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# Lean systems and continuous improvement

*Value Stream Concepts, Mapping and Design*



## Value Stream

- All-inclusive view of the system
- Consists of the **value-adding** and **non–value-adding activities** required to design, plan, and provide a product or service

  *from concept to launch*
  *from order to delivery*
  *from raw materials to customers*



## Value Stream

*... is a structured description of the actual or future value adding process, including*:

- description of **material flows**
- description of **information flows** to control the system
- description of **KPIs** of the value stream

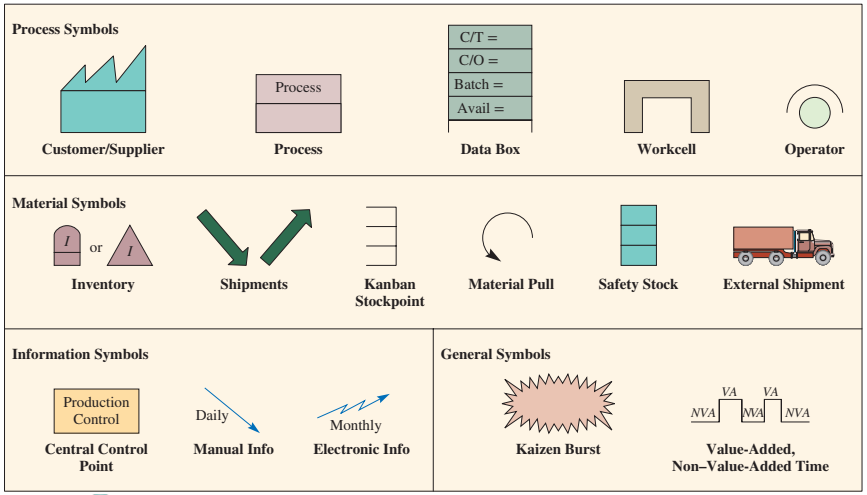
- *description from customer to supplier, plant internal from "dock to dock", or value streams of working systems (e.g. machining, assembly)*



## Value Stream Mapping (VSM)

- Illustrates information flows that result from the process, as well as information used to control flow through the process
- A graphical way to analyze **where value is or is not** being added as material flows through a process
- VSM uses **standardized symbols**
  - All persons working with the value stream have the same understanding of the symbols
  - This common understanding leads to efficient improvement work

# Value Stream Mapping Symbols



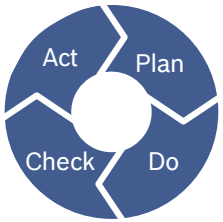



# Value Stream Design (VSD)

- Value stream planning is a two-part process—first depicting the "current state" of the process and second a possible "future state"
- Value Stream Mapping (VSM) involves first and develops a baseline map of the **current situation** of a company's internal and/or external operations
- Value Stream Design (VSD) applying **lean concepts**, develops a future state map that shows and measures **improved operations**



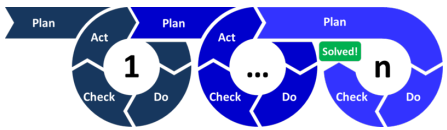
# Continuous Improvement PDCA (Plan–Do–Check–Act)




a problem-solving method (*Deming Cycle*)

- **Plan**: Analyze the problem and plan improvement measure
- **Do**: Implement the plan
- **Check**: verify if the plan/implementation has achieved the target
- **Act**: If the target has not been achieved, why not? Otherwise, address the next problem

*Check and Act are especially likely to be forgotten!*






# Kaizen

- **Kaizen** is the Japanese philosophy that focuses on continuous improvement
- The VSM can be annotated using **Kaizen bursts** that suggest the areas for improvement
- The Kaizen bursts identify specific **short-term projects** (often referred to as "Kaizen events") that teams work on to implement changes to the process

# Actions for improvement (Lean)

1. Clarify Process Flows
2. Organize Problem-Solving Groups
3. Eliminate Unnecessary Activities
4. Upgrade Quality
5. Upgrade Productive Maintenance (Housekeeping)
6. Introduce Demand-Pull Scheduling
7. Level the Facility Load
8. Reorganize Layout
9. Revise Equipment and Process Technologies
10. Develop Supplier Networks



# KPIs for the Value Stream

*Takt and Cycle Time, OEE, TPT*

# Takt Time (TT) or Customer Takt

- Derived from the German term "chronometer"
- The customer takt is the **takt time based on the customer demand** and the **planned operating time** (without losses) and on which the production cycles are aligned
- It represents the **required pace of production** (usually in [s/u])

$$TT = \frac{\textit{Planned Operating Time (POT)}}{\textit{Average Customer Demand in POT}}$$

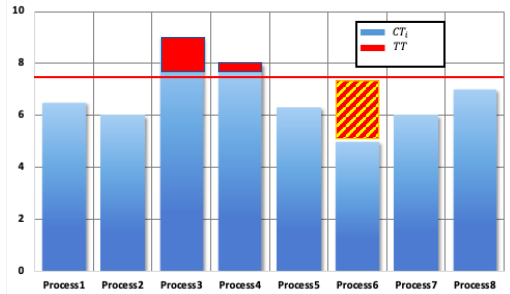
*POT = Available Working Time — Planned Breaks and Stoppages*



# Takt Time and Cycle Time (CT)

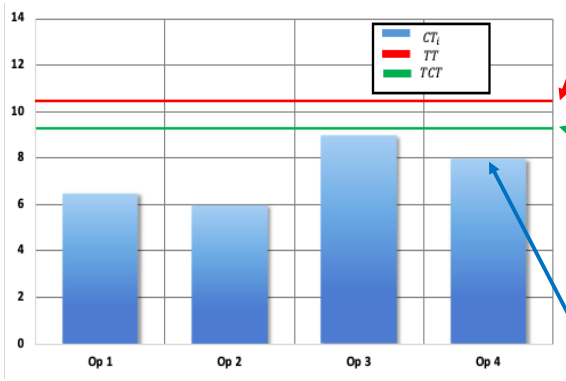
CT → **Time interval between two parts produced** (without malfunction) → average time at each WS

- CT of each stage (process or operation) must be less than TT
- CT of each stage must tend towards TT
- Too low a CT is inefficient, as it would result in too low a utilisation rate of the resources, which would have to wait for the completion of the upstream stages before starting to produce




**Takt Time** is not the **Cycle Time!**

# Target Cycle Time (TCT)




**Takt Time (TT)**

the customer demand rate

**Target Cycle Time (TCT)**

has to be less than TT

It includes changeover and/or downtimes

*TCT = [TT * OEE]*

**Cycle Time (CT)**



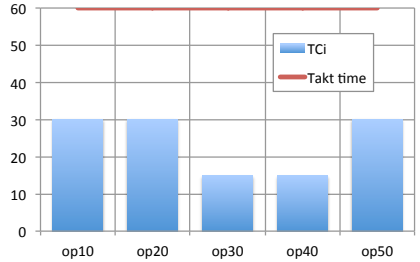
# Example

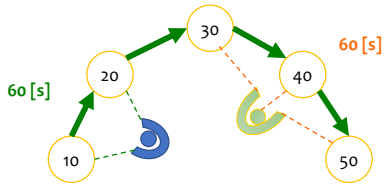
- Customer Demand: 8600 [u/month]
- Work shift: 06:00-14:00; Lunch break: 30 [min]; Scheduled breaks: 2*10 [min]

Takt Time = POT [min/d] / Demand [u/d]

TT=430/430= 1 [min/u] = 60 [s/u]

- POT = (8)(60) – (30+20) = 430 [min/d]
- Demand = 8600/20 = 430 [u/d]




Number of Operators = Total CT [s/u] / Takt Time [s/u]

- N op = (30+30+15+15+30)/60 = 2 [op]



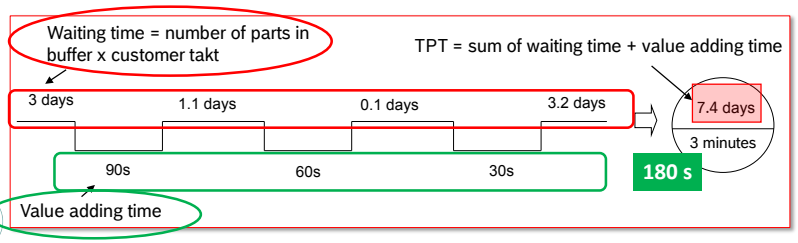
# Throughput Time (TPT) or Flow Time (FT)

*How long do we actually need until a part is produced?*

TPT or FT --> **Time necessary for a production part to move through the value stream**, from the start to the end, including all waiting times

*TPT = [Process Time + Transportation Time + Waiting Time]*

- Displayed as timeline below the value stream




# Tools for lean re-engineering

*Kanban card control*

*Supermaket*

# Kanban Production Control Systems
## *the 5 rules*

1. The downstream process must only take from upstream the necessary parts in the required quantity and at the right time
2. The upstream process must produce the amount that is withdrawn downstream
3. Defective parts can't move downstream
4. The number of kanban must be the minimum
5. Kanban is the control tool to adjust to small fluctuations in demand



# Two card kanban system

Pull signal system to control the production at each stage

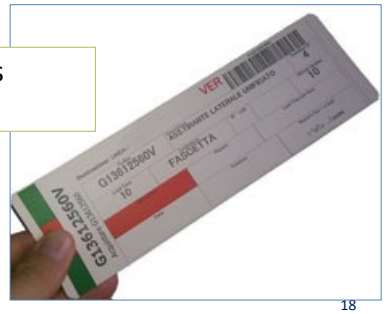
**Withdrawal kanban**

Specifies the quantity the process downstream must withdraw

**Production kanban**

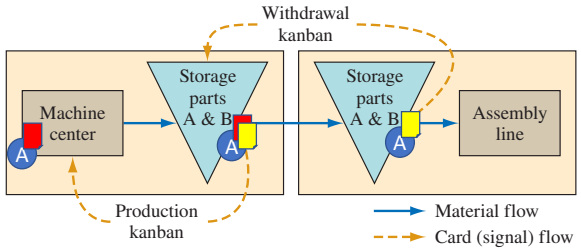
Specifies the quantityt the process upstream must produce

***The kanban moves with the product (or container) and shows the information necessary for correct identification (name, code number, quantity, ...)***






# Two card kanban system




*The machine center makes two parts, A and B, to feed an assembly line*

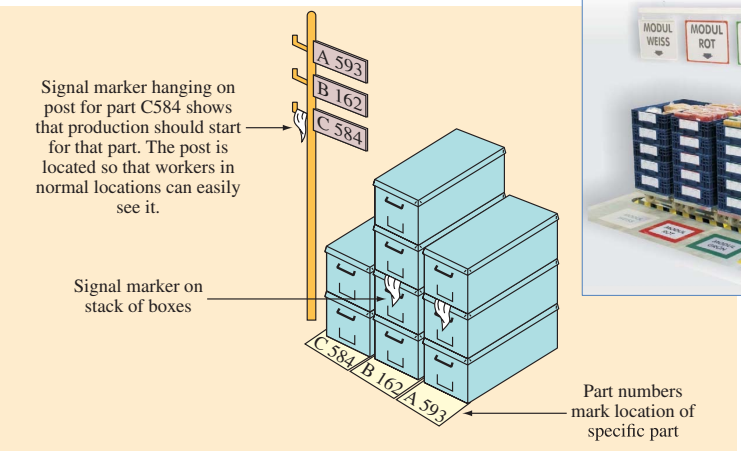
- When the assembly line takes a lot of part A from the storage, a worker takes the **withdrawal kanban** from the container. The card is the replenishment signal to the machine center storage area
- In the machine center area, the worker finds a container of part A, removes the **production kanban**, and replaces it with the withdrawal kanban

  Placement of this card on the container authorizes the movement of the container to the assembly line
- The freed production kanban is placed on a rack by the machine center, which authorizes the production of another lot of material A

  The cards on the rack visually show upcoming work for the machine center



# Outbound Stockpoint (supermarket) with Warning Signal Marker (prod. kanban)



*Fonte: Chase et al., 2018 - Chap. 14*

# Number of Kanban cards

- The **kanban cards** represent the **number of containers** of material that flow back and forth between the supplier and the user areas
- Each container represents the **minimum production lot size** to be supplied
- The number of containers directly controls the amount of **WIP inventory** in the system
- Container size should be **standard and «small»** (generally <10% of the average daily demand)



# Number of Kanban cards

$$k = \frac{\textit{Expected demand during lead time + Safety stock}}{\textit{Size of the container}} = \frac{D\,L\,(1+S)}{C}$$

*k* Number of kanban cards

*D* Average number of units demanded per period [u/time]

*L* Lead time to replenish an order (expressed in the same units as demand *D*) [time]

*S* Safety stock (expressed as % of demand *D* during the lead time *L*)

*C* Standard Container size [unit]

*Note*:

Generally the safety stock is < 10% of *D* during *L*



# Example

- Use of kanban to pull material through its manufacturing cells from the assembly cell
  - Demand = 8 [u/h]
  - Safety stock = 10% of the expected demand
- Multi-purpose fabrication cell
  - Production and transportation batch = 10 [u]
  - Change Over Time = 0 [s]
  - Production lead Time = 4 [h]
  - Transportation time = 0 [s]
- The number of the kanban to manage the replenishment cycle

$$k = \frac{D \cdot L \cdot (1+S)}{C} = \frac{8 \cdot 4 \cdot (1+0{,}1)}{10} = 3{,}52 \Rightarrow k = 4$$



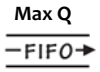
# Buffers

**Stock**

- Undefined rule

**FIFO Line**

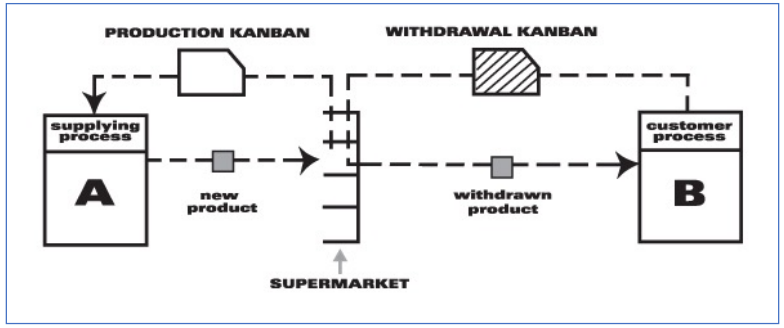
- FIFO picking logic
- Max Inventory defined
- Stop signal upstream and downstream (full/empty)




**Supermarket (SM)**

- Assigned position per part/code
- FIFO picking logic per part/code
- Max Inventory defined per part/code
- Unique control signal (kanban)

# Supermarket






# Supermarket - Features

- Products that the downstream process may require are present in **specified quantities**
- Products are stocked in such a way that you can choose **exactly the code** you want
- The production of the process upstream of the supermarket is regulated by a **kanban** system
- The supermarket is the **pull tool** that allows the upstream stage to **follow** the production of the downstream station
- They are positioned in close **proximity to the supplier** process to help that process maintain **visual contact** with customer demand

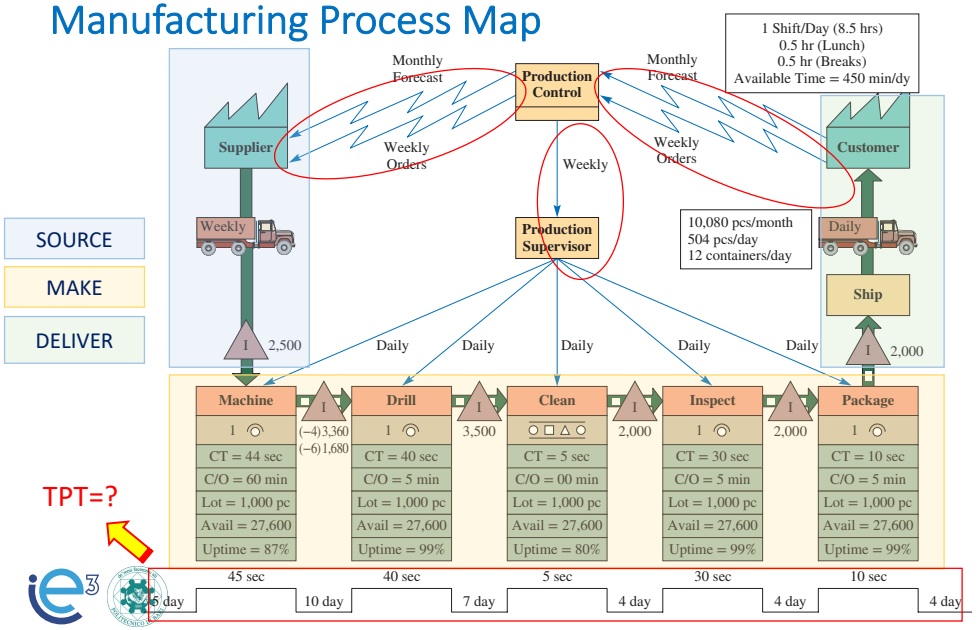


# Supermarket

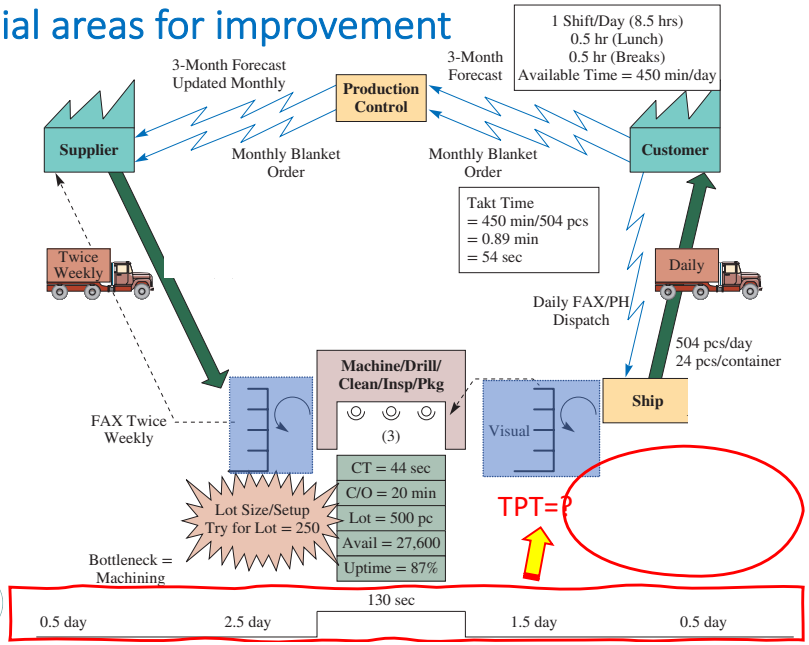
BOSCH REXROTH Solutions



# Example VSM1
# Manufacturing Process Map



# Example VSM2
# Potential areas for improvement




# Summary

- What a Value Stream is
- How to map a Value Stream
- KPIs for a Value Stream
- How to improve a Value Stream

- References:
  *Ch. 14 Jacobs, Chase*