SMA 6304
Factory Planning and Scheduling
Lecture 20: Toyota Production System

Stanley B. Gershwin

TPS

- *Primary source: Toyota Production System* by Yasuhiro Monden
- Goals of TPS:
  - ★ reduction of costs — ie, reduction of waste
  - ★ increase of total sales/total assets
  - ★ improvement of total productivity

TPS

- Developed by Toyota after WWII:
  - ★ In the postwar period, the West was prosperous. It was important to satisfy demand.
  - ★ Japan was poor. Cost minimization and efficiency were most important.
  - ★ TPS is low tech, not dependent on computers. All actions easily understandable.
- Currently, TPS is widely imitated — Ford PS, Alcoa PS, etc.

- Quantity control: adapt to daily and monthly fluctuations in quantity and variety
- Quality assurance
- Respect for people

- Continuous flow of production
  - ★ Just in time: produce necessary units in the necessary quantities at the necessary time.
  - ★ "Autonomation" — jidoka — autonomous defects control.
- Flexible work-force — shojinka.
- Creative thinking — soikufu — capitalizing on worker suggestions.

TPS

Basic ideas

Systems and methods

- kanban
- production smoothing
- reduction of setup time
- standardization of operations to attain line balancing
- machine layout and multi-function workers
- improvement activities
- visual control
- functional management

TPS

Basic ideas

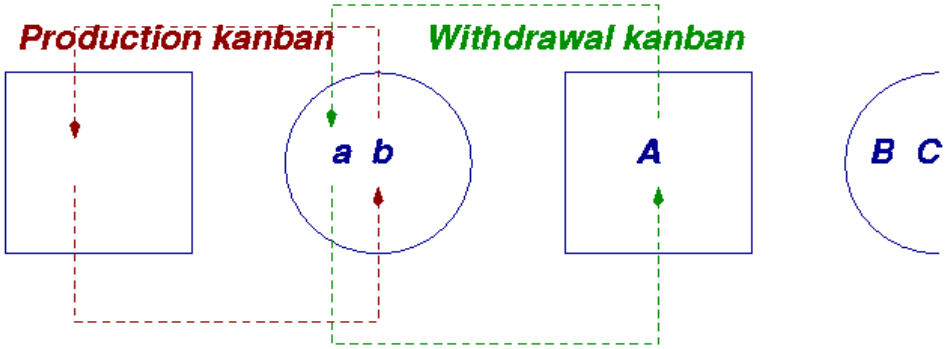
Just in time

- In final assembly of a car, the subassemblies arrive just when they are needed.
- Inventories are therefore not needed.
- Cannot be achieved by central planning.
- People at each process withdraw from previous process only what they need.
- People at each process produce what is necessary to replenish what has been taken by next process.

- A *part* of TPS.
- An information system to control production quantity.
- Kanban: a card in rectangular vinyl envelope.
- Withdrawal kanban: describes quantity that subsequent process must withdraw.
- Production-ordering kanban: describes quantity that preceding process must produce.
- Kanbans circulate within factories and between factories.

Basic ideas

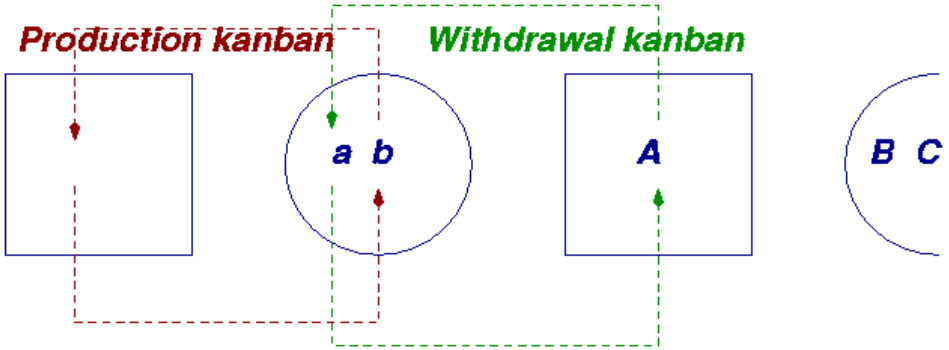
Kanban system



- Products: A, B, C
- Components: a, b
- a's and b's are made at upstream stage, and production kanbans attached to parts as they are put in storage.

Basic ideas

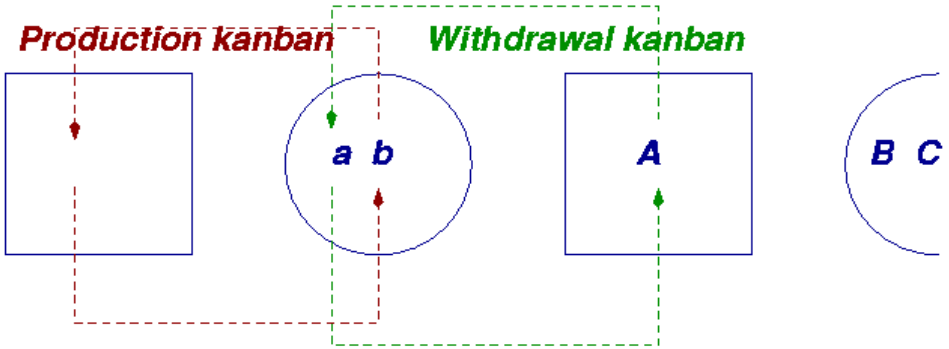
Kanban system



- Worker from downstream stage withdraws some a's from storage, with withdrawal kanban.
- He detaches production kanbans.

Basic ideas

Kanban system



- Unattached production kanbans are the signal to tell upstream stage how much to produce.

- Engine line normally producing 100 engines per day.
- Next process requests lots of 5 with withdrawal kanban.
- Withdrawals occur 20 times per day.

- If demand is reduced to 90 per day, withdrawals occur 18 times per day.
- The process is stopped after 90 are produced.
- If demand is increased to 110 per day, withdrawals occur 22 times per day.
- The additional engines are produced in overtime.

- If kanban is used and production at a stage fluctuates, the previous stage must hold inventory, and have excess capacity.
- Therefore, final assembly will use minimal lot sizes to reduce fluctuation.
- Also, final assembly will withdraw small lots from previous stages.

- Plant produces 10,000 Toyota Coronas in a month.
  - ★ 5,000 sedans, 2,500 hardtops, 2,500 wagons
- 1 month = 20 eight-hour shifts
- Production is divided equally. Every shift:
  - ★ 250 sedans, 125 hardtops, 125 wagons (500 cars).
- eight-hour shift = 480 minutes. Therefore *unit cycle time* = 480/500 = .96 minute = 57.5 seconds.

- One sedan must be generated every 1 min, 55 sec.
- One hardtop must be generated every 3 min, 50 sec.
- One wagon must be generated every 3 min, 50 sec.
- Possible sequence: sedan, wagon, sedan, hardtop, sedan, wagon, sedan, hardtop, ...
- As long as there is no setup cost, a sequence like this is preferable because it minimizes inventory.
- Machines must be flexible for this.

- Major emphasis on reduction of setup time.
- Pressing department setup times:
  - ★2-3 hours, 1945-1954.
  - ★15 min., 1955-1964.
  - ★3 min. after 1970.
- *External* setup: setup work that can be done while operation is taking place.
- *Internal* setup: only done while machine is stopped.

- Previous layout: rows of machines organized by type (lathe, mill, etc.), and one worker per machine.
- TPS layout:
  - ★ Machines organized to smooth material flow.
  - ★ Each worker handles three different machines.
  - ★ Worker deals with one piece at a time *(one-piece flow)* .

- Benefits
  - ★ inventory reduced
  - ★ fewer workers needed
  - ★ workers feel better about their jobs
  - ★ workers become part of factory team because of their increased knowledge

- *Standard operations routine sheets* are posted in the factory — visible to all workers.
  - ★ detailed sequences of operations
- *Takt time* = (duration of a time period)/(demand over the time period) = amount of time available to produce each demanded item
  - ★ Monden calls this *cycle time* . (This is the third use of this term I have seen.)

- Late in the month, central planning office tells each production department the volume required for the next month — ie, the next month's takt time (push system).
- Process managers determine how many workers are needed.
- Lines are rebalanced so cycle time = takt time.

- Not automation.
- “The autonomous check of the abnormal in a process.”
- Built-in mechanism to prevent production of defective products.

- If a machine produces a defect, it stops the whole line.
- For manual operations, workers can stop the entire line.
- *Pokayoke:* "foolproof" system for checking to prevent defects.

Basic ideas

Visible control system

- *Andon:* electric light board.
- Board is large and high and therefore visible from all points in factory.
- When a worker delays a job, he turns on a yellow light.
- When a worker stops a job, he turns on a red light.

- Worker suggestions via *Quality Control (QC) circle.*
- This provides good ideas, and workers become more part of the team.

Kanban

- Kanban is *not* TPS. Kanban is a subsystem of TPS.
- Information flow system.
- Low level shop floor control.

Non-kanban systems

- In ordinary production control systems, schedules are issued to all processes (*push*).
- It is difficult to adapt to demand fluctuations, disruptions, etc.
- Therefore, the company must hold inventory.

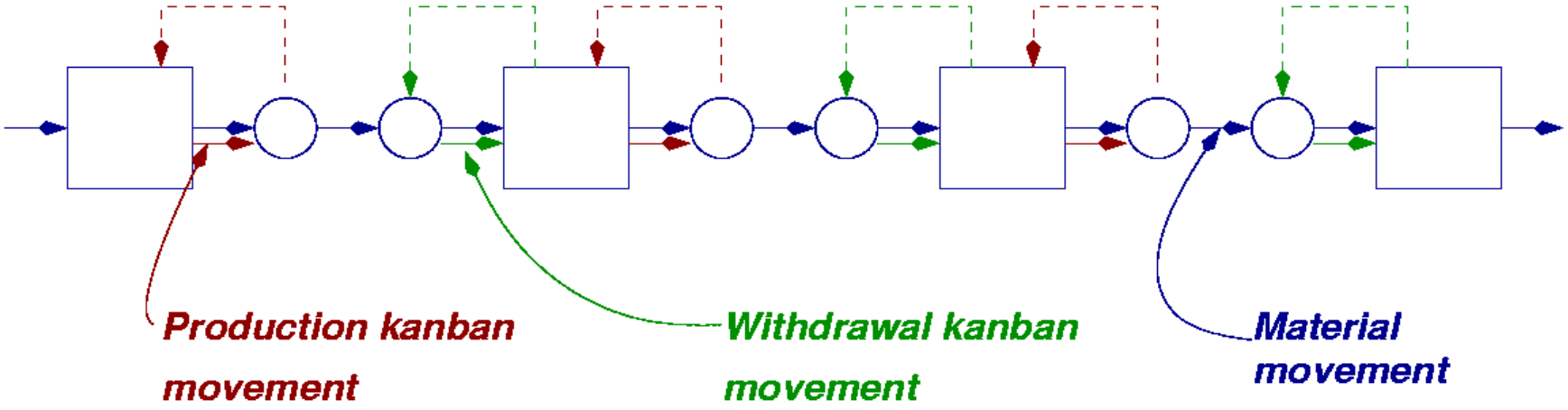
Kanban

- Kanban is a *Pull system* .
- When scheduling changes occur, it is enough to notify final assembly.
- All preceding stages learn about changes through the kanban system.

Kanban

two cards

simplified flow

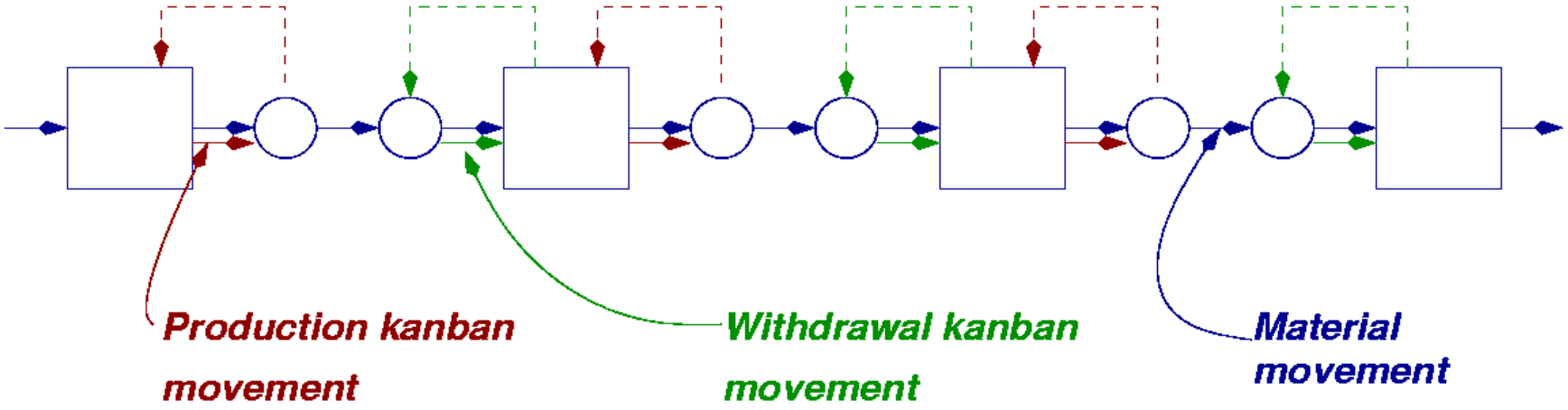


- When a machine is available, and it has a production kanban, a part and a withdrawal kanban move from upstream buffer to machine.

Kanban

two cards

simplified flow

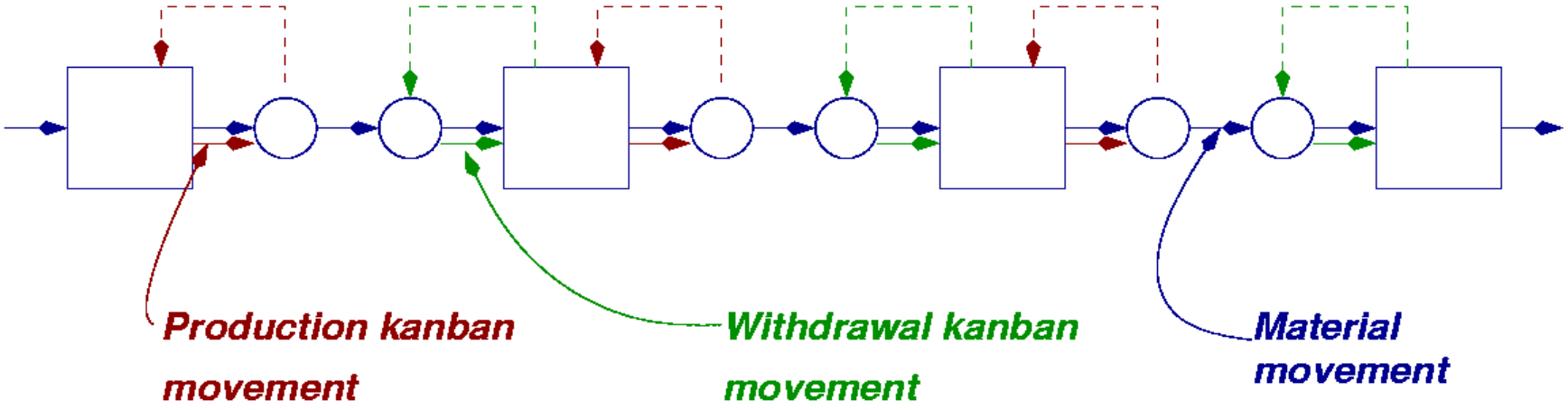


- After the operation, the withdrawal kanban returns to the upstream buffer, and a part and a production kanban move to the downstream buffer.

Kanban

two cards

simplified flow

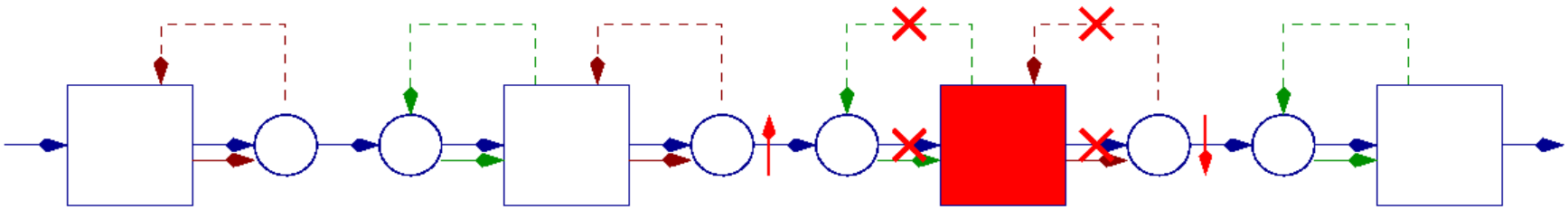


- When a buffer has a free withdrawal kanban, a part moves to it from the upstream buffer, and a production kanban moves to the machine.

Kanban

two cards

simplified flow



- The number of each kind of kanban is fixed at each stage.
- If a machine fails, the next machine can keep operating

Kanban

two cards

simplified flow

- Each box in this picture can represent a sub-process, consisting of several machines, rather than just a single machine.
  - ★ It could be an entire factory.
- Therefore, flow into and out of a box need not be the same, at each time instant.
- Actual movement of kanbans can be more complex.

Kanban

two cards

Withdrawal kanban

Store
Shelf No. 5E215 Item Back No. A2-15

Item No. 35670S07

Item Name DRIVE PINION

Car Type SX50BC

Box Capacity	Box Type	Issued No.
20	B	4/8

Preceding Process

FORGING
B-2

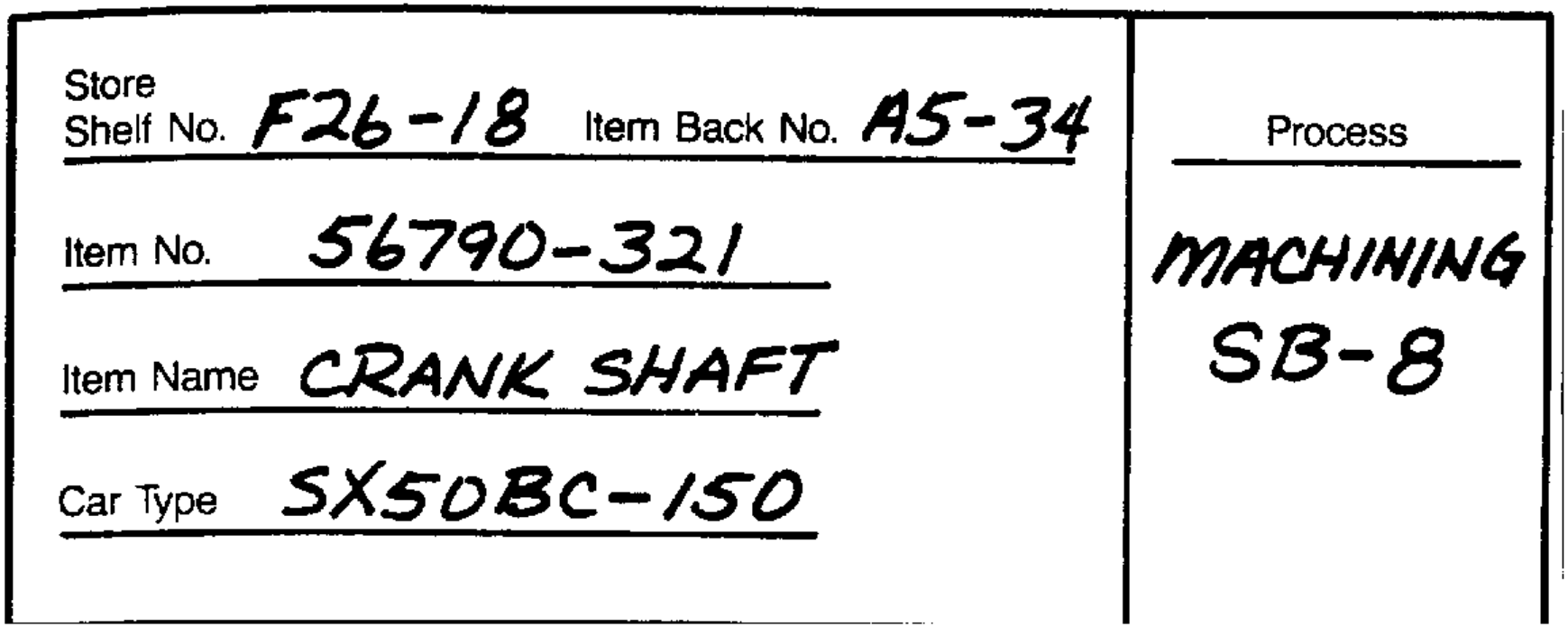
Subsequent Process

MACHINING
M-6

Kanban

two cards

Production-ordering kanban



Kanban

Other kanbans

- *Supplier kanban:* same as withdrawal, except for external supplier
- *Signal kanban:* same as production kanban, but sent to production station when inventory goes down to a reorder point.
- *Material requisition kanban:* same as production kanban, but sent to a material storage area when local inventory goes down to a reorder point.
- ... and more.

Kanban

Rules

1. Each process withdraws the *necessary* products from the previous in *necessary* quantities at the *necessary* time.
   - To enforce this, workers must first be won over.
   - Kanbans must be attached to the product.

Kanban

Rules

2. Each process produces only what is withdrawn by subsequent process.
3. Defective products are never moved to next process.
4. The number of kanbans should be minimized.
5. The kanban system should be used to adapt to small fluctuations in demand.

Smoothing Production Quantities

Total Production

- Minimize the variance of total output in a period.
  - ★ Produce the same amount every day.
- Amount produced in a day is the total for a planning period (eg, one month) divided by the number of days in a month.
  - ★ The planning period should be as short as possible.

Smoothing Production Quantities

- System must be set up for peak demand in a period. When demand is less than the peak, capacity is wasted.
- When production is not smoothed, inventory accumulates between stages.

Smoothing Production Quantities

Total Production

Adaptation to Demand

- If demand increases, hire temporary workers; add shifts, etc.
- If demand decreases,
  - ★ dismiss temporary workers,
  - ★ transfer workers to lines with increased demand,
  - ★ decrease overtime,
  - ★ fill up workers' time with quality control meetings, set-up practice, maintenance, etc.

Smoothing Production Quantities

Total Production

Each Model's Production

- Mix models to minimize inventory.
- Mix models to maximize utilization. *Example:*
  - ⋆ A parts require 70 minutes in a line; B parts require 60 minutes; C parts require 50 minutes.
  - ⋆ If they are produced $AAAA...BBBB...CCCC...$, the production rate of the line changes over time (1/70; 1/60; 1/50).
  - ⋆ If they are produced $ABCABCABCABC...$, the production rate is constant (3/180).

Smoothing Production Quantities

Comparison with MRP

- MRP: more data handling.
- MRP: usually weekly time buckets.
- Kanban designed to absorb fluctuations; MRP must recalculate master production schedule weekly.
- MRP may be better with very short production runs, where smoothing is difficult.

5S

- Seiri: throw out what you don't need.
- Seiton: lay out things neatly.
- Seiso: clean up
- Seiketsu: standardize above activities.
- Shitsuke: inspire workers, and have them make conforming to rules a habit.

TPS

- This has been a *very* brief overview.
- TPS has been extremely successful.
- TPS has been extremely influential.