Value Stream Mapping

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What you will learn

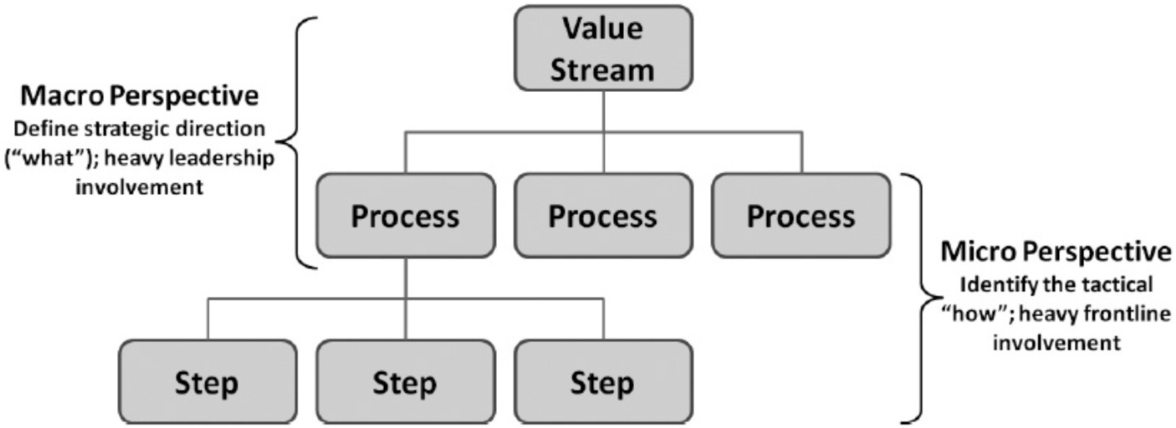
- What is Value stream
- What is Value stream mapping (VSM)
  - Understanding the Current state
  - Designing the Future state
    - Improvement and action plan

Assignment

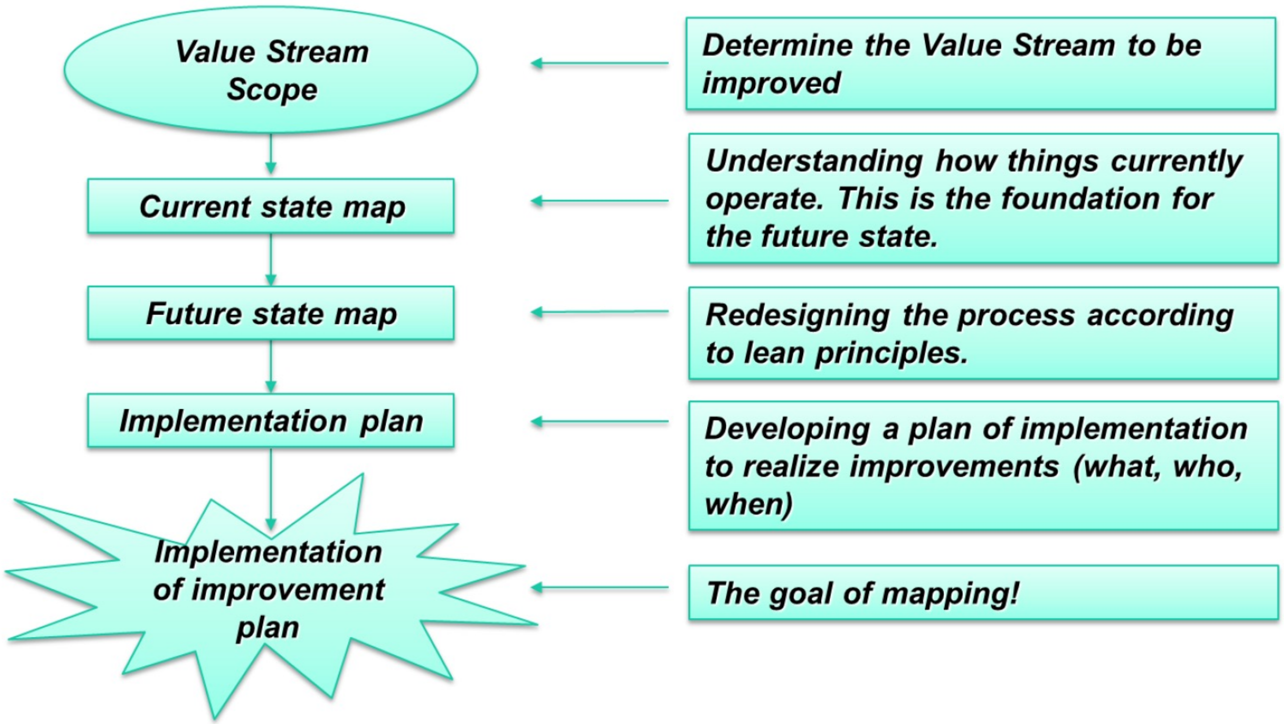
- Presentation of VSM project

What is Value Stream

A value stream is a series of processes that connect together and transform a customer request into a good or service that is delivered to the customer (from request-to-delivery).
Each process adds value for the customer.



What is Value Stream Mapping (VSM)



Understanding the Current State

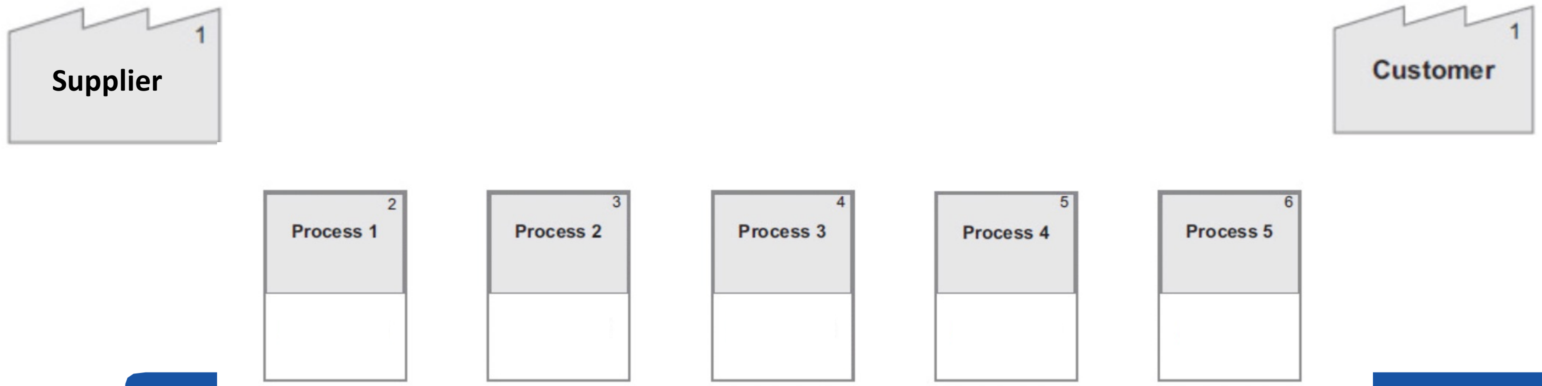
Walking the value stream to obtain the most basic information:

- the sequence of processes that connect together to form the value stream
- the functions that perform the work.

Steps:

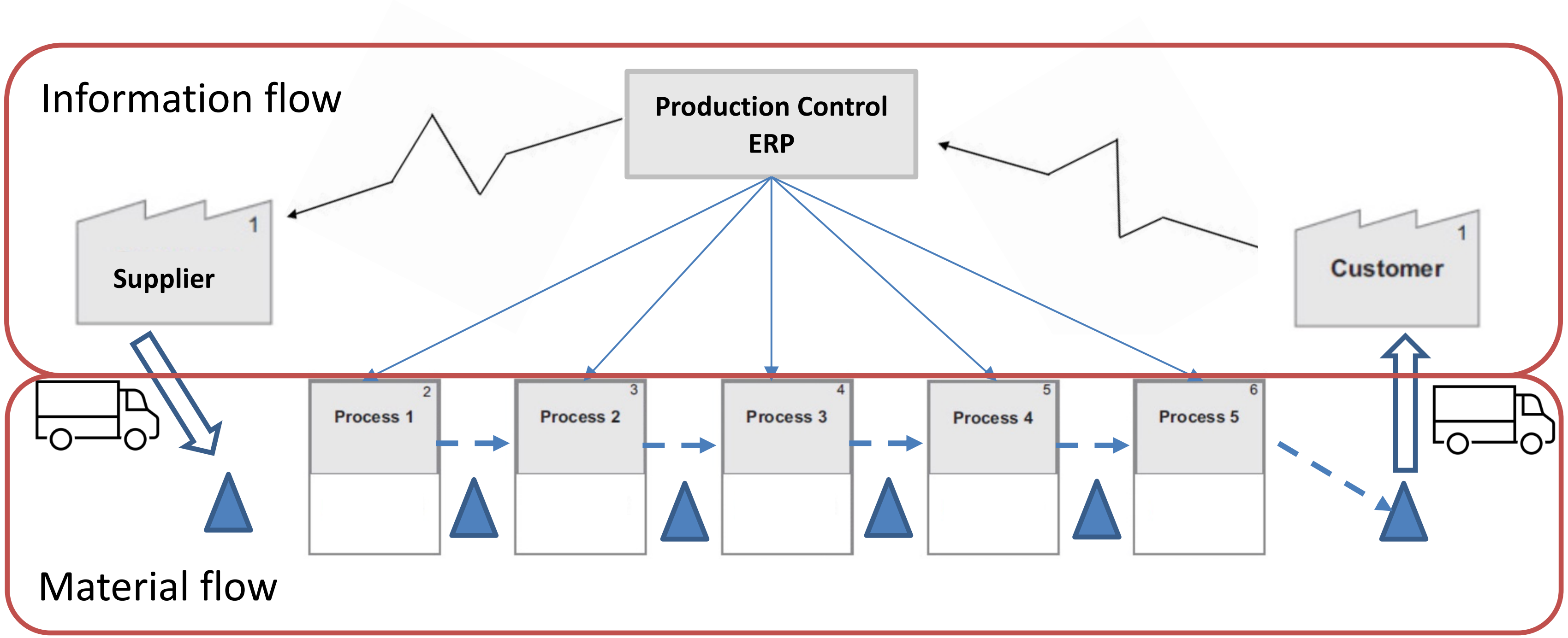
1. Create an outline of the process

→ identify the operations and add external sources, i.e., customers and suppliers.



Understanding the Current State

2. Draw the flow of information and materials

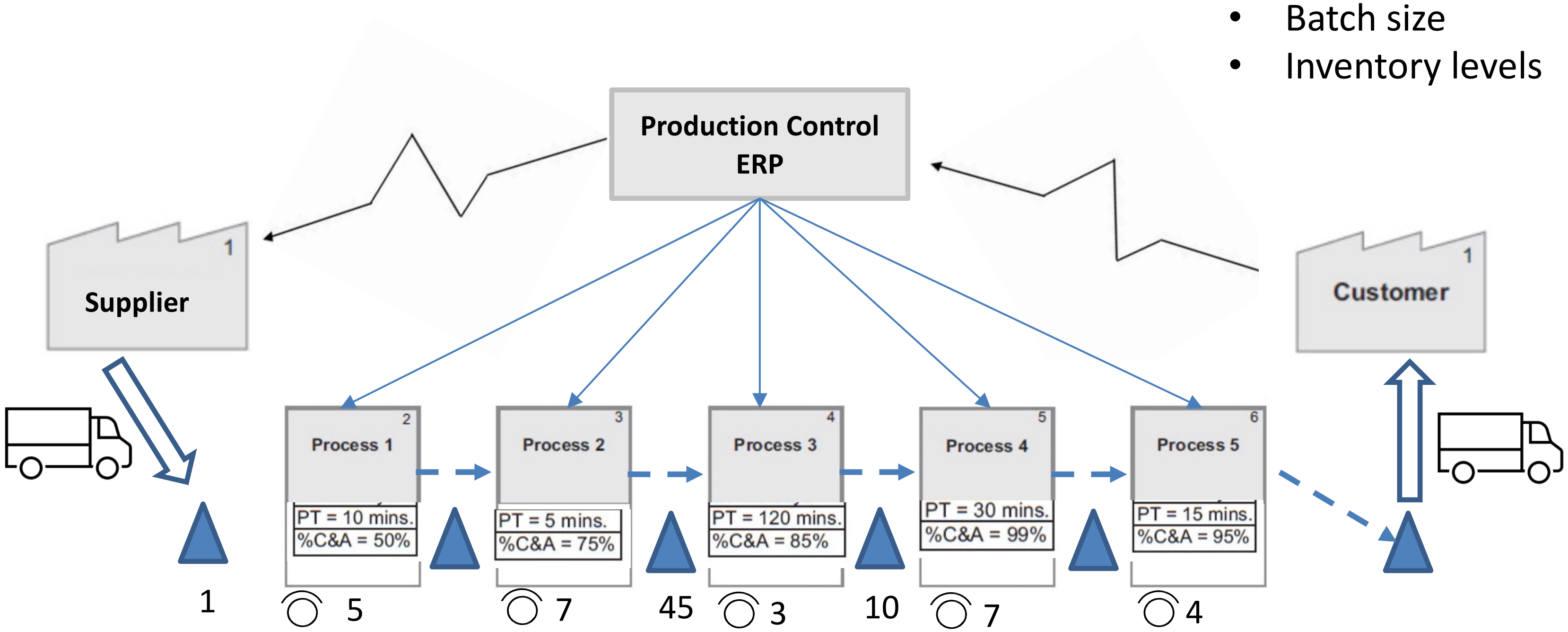


Understanding the Current State

3. Add process data that you collect while walking the stream

Overview of possible process data:

- Customer demand
- Process time (PT)
- Changeover time (CO)
- Number of operators
- Capacity
- Available time
- Uptime/downtime
- Quality or defects rate
- Number of product variations
- Batch size
- Inventory levels



Not all the data will be given! You need to calculate them yourself

Understanding the Current State

4. Make calculations:

- Takt time
- Total process time
- Total lead time
- Process efficiency

Understanding the Current State

$$\text{Takt time (TT)} = \frac{\text{Available time during a given period}}{\text{Demand during this period}}$$

Function:

- **Levels** the rate of production
- Sets the **pulse** in a production flow

  → Product assembly duration that is needed to match the demand.

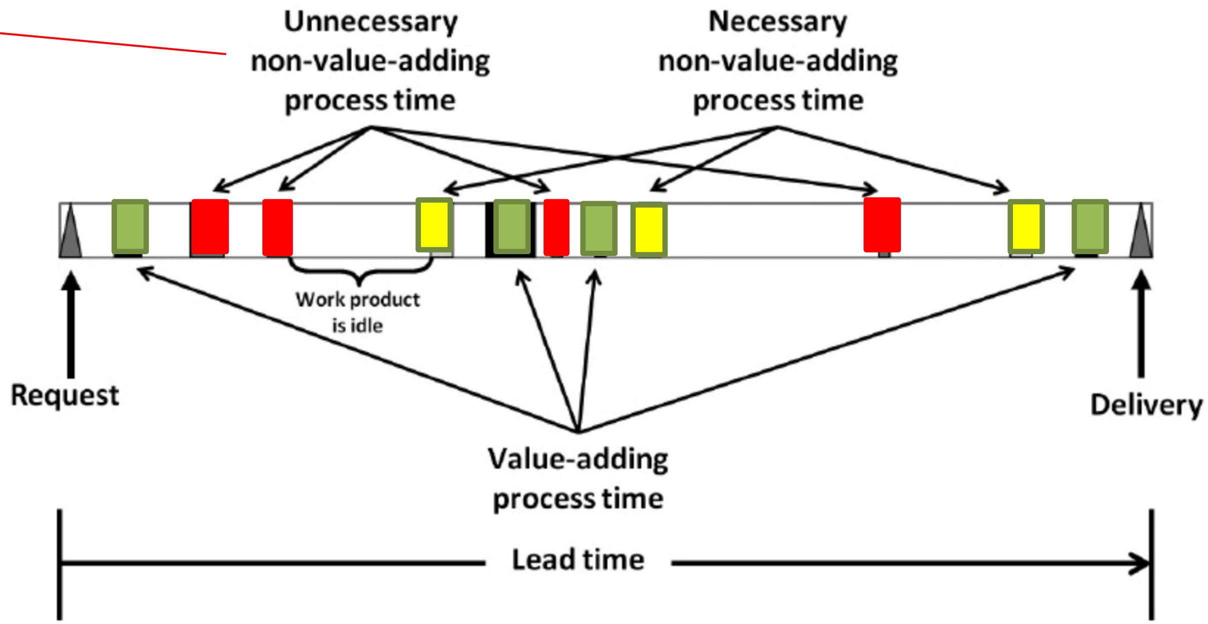
The **aim** of Takt is to detect **deviations**.
→ If a product has not left the production flow when the takt time is out, it is a signal that there is waste in the process.

Understanding the Current State

- **Total process time →** time it takes operators to complete the process tasks to transform an input into an output for one unit of work

7 wastes:

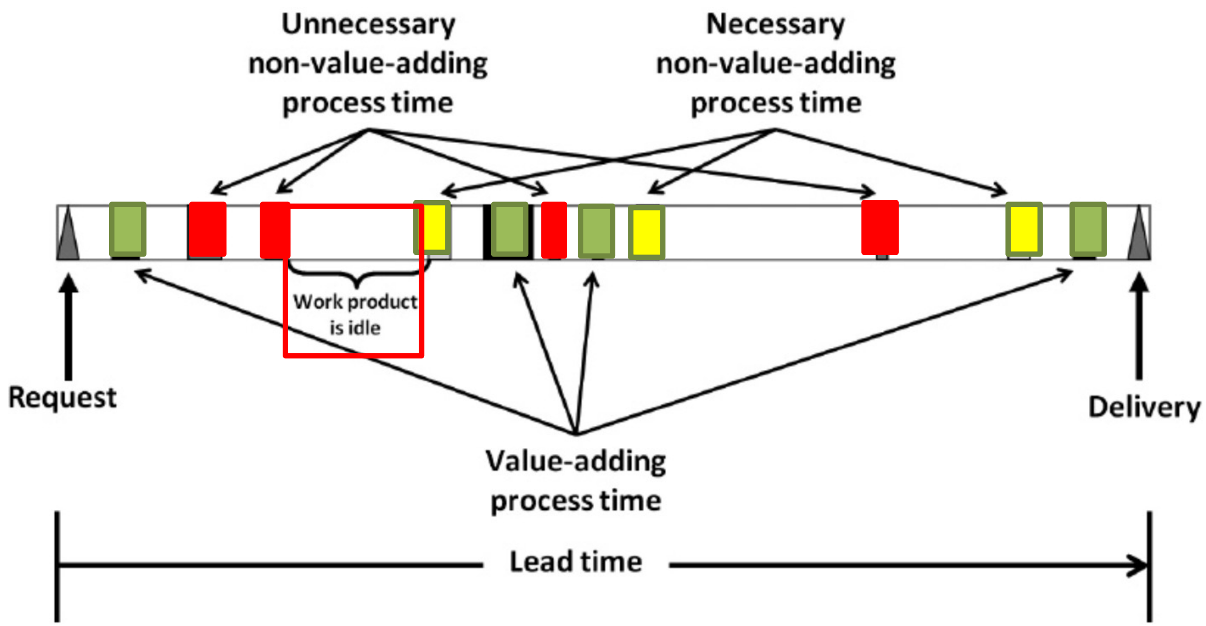
- Transport
- Inventory
- Motion
- Waiting
- Overproduction
- Overprocessing
- Defects



3.4 Process time versus lead time across the value stream

Understanding the Current State

- **Total lead time →** estimated time for a single product to pass through the entire process from request to delivery



$$Total\ lead\ time = Process\ time_{tot} + Inventory\ lead\ time$$

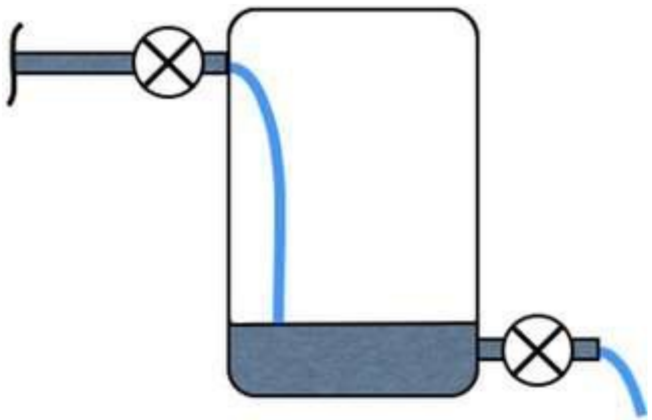
Little's Law

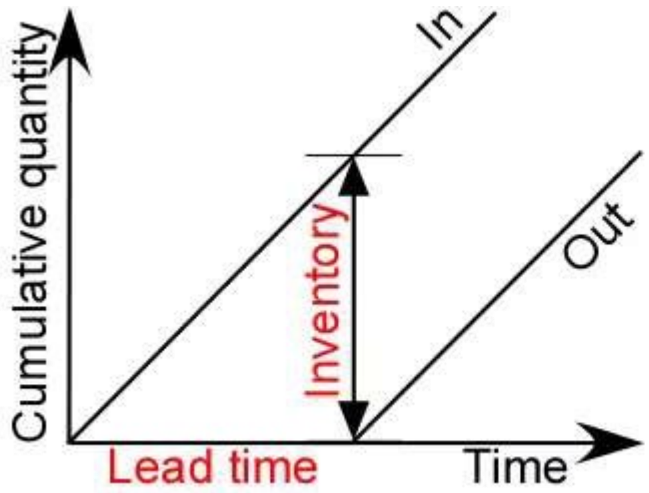
states that average throughput time through a production system is directly proportional to average inventory

$$Inventory\ (I) = throughput\ rate\ (R) * flow\ time\ (T)$$

In steady state:
inflow =outflow

$$\text{Lead Time (T)} = \frac{\text{Work in process (I)}}{\text{Production rate (R)}}$$

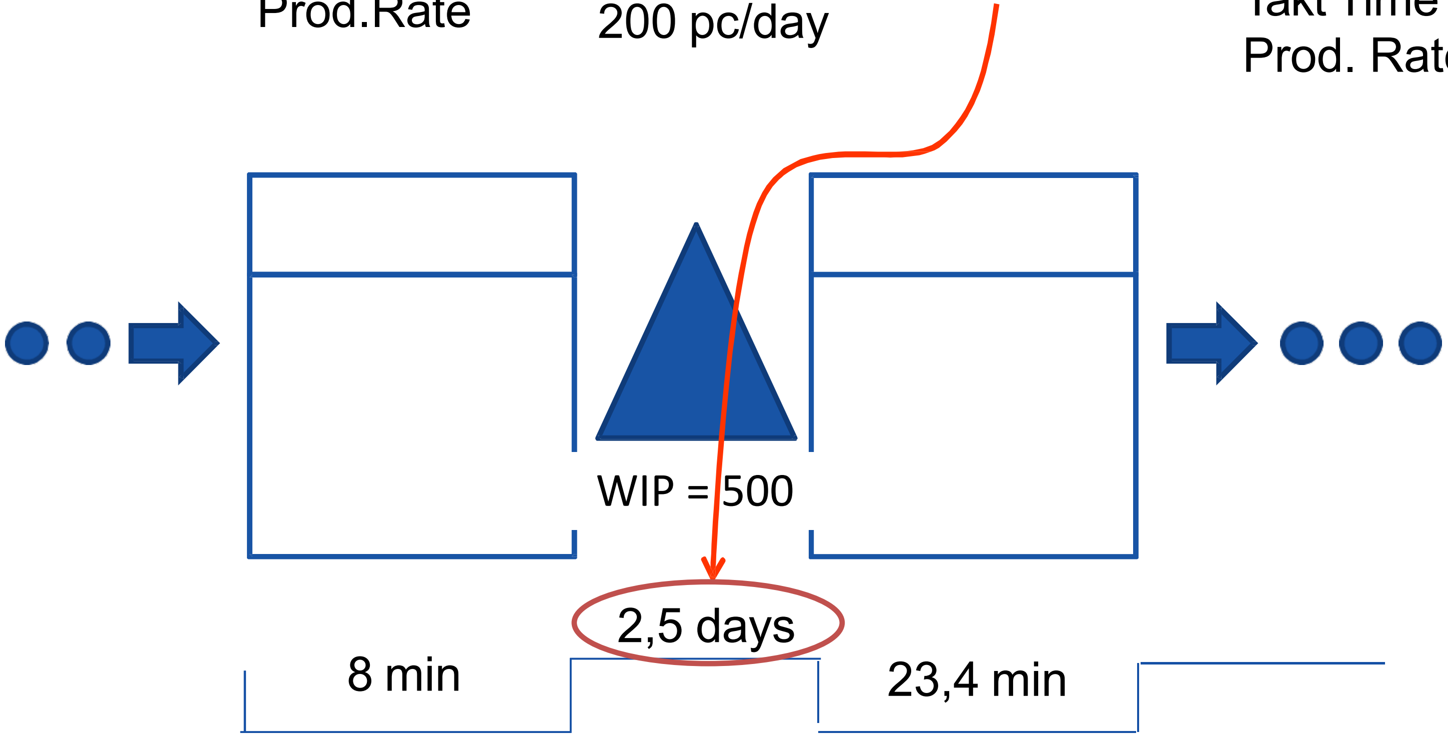




Little's Law

$$\text{Inventory Lead time} = \frac{\text{WIP}}{\text{Prod.Rate}} = \frac{500\text{ pc}}{200\text{ pc/day}} = 2{,}5\text{ days}$$

Takt Time = 2 min
Prod. Rate = 200 pc/day



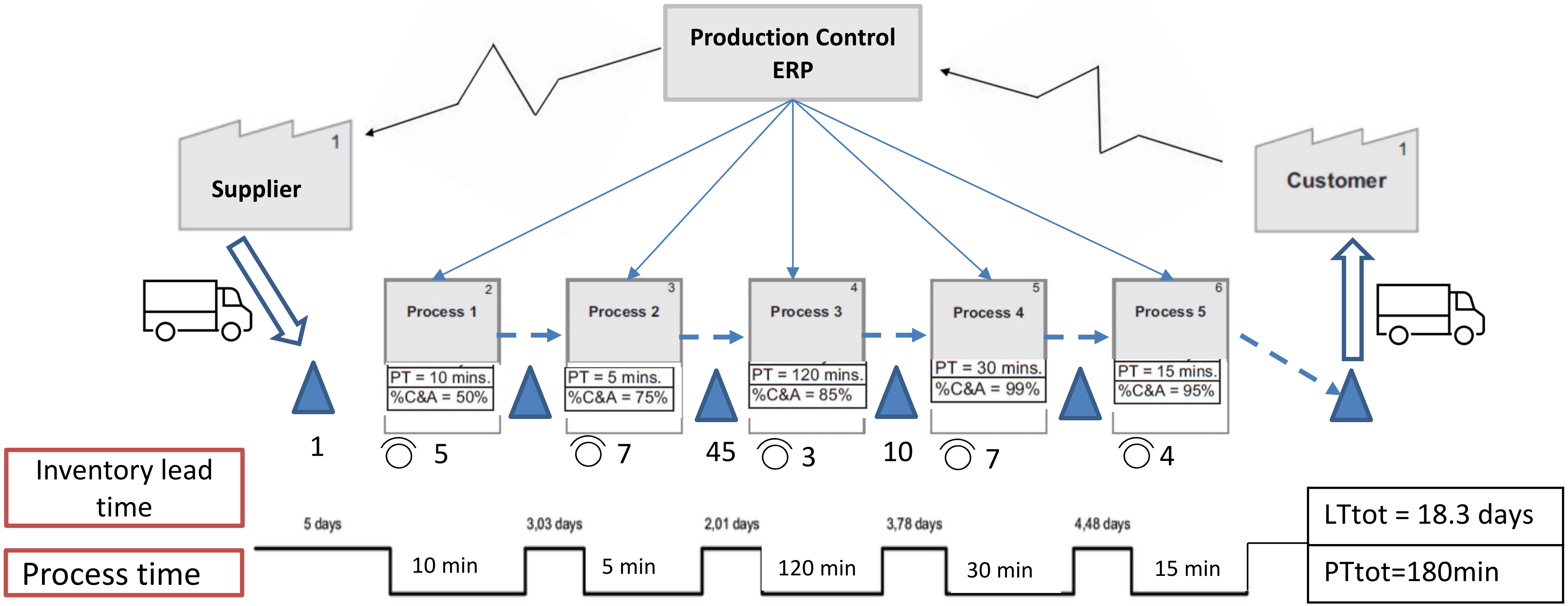
Understanding the Current State

Process efficiency: ratio of value adding time (process time) to total lead time

$$Process\ efficiency = \frac{\sum process\ time}{\sum lead\ time}$$

Understanding the Current State

4. Add timeline and calculations



Analyse the current state

1. Look for WASTES

Seven + 1 categories of waste:

- overproduction,
- overprocessing,
- defect,
- inventory,
- waiting,
- transportation,
- motion,
- underutilization of people (in terms of experience, knowledge, skills and creativity).

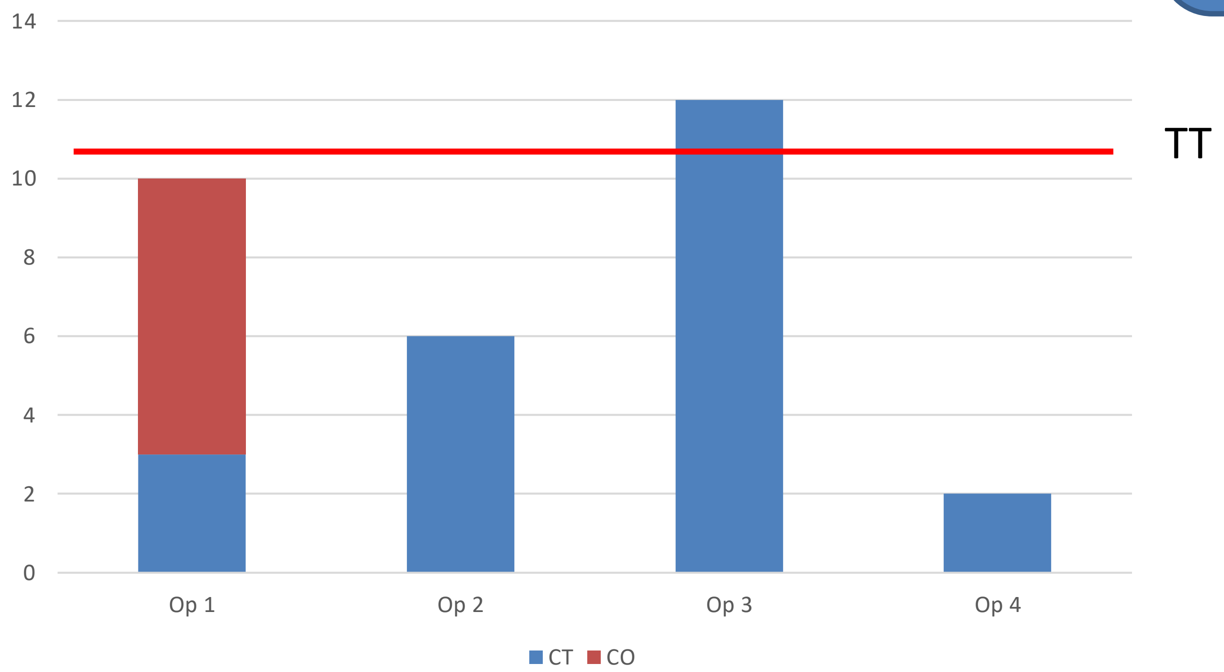
Make the “**right work**” flow across the value stream without delays and unnecessary effort and expense. The goal should be to deliver high quality as quickly and inexpensively as possible.

Analyse the current state

2. **Analyse process capacity**

→ Capacity analysis diagram

Consider the amount of capacity is used in each machine.



CT= cycle time   CO = change over time

Analyse the current state

Can the process meet the customer demand?
How well the process is equipped to handle increasing demand levels?

$$Over\ capacity = Takt\ time\ - Cycle\ time\ _{bottle\ neck}$$

$$Max\ output = \frac{Available\ time}{Cycle\ time_{bottle\ neck}}$$

Designing the Future state

Three overall considerations to address when designing the future state:

- Determining the work that should be done,
- Making that work flow,
- Managing the work to achieve continuously improved performance.

Determining the "Right Work"

The work should be designed to eliminate delays, improve quality, and reduce unnecessary cost, labor effort, and frustration.

Optimal system's performance:

- Delivering customer value in a way in which the organization has **no unnecessary expense**;
- Work flows **without delays**;
- Organization is 100% **compliant** with all local, state and federal laws;
- Organization meets all customer-defined requirements;
- Employees are **safe** and treated with respect.

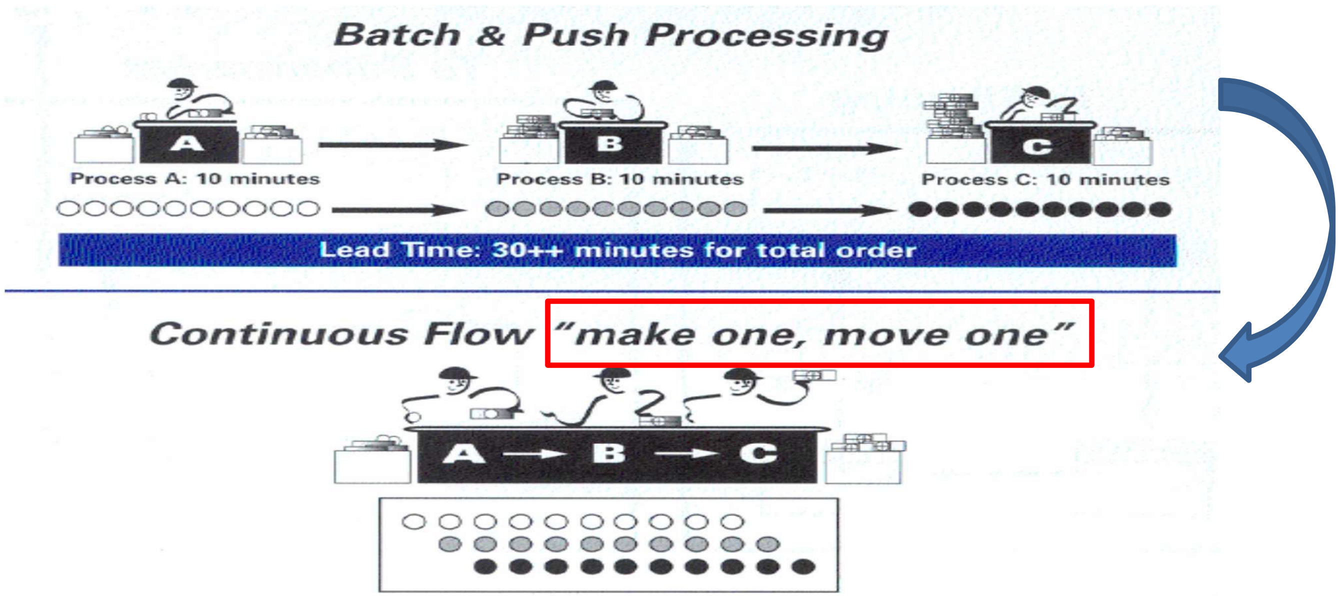
Move towards continuous flow

Continuous flow

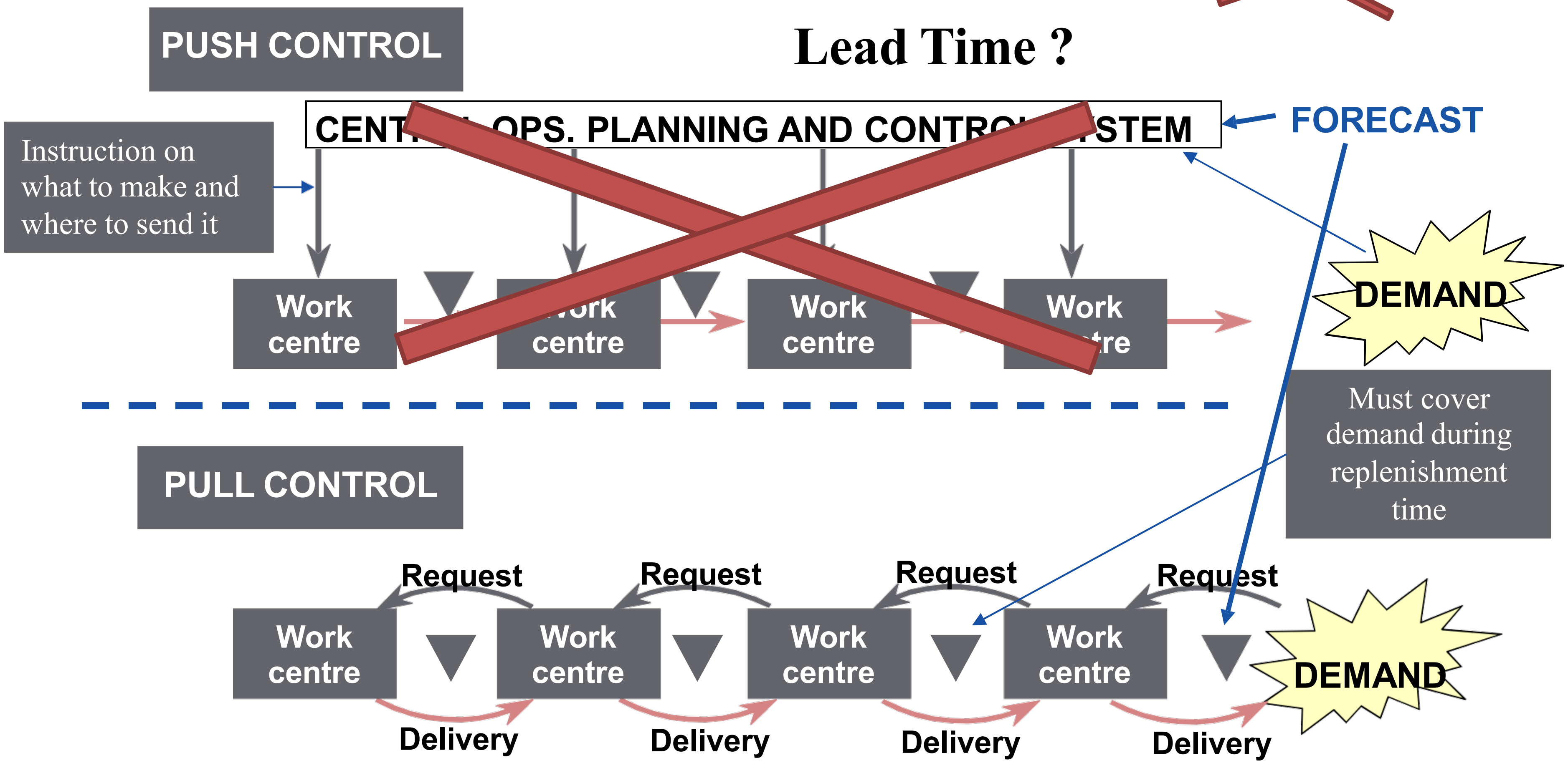
- **minimising** the number of steps as well as stoppage times.
  → reduce the lead time.
- make the "**right work**" flow across the value stream without delays and unnecessary effort and expense.

Move towards continuous flow

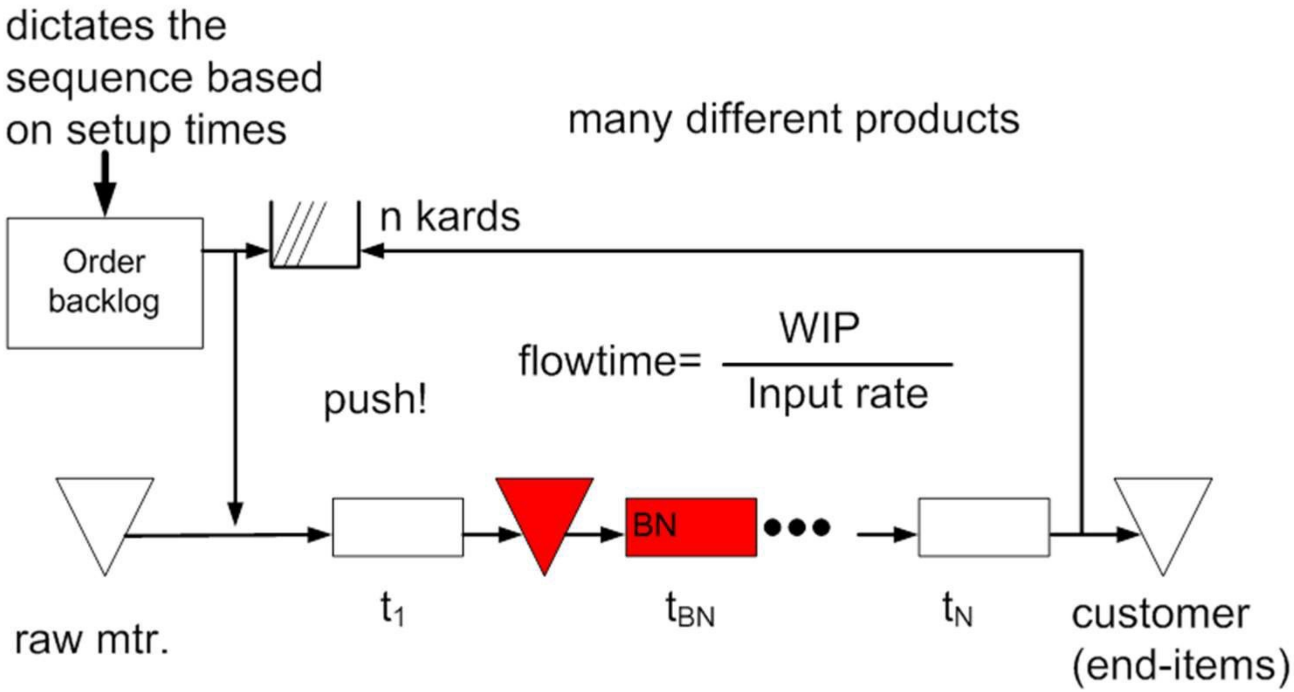
How to achieve continuous flow?



Control of production flow: Pull vs Push



CONWIP (constant work in progress)

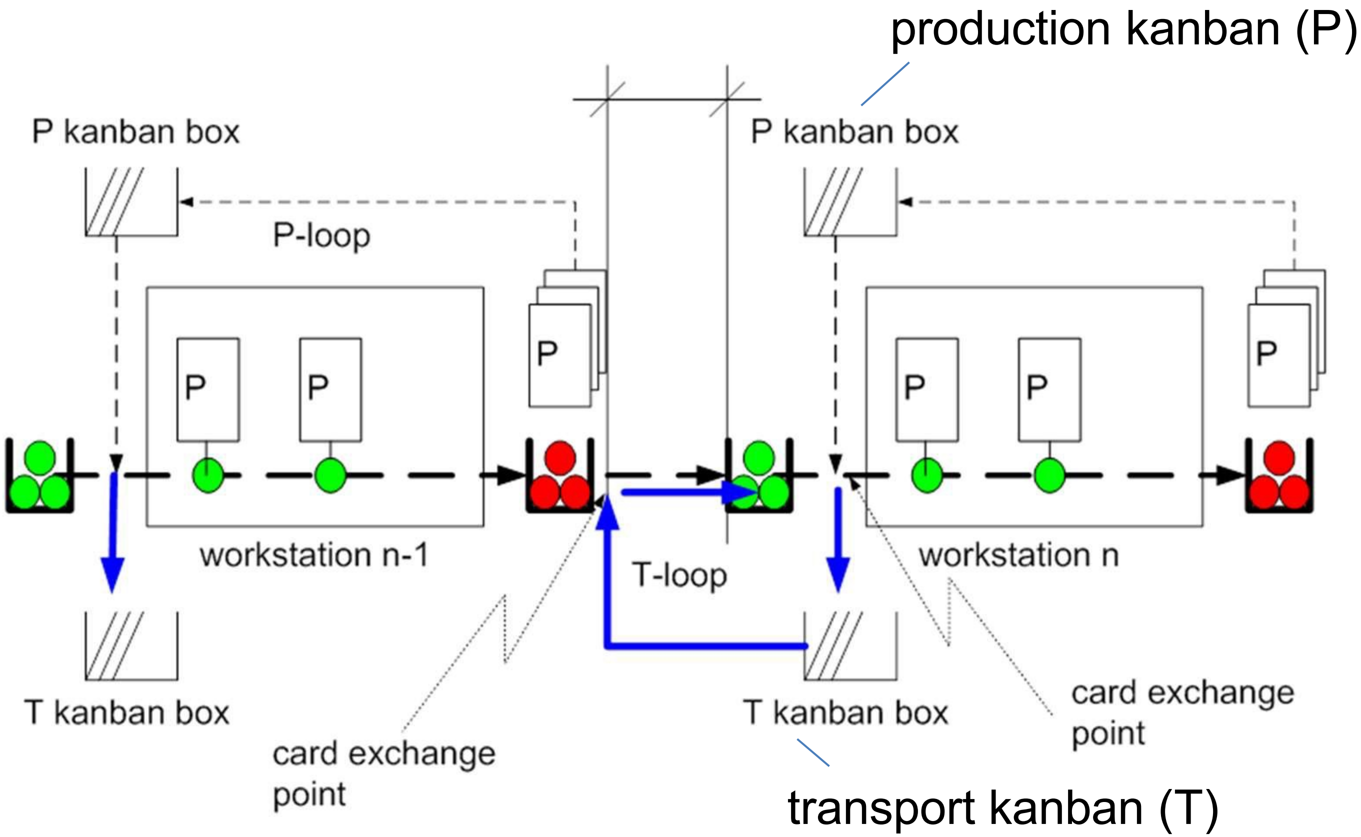


$$\Sigma^N t_i - t_{BN} = (n-1)t_{BN}$$

Number of kanban

$$n = \frac{\Sigma^N t_i}{t_{BN}}$$

Kanban



production kanban (P)
P kanban box
P kanban box
P-loop
P
P
P
P
P
P
workstation n-1
workstation n
T-loop
T kanban box
T kanban box
card exchange point
card exchange point
transport kanban (T)

transport kanban (T)
produktions kanban (P)

Kanban

Number of P and T kanban sets for a given part → $n = \frac{DL(1+\alpha)}{C}$

$n_p = \frac{Dt_p(1+\alpha)}{C}$

$n_t = \frac{Dt_w(1+\alpha)}{C}$

Where:

- **D** = demand per day (leveled demand per day)
- **L** = average lead time for the container (in fractions of the day)

  $L = t_p + t_w$

- **tp** = average processing time per container (in fractions of the day)
- **tw** = average waiting time during the production process + transportation time per container (in fractions of the day)
- **C** = container capacity in units of products (not more then 10% of daily demand)
- **α**= safety coefficient (not more than 10%)
- average demand during lead time plus a safety stock = $DL(1+\alpha)$

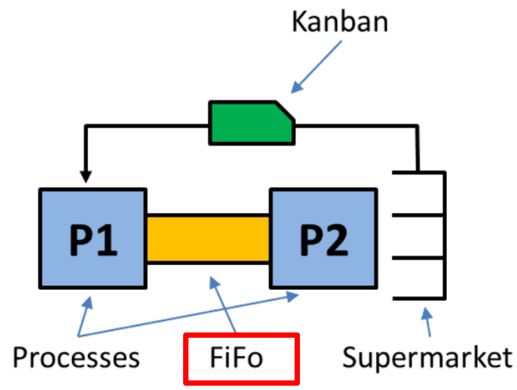
Implementing pull production flow

One-piece flow

First we check **where** you can implement one-piece flow between processes.

- Process times must be **repeatable**. If there is much variation, one-piece flow is impossible.
- Equipment must have very high (near 100 percent) **uptime**. Equipment must always be available to run. If equipment within a manufacturing cell is plagued with downtime, one-piece flow will be impossible.
- Processes must be able to be scaled to **takt** time, or the rate of customer demand.

Implementing pull production flow



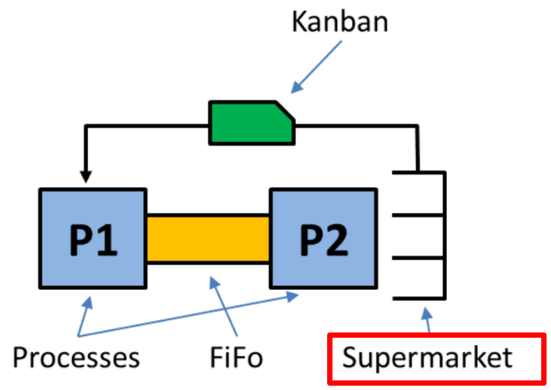
FIFO lane

A controlled inventory point between two process steps, which has a maximum number of products in it and a fixed sequence in which products are taken out of the inventory.

FIFO could be used:

- When P2 has longer **change-over times** than P1. The FIFO prevents P1 from waiting when P2 is working on a change over.
- When **P2 is a bottleneck** machine. The FIFO prevents P2 from idling when P1 has a change over or a breakdown.
- When the **physical distance** between P1 and P2 is relatively large, in which case Transport might be done in batches.
- In **Mixed Model environments** where cycle times vary on P2. The FIFO prevents idling time on machine P1 when P2 is working on products with longer cycle times.

Implementing pull system product

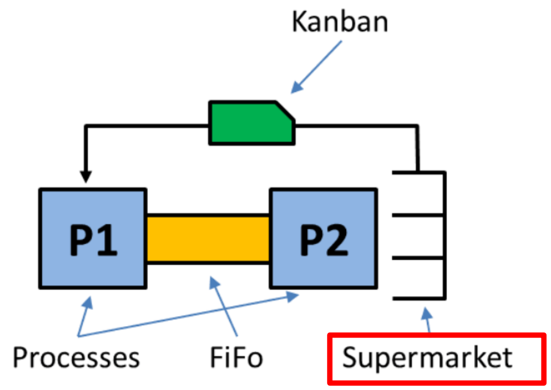


Supermarket

A supermarket is a method of managing inventory in which a variation of parts can be kept without knowing in what order the parts will be taken from the inventory.

A supermarket is a combination of **FIFO lanes** for different parts. The parts by type leave in the same sequence as they arrive. When a part leaves, information is sent back along the value stream to replenish the part

Implementing pull system producti



Supermarket

When to use a supermarket:

1: Use Supermarkets for Lot Size Differences

2: Supermarket in Front of the Customer

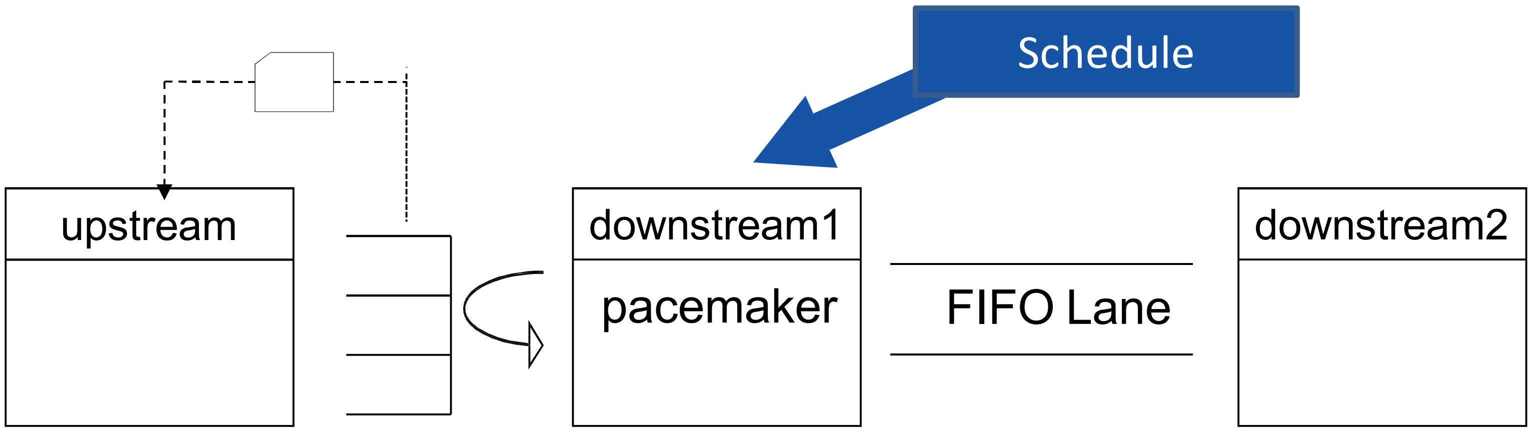
3: Material Flow Splits Up into Different Directions

4: Supermarket Between Very Different Cycle Times

5: Long distance between processes.

Pacemaker Process

1. Sets the paste for all upstream processes
   a) Upstream processes only produce when there is a pull signal from the pacemaker
   b) All downstream processes have a continuous flow.
2. Decides upon lead time to customer
3. Fluctuation in volume affects capacity requirements in upstream processes



Continuous flow

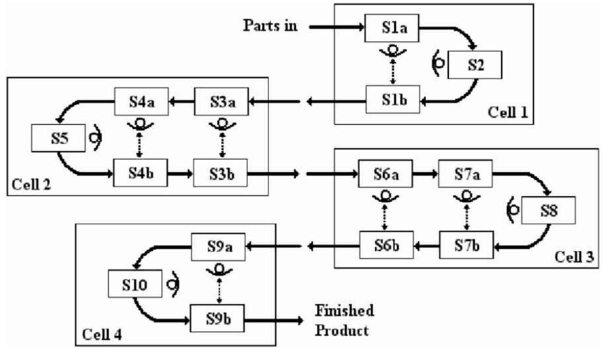
The **layout** of the production flow has significant **influence** on the possibility of approaching continuous flow.

Strive for:

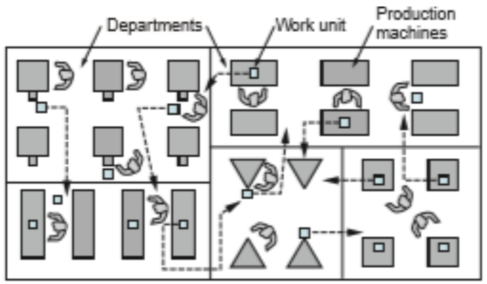
- short distance between process steps
- Small buffer
- Small package units
- Frequent transports

Selection of Layout

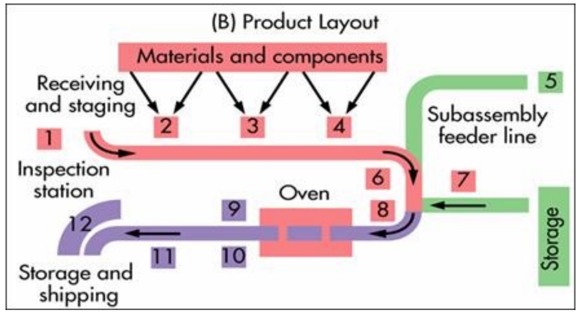
Fast position



Cell layout

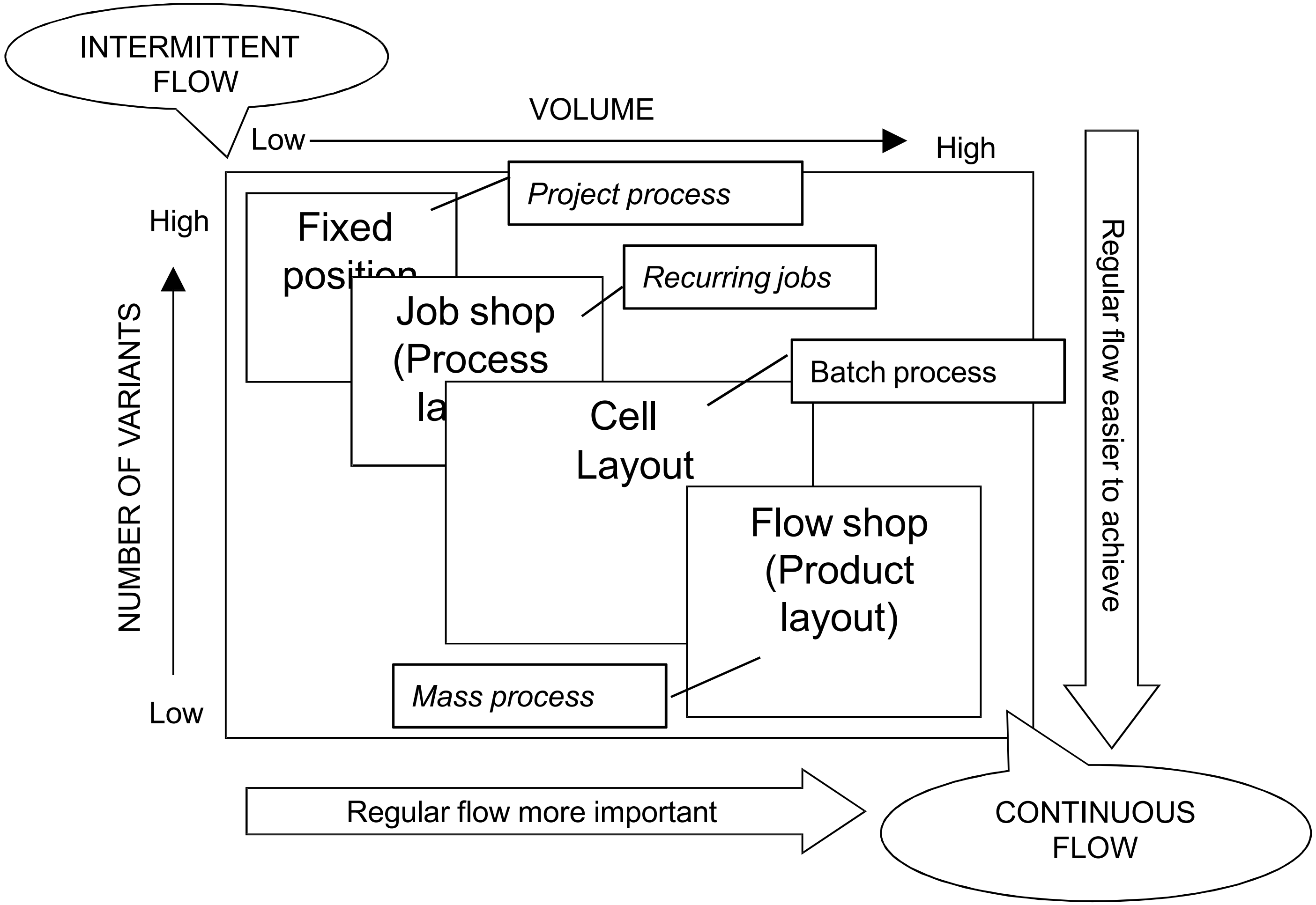


Process layout



Product layout

Volume / number of variants



Select number of stations

$$\text{Nb of stations} = \frac{\text{Sum of operation times}}{\text{Takt time}}$$

How to group operations into process steps?
How many process steps do we need?

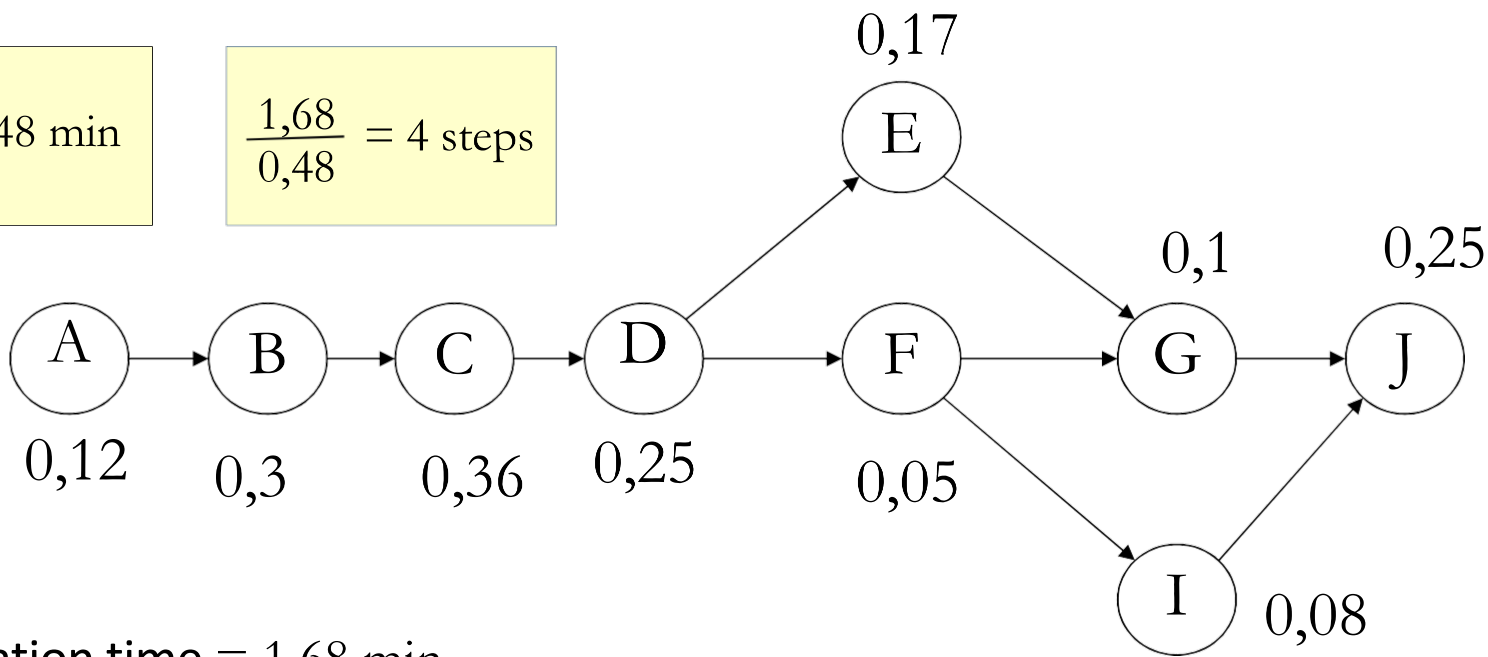
Example: Design of product layout

Demand = 5000 items/week

TT =	$\frac{5*8*60}{5000} = 0{,}48$ min

$$\frac{1{,}68}{0{,}48} = 4 \text{ steps}$$

Precedence diagram:
(A, B, … - operations)

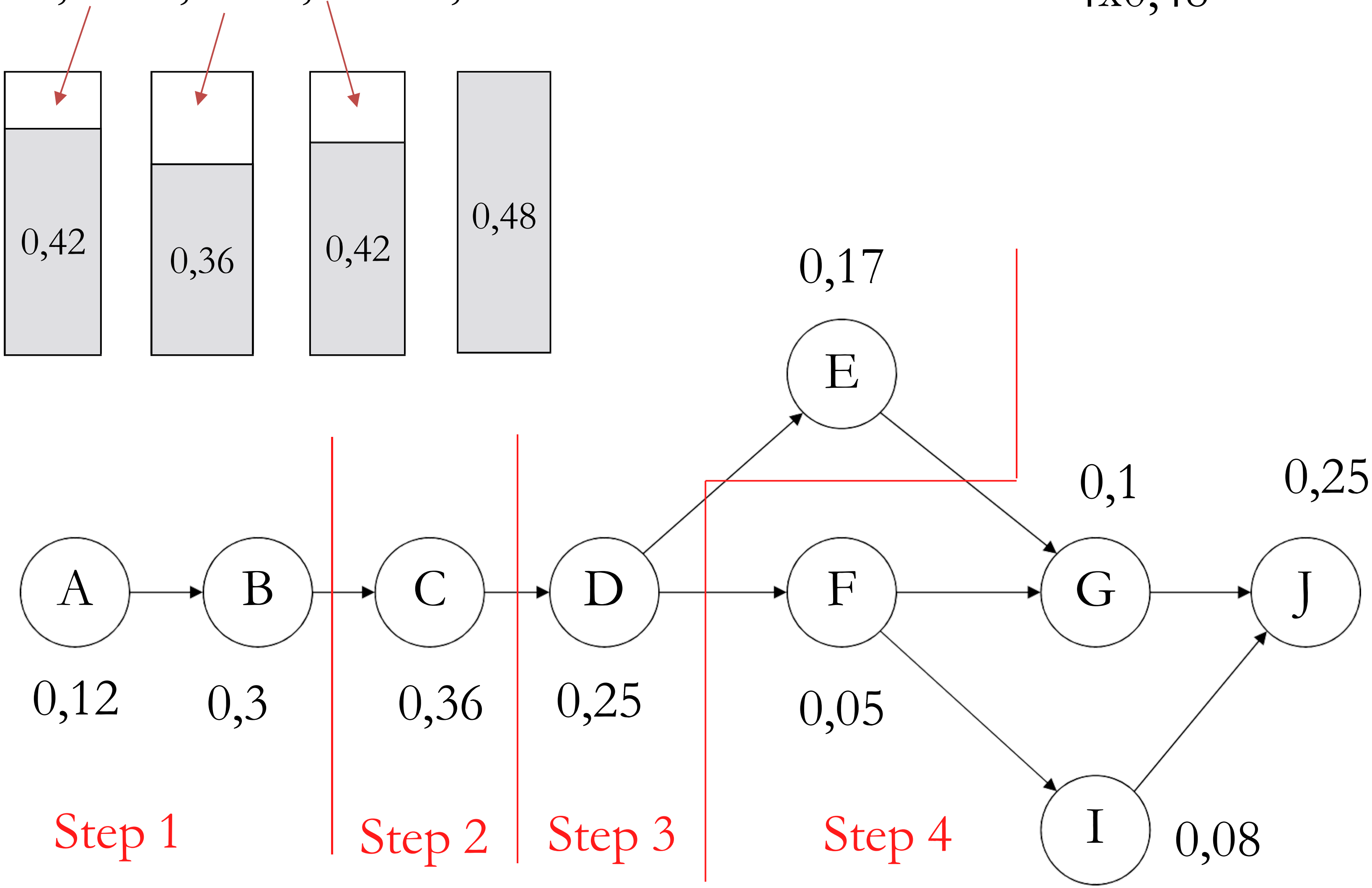


Sum of operation time = 1,68 min

Time losses in all steps

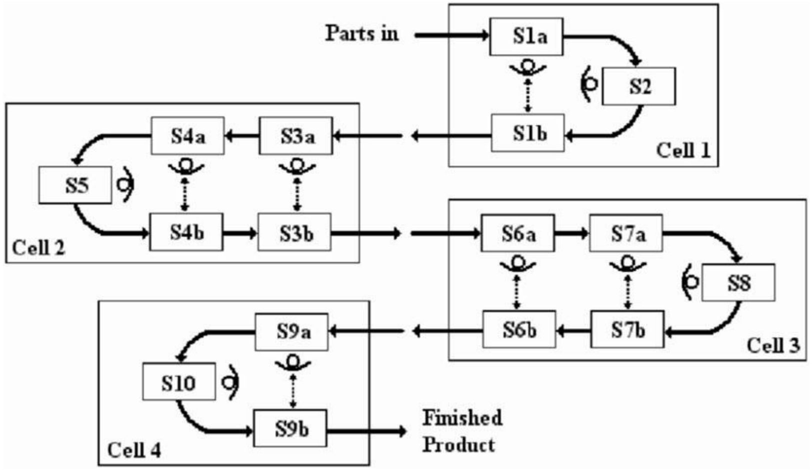
0,06+0,12+0,06 = 0,24 min

$$\text{Balance losses} = \frac{0{,}24}{4\text{x}0{,}48} = \mathbf{12{,}5\%}$$



Cell layout

- A compromise between process and product layout
- Make one move one material flow within the cell



Selection of cell layout

Requirement for the cell layout
- Identification of **families products** → Products grouped together into families with similar manufacturing requirements
- High level of training, flexibility and empowerment of **employees**
- Being **self-contained** with its own equipment and resources.

Available Methods:

→ Intuitive grouping (*Max 100 article numbers and 12 machines*)

→ Coding and Classification *(used for complex product mix)*

→ "**Production Flow Analysis**"

Production Flow Analysis (PFA)

Before Grouping — Products

Pump Machining Production Flow Analysis

		Broach	HMC	Lathe-Chuck	Hob	Lathe-Manual	Hob	Lathe-Bar	Lathe-'
61354	Cover Bearing			X					
70852	Gear Driven 8P ,56T , RH	X		X	X		X		
52594	Spacer,cplg Shaft							X	
81357-T	Impellor	X		X					
50547-D	Gland, MU, 6"					X			
70935	Gear,Driven,8P ,26T,LH	X		X	X		X		
51171	Retainer Bushing							X	
81176	Body Volute		X						
72298	Elbow, Relief Valve		X						
50763	Spacer, Bearing							X	
71972-8	Adapter, Intake, 8"		X			X			
62575	Shaft Shift							X	
63160	Seat, Spring							X	
62966	Generator, Tach Pulse			X	X				
71928	Head, Pump					X			

Process

After Grouping

Pump Machining Production Flow Analysis

		Lathe-Manua	Lathe-Ver	HMC	Lathe-Chuck	Broach	Hob	Lathe-Bar
50547-D	Gland, MU, 6"	X						
71928	Head, Pump	X	X					
71972-8	Adapter, Intake, 8"	X	X	X				
81176	Body Volute		X	X				
72298	Elbow, Relief Valve			X				
81357-T	Impellor				X	X		
62966	Generator, Tach Pulse				X		X	
70852	Gear Driven 8P, 56T, RH				X	X	X	
70935	Gear,Driven,8P, 26T,LH				X	X	X	
61354	Cover Bearing				X			
52594	Sp[acer,cplg Shaft							X
62575	Shaft Shift							X
63160	Seat, Spring							X
51171	Retainer Bushing							X
50763	Spacer, Bearing							X

Turn-Mill Cell

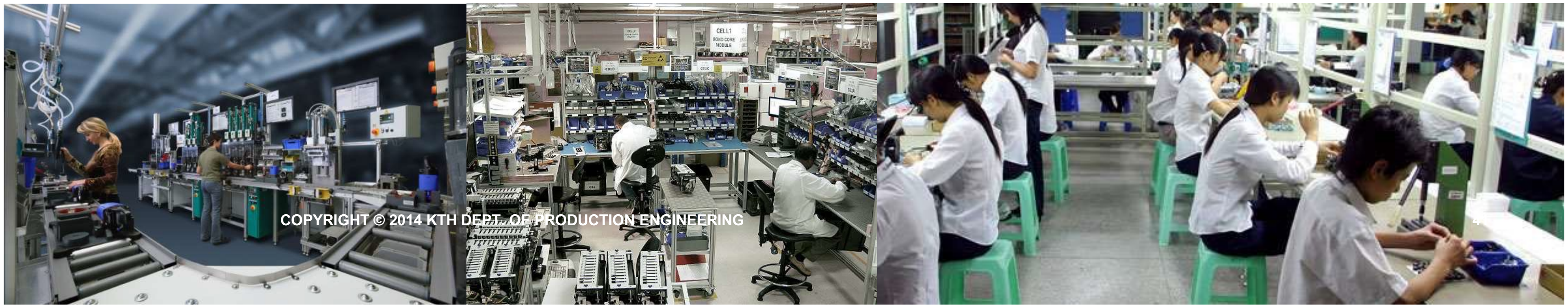
Chucking Lathe Cell

Barfeed Lathe Cell

Rearranging the rows and columns, as in the second matrix, clearly shows families

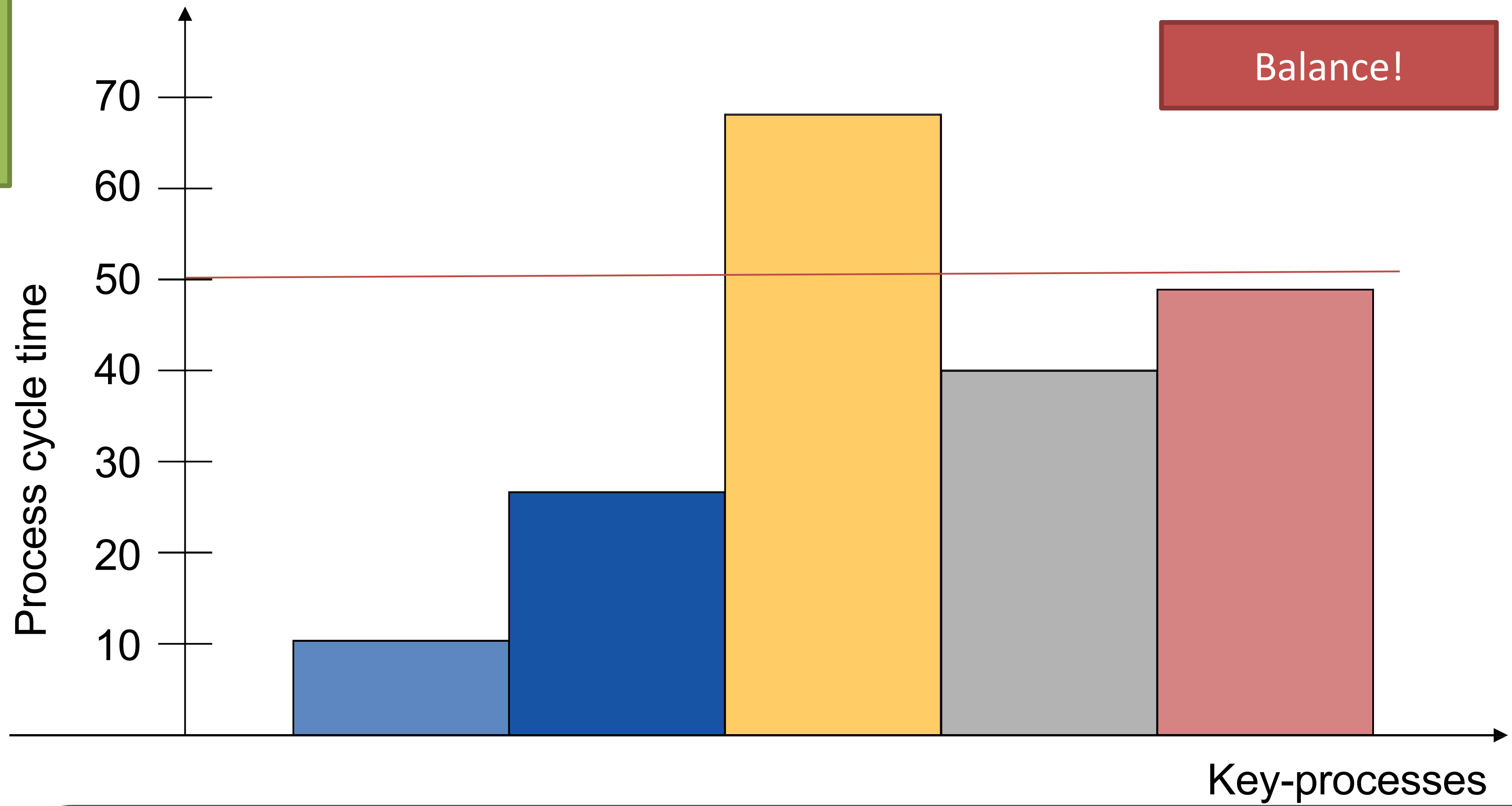
Balancing of cells

- Difficulty to divide the work equally between stations
- Natural variation in work time
- Difference in product mix



Rebalancing the process

Observation from current state



Balancing of equipment /Inherent balance

Divide the job equally between the machines

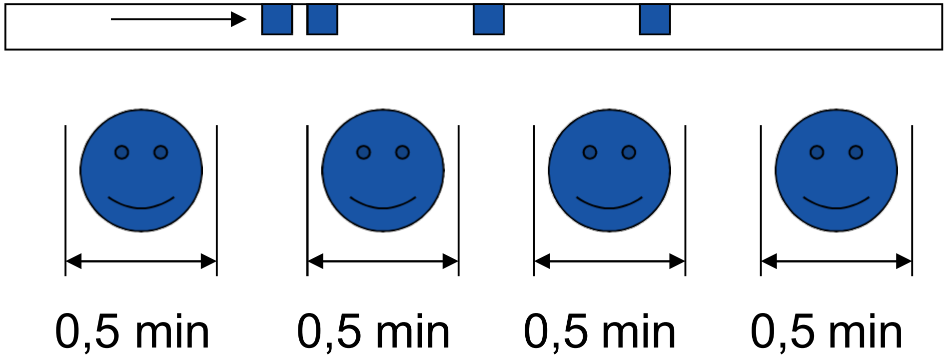
The line has to be rebalanced anyway

→ for each new product

→ at each setup

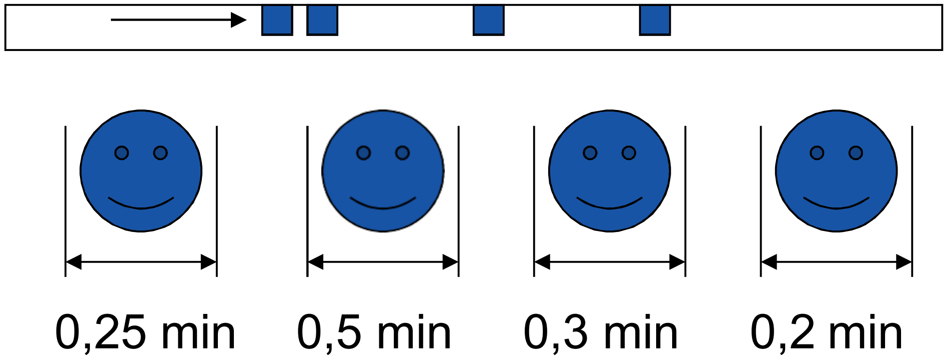
Balancing people

Inherent line balance



Difficult to achieve

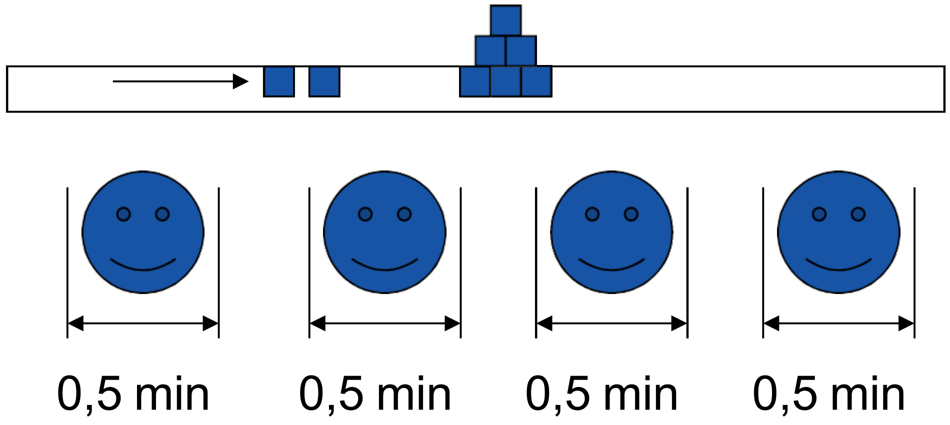
Surplus people capacity



Unacceptable

Balancing people

Queuing



Compensates for cycle-to-cycle variation
Queue before worker shows who is unbalanced

Distributing the job

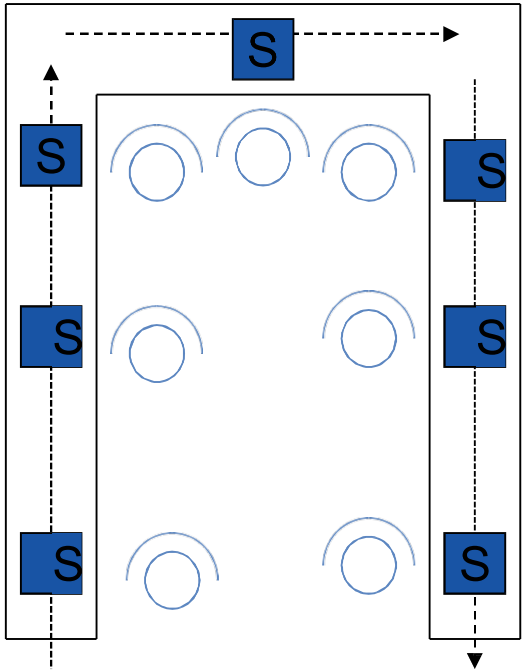
- Rearrange tasks to reduce excess capacity and (eventual) bottlenecks.

- Move resources (workers) of the line that have excess capacity to bottlenecks.
  - Alleviate the workload where there are blockages, and move it to places where excess capacity can be filled by absorbing more work.

- Result:
  - Reduced **waiting waste** in the places where there was excess capacity.
  - Improved production flow where there were bottlenecks.

Which work content to assign to each operator?

One operator per station

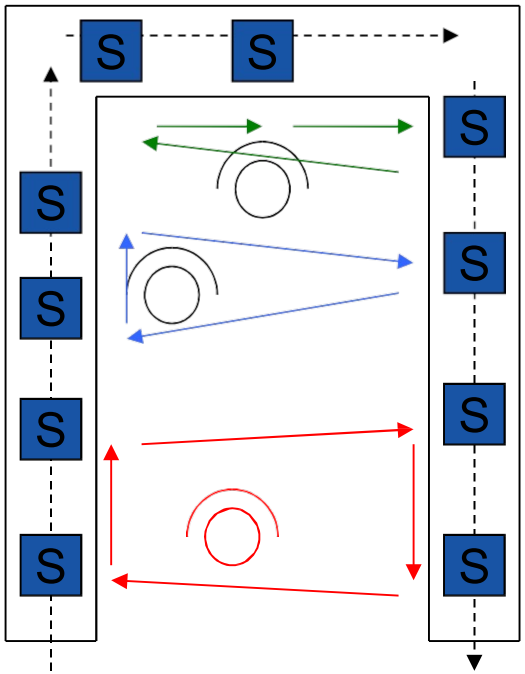


+ if a lot of manual work, no automated equipment (i.e. assembly)
+ easy assignment of work

- Balance of work
- Possibility to diversify the work
- Often a conveyor required to provide the sense of continuous flow (tendency to regression to batching)

Which work content to assign to each of the operators?

Splitting

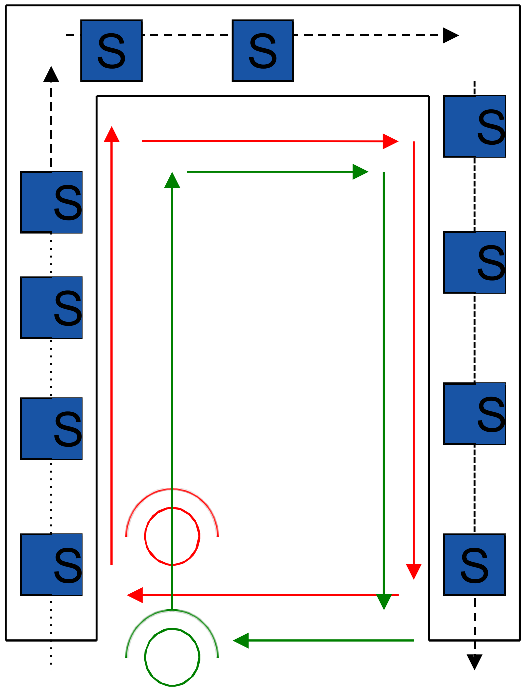


Splitting of the work
(Cross the cell work combination)

- Many combinations of work elements
- Assign the first and the last operation to one and the same operator to improve the sense of takt time

Which work content to assign to each of the operators?

The circuit



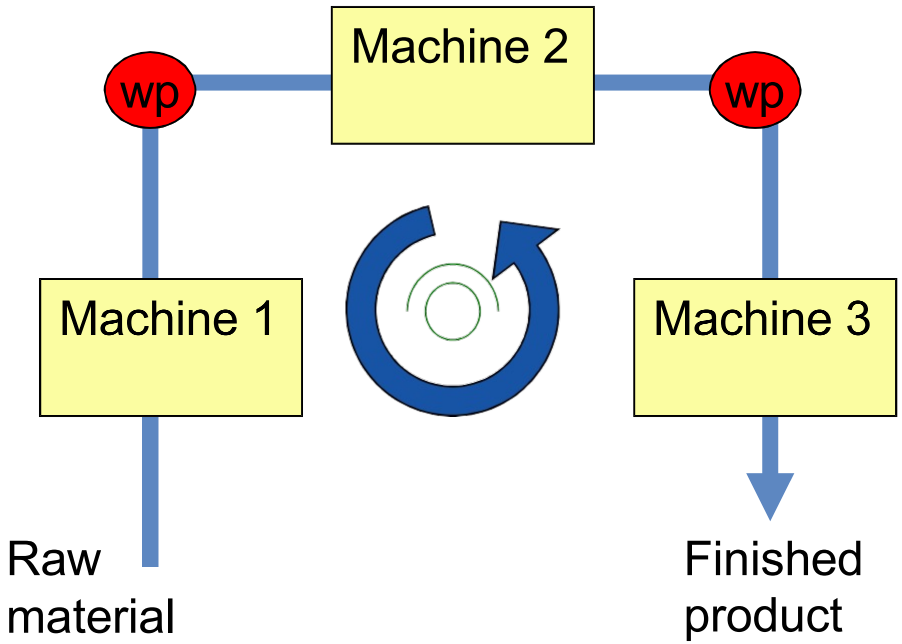
+Natural pacing effect
+Easy to implement
+Volume flexibility
+Job rotation (work more interesting)

-Difficult to coordinate more than <u>two</u> operators
-Similar work time at each station required (<40% of Cycle Time at one station)
-Skilled operators required

Which work content to assign to each of the operators?

Reverse flow

+More natural working sequence
- One piece between workstations required (WIP)

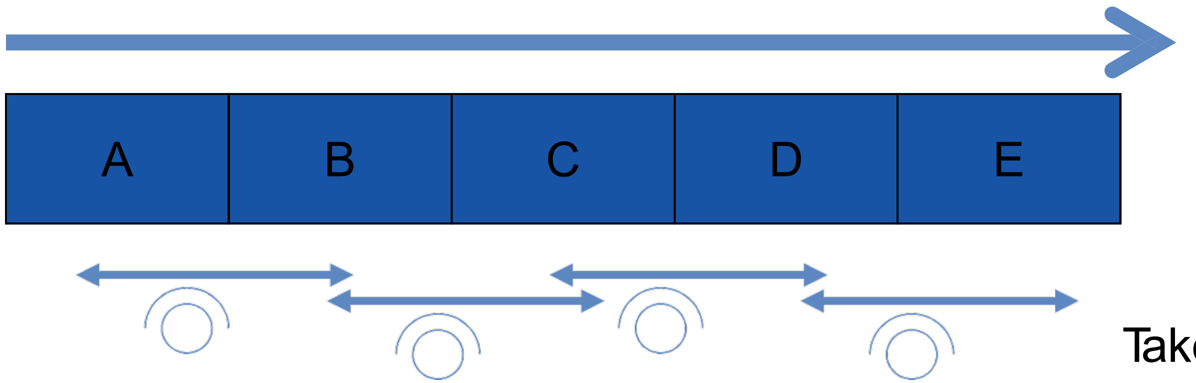


Start at machine 3 –
unload
place in out box
take wp from between m2 and m3 and load,
start cycle m3
go to m2 empty handed
Machine 2
(as above)
go to m1 empty handed

Which work content to assign to each of the operators?

Ratchet

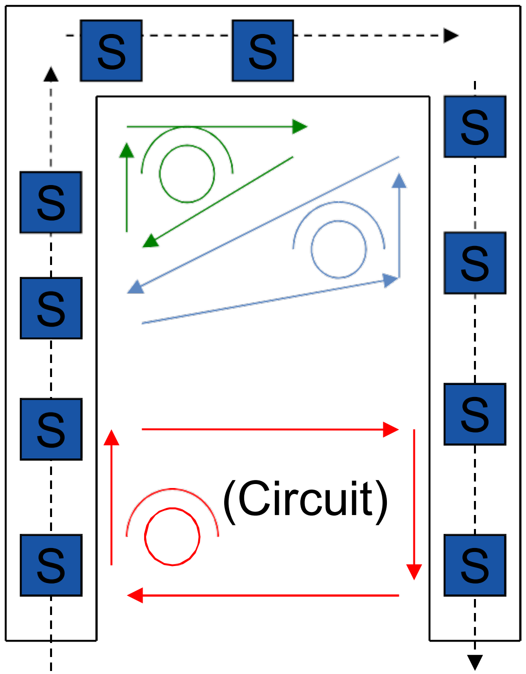
Nb of operators = nb of machines -1
2 operators work in one station
Each operator moves back at 50% of takt time



Take a wp from A to B
Put into machine
Start the cycle
Move back empty-handed

Which work content to assign to each of the operators?

Combination



Splitting + circuit or reverse

Benefits of circuit if more than 2 operators required

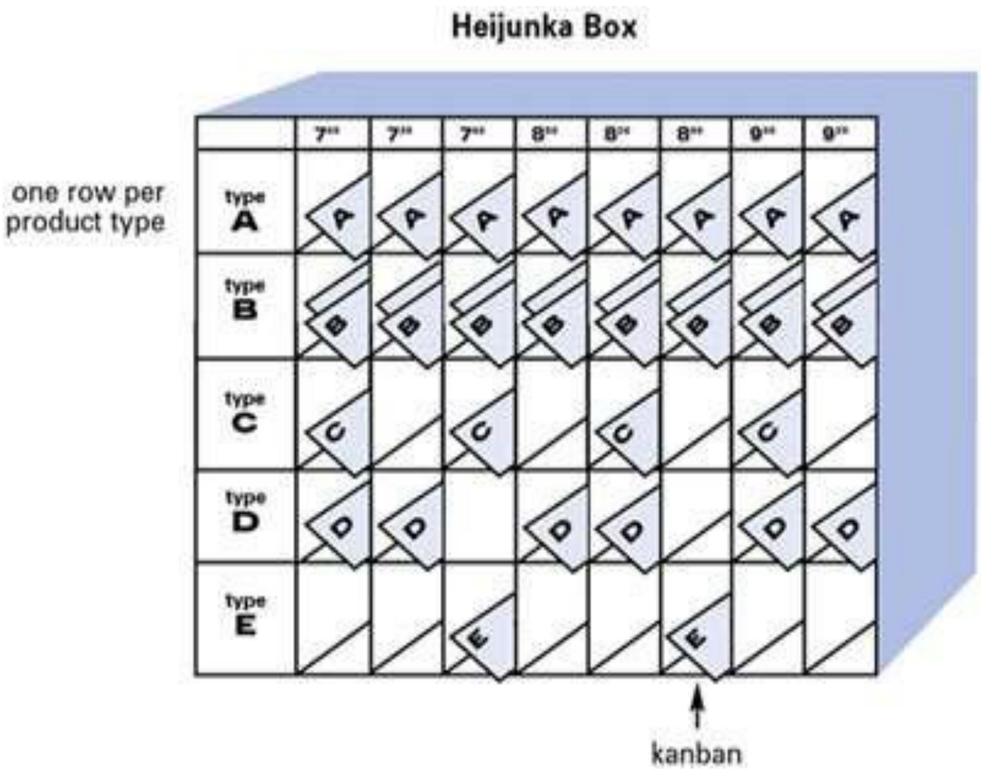
Leveling the mix

Large batches makes lead time large – this forces more inventory both down- and up the stream

To decrease lead time – level the mix!

(**Inventory** is what we need to cover demand during lead time plus safety stock to cover variation in customer orders and lead times)

Heijunka box



A pitch

Time to make 1 box of an article

Pitch = takt time * box size

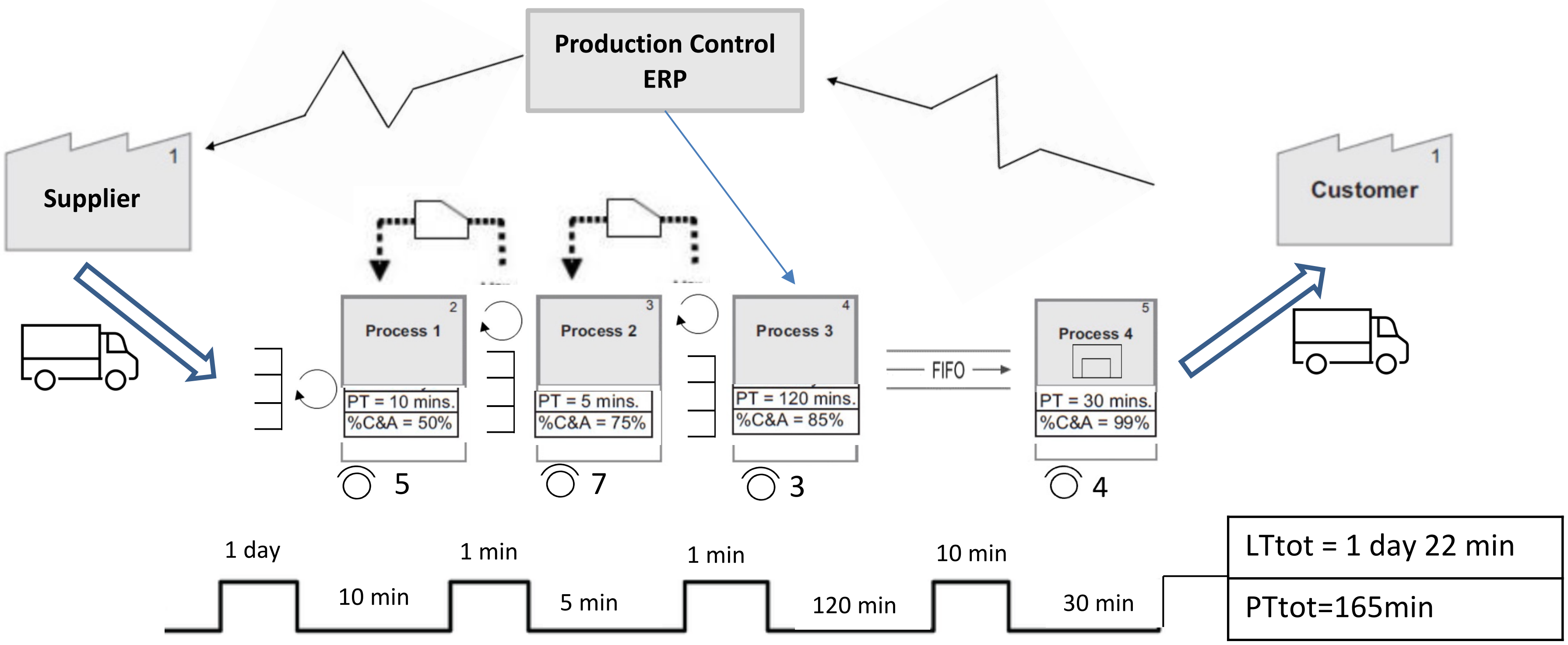
TT= 40s; box =30 pieces => pitch = 20 minutes

6.00	6.20	6.40	7.00	7.20					
S	S						S	S	
			L	L	L				
						A			

The mix: SSLLLAS…repeat

Design the future state map

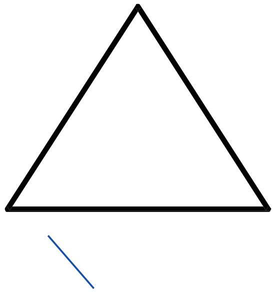
Put everything together



Symbols: summary

Process 1	
CT	2min
CO	1h
A	80%
Shift	3

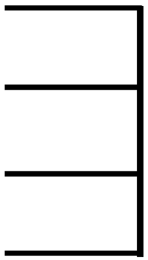
inventory



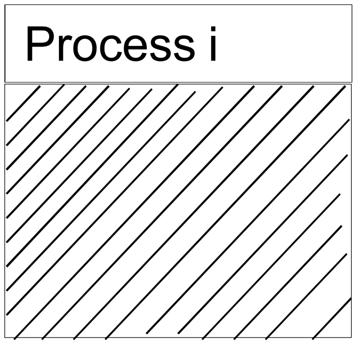
107 pc

Process 2	
CT	5min
CO	2h
A	90%
Shift	2

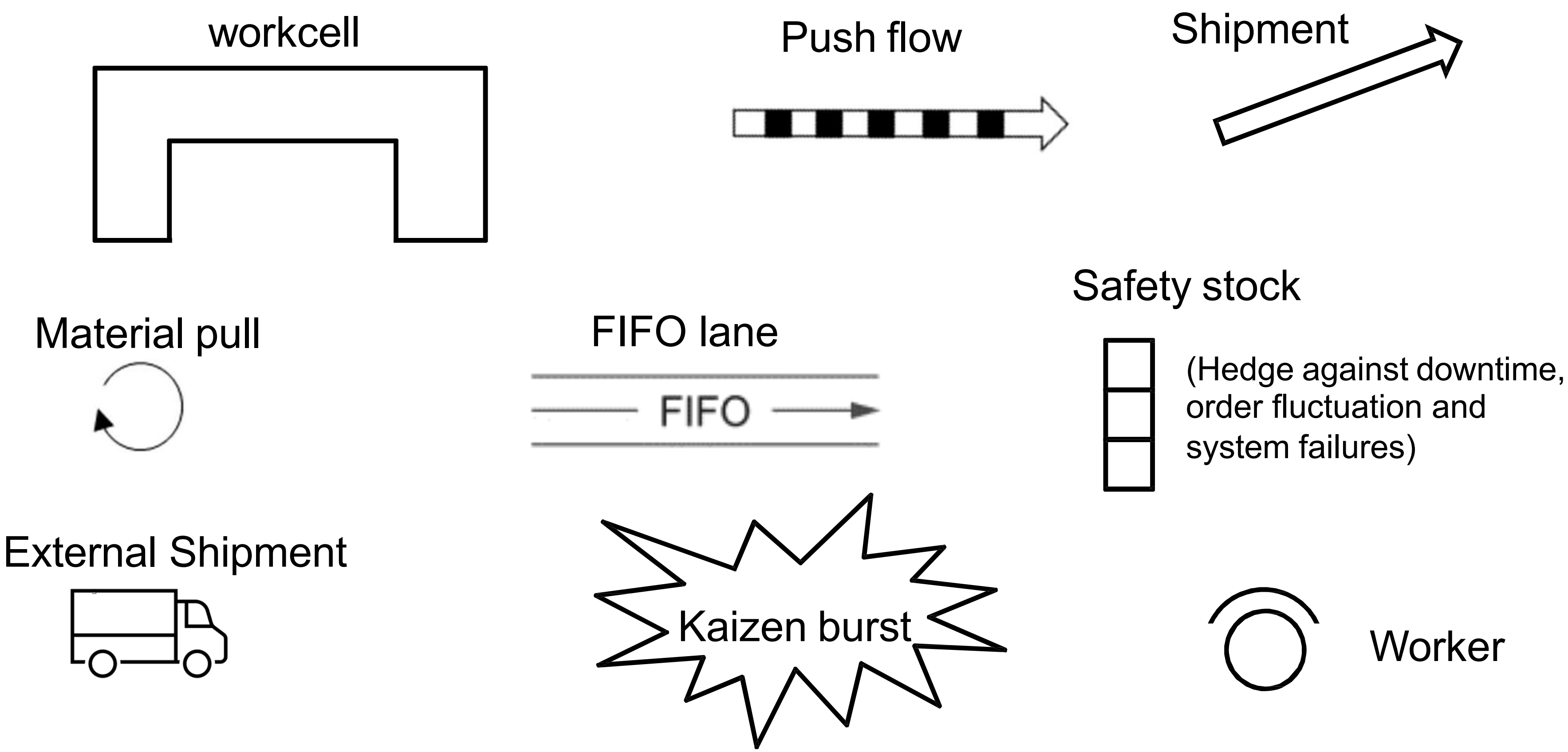
supermarket



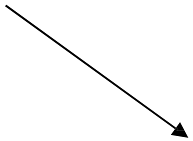
Shared process



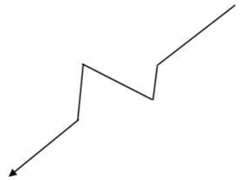
Symbols: summary



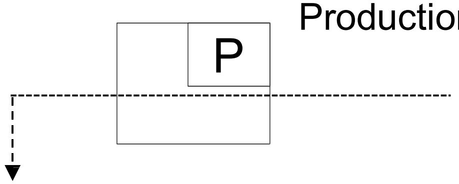
Information sysmbols



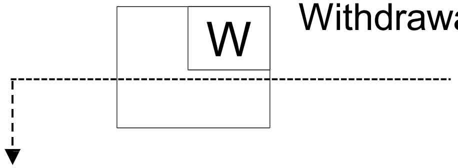
Manual information from
meetings, memos, conversations



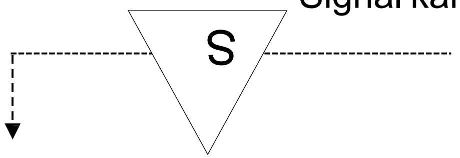
Electronic information exchanged
by internet and ERP systems /DB



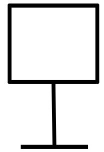
Production kanban



Withdrawal kanban

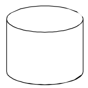


Signal kanban

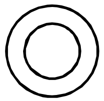


Kanban post

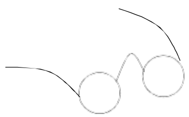
Load leveling



MRP



sequencing



Go see

Value Stream Mapping Project

“Lean manufacturing initiative at M AB”

Industrial Process Engineering MG2029ht2023

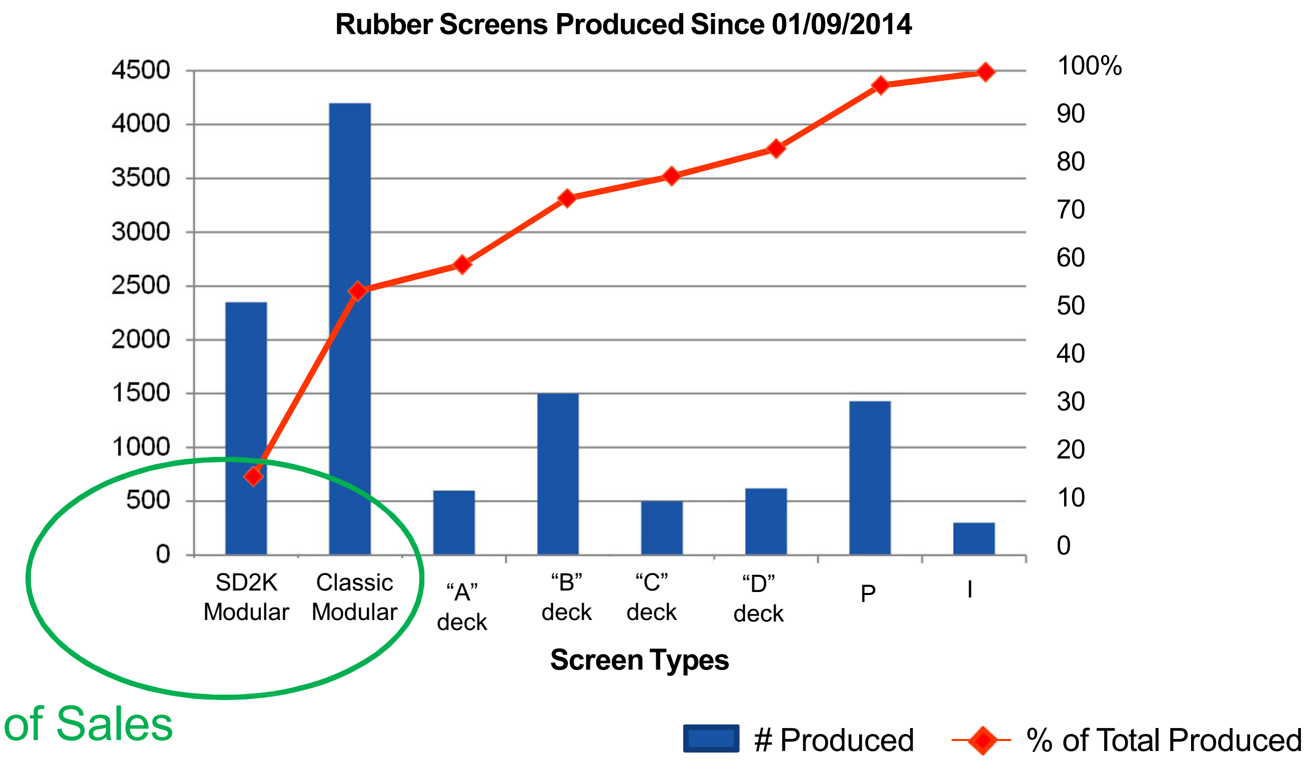
Overview

- The “M AB” Company produces armed rubber panels for mining industry.
- The panels are used for protection during blasting operations
- High increase in sales
- Decreasing Profit
- Product lead-times are increasing.
- Chaotic situation
  - operators are waiting to get material
  - managers are stressed to ship orders on time.

Overview

- Many variants and sizes in production
- Batch production: batch=entire order
- High levels of work in process
- Shift work
- The production scheduling and planning is quite complex => frequent planning mistakes

Sales during last 12 months



Your task (in groups 5 people)

- Form a group! (Canvas groups will open soon)
- Read the project description and draw a current state map
- Ignore suppliers (vendor managed stocks)
- Create the current state map "collecting" the data (if missing assume reasonable values)
- Analyze the production flow and identify major problems
- Investigate what may be done to reduce lead times and increase throughput and propose a solution (motivate **why**)
- Discuss the proposed improvements in terms of lead time, throughput time, work in progress, and end-item stock.
- Discuss required buffers and safety stocks (what in your solution affects them?)
- Create future state map

The key questions

1. How to select the right product family?
2. How to manage takt time?
3. Cycle times possible at the machines /cells
4. Throughput time?
5. Balance charts for stations
6. How to balance the flow
7. Pacemaker –
   - pitch,
   - scheduling of product mix
8. How to deal with changes in customer demand?

Deliverables

- Written report (upload on Canvas)
  - Deadline **12th** of October
  - Text 1200-1500 words + 1 page current state map + 1 page future state map.
  - Proposed solutions well motivated
- Peer review of another group's report (upload on Canvas)
  - **13th** of October you will receive the report
  - Max 1 page
  - Deadline **20th** of October
  - Use the "Grading template VSM project" file in Canvas
- Bonus: **5** points based on both parts (the own solution and the quality of evaluation of the other project)

Tutorials

- Book and attend the two 2h tutorials week 39-40-41
- Canvas booking will open soon in the Calendar
- Tutorials are **NOT** lectures
- Prepare questions!

w39	Thursday	28-09-2023	10:00	12:00	Lab-VSM	M231	VSM1-1
w39	Friday	29/09/2023	10:00	12:00	Lab-VSM	M231	VSM1-2
w39	Friday	29/09/2023	13:00	15:00	Lab-VSM	M231	VSM1-3
w40	Monday	02-10-2023	10:00	12:00	Lab-VSM	M231	VSM1-4
w40	Monday	02-10-2023	13:00	15:00	Lab-VSM	M231	VSM2-1
w40	Friday	06/10/2023	10:00	12:00	Lab-VSM	M231	VSM2-2
w40	Friday	06/10/2023	13:00	15:00	Lab-VSM	M231	VSM2-3
w41	Monday	09-10-2023	10:00	12:00	Lab-VSM	M231	VSM2-4

Thanks for listening!