like? Which of these material systems have influence over the work teams ability to flow product?
  - Picked kits from stock in a buffer inventory (MRP push)
    - Control is outside; requires waiting for someone else; usually requires buffer inventory of kits picked several days ahead of need; requires receiving & stockroom material process time be included in the purchasing lead time (L/T).
  - Material is clear to build JIT to actual need
    - What percent of kits picked have a stock-out problem.
    - What are the rules for safety stock, buffer inventory, and material management for shortages.
  - Material handling systems that require a large proportion of extra handling
    - Bag ‘n tag all material into a kit; bag ‘n tag large items and use material kits for hardware; bag ‘n tag large items and 2-bin kanban trays for hardware; local Point of Use (POU) for all items; local POU for large items and kanban tray for hardware.
  - ***Local POU inventory picked on demand (kanban pull) [preferred]***
    - Control is inside the work team but requires adding resource time;
    - usually involves additional skill set development;
    - material can arrive just in time to the POU as long as it is available when the operator needs it;
    - allows shrinkage of receiving & stockroom material process lead time.

Establish the work environment

- Customer demand logic:
  - What are your customer’s expectations?
  - Firm sales far in advance of material lead time.
    - Long term contracts, military contracts, and certain special customer situations like uncancelable contracts allow sufficient material lead time to assure near-zero stock-out will occur during production.
    - Carrying high levels of inventory long in advance of need carries with it huge hidden factory costs of floor space, material handling, storage overhead, poor use of cash , etc.
  - Forecast with firm conversion at or just inside material L/T
    - High risk because material is ordered in advance of firm order and any product mix inaccuracies in the forecast will amplify through purchasing and MRP to cause unpredictable stock-outs and excess use of resources expediting.
    - Conversions close to L/T assume the material lead times loaded into the MRP system are accurate and supportable by the suppliers.
  - Forecast a range of mix with firm conversion inside mfg L/T
    - Higher risk than described above, and results in juggling shop orders to fit the demand to available resources as material becomes clear on a job by job basis.
    - Very high levels of personal involvement by shop supervisors, planners and and support personnel.
    - Huge cost of hidden factory in storage, handling, inventory, and expediting.
  - ***Firm sales and forecast conversions at short material L/T and short mfg C/T***
    - Items not in a consistent flow are held to a short but still realistic material L/T, say 12 or 16 weeks max.
    - Items not active are held to standard L/T (16 to 24 weeks).
    - Items actively inbound are enabled with very short L/T and accompanied with pull from supplier to replenish (a few hours to a couple weeks).
    - Mfg cycle time is held as short as possible using lean mfg methods.
    - Helps to reduce the hidden costs described above, but slight risk still present.

Establish the work environment

- Production build logic
  - What is your production management style? All hands busy all the time? - or produce only what is sold and only just when the customer wants it?
  - Build firm sales far in advance of delivery (carry Finished Goods)
    - Typical MRP push system, build to MRP calculated dates with excessively long mfg lead times.
    - If CRP (capacity resource planning) is enabled, will also require high level of support in maintaining accurate standards, resource availability, and consistent skills and execution on the part of the human resources.
  - Build firm sales and wait for forecast conversions at L/T (carry Finished Goods)
    - Similar issues as above, but with an increased uncertainty on resource demand in the timeframe required.
    - Increased costs due to uncertainty, and a high probability of overtime.
  - Build firm sales only and roll forecast to lead time (carry Finished Goods)
    - Same issues as above, but detracts from customer satisfaction placing burden on the customer to know what they want and when – very unlikely.
  - Build firm plus forecast range of mix into Finished Goods
    - Improves customer satisfaction on certain products and misses the mark on others.
    - Causes consumption of inventory ahead of need and may as a result prevent the ability to build what is needed with some of that same set of parts.
  - ***Build firm sales only JIT (carry near-zero Finished Goods)***
    - Requires a very fast and flexible production system which can react with very short cycle times.

Establish the work environment

- Product Mix
  - What logic do you use to establish work teams? Typically, we want to create product group assignment by similar characteristics.
  - By human resource skill set
    - Solder or welding, hand tools and mechanical assembly, special tooling and fixtures use.
    - Inspection certification requirements, special process training.
  - By machine resource type
    - Unique, shared, fixed cycle like an temperature chamber, random cycle like moisture removal
  - By material resource types
    - Electronic, mechanical, heavy, light
  - By model changeover time
    - Should be similar, short, and less than takt time
  - By customer
    - Product lines devoted to specific customer versus single line distributing to several customers
    - Shared material or independent material stores to support the line
  - By project manager
    - Similar to customer above
  - ***By finite resource allocation and group technology***
    - As the above concerns are identified and product is categorized, the final arbiter of group assignment is the cycle time by resource as developed using the **synchronous flow chart**.

The LeanMan

Establish the work environment

- Finished Goods Logic
  - Finished goods supermarkets
    - Producing only to customer orders is, when practical, the best way to operate. However, producing to a small inventory may make more sense than flexing labor and plant processes to match day-to-day order variations. Products are often produced to a buffer called the finished goods supermarket rather than to customer orders.
    - For situations where the customer provides stable and reliable demand, it's often possible to operate with little or no finished goods supermarket. For a customer whose demand is highly variable, maintaining a larger supermarket will probably be required.
  - Supermarkets are essential for two reasons.
    - First, they provide a buffer of finished goods between highly variable customer demand and the pacemaker process that must run at a more stable and leveled rate.
    - Second, they can decouple processes that run at different rates, for example a finishing process that flows at a constant rate, and an earlier fabrication process with a long setup that runs large lot sizes at a much faster cycle time. This last type of supermarket does not contain finished goods but rather components that are used at the pacemaker.
  - Sizing the Supermarket
    - The size of an item's supermarket depends on the frequency of replenishment and the volume and variability of demand for the item.
    - Start with a reasonable buffer quantity of FGI on high sales items such that they are likely to sell off within a reasonable period (say 45 days.) Hold less of any item with lower sales volume and in reasonable proportion. Rarely sold product should be zero FGI and sold at full L/T.
    - As cycle time stabilizes, drive the buffer toward near zero.

The LeanMan

Establish the work environment

- Finished Goods Logic . . . continued
  - Pull replenishment – the ideal lean state.
    - Inventory for items in a supermarket is divided into equal units called kanbans. As a kanban-worth of inventory is consumed, it is reported. When the number of empty kanbans hits a predetermined level, a signal is generated to schedule replenishment. In a company with low setups, small order quantities, and lots of manufacturing flexibility, one kanban of consumption might signal one kanban of replenishment. In other cases, several kanbans may need to accumulate before a replenishment is signaled.
      - Demand for the item must be relatively repetitive.
      - Lead times must be relatively short.
      - Components must be available so an item can be produced on demand when the visual signal is generated.
  - ***Lean heijunka replenishment.***
    - Material Requirements Planning (MRP) systems assume an infinite production resource availability and tend to push jobs to the shop without regard to capacity, assuming the CRP module is not implemented.
    - With Lean, the traditional techniques often associated with MRP are shut off for items that are not being replenished using pull. For instance, order releasing based on planned order dates is replaced in favor of releasing only firm orders for sold items, and traditional shop floor control based on push dispatching rules are replaced with techniques used to create level demand using load-leveling mechanisms like the heijunka box or other level-scheduling methods for both volume and mix.
    - Typically MRP planning continues to drive material into the company based on both forecast and firm sales, and to run to project requirements for suppliers of purchased components and raw materials. The disconnection from MRP occurs at the conversion of firm orders into shop work orders by the planner.

Establish the product group

The next step is to use the information to create a subset of products that share a common set of criteria that can become an "independent" product line. The quotes indicate that this product group will have near exclusive use of the resources necessary to maintain a stable production flow, which is essential to calculating the takt time and maintaining feedback and control metrics.

We create a set of rules that we want to apply to the fixed resources used to produce the group, with each product in the group taking on a "resource utilization shape" or, as we'll call it, a "puzzle" shape. These puzzle shapes will be designed to fit together and fill up the available resource schedule, or "puzzle board" and will be key to determining capacity and schedule.

- **Each product is analyzed for min/max cycle time.**
- **Average cycle time determines "pitch."**
- **Each product is analyzed for pacemaker constraint.**
- **Each product requires a resource "puzzle shape."**
- **Each puzzle shape defines planning parameters.**
- **Puzzle board is key to defining finite capacity**
- **Finite capacity planning in your head**
- **The final Heijunka schedule**

Establish the product group

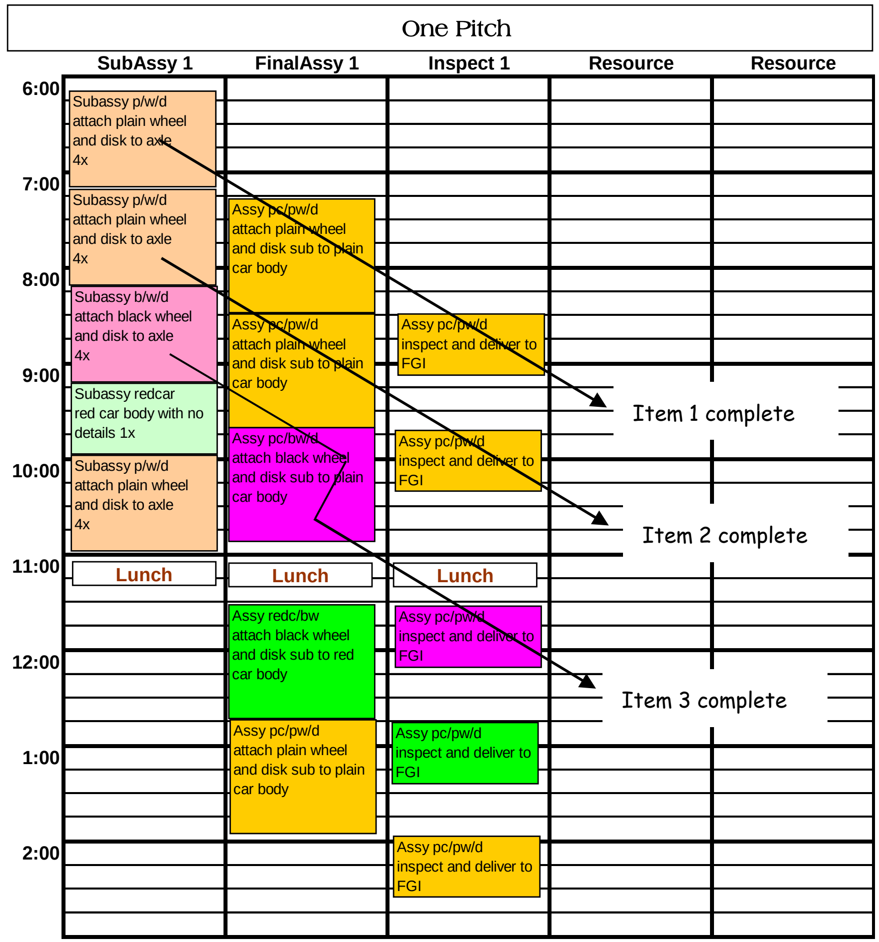
- Each product is analyzed for min/max cycle time.
  - The historical perspective on each product must be reviewed. Look for consistency in work order completion cycle time by resource and as defined by first labor applied to last labor applied. Ignore any queue time from release of the job until the first resource was available, and ignore any queue time the job sat waiting to be received into stock and the work order closed.
  - Look for unusual conditions that may have unduly influenced cycle time at this resource in a way that will unlikely occur in the short term future (say, less than weekly)
  - Categorize cycle time by resource. Draw out a sketch of the flow line and indicate the series of resources the product touches and the approximate amount of the cycle at that resource.

Assy	Cure	Assy	Test	Insp
1.2 hr	.5 hr	2 hr	1 hr	.1 hr

  - Look for patterns in the major resources, like assembly, test and temp chambers between products in the group. The final outcome will be a list of products with similar resource requirements. Resources may be used in multiples of a common denominator. Example, Prod A uses 1x assembly and 2x test, Prod B uses 1/2x assembly and 1x test. Two of product B can be produced in the same "resource shape" as one of Prod A.
  - Calculate the average cycle time for the first major resource, such as assembly, and round into increments of time no greater than ½ work shift. For purposes of this discussion, let the period be 4 hours and we'll call it the "half-day rate." By adjusting batch size, all grouped product should fit into some multiple of this half-day rate.
  - A useful tool to help assess a product resource utilization is the **synchronous flow chart**.

Establish the product group

- The synchronous flow chart.
  - The chart is a time oriented graph of the work shift, with time in increments of 15 minutes on the vertical scale.
  - The horizontal indicates the various resource elements that are available to the work team. In this example, there are subassembly, assembly and inspection resources.
  - Each process step is layered onto the chart in the sequence implemented and under the resource heading that applies. Time is also provided for planned breaks and lunch times.
  - There may be several days required to completely process the work order. Each day may require a different resource utilization pattern.
  - Once all the products of a work group are mapped in this way, visual patterns of resource usage and of how the "pipeline" will fill become apparent, as well as excess bits of resource time available to balance the work load.
  - Working with this pattern we will determine how each product puzzle shape will fit the work group and in what sequence or with what constraint.



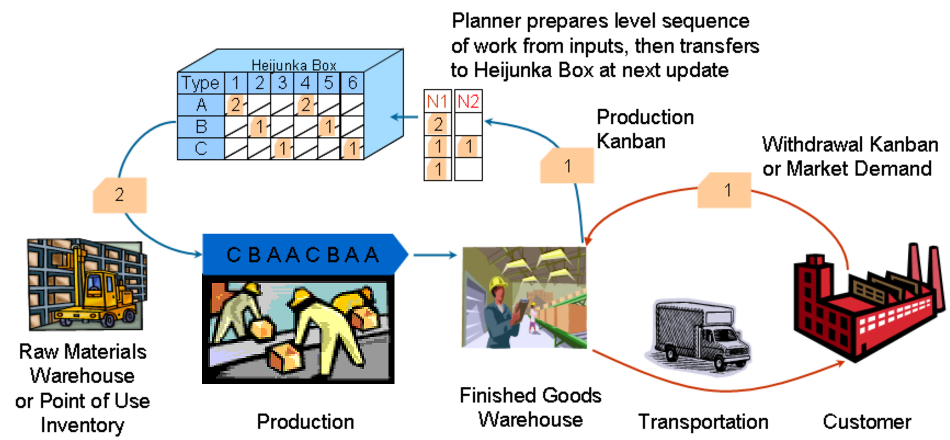
Establish the product group

- Average cycle time determines "pitch."
  - Pitch is the **takt time** multiplied by some number of pieces that gives a practical time increment for releasing and taking away work from the work cell.
  - A practical time increment is one that moves product quickly through the shop with an optimum use of resources.
    - Example: a pitch of 4 hours in an 8 hour shift means that twice per day, once at the start of the shift and once at mid day, a new work order is pulled into the pacemaker operation step, while the pacemaker moves a completed work order out into it's next stage in the process flow. This half-day "beat of the drum" is constant, and repeats each day. All members of the product line know when to expect movement, and thus when to have their part of the process completed. All parts of the flow synchronize to this half day beat. A simple look at the clock tells any team member approximately where they are in relation to process time and expected completion.
    - The shorter the pitch, the shorter the process time and therefore the faster new orders are processed through the pacesetter in a day, resulting in a greater the number of work orders handled and processed by the line. A longer pitch results in fewer changeovers during the day and fewer work orders.
  - Batch size is how many of an item are in the work order. Together, batch size and pitch determine the quantity of items produced per period.
    - In a mixed-mode product line where several unique but similar products are grouped by their common characteristics, pitch is held constant and batch size is varied to balance work load for the period.
    - Example, Prod A can produce a batch of 2 units in a single pitch, while Prod B requires only half the time, so B's batch size would be set to 4 to keep pitch constant and maintain the heartbeat.

Establish the product group

- Each product is analyzed for pacemaker constraint.
  - The pacemaker constraint is often the process step that is most common to all products within the group, and therefore is most likely to be used to set the pace for flow through all other steps.
    - Metrics at the pacemaker are critical for control of the entire line. Here are the essentials:
      - Know the target (e.g. a 3 piece batch for every 60 minute pitch)
      - Check progress regularly to spot abnormalities (e.g. every 60 minutes or 1 pitch)
      - Quickly respond to abnormalities
  - The pacemaker process and heijunka
    - A basic concept of lean manufacturing is to schedule at only one point in the overall value stream. The value stream comprises all the actions required to bring a product from order to delivery. Scheduling at this one point—the pacemaker—results in pulling work from upstream processes and flowing product to the customer through the subsequent processes either by push or by kanban.
      - The planned volume and mix at the pacemaker process typically corresponds to what's known as the master schedule; the scheduled mix for the day's actual production, as defined by the heijunka box, corresponds to the finishing schedule.

A Kanban System with Heijunka Leveling



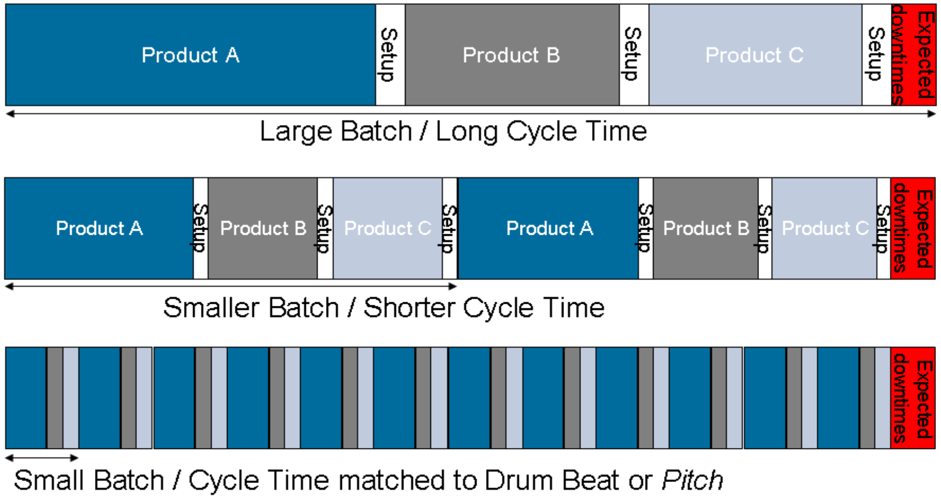
Establish the product group

- Takt Time
  - The basic rate of production needed in order to meet customer demand is the takt time, sometimes called the drumbeat for the process.
    - Takt time communicates the frequency of demand and, consequently, the frequency at which a product must be produced by the finishing process.
      - The basic calculation of takt time is:

        Takt time = operating time ÷ required quantity
    - For example, if a customer requires 240 items per day and the factory operates 480 minutes per day, takt time is two minutes, or 120 seconds. To meet customer demand, the plan must authorize sufficient resources, both in people and equipment, to produce one unit every 120 seconds.
    - Using the language of demand and supply, we can say that takt time is the *demand* for capacity and that engineered cycle time represents the *supply* of capacity. Supply must equal or exceed demand, or the total demand will not be met and the customers will be disappointed.
  - Frequently there are other issues that need to be considered in setting actual production rates. Inventory adjustments, products with seasonal sales curves, plant vacation shutdowns, intermittent large demand shifts, and other factors may require a wider view than pure takt time provides.
  - Operational takt time is the rate of production required to meet customer demand *as well as the other factors cited above*.
    - Within the context of sales and operations planning, pure takt time would be calculated from customer orders and forecasts; operational tact time would be derived from the production plan, which is the pure demand plus or minus necessary adjustments.

Establish the product group

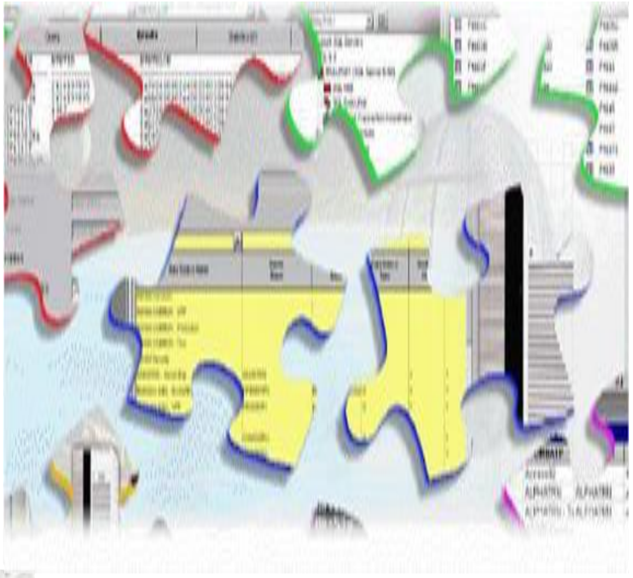
- Each product requires a resource “puzzle shape.”
  - A resource “puzzle shape” is simply the plan parameters associated with a product: they are batch size, release rate, human resources, equipment resources and material resources.
    - The pacesetter process is the point of introduction of the work order into the stream, and is the point where the heijunka schedule (box, calendar, or schedule) is located.
    - The pacesetter process is typically the key process used to align and calculate all other process point resource allocations in the flow. It need not be the capacity constraint process point, but it is the controlling point for upstream processes pulled in and for downstream flow pushed out.
    - The goal is to create a flow of products that fit into the schedule like puzzle pieces, one after the other, to completely fill up the cell resources in a level, but continuous, flow to the beat of the drum. This makes possible the heijunka concept of EPEI “every part every interval.”
    - As batch size is reduced, and excess waste is removed from the process, the mfg cycle time and setup times diminish in length. This creates the opportunity for establishing a reasonable pitch period with enough time to fit one or more of each puzzle shapes into each interval, and thus provide the opportunity to increase the broadcast “some quantity” of each product to finished goods each interval.



The LeanMan

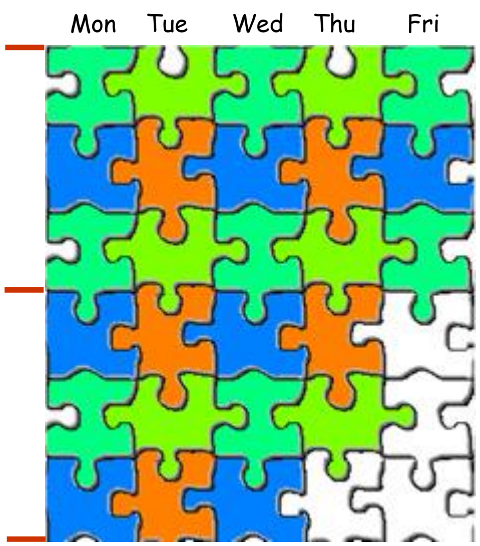
Establish the product group

- Each puzzle shape defines planning parameters.
  - Each product that flows through the team is characterized by its finite resource requirements, the demand rate, and the constraints imposed by adjacent puzzle pieces.
    - Prod A = 2 assembly, 1 technician, 1 ATE test station, 1 temp chamber 12 hr period over night; batch size 3pcs, release rate 1 job per half-day (4 hours).
    - Prod B: = 1 assembly, 1 technician, 1 ATE test station, 1 temp chamber 12 hr period over night; batch size 1pc, release rate 1 job per half-day (4 hours).
    - Prod C: = 1 assembly, batch size 6pcs, release rate 1 job per half-day (4 hours).
    - The pacesetter process in our work cell will be assembly, and the work cell for our example will consist of these finite resources: 2 assemblers, 1 test technician, 1 ATE test station and 1 temp chamber.
    - The synchronous flow chart provides a visual on how work will flow, and what constraints each puzzle piece will have on those adjacent to it, dependent on release sequence. As each piece of the puzzle is defined the planner will visualize how each product fits together to form a continuous build plan.
    - The sequence of work is then determined by the planner and the appropriate kanban cards inserted into the Heijunka Box. Assembly pulls the kanban and sends product to finished goods in the proper sequence. Product is pulled by the customer which results in another kanban signaling the planner to insert a replacement kanban into the next available slot in the Heijunka Box that will accept that product shape.



Establish the product group

- The "puzzle board" is key to defining finite capacity.
  - Since the work cell is designed by group technology methods to produce products of a similar nature and resource requirement, the number of product models will usually be small. This allows the planner to keep the puzzle shape fairly consistent between just a very few choices, with multiple models fitting the same shape.
  - The "puzzle board" is the daily schedule from shift start to shift end, and usually covers a week at a time. Each day is a multiple of pitch time and so as the planner begins to lay into the schedule each product piece, the day's work load and sequence becomes established.
  - Each available pitch time slot is continued to be filled for the day, for the week, and even for the month, with the customer demand filling in the next available matching shape.
    - Some customer orders will have a future need date. Those orders will be pre-planned into the schedule to be built just in time to delivery.
    - Some customer orders may have a future need date range where precise delivery will not be firm until a pull signal is received. These orders are used to fill in available time slots to help level the work load, but with a bit of "guess" risk on the part of the planner. Err on the side of holding a small amount of finished goods to assure customer delivery.



Establish the product group

- Finite capacity planning in your head.
  - The heijunka schedule is very visual, and so as it fills up it becomes very easy to see the next available pitch slot as well as future slots. And since each product “puzzle piece” fits one of only a few shapes, the ability to accept a new order is as simple as looking for the next available matching shape and placing the order into that definite time and date.
  - With the heijunka schedule box, it becomes possible to visualize the work cell capacity, current work load, and future available product openings – all in your head.

Establish the product group

- The final heijunka schedule.
  - The heijunka schedule is very visual, with clear time and space relationships presented in a manner easily read by the user.
  - The example shown is for an assembly cell with variable resource of one or two assemblers, the days of the week are shown with a distinction between AM and PM, and work is assigned between Assembler 1 and Assembler 2.
  - This form of the Heijunka is a paper “weekly calendar” printed and posted at the pace setter operation in the cell.
  - Each assembler assigned to support this cell can see at a glance the *What and When* requirements for their presence, or if there may be an opportunity to cross train in another cell (Monday and Tuesday PM in this example)

Heijunka Schedule
November, 2006

Monday, November 06, 2006

	Work Order	Qty	Model	Part Number	Notes
AM ASSY 1	342664	25	Tray	xxxxxxxxxxxxx	
AM ASSY 2	307398	4	bbbbbb	xxxxxxxxxxxxxx	
	342759	4	Switch Bd	xxxxxxxxxxxxxx	
	Work Order	**Qty**	**Model**	**Part Number**	**Notes**
PM ASSY 1					
PM ASSY 2					

Tuesday, November 07, 2006

	Work Order	Qty	Model	Part Number	Notes
AM ASSY 1	342665	25	Tray	xxxxxxxxxxxxx	
AM ASSY 2	307398	4	bbbbbb	xxxxxxxxxxxxxx	
	342759	4	Switch Bd	xxxxxxxxxxxxxx	
	Work Order	**Qty**	**Model**	**Part Number**	**Notes**
PM ASSY 1					
PM ASSY 2					

Wednesday, November 08, 2006

	Work Order	Qty	Model	Part Number	Notes
AM ASSY 1	342666	25	Tray	xxxxxxxxxx	Not POU
AM ASSY 2					
	Work Order	**Qty**	**Model**	**Part Number**	**Notes**
PM ASSY 1	342677	25	Tray	xxxxxxxxxx	
PM ASSY 2	307400	4	bbbbbb	xxxxxxxxxxx	
	342761	4	Switch Bd	xxxxxxxxxxx	

Thursday, November 09, 2006

	Work Order	Qty	Model	Part Number	Notes
AM ASSY 1	342667	25	Tray	xxxxxxxxxx	
AM ASSY 2	307399	4	bbbbbb	xxxxxxxxxxx	
	342760	4	Switch Bd	xxxxxxxxxxx	
	Work Order	**Qty**	**Model**	**Part Number**	**Notes**
PM ASSY 1	342668	25	Tray	xxxxxxxxxx	
PM ASSY 2	307401	4	bbbbbb	xxxxxxxxxxx	
	342762	4	Switch Bd	xxxxxxxxxxx	

Friday, November 10, 2006

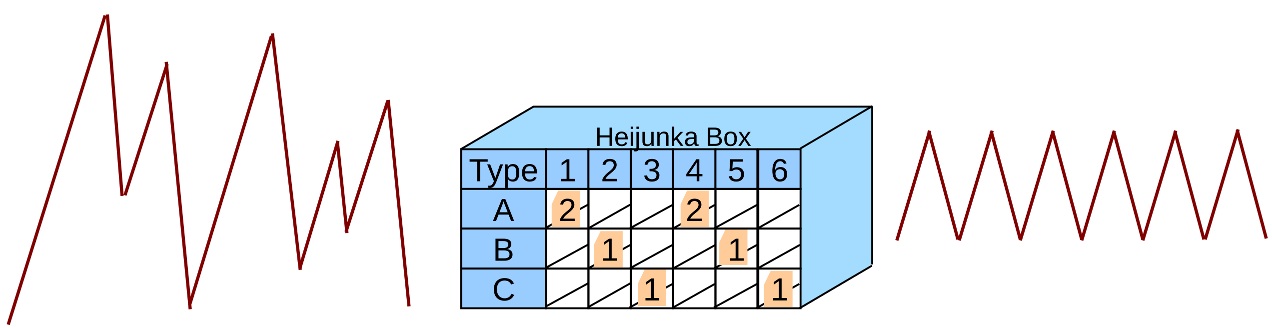
	Work Order	Qty	Model	Part Number	Notes
AM ASSY 1	342668	25	Tray	xxxxxxxxxx	Not POU
AM ASSY 2	307402	4	bbbbbb	xxxxxxxxxxx	
	342763	4	Switch Bd	xxxxxxxxxxx	
	Work Order	**Qty**	**Model**	**Part Number**	**Notes**
PM ASSY 1	342680	25	Tray	xxxxxxxxxx	
PM ASSY 2	307500	4	bbbbbb	xxxxxxxxxxx	
	342770	4	Switch Bd	xxxxxxxxxxx	

Heijunka:

The act of leveling the variety and or the volume of items produced at a process over a period of time. Used to aviod excessive batch of product types and/or volume fluctuations, especially at a pacemaker process.

Design the Heijunka Box

- Leveling, or Demand Production Leveling, is technically known as Heijunka.
  - This word comes from the Toyota Production System and is a Lean Manufacturing term. The goal of heijunka is to create balance by leveling demand in the flow of work.
  - Graphically, you can imagine Heijunka to have the effect like the following graphic. Traditional customer orders arrive sporadically, stochastically, and unpredictably. The solution is to smooth out the peaks and valleys in the demand coming into the process by leveling the type and quantity of production and filling orders from carefully controlled finished goods supermarkets or on-hand inventory.
  - Either in a production or service environment, the heijunka provides greater predictability of capacity and flow by using engineered cycle times by categories, completing orders by plan, and delivering to a carefully controlled schedule.

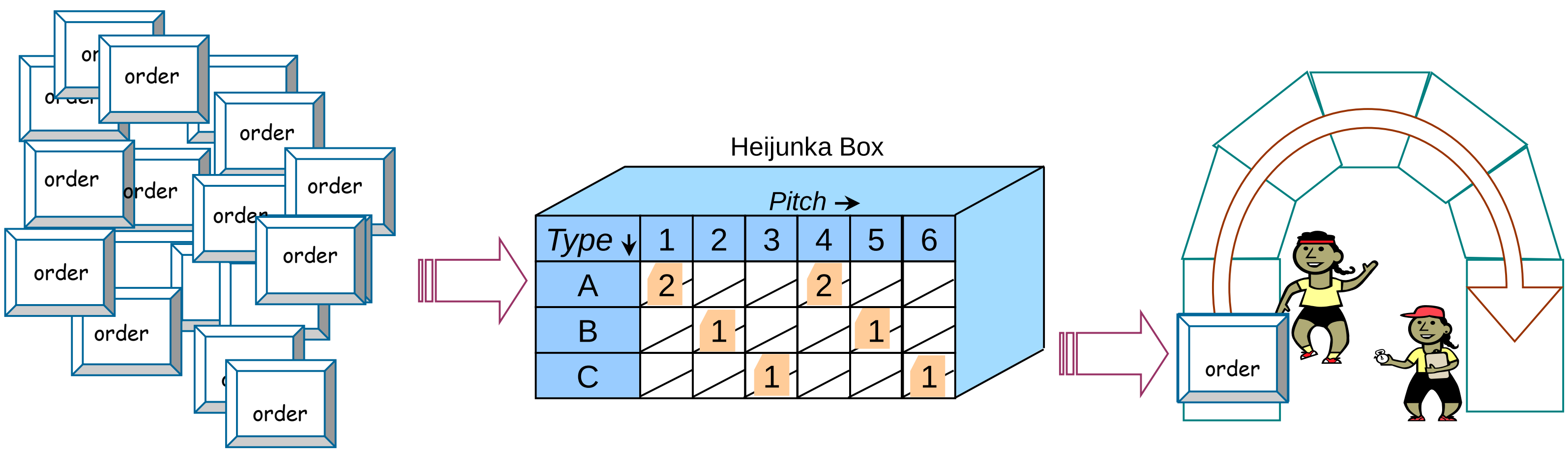


Traditional PUSH based on demand peaks and valleys

Lean PULL based on Heijunka leveling

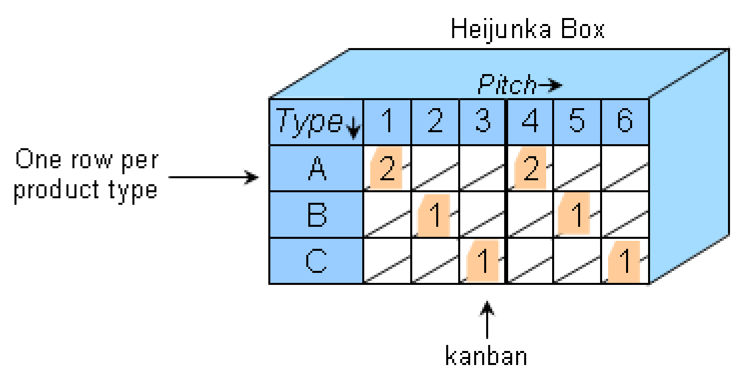
Design the Heijunka Box

- Heijunka is a buffer that stages all orders.
  - This means that when an order is made, orders sit in a queue — a virtual queue before that order is dropped or assigned to a work center. This buffer or waiting queue acts as a load leveler; otherwise orders would be coming into the work center at the rate of demand, which is characterized by peaks and valleys.
  - The goal is to level production build since we can't entirely control customer demand. In other words, velocity is still key, but we must have balance in the system first in order to pull an order through with velocity.



Design the Heijunka Box

- Heijunka Box design
  - The “box” can literally be a box made of wood with rows to relate to product models or categories (or puzzle pieces), and columns to relate to the pitch, or time period (or beat of the drum) for all of the products in the column to be completed. The pitch is identical for all columns, while the puzzle piece is a finite set of resource elements required to produce a product, and batch size is the number of puzzle pieces (items) that fit into a square.
    - Example: in the box shown the build sequence for pitch #1 is A A B C. Note that two pieces of A can be produced in the same pitch.
  - The “box” can also be an excel sheet posted at the pacesetter stage, or a peg board with kanban card on hooks, or a any similar display mechanism that allows the planner to sequence work, the operator to pull the work to a beat, and visual communication to all to take place.
  - A puzzle piece can also take up multiples of pitch, which in effect reserves the resources for a longer period.



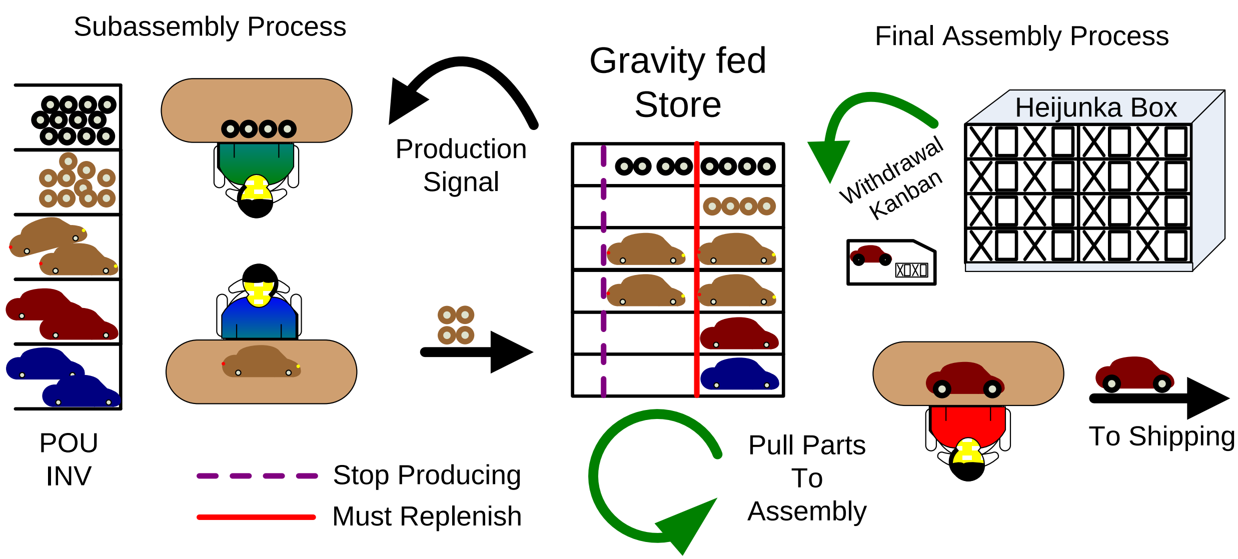
Planning

- The role of planning in lean production
  - Key scheduling people in a lean environment—whether their job title is master scheduler or something different—typically are involved in the following activities:
    - Developing better strategies for dealing with highly variable demand. They focus on reducing variability by inventory supermarkets or through a pure finish-to-order or make-to-order strategy to dampen the impact of that variability on the plant.
    - Leveling the schedule for both the volume and mix. They create a plan for flow that supports the drumbeat of expected customer shipments and enables smooth movement of work through the plant.
    - Monitoring customer order patterns and validating the daily execution mechanisms. They produce to customer orders whenever possible at the exact day's mix using heijunka or other leveling techniques.
    - Driving improvement activities so all processes can produce smaller quantities at shorter intervals. They create a true mixed-model schedule as well as more repetitive demand for components being pulled from upstream processes.
  - Such activities are in addition to traditional roles of balancing supply and demand, ensuring customer responsiveness isn't sacrificed in the name of factory stability (or vice versa), and deciding how to manage changes to the plan.
  - These, then, are the basic tools needed for effective planning and scheduling in lean manufacturing: operational takt time, scheduling at the pacemaker, supermarkets, heijunka load leveling, and kanban pull. These are the most important areas to understand for those performing the planning function to integrate their master scheduling processes effectively into a lean manufacturing environment.

The LeanMan

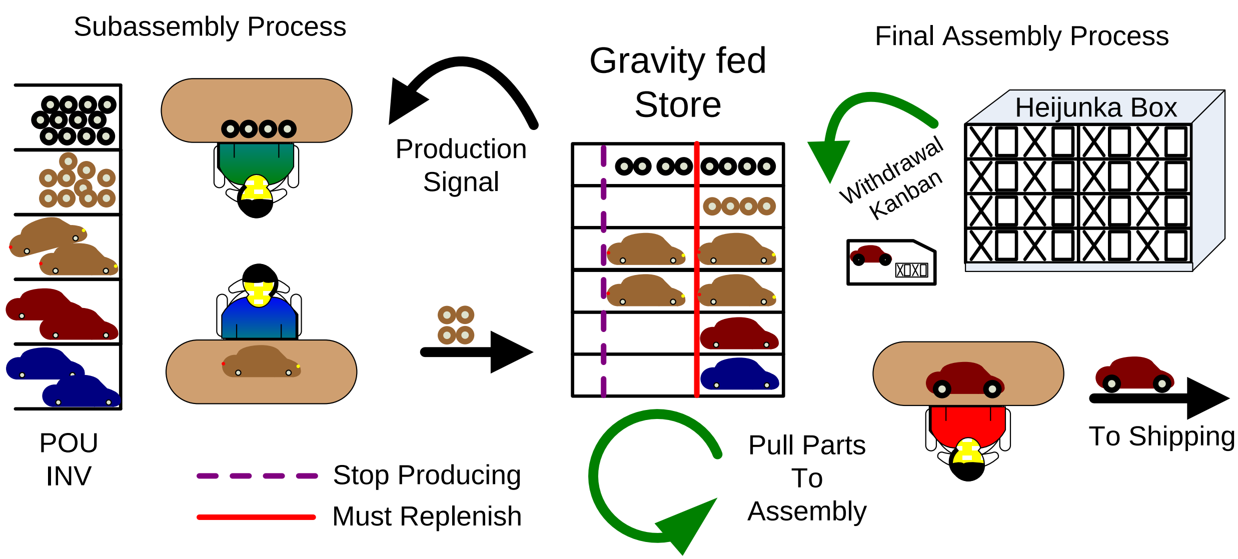
Heijunka Simulation Exercise

- A Simple Simulation with Heijunka
  - In the example operation below, the subassembly department consists of two subassembly processes, each feeding into a gravity fed store. The store is set up with a min and max limit for each of the items produced at subassembly. Each subassembly person produces a part when the store drops below its minimum, and stops when it has filled the store to maximum.
  - Other materials may also be supplied as raw components held in this point of use (POU) inventory and replenished from the main warehouse by kanban signal.
  - For this example, let's say the following:
    - Subassembly 1 produces plain or black wheel/axle/disk subassemblies.
    - Subassembly 2 produces plain car bodies with headlight and tail light details.

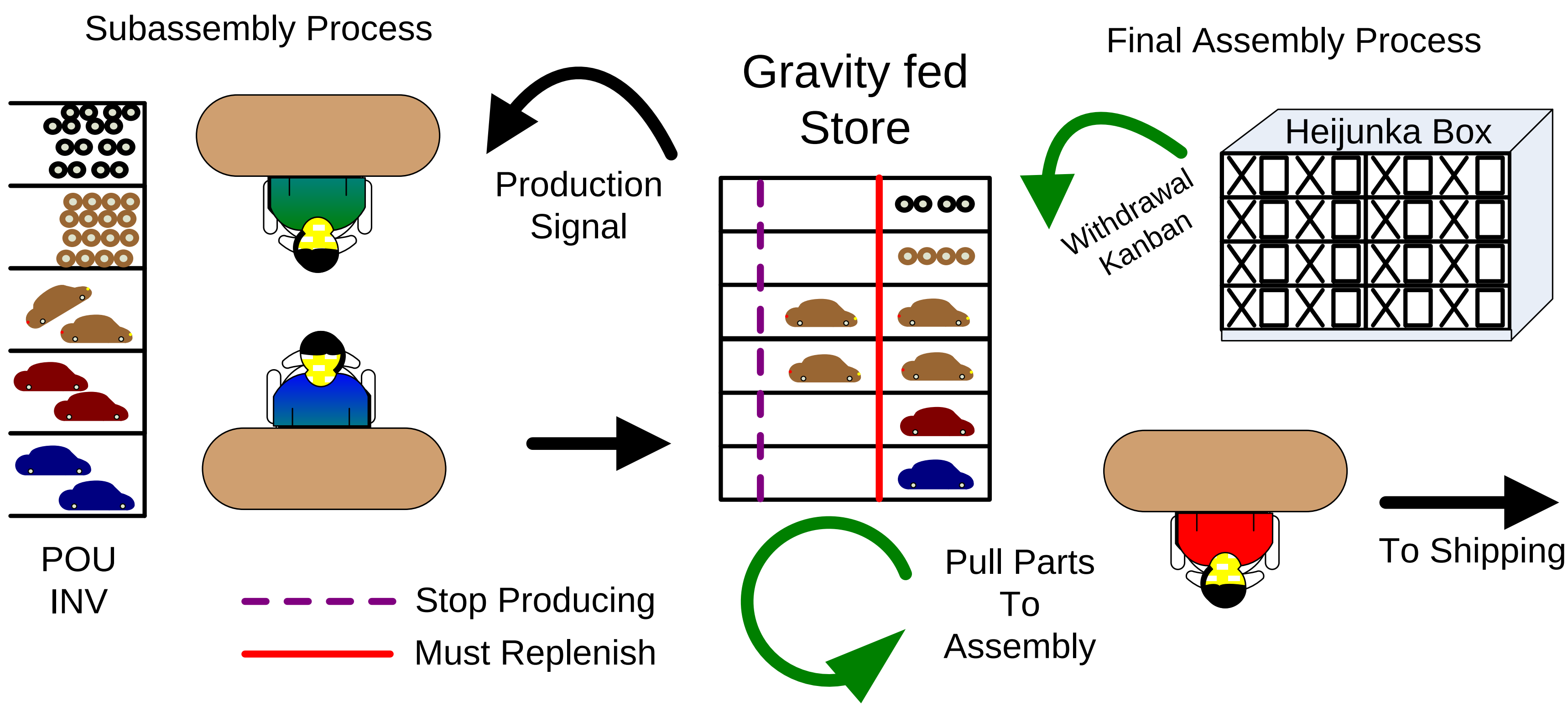


Heijunka Simulation Exercise

- A Simple Simulation with Heijunka
  - The planner receives orders from the customer for models of the product. The planner marks the Heijunka kanban card with the required model information and places it into the Heijunka Box in the appropriate sequence and pitch increment.
  - The final assembly department withdraws the kanban card from the Heijunka Box in the specified sequence and completes assembly of the specified product using the appropriate subassembly and raw materials pulled from the store.
  - Regardless of the random sequence of customer orders that arrive at the planner's desk, the stream of product produced by the operation is steady and balanced.

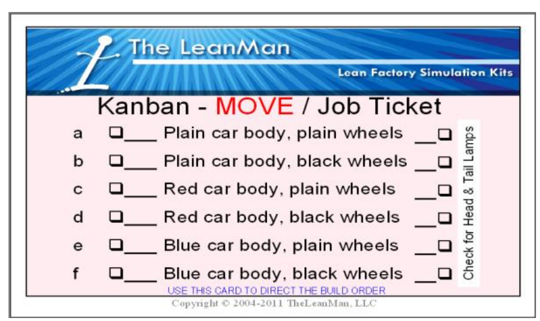


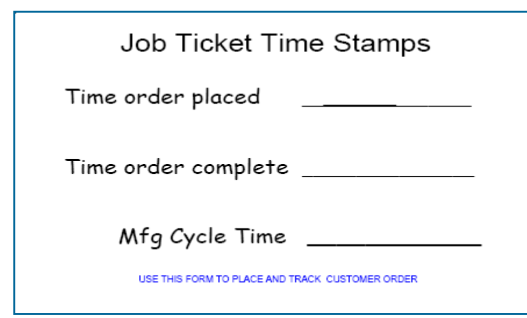
Heijunka Simulation Exercise



Heijunka Simulation Exercise

- The LeanMan Car Factory Simulation with Heijunka
  - Let's create an actual simulation using the LeanMan Car Factory Kits. The first step is to design the proposed flow. We can do this using a proposed state Value Stream Map, shown in the next slide.
  - The purpose of the VSM is to allow visualization of the flow and the communications methods that will be implemented to maintain flow and to allow for sufficient metrics to assure the final design will support the goal.
  - Two communication tools we will use are the Job Ticket [MOVE] Card and the Kanban [Production] Card. The Kanban [Production] Card is used to indicate the model and quantity. The kanban [Production] card is placed into the Heijunka box in the appropriate pitch and model slot (or cell) to indicate to the operator to produce the item.
  - The Job Ticket [MOVE] Card is used when the customer places an order and it goes to the planner/master scheduler to indicate the model and quantity to move. The back of the card is used for time stamps to track the mfg cycle time and support on-time delivery metrics.

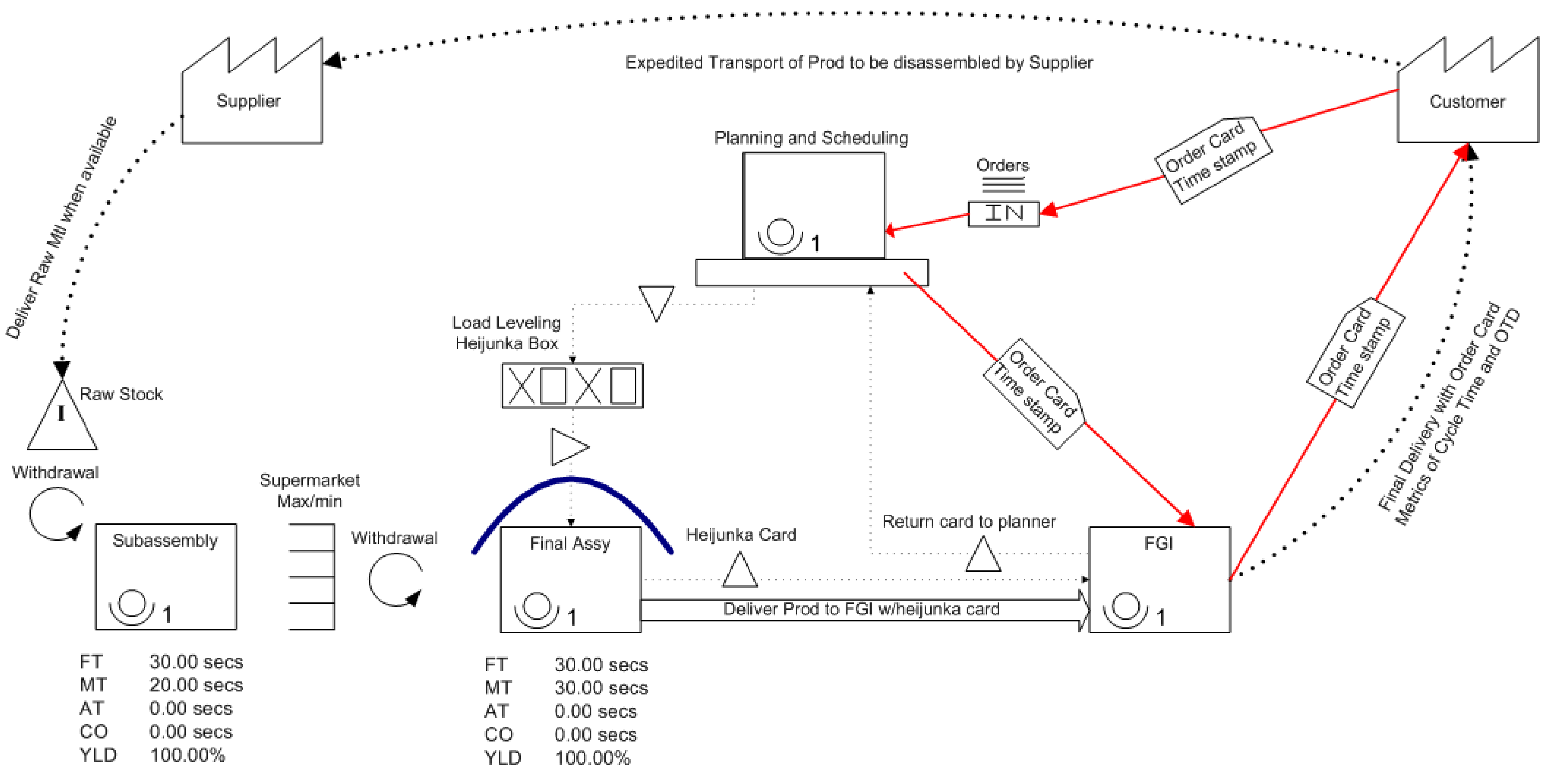




Value Stream Map

Customer Zoom Zoom Car Factory

Business Case	Value Statement	Key Requirements	Measurements	Ideal State
• Mixed mode work cell • Heijunka schedule • Supermarket stock •	• Customer driven demand, build to order	• ProdA rate 16/11 • ProdB rate 16/5 • Prod C or E 16/3 • Prod D or F 16/3	• Mfg cycle time • Order cycle time • On time delivery •	• On-Demand • Defect Free • 1-By-1 • Lowest Cost



Pacemaker Loop

Heijunka Simulation Exercise

- The LeanMan Car Factory Simulation with Heijunka
  - The next step is to determine the labor and resource “pieces” necessary to produce the product. Here, the six basic process steps are each performed several times and the average time needed to produce each piece of a single product are recorded. The process steps are evaluated from minimum to maximum amount of labor a single person might perform so as to evaluate where each piece of labor will be performed; e.g. at subassembly or at final assembly.
    1. Slip wheel onto axle peg
    2. Slip wheel onto axle peg then slip brake disk onto peg
    3. Slip a brake disk onto a wheel/axle subassembly
    4. Attach a wheel/disk/axle subassembly onto a car body
    5. Inspect & adjust a car’s wheel/axle/disk for rotation
    6. Attach headlight & tail light details to a car body
  - Also stated is the calculated takt time of the customer demand.
  - Any plan constraints are also indicated, such as those caused by material availability or machine load patterns.

wheel to peg	x4	18 sec
wheel to peg /disk	x4	40 sec
disk to peg/wh	x4	20 sec
wh sub to car	x4	18 sec
insp / adjust	x4	4 sec
add detail	x4	18 sec

Customer demand for cars, or minimum TAKT time				actual	
Prod A is for at least 1 car every 1.5 minutes	in 16 minutes, deliver	11	cars	Rate =	1.5
Prod B is for at least 1 car every 3.5 minutes	in 16 minutes, deliver	5	cars	Rate =	3.2
Prod C or E is for at least 1 car every 5 minutes	in 16 minutes, deliver	3	cars	Rate =	5.3
Prod D or F is for at least 1 car every 5 minutes	in 16 minutes, deliver	3	cars	Rate =	5.3

Plan Constraints: cannot build prodC or prodD in two consecutive periods, nor prodE or prodF in two consecutive periods

Plan Constraints: cannot build more than 1 of prodC or 1 prodD in same period, nor more than 1 prodE or 1 prodF in same period

Heijunka Simulation Exercise

- The LeanMan Car Factory Simulation with Heijunka
  - In Plan #1, the initial process flow is defined and the initial heijunka schedule is loaded with the mix of product. Orders are placed into the Heijunka in a repeating pattern and used for time evaluation. Use any pattern, but keep it fairly simple because this first attempt is to just get a feel for how the time elements fit together and how the resources are loaded.
  - By calculating the resultant resource demand at each process point, we can see that this pattern will not produce the needed rate of flow. We also see the workload at final assembly provides a bit of excess capacity while the subassembly load is at 100%. We can now begin to adjust the process.

Plan #1
Symetrical pattern

Pattern rates are Rate Prod A = 1 car every 4.0 minutes
Rate Prod B = 1 car every 4.0 minutes
Rate Prod C = 1 car every 4.0 minutes
Rate Prod D = 1 car every 4.0 minutes
Rate Prod E = 1 car every 4.0 minutes
Rate Prod F = 1 car every 4.0 minutes

assy 1 = add sub/insp/detail 60 sec =Prod A
assy 1 = add sub/insp/detail 60 sec =Prod B
assy 1 = add sub/insp 20 sec =Prod C,D.E.F

1 "a" = 4 wheel/axle/disk = 40 sec plus 1 car 0 sec = 40
1 "b" = 4 blk wheel/axle/disk = 40 sec plus 1 car 0 sec = 40
1 "c" or "e" = 4 wheel/axle/disk = 40 sec plus 1 car 0 sec = 40
1 "d" or "f" = 4 blk wheel/axle/disk = 40 sec plus 1 car 0 sec = 40

final assy installs the wheel subs and adds detail to car as required
Fails to meet the needs of ProdA or prodB rate; excess waste time at assembly

	minutes ==>	2	4	6	8	10	12	14	16	18	19	20
	a	a		a		a		a		a		a
	b		b		b		b		b		b	
	c	c		c		c		c		c		c
	d		d		d		d		d		d	
	e	e		e		e		e		e		e
	f		f		f		f		f		f	
1	avail	120	120	120	120	120	120	120	120	120	120	120
	used	100	100	100	100	100	100	100	100	100	100	100
	remain	20	20	20	20	20	20	20	20	20	20	20
1	avail	120	120	120	120	120	120	120	120	120	120	120
	subassembly	120	120	120	120	120	120	120	120	120	120	120
	remain	0	0	0	0	0	0	0	0	0	0	0

2 people build
1 planner
1 customer
1 supplier
5 total team members

prodA 4 cars in 16 minutes
prodB 4 cars in 16 minutes
prodC or E 4 car ea in 16 minutes
prod D or F 4 car ea in 16 minutes

Heijunka Simulation Exercise

- The LeanMan Car Factory Simulation with Heijunka
  - In Plan #2, the process flow is changed to move a bit of labor to the subassembly area from final assembly and the heijunka schedule is adjusted to attempt to provide a mix of product that more accurately meets the customer demand.
  - By calculating the resultant resource demand at each process point, we can that the final assembly person is well balanced, but the subassembly area has a much high level of excess manpower.
  - Again, this pattern will not quite produce the needed rate of flow, and it is more wide spread out over a higher number of pitch increments before repeating. This will greatly dampen the flexibility for planning.

Plan #2
Symetrical pattern

Pattern rates are	Rate Prod A = 1 car every	1.3	minutes
	Rate Prod B = 1 car every	4.0	minutes
	Rate Prod C = 1 car every	16.0	minutes
	Rate Prod D = 1 car every	16.0	minutes
	Rate Prod E = 1 car every	16.0	minutes
	Rate Prod F = 1 car every	16.0	minutes

Final assy = add detail/add disk/add sub/insp = 60 sec	=Prod A
Final assy = add detail/add sub/insp = 40 sec	=Prod B
Final assy = add sub/insp = 20 sec	=Prod C,D.E.F

1 "a" = 4 wheel/axle = 20 sec plus 1 car 0 sec = 20
1 "b" = 4 blk wheel/axle/disk = 40 sec plus 1 car 0 sec = 40
1 "c" or "e" = 4 wheel/axle = 20 sec plus 1 car 0 sec = 20
1 "d" or "f" = 4 blk wheel/axle/disk = 40 sec plus 1 car 0 sec = 40

Shift labor toward higher volume prodA
Fails to meet prodB and prodC-F rates; excess waste time at subassembly

	minutes ==>	2	4	6	8	10	12	14	16	18	19	20	
	a	aa	a	aa	a	aa	a	aa	a	aa	a	aa	
	b		b		b		b		b		b		
	c		c								c		
	d				d								
	e						e						
	f								f				
1	avail	120	120	120	120	120	120	120	120	120	120	120	
	used	120	120	120	120	120	120	120	120	120	120	120	
	remain	0	0	0	0	0	0	0	0	0	0	0	
1	avail	120	120	120	120	120	120	120	120	120	120	120	
	subassembly	40	80	40	100	40	80	40	100	40	80	40	
	remain	80	40	80	20	80	40	80	20	80	40	80	

2	people build
1	planner
1	customer
1	supplier
5	total team members

prodA	12	cars in 16 minutes
prodB	4	cars in 16 minutes
prodC or E	2	car ea in 16 minutes
prod D or F	2	car ea in 16 minutes

Heijunka Simulation Exercise

- The LeanMan Car Factory Simulation with Heijunka
  - In Plan #3, the process flow is changed to add a second person to the final assembly area and to shift some labor from the subassembly area to final assembly. The heijunka schedule is adjusted to attempt to provide a mix of product that more accurately meets the customer demand.
  - Again, this pattern will not quite produce the needed rate of flow for prod B, but is much closer to target and has a short 2-pitch repeat pattern which provides great flexibility at planning. With a bit of management, this pattern can be altered to meet the delivery needs.

Plan #3
asymetrical pattern

Pattern rates are			
Rate Prod A = 1 car every	1.5	minutes	actual
Rate Prod B = 1 car every	3.2	minutes	actual
Rate Prod C = 1 car every	6.0	minutes	
Rate Prod D = 1 car every	6.0	minutes	
Rate Prod E = 1 car every	6.0	minutes	
Rate Prod F = 1 car every	6.0	minutes	

assy 1 = add disk/add sub/insp 40 sec	=Prod A
assy 1 = add sub/insp 20 sec	=Prod B
assy 1 = add sub/insp 20 sec	=Prod C,D.E.F
assy 2 - detail = 20 sec	=Prod A
assy 2 - detail = 20 sec	=Prod B
assy 2 - nothing = 0 sec	=Prod C,D.E.F

1 "a" = 4 wheel/axle = 20 sec plus 1 car 0 sec = 20
1 "b" = 4 blk wheel/axle/disk = 40 sec plus 1 car 0 sec = 40
1 "c" or "e" = 4 wheel/axle = 20 sec plus 1 car 0 sec = 20
1 "d" or "f" = 4 blk wheel/axle/disk = 40 sec plus 1 car 0 sec = 40

Balance labor at assembly by adding Detail person at final assy and increase prodC-F rate
Plan almost meets the customer delivery needs except prodB. Could swap 1 prodA for 1 ProdB at 1st beat; excess labor waste in assembly and excess labor waste in subassembly and increase in team size is very inefficient

	minutes ==>	2	4	6	8	10	12	14	16	18	19	20
	a	a	a	aa	a	aa	a	aa	a	a	a	aa
	b	b	b		b		b		b	b	b	
	c		c		c		c		c		c	
	d	d		d		d		d		d		d
	e	e		e		e		e		e		e
	f		f		f		f		f		f	
1	avail	120	120	120	120	120	120	120	120	120	120	120
	used	100	100	120	100	120	100	120	100	120	100	120
	remain	20	20	0	20	0	20	0	20	0	20	0
1	2nd assy	120	120	120	120	120	120	120	120	120	120	120
	used	40	40	40	40	40	40	40	40	40	40	40
	remain	80	80	80	80	80	80	80	80	80	80	80
1	avail	120	120	120	120	120	120	120	120	120	120	120
	subassembly	120	120	100	120	100	120	100	120	100	120	100
	remain	0	0	20	0	20	0	20	0	20	0	20

3	people build
1	planner
1	customer
1	supplier
6	total team members

prodA	11	cars in 16 minutes
prodB	5	cars in 16 minutes
prodC or E	4	car ea in 16 minutes
prod D or F	4	car ea in 16 minutes

Heijunka Simulation Exercise

- The LeanMan Car Factory Simulation with Heijunka
  - In Plan #4, the process flow is changed to try another option – keep a single person at final assembly and move additional resources to subassembly. The heijunka schedule is adjusted to attempt to provide a mix of product that meets the customer demand.
  - This pattern does produce the needed rate of flow to meet the delivery needs and provides a 2-pitch flexible planning ability, but it has a very inefficient use of resources.
  - Looks like Plan #3 is the best fit. It's now time to test it out with simulation.

Plan #4
Symetrical pattern

Pattern rates are Rate Prod A = 1 car every 0.7 minutes
Rate Prod B = 1 car every 2.0 minutes
Rate Prod C = 1 car every 4.0 minutes
Rate Prod D = 1 car every 4.0 minutes
Rate Prod E = 1 car every 4.0 minutes
Rate Prod F = 1 car every 4.0 minutes

assy 1 = add sub/insp 20 =Prod A
assy 1 = add sub/insp 20 =Prod B
assy 1 = add sub/insp 20 =Prod C,D.E.F

1 "a" = 4 wheel/axle/disk = 40 sec plus 1 car 20 sec detail = 60
1 "b" = 4 blk wheel/axle/disk = 40 sec plus 1 car 20 sec detail = 60
1 "c" or "e" = 4 wheel/axle/disk = 40 sec plus 1 car 0 sec = 40
1 "d" or "f" = 4 blk wheel/axle/disk = 40 sec plus 1 car 0 sec = 40

	minutes ==>	2	4	6	8	10	12	14	16	18	19	20
	a	aa	aa	aa	aa	aa	aa	aa	aa	aa	aa	aa
	b	b	b	b	b	b	b	b	b	b	b	b
	c	c		c		c		c		c		c
	d		d		d		d		d		d	
	e	e		e		e		e		e		e
	f		f		f		f		f		f	
1	avail	120	120	120	120	120	120	120	120	120	120	120
	used	100	100	100	100	100	100	100	100	100	100	100
	remain	20	20	20	20	20	20	20	20	20	20	20
1	avail	120	120	120	120	120	120	120	120	120	120	120
	subassembly	260	260	260	260	260	260	260	260	260	260	260
	remain	-140	-140	-140	-140	-140	-140	-140	-140	-140	-140	-140
1	2nd subassy	120	120	120	120	120	120	120	120	120	120	120
	remain	-20	-20	-20	-20	-20	-20	-20	-20	-20	-20	-20
1	3rd subassy	120	120	120	120	120	120	120	120	120	120	120
	remain	100	100	100	100	100	100	100	100	100	100	100

4 people build
1 planner
1 customer
1 supplier
7 total team members

prodA 16 cars in 16 minutes
prodB 8 cars in 16 minutes
prodC or E 4 car ea in 16 minutes
prod D or F 4 car ea in 16 minutes

Balance labor by moving detail to subassembly area and freeing up final assembly
Plan exceeds the customer delivery needs; excess production and excess labor waste in assembly and excess labor waste in subassembly plus increase in team size is unacceptable

Heijunka Simulation Exercise

- The LeanMan Car Factory Simulation Plan #3B
  - This version modifies plan #3 by challenging the labor efficiency for three of the operation steps; “adding the disk” task is reduced from 18 to 15 seconds, “installing the sub to the car” task from 18 to 15 seconds; and the “wheel to axle” task at subassembly was reduced from 18 to 15 seconds.
  - The inspection task was also moved to the second assembly person
  - The result is a freeing of resource at each process step. This extra capacity provides the planner with some options, but the pattern is asymmetrical and will require greater mental agility on the part of the team to visualize overall capacity. We’ll adjust that in the final Plan #5

Plan #3B
asymmetrical pattern

Pattern rates are Rate Prod A = 1 car every 1.5 minutes actual
Rate Prod B = 1 car every 3.2 minutes actual
Rate Prod C = 1 car every 6.0 minutes
Rate Prod D = 1 car every 6.0 minutes
Rate Prod E = 1 car every 6.0 minutes
Rate Prod F = 1 car every 6.0 minutes

assy 1 = add disk/add sub/ 35 sec =Prod A
assy 1 = add sub/insp 15 sec =Prod B
assy 1 = add sub/insp 15 sec =Prod C,D.E.F

assy 2 - detail = 20 sec + insp = 25 =Prod A
assy 2 - detail = 20 sec + insp = 25 =Prod B
assy 2 - nothing = 0 sec + insp = 5 =Prod C,D.E.F

1 "a" = 4 wheel/axle = 15 sec plus 1 car 0 sec = 15
1 "b" = 4 blk wheel/axle/disk = 35 sec plus 1 car 0 sec = 35
1 "c" or "e" = 4 wheel/axle = 15 sec plus 1 car 0 sec = 15
1 "d" or "f" = 4 blk wheel/axle/disk = 35 sec plus 1 car 0 sec = 35

Balance labor at assembly by adding Detail person at final assy and increase prodC-F rate
Plan #3B takes the modified version of Plan #3, where the first pitch is adjusted for B, and tightens the time allowed for inspection and wheel/axle subassembly. With this improvement, there exists sufficient time in each pitch to add another prod, as in Plan #5

	minutes ==>	2	4	6	8	10	12	14	16	18	19	20	
	a	a	a	aa	a	aa	a	aa	a	a	a	aa	
	b	b	b		b		b		b	b	b		
	c		c		c		c		c		c		
	d	d		d		d		d		d		d	
	e	e		e		e		e		e		e	
	f		f		f		f		f		f		
1	avail	120	120	120	120	120	120	120	120	120	120	120	
	used	80	80	100	80	100	80	100	80	100	80	100	
	remain	40	40	20	40	20	40	20	40	20	40	20	
1	2nd assy	120	120	120	120	120	120	120	120	120	120	120	
	used	60	60	60	60	60	60	60	60	60	60	60	
	remain	60	60	60	60	60	60	60	60	60	60	60	
1	avail	120	120	120	120	120	120	120	120	120	120	120	
	subassembly	100	100	80	100	80	100	80	100	80	100	80	
	remain	20	20	40	20	40	20	40	20	40	20	40	

3 people build
1 planner
1 customer
1 supplier
6 total team members

prodA	11	cars in 16 minutes
prodB	5	cars in 16 minutes
prodC or E	4	car ea in 16 minutes
prod D or F	4	car ea in 16 minutes

Heijunka Simulation Exercise

- The LeanMan Car Factory Simulation Plan #5
  - This final version of the plan takes advantage of the excess capacity at each process step by allowing the planner to add in an extra product to each pitch as appropriate to manage and balance the random incoming demand, but only as needed. That means occasional free resource time. The challenge to the planner is to keep the work load reasonably level and constant without over producing beyond the customer demand.
  - Until the planner is comfortable with managing the balance, holding a short term buffer inventory at Finished Goods of one or more of the difficult products may be a good choice.

Plan #5
Symetrical pattern

Pattern rates are Rate Prod A = 1 car every	1.5	minutes	actual
Rate Prod B = 1 car every	3.0	minutes	actual
Rate Prod C = 1 car every	6.0	minutes	
Rate Prod D = 1 car every	6.0	minutes	
Rate Prod E = 1 car every	6.0	minutes	
Rate Prod F = 1 car every	6.0	minutes	

assy 1 = add disk/add sub/ 35 sec	=Prod A
assy 1 = add sub/insp 15 sec	=Prod B
assy 1 = add sub/insp 15 sec	=Prod C,D.E.F
assy 2 - detail = 20 sec + insp = 25	=Prod A
assy 2 - detail = 20 sec + insp = 25	=Prod B
assy 2 - nothing = 0 sec + insp = 5	=Prod C,D.E.F

1 "a" = 4 wheel/axle = 15 sec plus 1 car 0 sec = 15
1 "b" = 4 blk wheel/axle/disk = 35 sec plus 1 car 0 sec = 35
1 "c" or "e" = 4 wheel/axle = 15 sec plus 1 car 0 sec = 15
1 "d" or "f" = 4 blk wheel/axle/disk = 35 sec plus 1 car 0 sec = 35

	minutes ==>	2	4	6	8	10	12	14	16	18	19	20	
	a	aa	aa	aa	aa	aa	aa	aa	aa	aa	aa	aa	
	b	b	b	b	b	b	b	b	b	b	b	b	
	c		c		c		c		c		c		
	d	d		d		d		d		d		d	
	e	e		e		e		e		e		e	
	f		f		f		f		f		f		
1	avail	120	120	120	120	120	120	120	120	120	120	120	
	used	115	115	115	115	115	115	115	115	115	115	115	
	remain	5	5	5	5	5	5	5	5	5	5	5	
1	2nd assy	120	120	120	120	120	120	120	120	120	120	120	
	used	85	85	85	85	85	85	85	85	85	85	85	
	remain	35	35	35	35	35	35	35	35	35	35	35	
1	avail	120	120	120	120	120	120	120	120	120	120	120	
	subassembly	115	115	115	115	115	115	115	115	115	115	115	
	remain	5	5	5	5	5	5	5	5	5	5	5	

3 people build
1 planner
1 customer
1 supplier
6 total team members

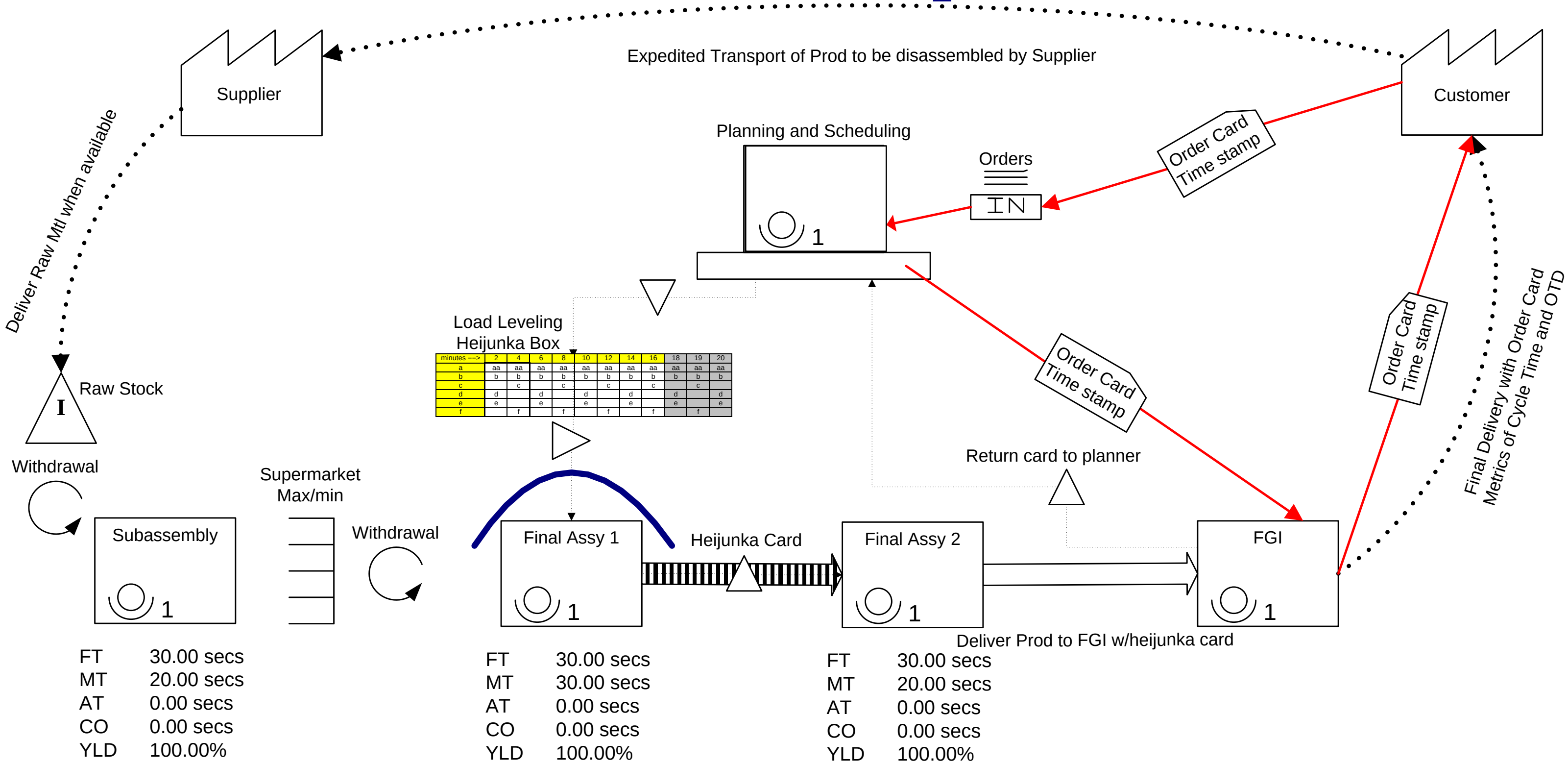
prodA	16	cars in 16 minutes
prodB	8	cars in 16 minutes
prodC or E	4	car ea in 16 minutes
prod D or F	4	car ea in 16 minutes

Balance labor at assembly by adding Detail person at final assy and increase prodC-F rate
Plan #5 takes the modified Plan #3B and further adjusts to increase velocity
Constraint on ProdC-F of no two consecutive days limits improvement in their velocity
With this much capacity, planning needs to assure overproduction doesn't occure

- The LeanMan Car Factory Simulation Plan #5
  - The final version of the VSM shows the single subassembly stage and the two-person final assembly stage. Orders are tracked for cycle time and on-time delivery.

Value Stream Map – Plan #5

Customer Zoom Zoom Car Factory



Pacemaker Loop

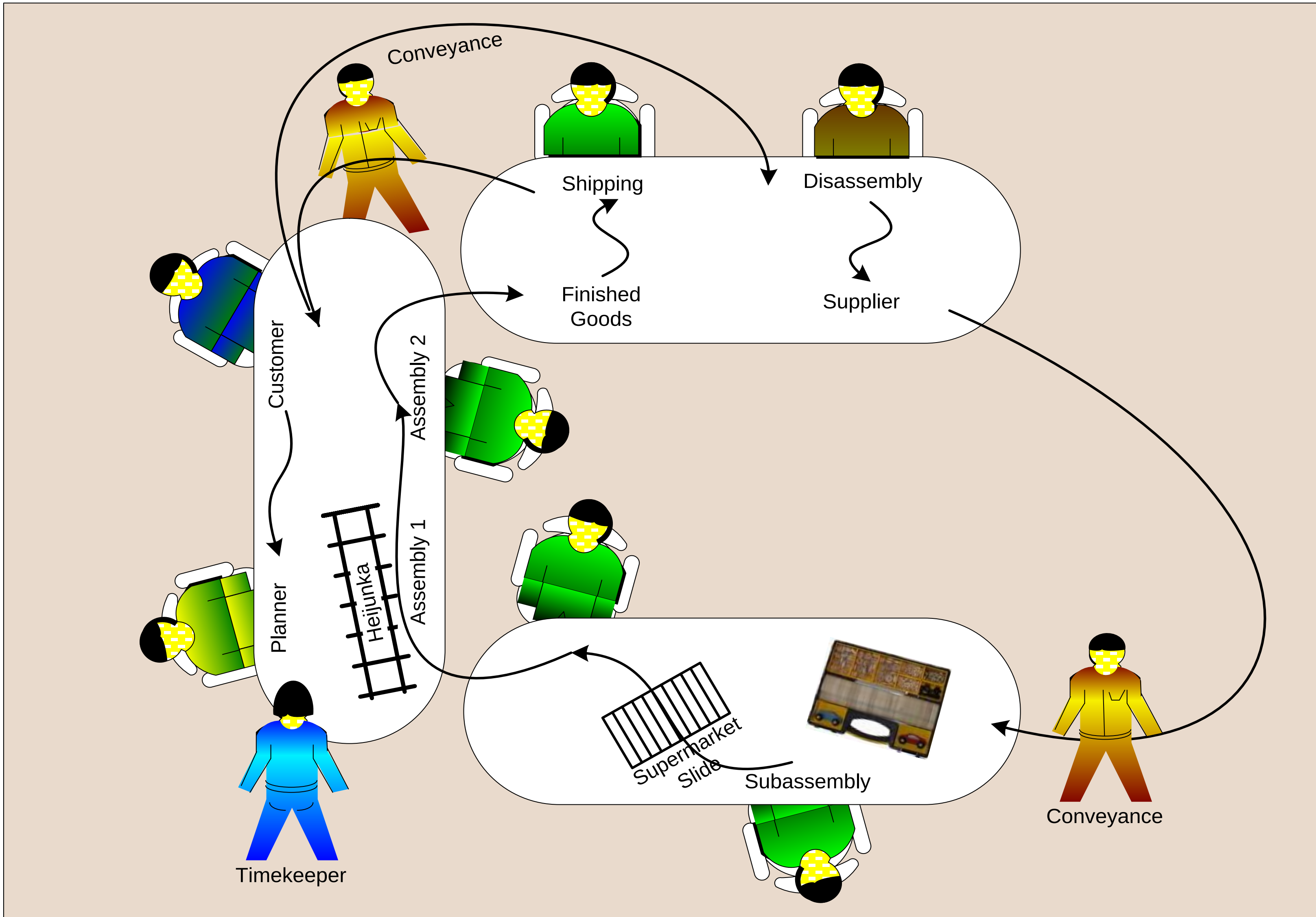
The LeanMan

Heijunka Simulation Exercise

- The LeanMan Car Factory Simulation Plan #5 Heijunka Box
  - The heijunka box for the simulation is shown below. As orders are received by the planner, the heijunka kanban cards are marked with the appropriate product and quantity and placed into the proper pitch and product position (or cell) in the box. The planning process typically runs several pitch increments ahead of production.
  - The heijunka card stays with the product through the cell operations and travels with the product to FGI / Shipping where the product is matched to the customer job order card. The heijunka card is wiped clean and then goes to the planning dept for reuse.
  - The job order card, which was time stamped at the time the customer placed the order, is again time stamped and the difference calculated to measure mfg cycle time.
  - The customer in this simulation records the time of the product delivery and calculates on-time performance. Cars are then disassembled for parts and returned by the “supplier” to the raw materials inventory.
  - The assembly simulation is typically run for 20 minutes, which includes a 2 minute pre-planning period to load the first pitch.

minutes ==>	2	4	6	8	10	12	14	16	18	19	20
a	aa	aa	aa	aa	aa	aa	aa	aa	aa	aa	aa
b	b	b	b	b	b	b	b	b	b	b	b
c		c		c		c		c		c	
d	d		d		d		d		d		d
e	e		e		e		e		e		e
f		f		f		f		f		f	

Heijunka Simulation



Heijunka Simulation Roles

Customer [1 person]

Able to order any of the items off the Customer List order card, in the sequence given, with adherence to the constraints. Note: The Optimal List will sequence the orders in a repeat pattern that mimics the Plan 5 pattern and allow the team to get the feel for the simulation. The Random List will sequence orders in a disarray more likely to mimic a series of customer orders, and allow the power of the Heijunka to show through.

Constraints

1. Only one job order card placed at a time.
2. Orders are selected from the Customer List and only to the maximum number of each model defined on the list.
3. Orders are placed at approximately 20 second intervals, plus or minus 4 seconds.
    1. Use a stopwatch if there is one available, or
        1. *hum the music to final Jeopardy*
        2. *hum it to yourself – quietly*
4. Each order for plain cars can be 1 or 2 cars per job order card, but typically use 1 pc batch orders
5. Each order for color car bodies can only be 1 pc jobs
6. Each order for same color car can only be placed for 1 car every 2 minutes (1 per pitch interval)

Completions

1. Take delivery of the completed order and the Job Order Card and check off completion on the Customer List.
2. Wipe the Job Order Card clean for reuse (wet erase markers clean with a damp tissue or sponge).
3. Send the completed car(s) to the Supply Chain person. Call out “conveyance” when cars are ready to be transported.

Heijunka Simulation Roles

Planner [1 person]

Receive periodic orders for cars from customer for the 6 models available and produce them assuring accurate on-time delivery while managing a level production work load.

Scheduling

1. Calculate order acceptance time for each job order card received from customer, basing the time on visual observation of the Heijunka Box and the next available pitch increment time for the model ordered. The time is obtained from the timekeeper's stopwatch by calling out "time stamp" and adding the appropriate additional time for the pitch increment where the order is expected to be planned. The Timekeeper will respond in minutes and seconds. Record the TimeStamp on the back of the Job Ticket card.
2. On-time is defined as TimeStamp plus 90 seconds per car. Record the due time on the card by adding 1 minute 30 seconds to the recorded TimeStamp, less the early delivery window of 15 seconds.
   1. a 2 pc order is due in TimeStamp+2 min 30 sec
   2. a 1 pc order is due in TimeStamp+1 min 15 sec
3. Create the kanban Production Card from the Job Order [MOVE] Card, and send the Job Order [MOVE] Card to Finished Goods / Shipping.
4. The Kanban Production Card is created using the plan rules for each model as defined by the team for the Heijunka and flow selected. Insert the Heijunka Kanban Production Card into the proper pitch and row of the Heijunka Box, leveling the work for each pitch.
5. The planner should stay ahead of the work team, preferably at least one pitch period.

Constraints

1. Only one job order card placed at a time from the customer.
2. Orders are placed by the Customer only to the maximum number of each model defined on the Customer List.
3. Orders will be placed at 20 second intervals (+ / - 4 seconds) but not more than 24 seconds.
4. Each order for plain cars can be between 1 and 2 cars per job order, but typically they will be 1 pc batch orders.
5. Each order for color car bodies can only be 1 pc jobs and the same color car can only be placed for only 1 car of the same color in the same pitch interval.

Heijunka Simulation Roles

Timekeeper [1 person]

Keep time for the simulation event, provide the time stamps used for metrics, and maintain the "drum beat" used to regulate the flow.

Timekeeper

1. Start the simulation event and the stopwatch. Time the overall event and run for 20 total minutes, then call stop.
2. At time zero, start the customer placing orders and the planner setting Heijunka kanban cards into the Heijunka box. The assembly team waits idle while you allow two minutes for this head start.
3. Anytime a team member calls out "time stamp" reply with the time reading off the stopwatch in minutes and seconds. Avoid excess word like "2 minutes 15 seconds" and use "2 15" instead.
4. The timekeeper maintains the "beat" for the assembly team by using the Timekeeper marker – a simulation only device placed on top of the "pitch in operation" column of the Heijunka Box, and moved to the next pitch on two minute intervals.
    1. In actual practice, the pitch is typically a half-day, or a shift change or some period such as a break horn sounding that is easily recognized across the value stream as a "drum beat."

Timekeeper

5. At the 2 minute mark, call start for the assembly operation and place the Timekeeper on top of the first pitch column of the Heijunka box. The Timekeeper is moved one column over at the stroke of each additional two minute mark on the stopwatch. At the end of the last column, move the Timekeeper back to the first column and repeat until the simulation is finished.
6. The simulation operation will run for a total of 20 minutes on the stopwatch. Call "all stop" to end the simulation. You may allow conveyance to continue for another minute until all cars in process are delivered and metrics are complete.

Heijunka Simulation Roles

Finished Goods / Shipping [1 person]

Manage finished goods inventory, regulate the delivery of customer orders, and maintain the on-time delivery metric.

Finished Goods

1. Receive completed cars from production into finished goods inventory.

Shipping

1. Receive the Kanban Job Order [MOVE] Card from planning and line them up in delivery sequence, delivering the car(s) from finished goods as ordered to the customer at the delivery time specified (TimeStamp plus 90 seconds per car ordered, or the due time written on the card if pre-calculated by the planner).
2. Deliver the completed car order and Kanban Job Order [MOVE] Card to the customer on time. If at a distance, call out "conveyance" to have the car and card delivered to the customer.
3. Record the on-time metric on the metric sheet. The on-time window is defined as "15 seconds early - zero seconds late."
4. Return the completed Heijunka Kanban Production Card, wiped clean, to the planner for reuse (wet erase markers clean with a damp tissue or sponge.)

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Heijunka Simulation Roles

Supply Chain [2-3 people]

Provide raw materials to the Subassembly inventory location and provide transportation for materials and goods.

Disassembly [1 person]

1. Receive completed cars from the customer and disassemble them into their component parts.
    1. Color car bodies are very few in number and must be available for reuse within less than 30 seconds. Therefore, any color car returned takes priority over any plain car for disassembly.
    2. Black wheels are less in number than plain wheels, and are to be considered as the second priority for disassembly
    3. Plain cars have headlight and tail light "details" which are to be removed and discarded.
2. Call out "conveyance" when materials are ready to be delivered.

Conveyance [1 or 2 people]

1. Transport materials between the customer and the supply chain disassembly person's input, and between the disassembly person's output and the subassembly inventory area.
2. Respond whenever someone calls out "conveyance" to transport the materials or goods as required.
    1. Develop a sense of priority to respond appropriately when two or more calls for conveyance are requested. When two or more conveyance persons are available, work out a system of response that will assure success.
        1. Color car bodies are very few in number and must be disassembled and the car body available for reuse within less than 30 seconds. Therefore, any color car returned to raw inventory takes priority over all other needs.
        2. Customer on-time is also very important, and fortunately operates within a window of time. 15 seconds early – zero seconds late. Use the buffer wisely.
        3. Black wheels are less in number than plain wheels, and are to be considered as a higher priority than plain car bodies or plain wheels for return to raw inventory.

Heijunka Simulation Roles

Subassembly [1 person]

Maintain the min/max point of use supermarket inventory for the assembly area.

Subassembly

1. The min/max slide supermarket contains plain wheel subassemblies, black wheel subassemblies, plain car bodies with head light and tail light detail, and color car bodies with no detail. Each with a minimum number of each to be maintained at all times, and a maximum number to be used to prevent overproduction.
2. When a subassembly drops below its max level point, the subassembly person picks raw components from inventory, completes the subassembly, and fills up the supermarket to the max line again.
   1. If a subassembly or component drops below its minimum level then this subassembly or component becomes the priority to replenish as soon as possible.

      NOTE: You may discover that the subassemblies do not want to behave and stay where put in the gravity fed store. If you place one of the subassembly holding fixture blocks from the car factory simulation kit into each of the gravity store subassembly areas, you can easily mount each subassembly onto a fixture to contain them in place.
   2. When applying headlight and tail light details to car bodies, place the color dot on the end so it overlaps the edge of the car and wraps slightly around to the side. It will make later removal much easier.

Heijunka Simulation Roles

Assembly [2 people]

Pull the Heijunka Kanban Production Card from the Heijunka box, complete assembly of the model indicated and in the quantity indicated and deliver to Finished Goods inventory.

Assembly 1

1. Monitor the Heijunka Box for the active pitch which is indicated by the “Timekeeper” at the top of one of the columns. Pull the production cards starting at the top one at a time and assemble the car model indicated and in the quantity specified.
2. Pull material from the slide supermarket one piece at a time as required, assembling the car as you go.
3. Pass the car to the second assembly person in 1-pc flow for final assembly and, if required, continue with the next car until the quantity required is complete.
4. Repeat the steps again, pulling the next lower Kanban Production Card from the same pitch and comp each assembly until all production cards in the pitch are complete.
5. Wait until the Timekeeper is moved to the next pitch column, and repeat again. If finished early, stop until the Timekeeper is moved. If finished late, work to catch up to the correct pitch.

Timekeeper

Assembly 2

1. As each car is passed from assembly 1, perform an inspection to assure the model indicated on the Heijunka Production Card is the model actually built.
2. Perform the final assembly as required.
3. Perform final inspection.
   1. Color of wheels, color of body, wheels rotate, headlight and tail light details attached as required.
   2. If rework is required which requires subassembly materials from the slide supermarket, pass the car upstream to assembly 1 for repair.
   3. If rework is required which you can perform, such as wheel adjustment, perform the task.
4. Pass the completed car(s) and Heijunka Kanban Production Card to Finished Goods as a set.
5. Repeat the steps again, as required.

Heijunka Customer List

- **The Customer List – Event #1**
  - The role of the customer in the simulation event is to place orders for zoom-zoom cars with the same "randomness" of your customers. However, customer orders can be categorized by type, e.g. repeat business where customers place orders with a repeating pattern. One time buy customers are totally random, but there are enough customers to typically take the standard product at a steady pace. Some customers buy the custom or made to order product and are willing to wait.
  - Every order placed with master scheduling will be accepted with a delivery due date calculated based on visual observation of the Heijunka Box and capacity constraints.
  - In this simulation exercise, the customer will place orders for cars by following the list and creating Job Ticket cards for each order as specified. Check off each car when the order is placed, and again when it is delivered. The on-time metric is calculated by the shipping person, but may also be calculated here by the customer.
  - Run this optimum schedule to allow the team to get used to the feel of the work cell and use of the Heijunka Box, then run Event #2 to see how well the work cell accommodates a more random order placement sequence.

Customer List - optimum sequence					
Seq			**Car**	**Wheels**	**Details**
Pitch 1			2 minutes		
1	a	☐ ☐	Plain	Plain	Yes
2	a	☐ ☐	Plain	Plain	Yes
3	b	☐ ☐	Plain	Black	Yes
4	d	☐ ☐	Red	Black	No
5	e	☐ ☐	Blue	Plain	No
Pitch 2			2 minutes		
6	a	☐ ☐	Plain	Plain	Yes
7	a	☐ ☐	Plain	Plain	Yes
8	b	☐ ☐	Plain	Black	Yes
9	c	☐ ☐	Red	Plain	No
10	f	☐ ☐	Blue	Black	No
Pitch 3			2 minutes		
11	a	☐ ☐	Plain	Plain	Yes
12	a	☐ ☐	Plain	Plain	Yes
13	b	☐ ☐	Plain	Black	Yes
14	d	☐ ☐	Red	Black	No
15	e	☐ ☐	Blue	Plain	No
Pitch 4			2 minutes		
16	a	☐ ☐	Plain	Plain	Yes
17	a	☐ ☐	Plain	Plain	Yes
18	b	☐ ☐	Plain	Black	Yes
19	c	☐ ☐	Red	Plain	No
20	f	☐ ☐	Blue	Black	No

Customer List - optimum sequence					
Seq			**Car**	**Wheels**	**Details**
Pitch 5			2 minutes		
21	a	☐ ☐	Plain	Plain	Yes
22	a	☐ ☐	Plain	Plain	Yes
23	b	☐ ☐	Plain	Black	Yes
24	d	☐ ☐	Red	Black	No
25	e	☐ ☐	Blue	Plain	No
Pitch 6			2 minutes		
26	a	☐ ☐	Plain	Plain	Yes
27	a	☐ ☐	Plain	Plain	Yes
28	b	☐ ☐	Plain	Black	Yes
29	c	☐ ☐	Red	Plain	No
30	f	☐ ☐	Blue	Black	No
Pitch 7			2 minutes		
31	a	☐ ☐	Plain	Plain	Yes
32	a	☐ ☐	Plain	Plain	Yes
33	b	☐ ☐	Plain	Black	Yes
34	d	☐ ☐	Red	Black	No
35	e	☐ ☐	Blue	Plain	No
Pitch 8			2 minutes		
36	a	☐ ☐	Plain	Plain	Yes
37	a	☐ ☐	Plain	Plain	Yes
38	b	☐ ☐	Plain	Black	Yes
39	c	☐ ☐	Red	Plain	No
40	f	☐ ☐	Blue	Black	No

Heijunka Customer List

- **The Customer List – Event #2**
  - In this second simulation exercise, the customer will place orders for cars in a more random sequence at 20 second intervals, and the planner will use the plan parameters to level the build schedule by observing the present state of the heijunka, and placing order acceptance at the first opportunity that matches the flow pattern designed for the work cell.
  - Run this random schedule to allow the team to get a feel for how well the heijunka does its job of leveling the work flow. Observe the operation at each process step, and hold team discussions on how to optimize flow and resource utilization while still meeting the customer on-time delivery.
  - Once the team is comfortable with the concepts and has practiced the random exercise, try running with a totally random input. Use a numbered die to roll 1 thru 6, with each number corresponding to model a thru f. Discuss the constraints presented to the flow.

Customer List - random sequence

Seq			Car	Wheels	Details
1	a	☐ ☐	Plain	Plain	Yes
2	a	☐ ☐	Plain	Plain	Yes
3	b	☐ ☐	Plain	Black	Yes
4	a	☐ ☐	Plain	Plain	Yes
5	b	☐ ☐	Plain	Black	Yes
6	d	☐ ☐	Red	Black	No
7	e	☐ ☐	Blue	Plain	No
8	a	☐ ☐	Plain	Plain	Yes
9	c	☐ ☐	Red	Plain	No
10	f	☐ ☐	Blue	Black	No
11	a	☐ ☐	Plain	Plain	Yes
12	a	☐ ☐	Plain	Plain	Yes
13	a	☐ ☐	Plain	Plain	Yes
14	a	☐ ☐	Plain	Plain	Yes
15	b	☐ ☐	Plain	Black	Yes
16	a	☐ ☐	Plain	Plain	Yes
17	d	☐ ☐	Red	Black	No
18	e	☐ ☐	Blue	Plain	No
19	b	☐ ☐	Plain	Black	Yes
20	b	☐ ☐	Plain	Black	Yes

Customer List - random sequence

Seq			Car	Wheels	Details
21	c	☐ ☐	Red	Plain	No
22	f	☐ ☐	Blue	Black	No
23	a	☐ ☐	Plain	Plain	Yes
24	d	☐ ☐	Red	Black	No
25	e	☐ ☐	Blue	Plain	No
26	a	☐ ☐	Plain	Plain	Yes
27	a	☐ ☐	Plain	Plain	Yes
28	a	☐ ☐	Plain	Plain	Yes
29	b	☐ ☐	Plain	Black	Yes
30	c	☐ ☐	Red	Plain	No
31	f	☐ ☐	Blue	Black	No
32	a	☐ ☐	Plain	Plain	Yes
33	b	☐ ☐	Plain	Black	Yes
34	d	☐ ☐	Red	Black	No
35	e	☐ ☐	Blue	Plain	No
36	a	☐ ☐	Plain	Plain	Yes
37	a	☐ ☐	Plain	Plain	Yes
38	b	☐ ☐	Plain	Black	Yes
39	c	☐ ☐	Red	Plain	No
40	f	☐ ☐	Blue	Black	No

References

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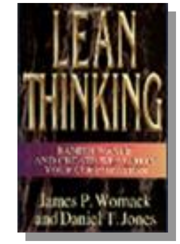
Publisher: Simon & Schuster

Publication Date: 9/9/1996



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