

POLITECNICO
MILANO 1863

LEAN TOOLS

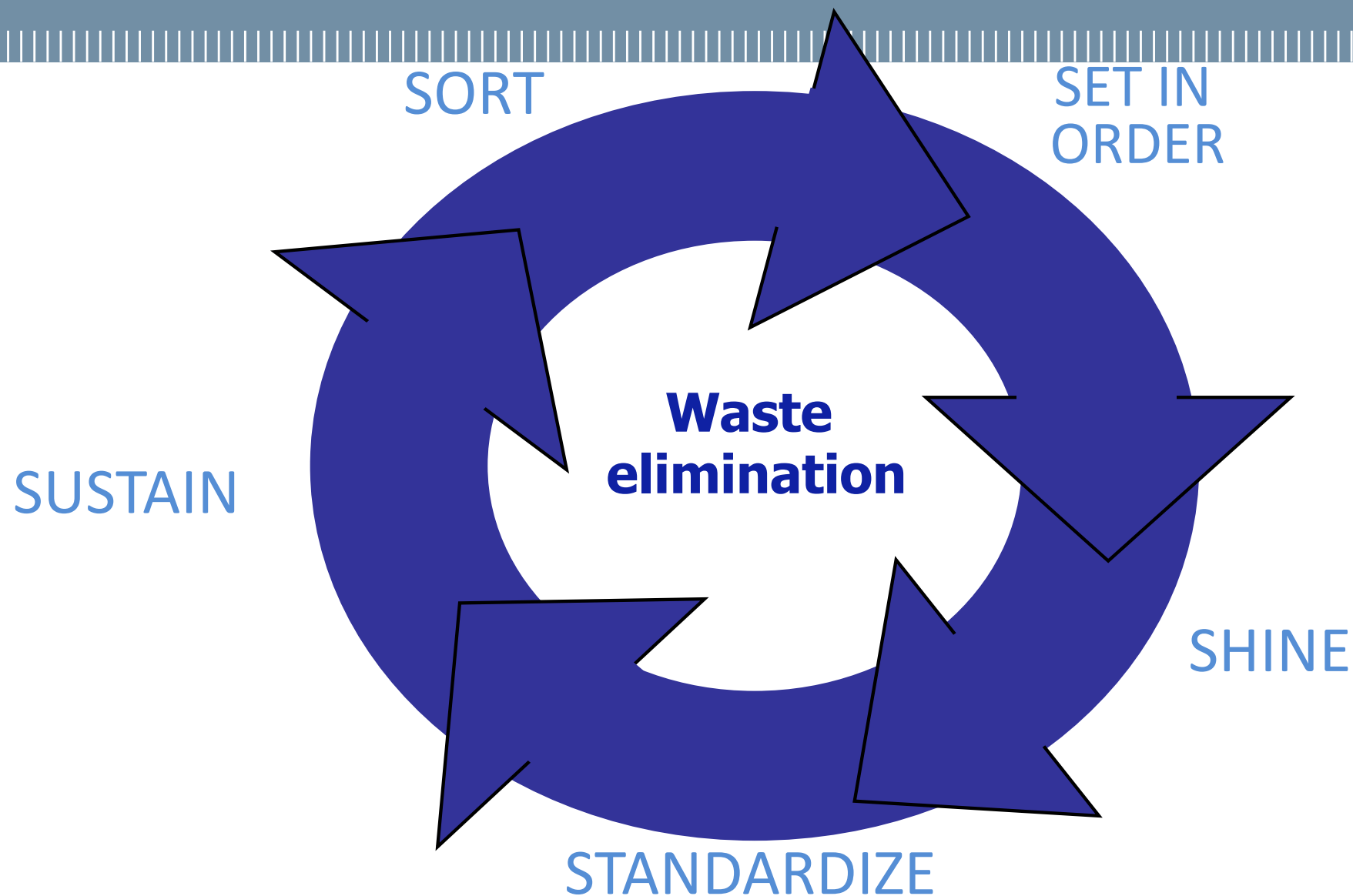
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This material and what the Professors say in class are intended for didactical use only and cannot be used outside such context, nor to imply professors' specific beliefs or opinion

Problem analysis techniques

- **Ishikawa**
- **5 whys**
- **Stratification**
- **Histograms**
- **Correlation diagrams**

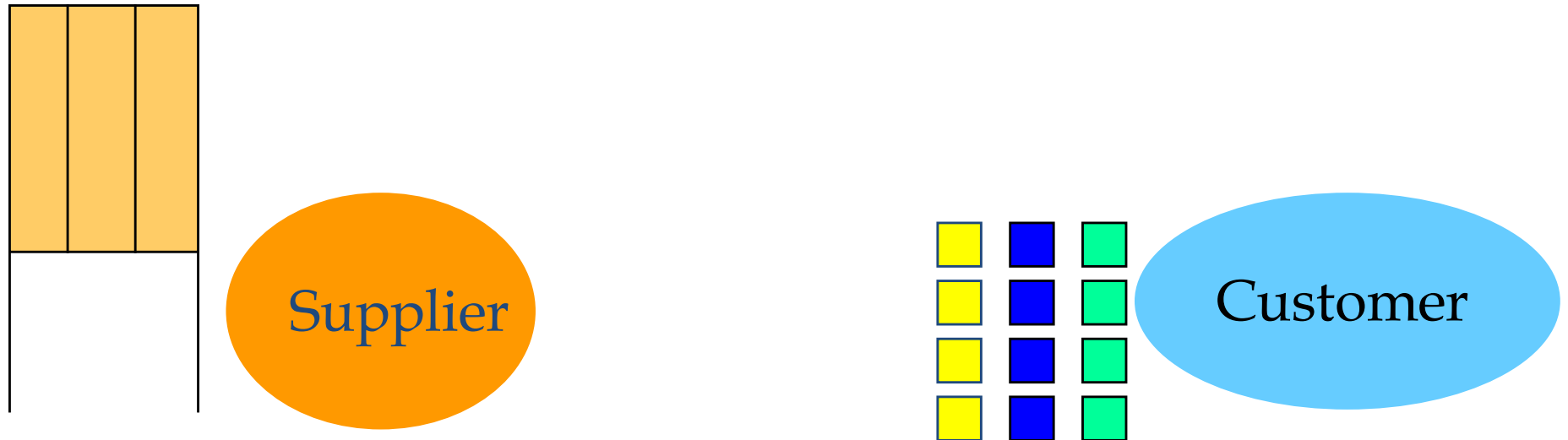
Improvement techniques: e.g. 5 S



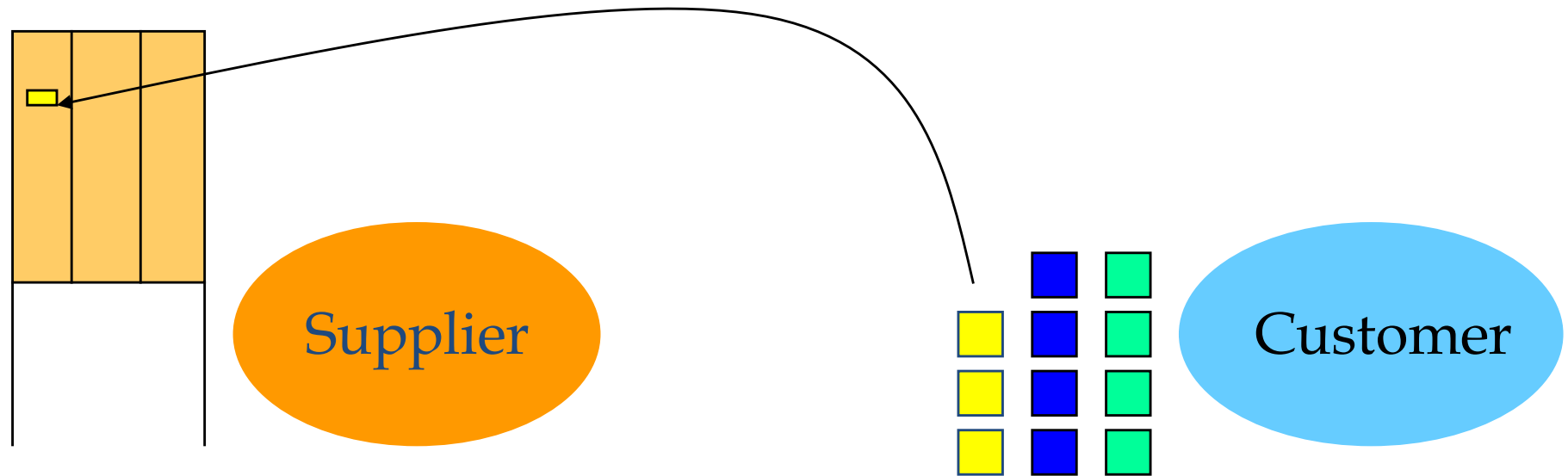


Techniques for a complex system

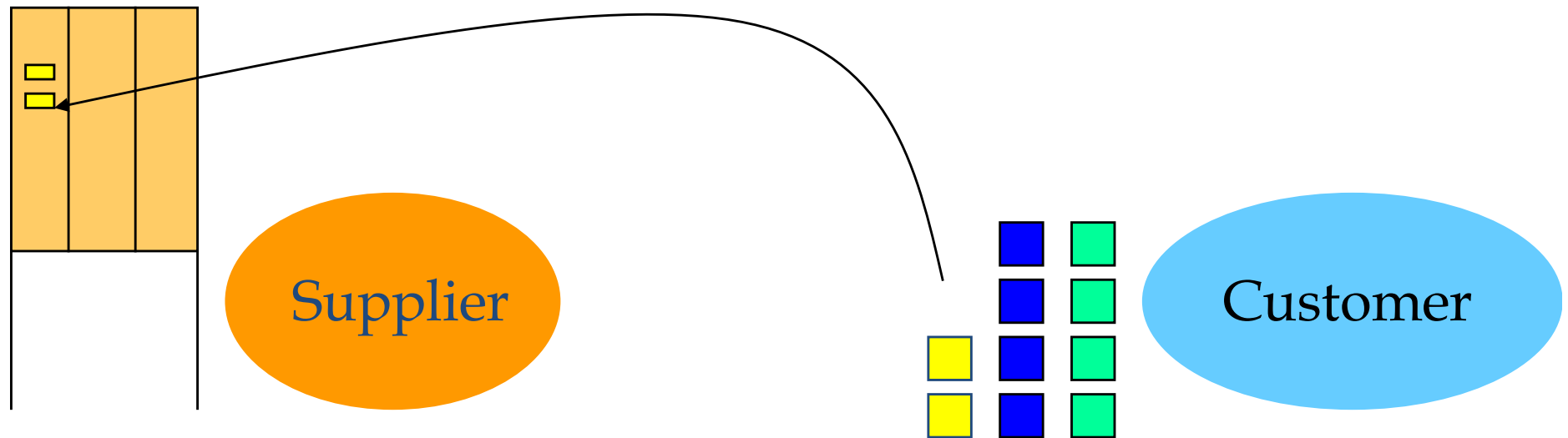
Kanban system



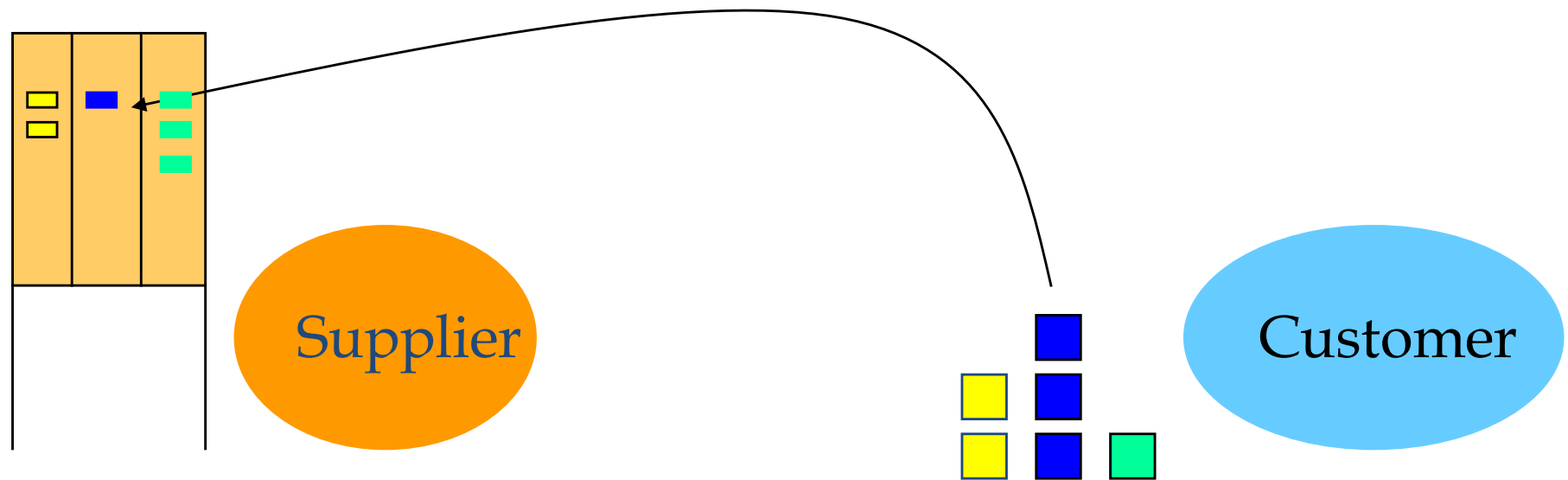
Kanban system



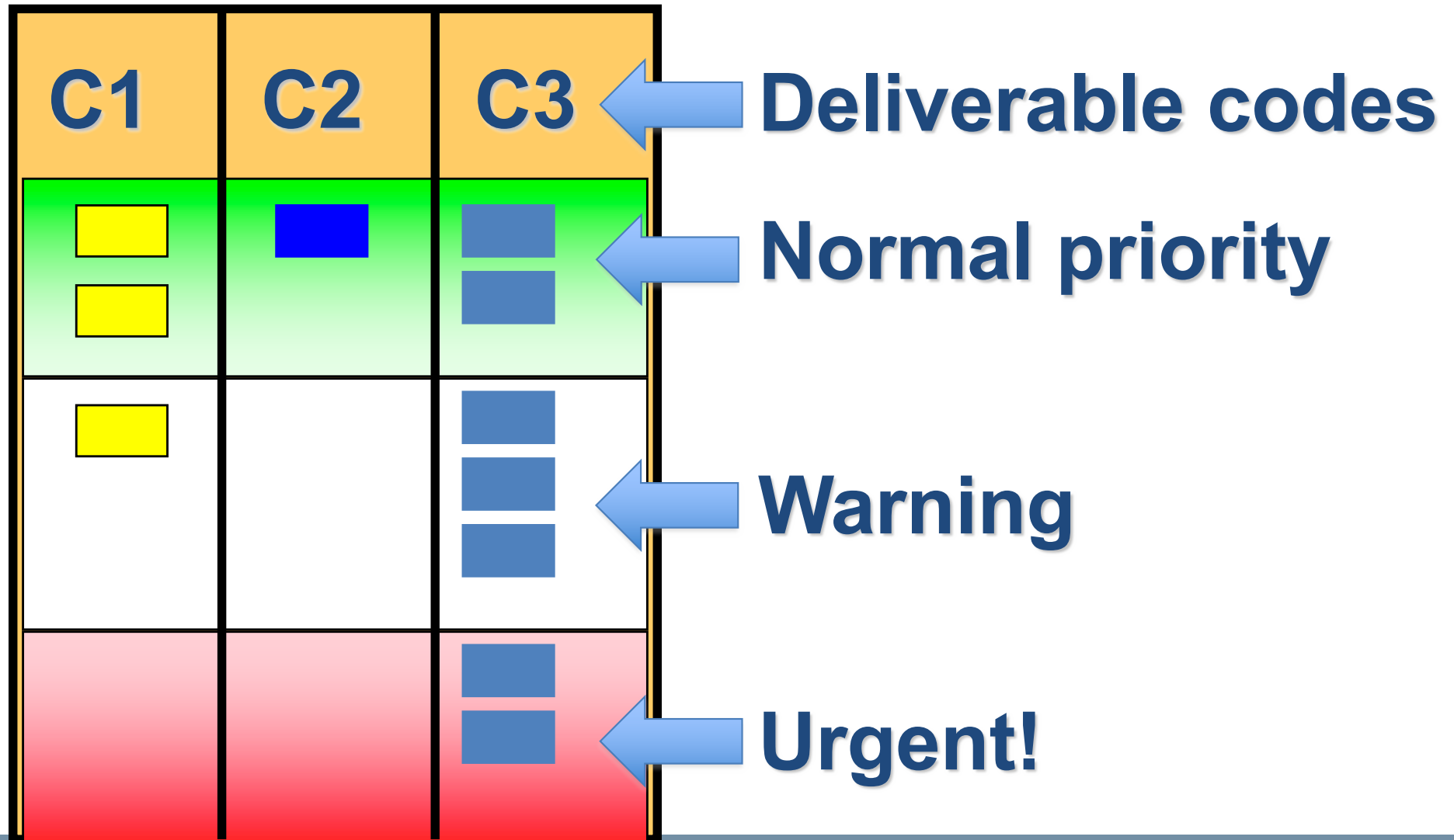
Kanban system



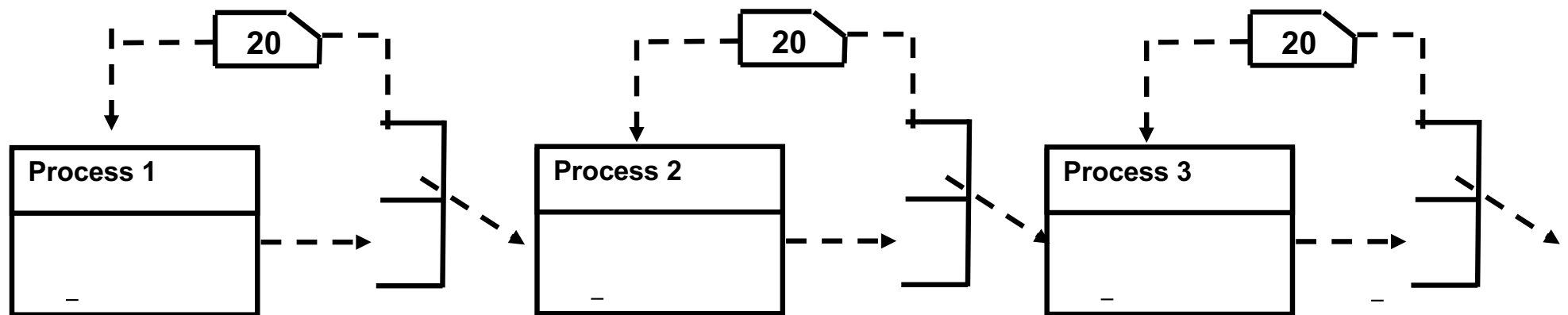
Kanban system



Kanban system



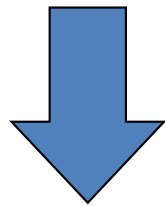
Pull supply chain



Link everything to the customer (pull)

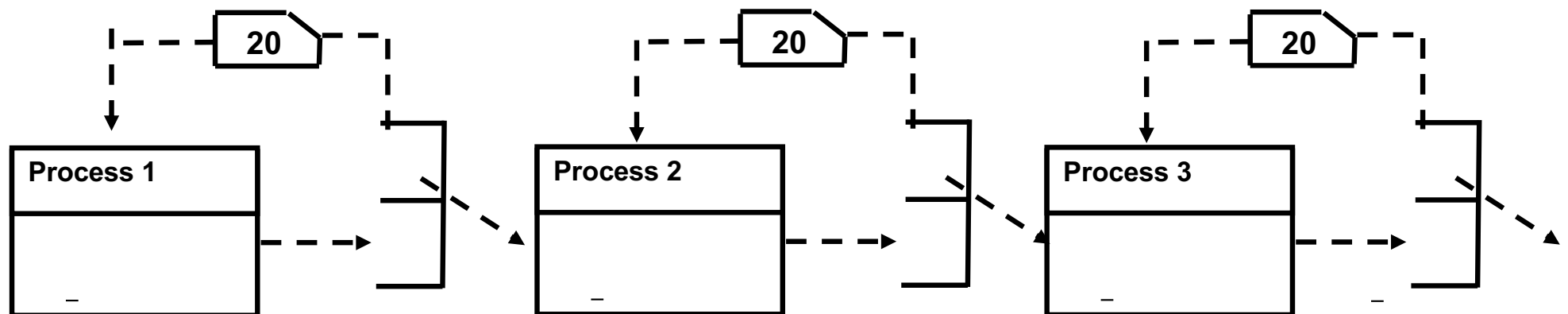
You should not produce if the customer has not made a request, otherwise you **overproduce**

- Forecasts are always wrong
- To be efficient you have to work on reliable information
- Market is not willing to wait

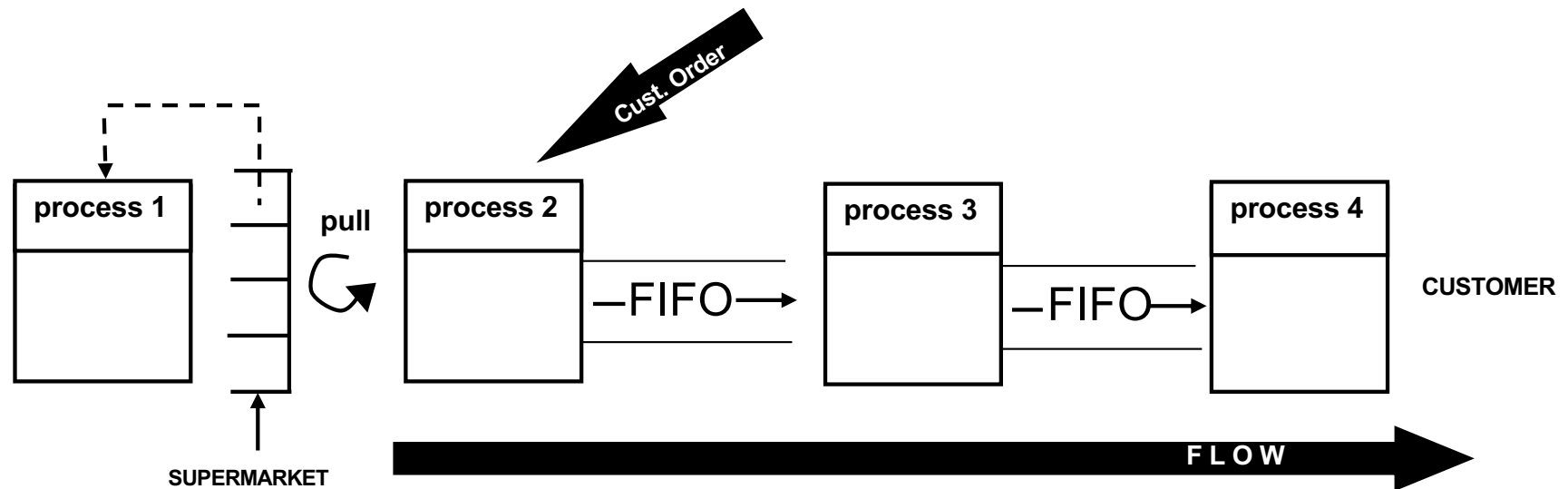


There is a need of an extremely fast system

Pull supply chain



Sequential pull



PULL advantages

- Simplicity
- Control over stocks
- No overproduction by the supplier
- An easy way to push towards constant improvements
- A single planning point, everything else just reacts
- Limited amplification of production and inventory across the supply chain (Bullwip effect)

Identify a product/service family

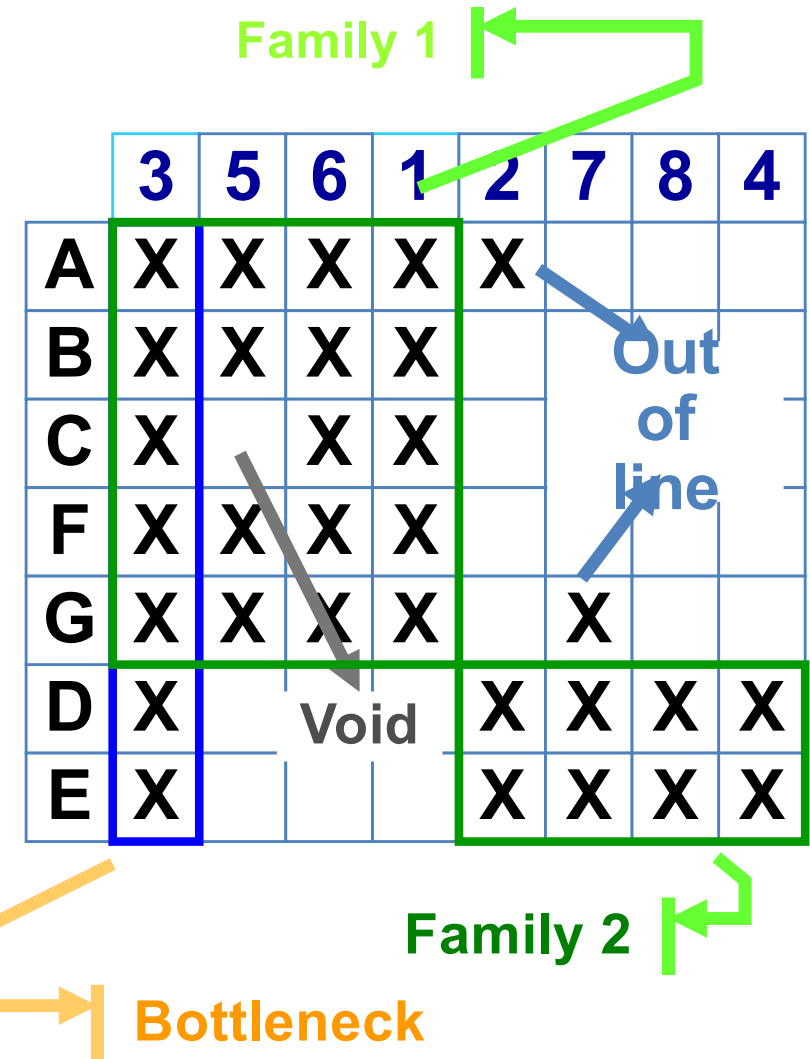
Single product (if volume is high enough to dedicate resources to it)

Production Flow Analysis (if variety is wide and single product volume is low, it is needed to group different products together to reach enough volume to dedicate resources)

Production flow analysis

Phases / Processes

	1	2	3	4	5	6	7	8
<i>Output</i>								
A	X	X	X		X	X		
B	X		X		X	X		
C	X		X			X		
D		X	X	X			X	X
E		X	X	X			X	X
F	X		X		X	X		
G	X		X		X	X	X	



Rank order clustering

- Example

OUTPUT	PROCESSES							
	1	2	3	4	5	6	7	8
A	1	1	0	0	1	0	0	0
B	0	0	0	1	0	0	0	1
C	0	1	1	0	0	1	1	0
D	0	0	0	1	0	0	0	1
E	0	0	1	1	0	1	1	0
F	1	1	0	0	1	0	0	0

Rank order clustering - Example

OUTPUT	PROCESSES								value
	1	2	3	4	5	6	7	8	
A	1	1	0	0	1	0	0	0	200
B	0	0	0	1	0	0	0	1	17
C	0	1	1	0	0	1	1	0	102
D	0	0	0	1	0	0	0	1	17
E	0	0	1	1	0	1	1	0	54
F	1	1	0	0	1	0	0	0	200
value									

Rank order clustering

- Example

OUTPUT	PROCESSES								value
	1	2	3	4	5	6	7	8	
A	1	1	0	0	1	0	0	0	200
F	1	1	0	0	1	0	0	0	200
C	0	1	1	0	0	1	1	0	102
E	0	0	1	1	0	1	1	0	54
B	0	0	0	1	0	0	0	1	17
D	0	0	0	1	0	0	0	1	17
value	48	56	12	7	48	12	12	3	

Rank order clustering

- Example

OUTPUT	PROCESSES								value
	2	1	5	3	6	7	4	8	
A	1	1	1	0	0	0	0	0	224
F	1	1	1	0	0	0	0	0	224
C	1	0	0	1	1	1	0	0	156
E	0	0	0	1	1	1	1	0	30
B	0	0	0	0	0	0	1	1	3
D	0	0	0	0	0	0	1	1	3
value	56	48	48	12	12	12	7	3	

What does stop the flow?

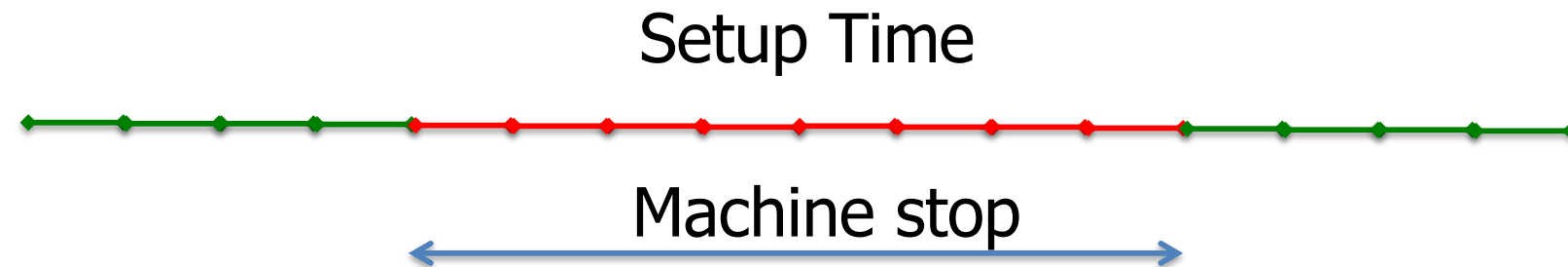
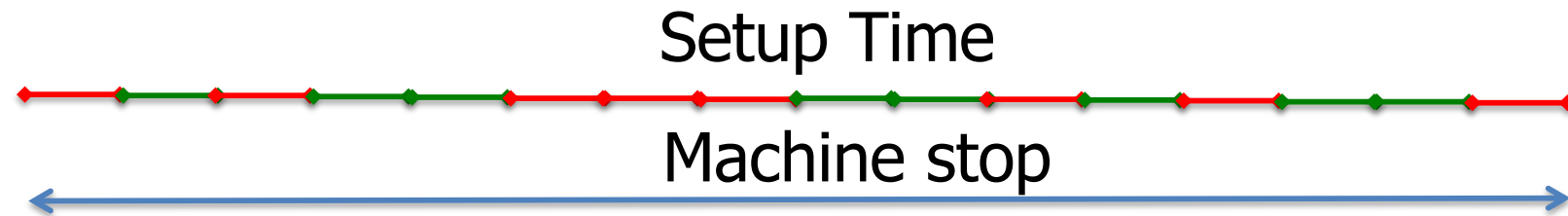
- Production change
- Wastes / lack of necessary information / re-entrant loops
- Breakdowns
- Batch (Quantity)
- Batch (Time)

Setup times reduction: SMED

INTERNAL setup times: carried out when the machine is not working

EXTERNAL setup times: carried out while the machine is working

Setup time Vs machine stop time



- Internal activity
- External activity

SMED steps

1. Identify the activities required by the setup and classify them in external and internal.
2. In this phase, internal and external operations are often interspersed.

Examples of criticality

- » equipment are brought at the machine in internal setup;
- » tools are placed far from the machine;
- » broken tools;
- » failure to verify the correct functioning of the equipment, before starting the setup or Before starting production

Do not analyse the procedures, but go at the **Gemba** (real behaviours)
Measure all you can, because the measure is not personal

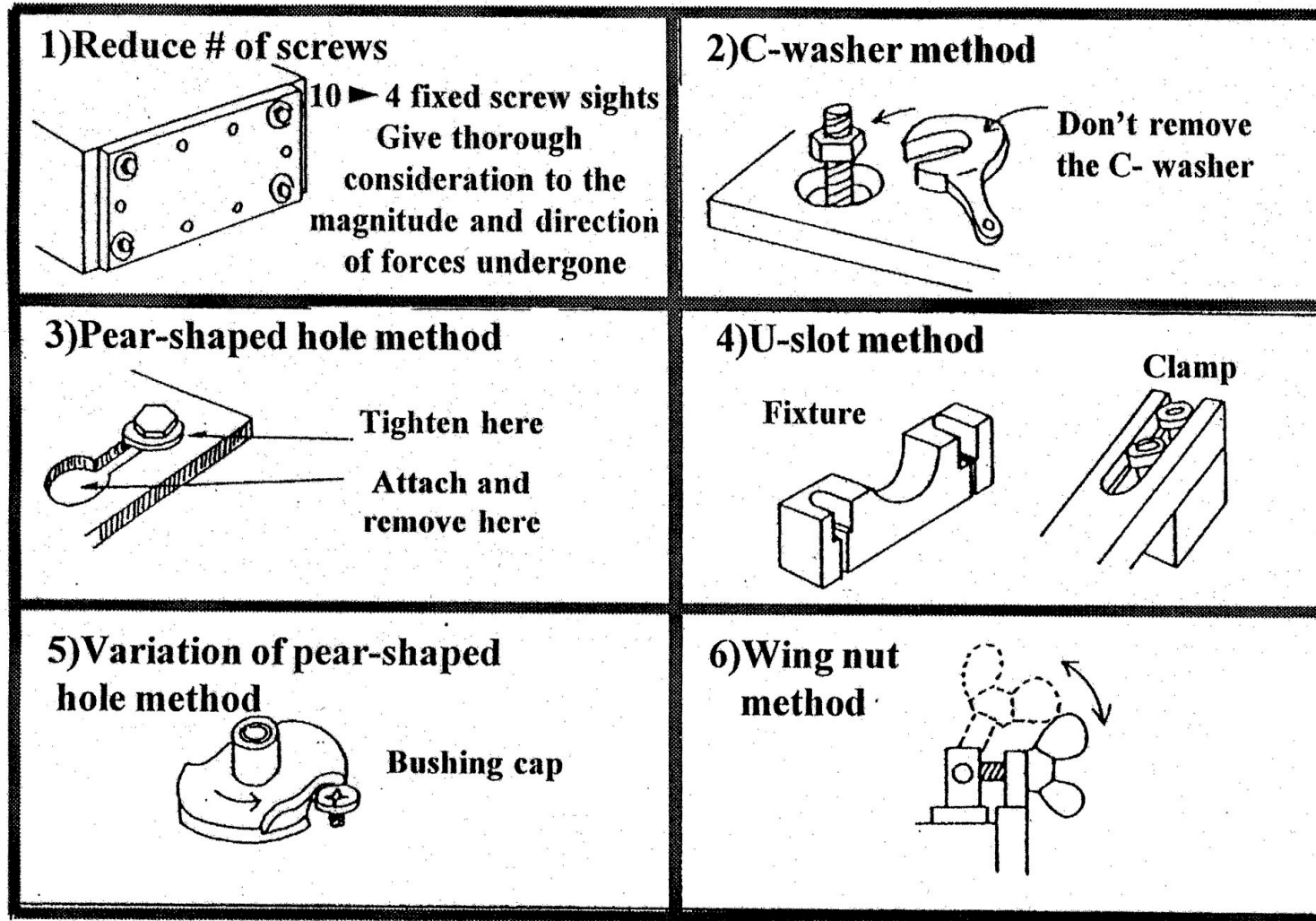
SMED steps

2. Re-organize activities in order to have the greatest number of external activities grouped together at the beginning of the setup, or at the end of it. Switch the largest number of activities (time) from internal to external.
3. Simplify and shorten the duration of internal and external operations.

Not Rocket Science, but continuous improvement of common operations.

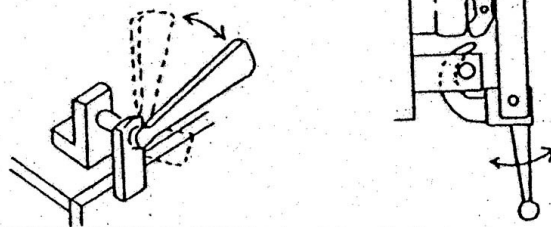
It may seem trivial, but it's so difficult that it creates a **sustainable competitive advantage**

Examples of fastening systems

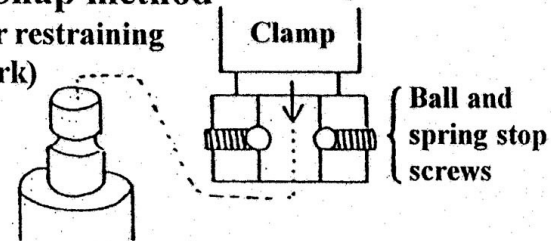


Examples of fastening systems

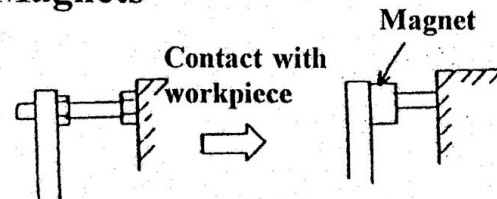
7) Cam method



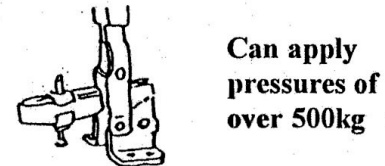
8) Snap method
(for restraining work)



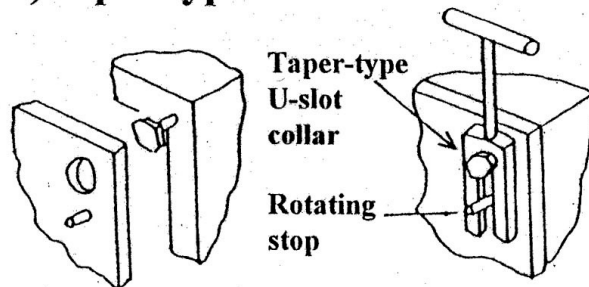
9) Magnets



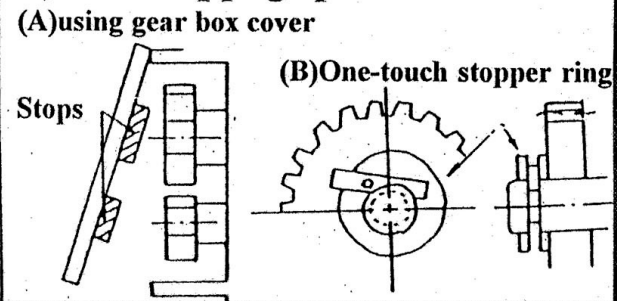
10) Toggle clamp



11) Taper-type U-slot collar



12) Gear slippage prevention



Create flows

- Eliminate wastes and reworks

Scrap, rework are also causes of stops in the flow and should be eliminated.

It was thought that a better quality leads to higher costs, it was discovered that a higher quality **decreases costs**

Create flow

- Eliminate process stops

The usable capacity is net of breakdowns, failures, and other stoppages for maintenance etc.. Compared to the potential rate, the system can actually produce much less.

Actual capacity= Theoretical Capacity * A

$$A = \frac{MTBF}{(MTBF + MTTR)}$$

Failures occur at unpredictable times. And, according to Murphy's Law, in the worst moments.

Create flow

- Eliminate process stops

Total Productive Maintenance

From failure based maintenance, to scheduled maintenance, to predictive maintenance.

Notice and act promptly on signs of malfunction and prevent failure

In addition to create a greater available capacity,
It avoids unforeseen events that cause problems and inefficiencies

Create flow

- Eliminate mix batching

Batch processing

AAAAA-**setup**-BBBBB-**setup**-CCCCC -**setup**-DDDDD

Mixed model processing

ABCADCDBACDABACADBACDADCAABDABB

Create flow Reduce batching

Bigger batches longer lead time, and higher variability

In many offices, and service activities, time batching is frequent:

- To process invoices once a week
- To process subscription requests every other day
- To process design change requests for a product once every 15 days...

Create flow

- Level the demand

Market demand is often more leveled than you believe (80% of mix and volume variations are determined by the company itself)

The more demand is aggregated, the more it is leveled (overall volume Vs single model; geographical areas, time, ...)

Advanced techniques Level production MIX 1/3

Product	1	2	3	4	
Weekly demand (units)	75	50	50	25	Average service factor
Part 1- service factor	2	-	-	1	0.875
Part 2- service factor	1	-	3	-	1.125
Part 3- service factor	-	1	-	1	0.375
Part 4- service factor	3	2	2	2	2.373
Part 5- service factor	2	4	1	-	2.0
Part 6- service factor	-	1	-	2	0.5
Part 7- service factor	-	-	1	2	0.5
Part 8- service factor	-	2	-	1	0.625
Part 9- service factor	-	-	3	-	0.750
	8	10	10	9	

Advanced techniques Level production MIX 2/3

Product	Mon	Tue	Wed	Thu	Fri	W1
1	40	35	0	0	0	75
2	0	5	40	5	0	50
3	0	0	0	35	15	50
4	0	0	0	0	25	25
Part	Supplier 1					
1	80	70	0	0	25	
9	0	0	0	105	45	
4	120	115	80	80	80	
5	80	90	160	55	15	
8	0	10	80	10	25	
Total	280	285	320	250	165	
Part	Supplier 2					
2	40	35	0	105	45	
3	0	5	40	5	25	
6	0	5	40	5	50	
7	0	0	0	35	65	
Total	40	45	80	150	185	

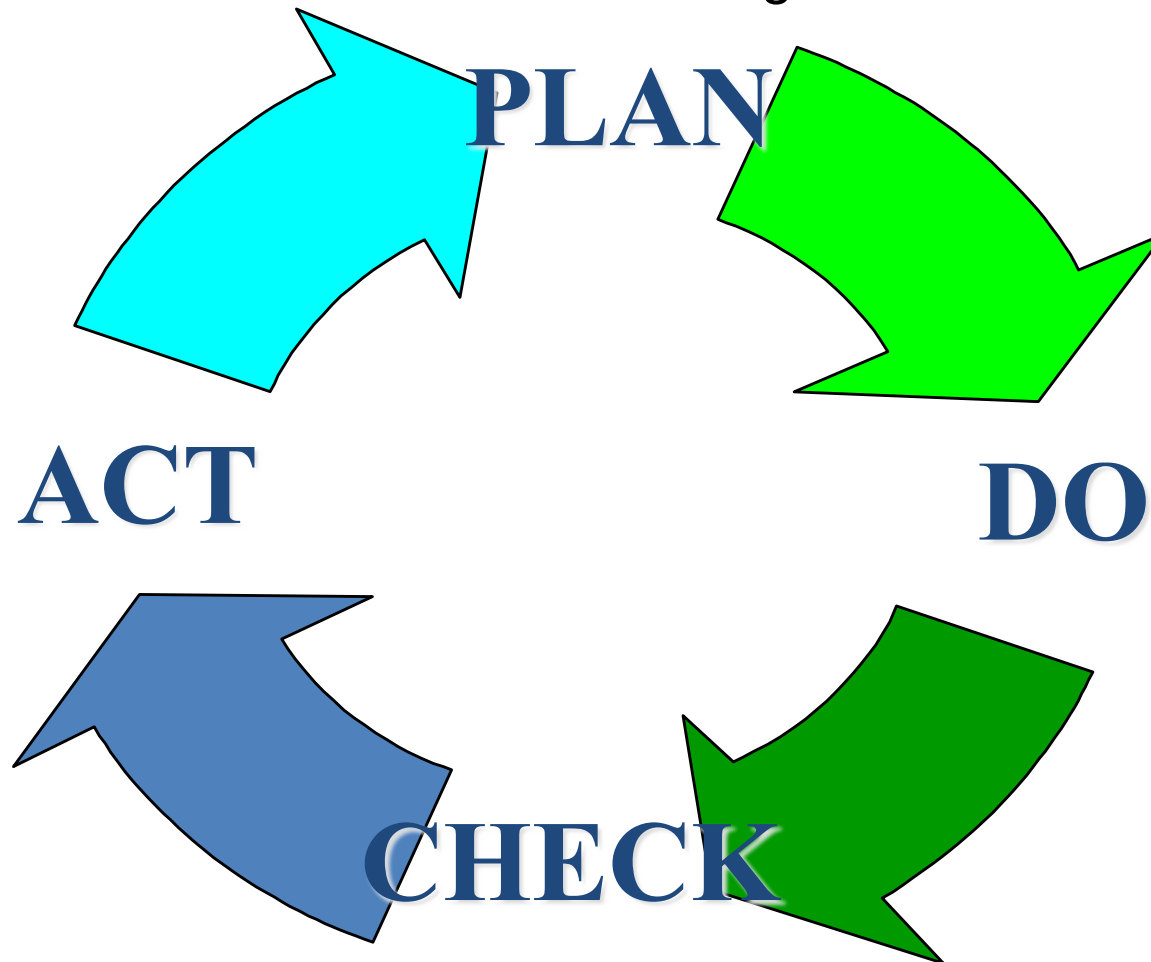
Advanced techniques Level production MIX 3/3

Product	Mon	Tue	Wed	Thu	Fri	W2 Morn.	W2 Aftern.	W3 Morn.	W3 Aftern.
1	15	15	15	15	15	15	0	8	7
2	10	10	10	10	10	5	5	5	5
3	10	10	10	10	10	0	10	5	5
4	5	5	5	5	5	0	5	2	3
Part						Supplier 1			
1	35	35	35	35	35	30	5	18	17
9	30	30	30	30	30	0	30	15	15
4	95	95	95	95	95	55	40	48	47
5	80	80	80	80	80	50	30	41	39
8	25	25	25	25	25	10	15	12	13
Total	265	265	265	265	265	145	120	134	131
Part						Supplier 2			
2	45	45	45	45	45	15	30	23	22
3	15	15	15	15	15	5	10	7	8
6	20	20	20	20	20	5	15	9	11
7	20	20	20	20	20	0	20	9	11
Total	100	100	100	100	100	25	75	48	52

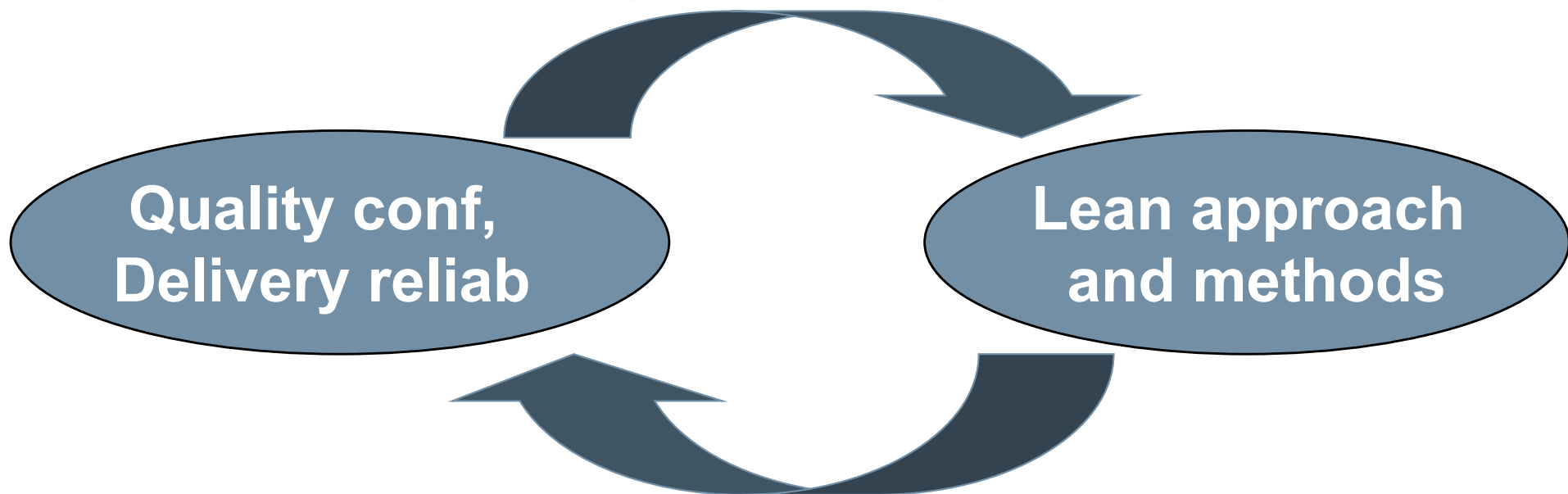
The system must see the variety that the market demands as it were a single product

Scientific method

Any intervention must be carried out following what is the scientific method



Are a prerequisite
(static vision)



Represent a stimulous to improve
(dynamic vision)



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