PPU231
Priority-based maintenance

Five main tasks - Project

1. Maintenance Policy Selection using RCM

    a) RCM proposition
    b) Advantages / disadvantages

Maintenance policy using RCM

2. Priority-based Maintenance

    a) Production capacity
    b) Prioritisation of reactive maintenance
    c) From reactive to proactive maintenance

Priority-based maintenance

3. Production service improvements and disturbance management
    a) Comparing OEE and acive periods
    b) Maximizing OEE
    c) Other factors impacting OEE

OEE and disturbance mgmt.

4. Design of a Production Service System

5. Evaluation of product design changes on production performance & Circular economy solutions

WS1 & WS2

PPU231
Priority-based maintenance

In this lecture…

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LO2: Explain, implement and distinguish various prevailing maintenance concepts;

LO3: Recognize and evaluate future maintenance concepts;

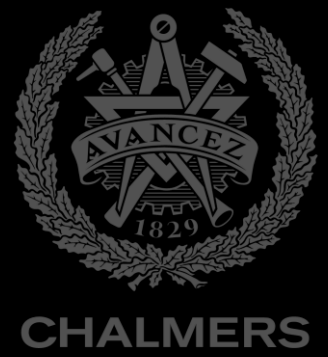
LO4: Interpret, describe and evaluate Production and Product Service Systems;

LO6: Differentiate, select and develop actions to improve production systems or products during the whole life-cycle.

Agenda

- Why we need to prioritise
- How to prioritise?
- Bottleneck
- Technology towards more proactive systems
- Some reflections about task 2

Agenda



Why we need to prioritise

How to prioritise?

Bottleneck prioritisation?

Technology towards more proactive systems

Some reflections about task 2

Prioritisation – as a fancy concept

Priority management is the allocation of resources, or the expression of preference, to specific order or order groupings (whether supplies, production, or customer orders), in response to current pressures on operational productivity and/or customer service, with the aim of relieving those pressures while at the same time promoting, or minimizing the deleterious impact upon, the wider economic and strategic goals of the company.

Roy, W. (1994), "Priority management: new theory for operations management", International Journal ofOperations and Production Management, Vol. 14 No. 6, pp. 4-24.

Decoding…

- There is pressure
- Need of minimize the pressure or promote positive impact
- Resources are limited!!!!!

Therefore, we prioritise. To do first things first.

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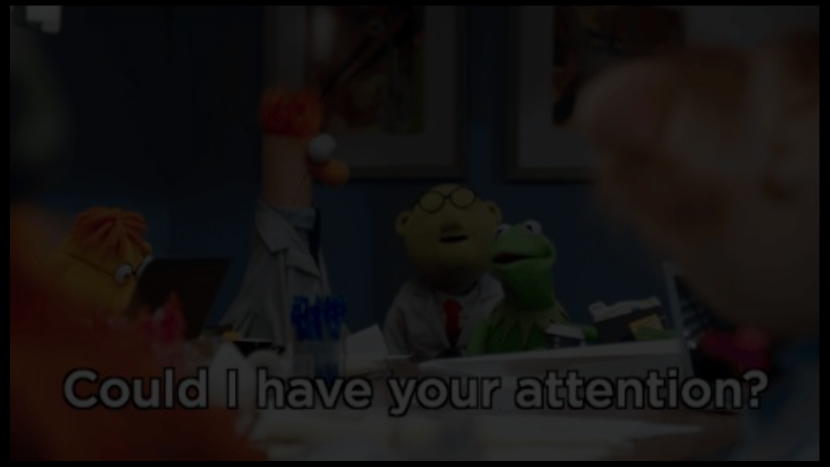
In the case of E-bike Ink, what do you think can be the limiting resources?

What happens in practice is that, when prioritising in chaotic situations (not so rare)…



People don’t have the opportunity to express themselves…

There is someone that screams louder…

… Or everything is a priority.

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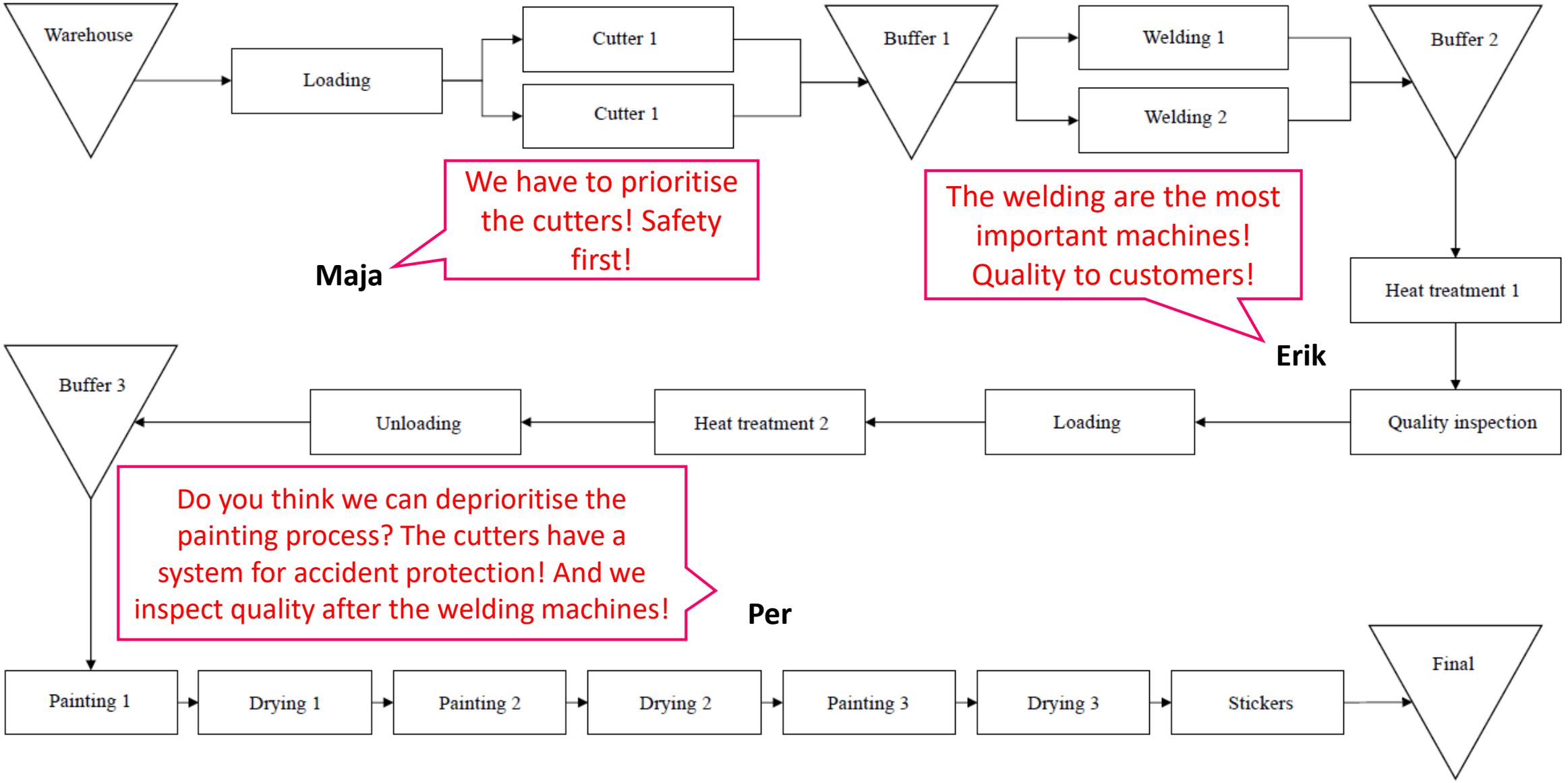
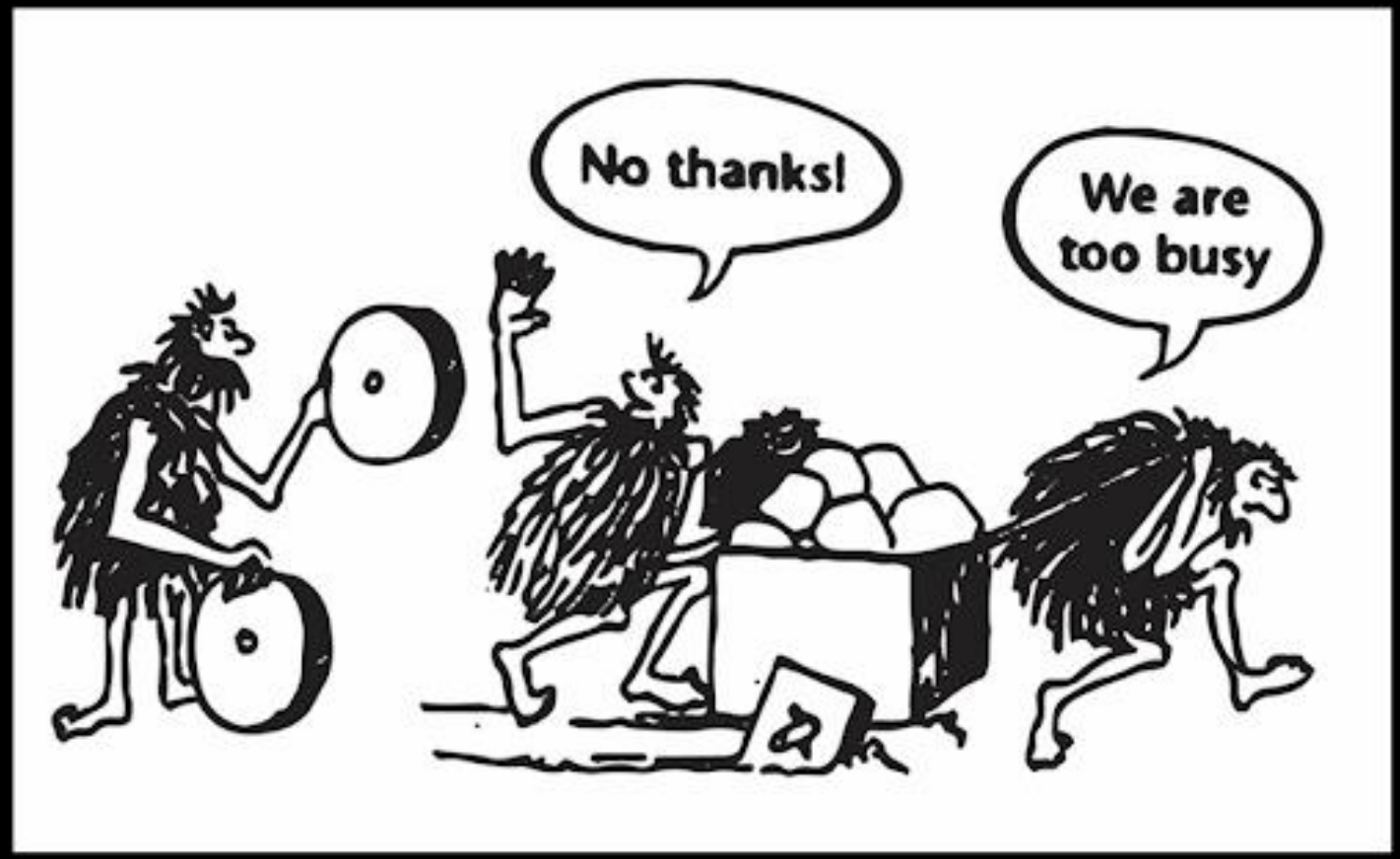
What do you think is the impact of those situations in the prioritisation decision?

In a production system, in a maintenance context…


Warehouse
Loading
Cutter 1
Cutter 1
Buffer 1
Welding 1
Welding 2
Buffer 2
We have to prioritise the cutters! Safety first!
Maja
The welding are the most important machines! Quality to customers!
Erik
Heat treatment 1
Quality inspection
Loading
Heat treatment 2
Unloading
Buffer 3
Do you think we can deprioritise the painting process? The cutters have a system for accident protection! And we inspect quality after the welding machines!
Per
Painting 1
Drying 1
Painting 2
Drying 2
Painting 3
Drying 3
Stickers
Final

If priorities are not set right…



No time to think proactively!

Why is prioritisation needed?

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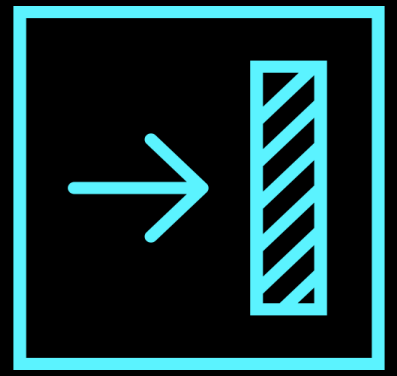
Focus

Effectivity

Alignment



The challenges in prioritisation in manufacturing companies
Results from multiple-case study

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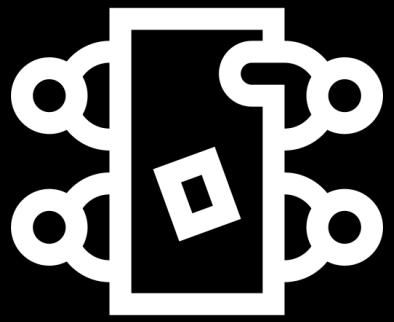
	GROUP	CENTRALIZED
		
CHALLENGES	- TIME TO CONSENSUS	- DEPENDENCY - PRODUCTION PERSPECTIVE
	- LIMITED USE OF PAST DATA - VAGUE CRITERIA	

Prioritisation of production disturbances_Working paper.pdf

Agenda

- Why we need to prioritise?
- **How to prioritise?**
- Bottleneck prioritisation?
- Technology towards more proactive systems
- Some reflections about task 2

Who is impacted and should be considered?
Results from focus groups

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STAKEHOLDERS

Individual level	Plant level	Firm level	External
Operators	Production department	Shareholders	Customers
Managers	Maintenance department	Owners	Suppliers
Consultants	Planning department		Equipment manufacturers
	Quality department		Employees' families
	Finance department		Academics
	Logistics department		Authorities
	Human resource dpt.		Industrial organizations
	Safety department		Society
	Sales/marketing dpt.		Environment
	Purchase department		

So many competing interests....

Prioritisation of production disturbances_Working paper.pdf

What is impacted and should be considered?

FACTORS

Individual level	Plant level	Firm level	External
Job satisfaction Work environment	Manufact. performance Quality Time Productivity Process flow Plannability	Organizational Results Profit	Customer related Customer satisfaction Deliverability
	Maintenance performance Machine health		Other Reputation
	Environm performance Resource utilization		
	Safety performance Safety		

Not exactly easy to balance the competing interests….

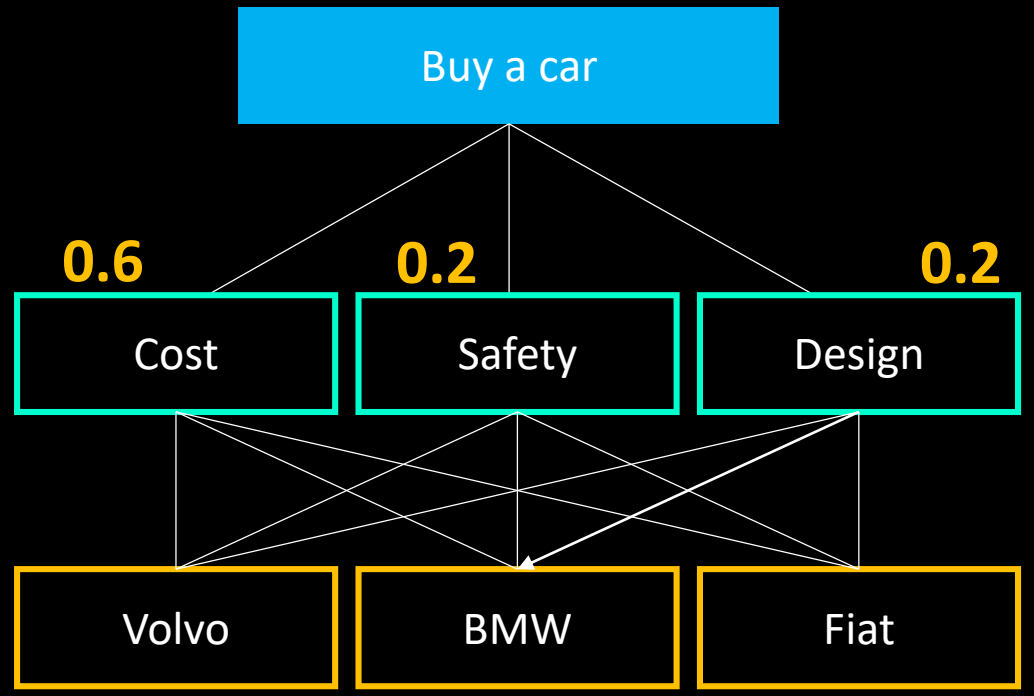
Methods in maintenance prioritisation

Methods	Nos of publication
AHP-based measurements	15
Priority criterion	7
Matrix-based measurement	5
FMEA-based measurements	4
Framework	4
Maintenance system	3
Multi-criteria decision-making	2
Genetic algorithm-based procedure	2
TOPSIS	3
Computerized maintenance system	2
Model-based measurement	2
JIT	1
ANN	1
Probabilistic risk assessment	1
Comparative risk analysis	1
Roue's formula	1
Benchmarking	1
Critical failure analysis	1
System reliability and cost-effectiveness	1
Fuzzy group ANP	1
CBC	1
Audit	1
Priority cost FMECA	1
ARAS	1
Criticality index	1
Triangulation technique	1
Frequency	1
Simple comparison	1

Chong et al. (2019) Maintenance prioritization – a review on factors and methods

Analytic hierarchy process

1. Alternatives
2. Define the criteria
3. Define the weight of each criterion
4. Compare the choices – make the decision



Cost: 1000 (1)
Safety: Very High (10)
Looks: Nice (7)

(4)

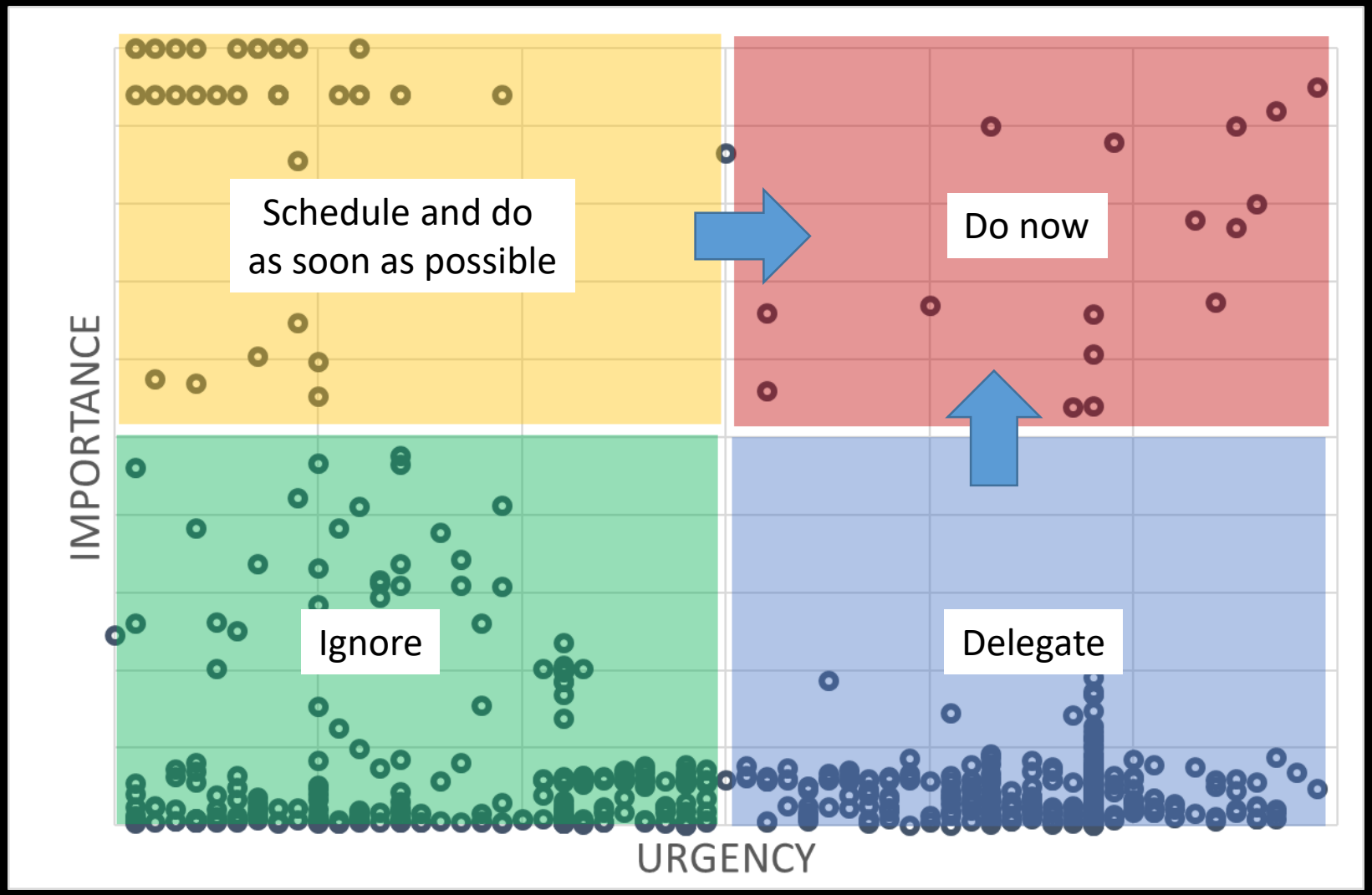
Cost: 800 (3)
Safety: High (9)
Looks: Great (8)

(5,2)

Cost: 500 (5)
Safety: Medium (6)
Looks: Good (6)

(5,4)

Priority matrix



1. What is important?
2. What is urgent?
3. Other: impact x effort, impact x cost…

Challenges in prioritising methods

1. Defining the criteria can be difficult
2. Comparing things that are difficult to compare (productivity x safety x cost)
3. Criteria might change over time
4. What is perceived as critical / urgent varies from person to person
5. Lack of data
6. Dynamic process

Agenda

Why we need to prioritise?

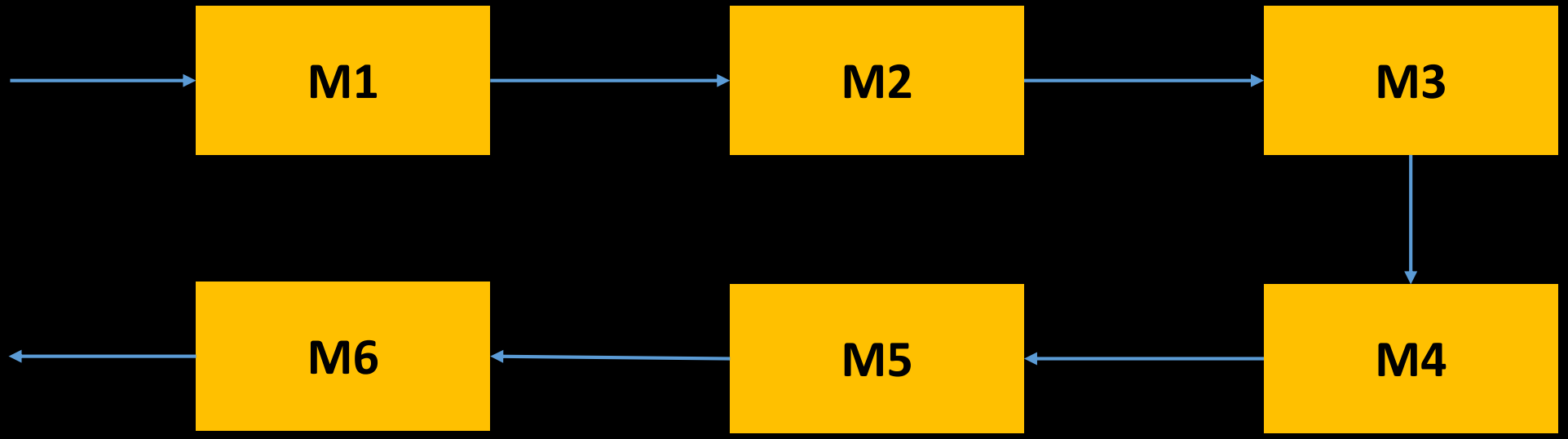
How to prioritise?

Bottleneck prioritisation?

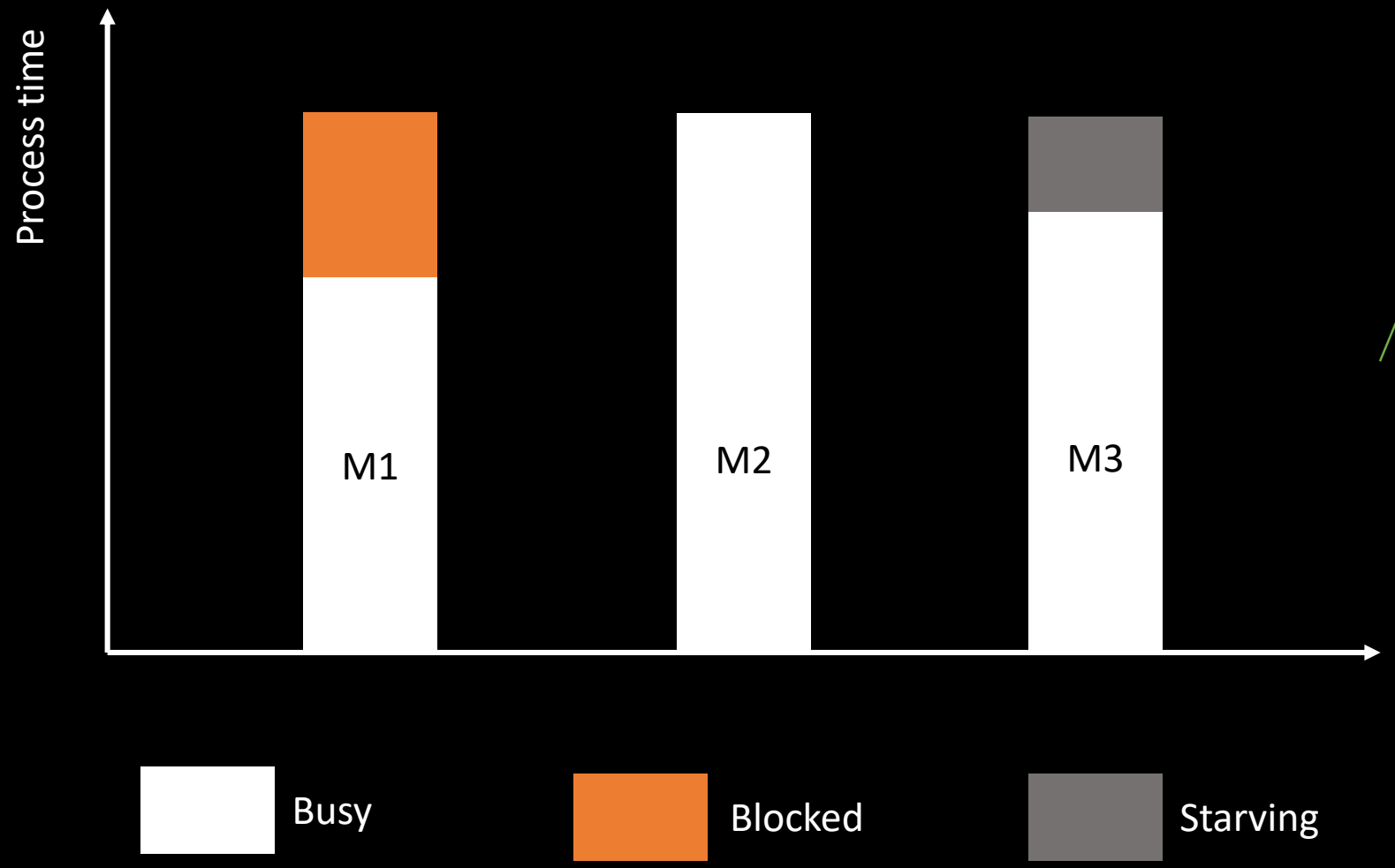
Technology towards more proactive systems

Some reflections about task 2

Bottlenecks…



To identify bottlenecks…



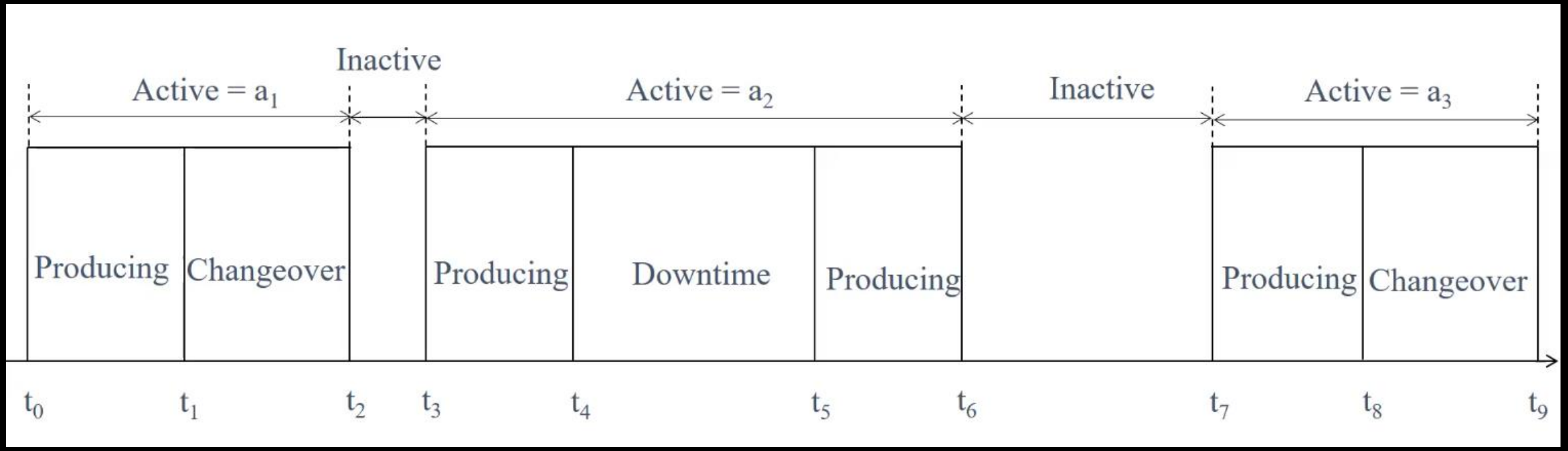
What about disturbances in the system?

To identify bottlenecks…

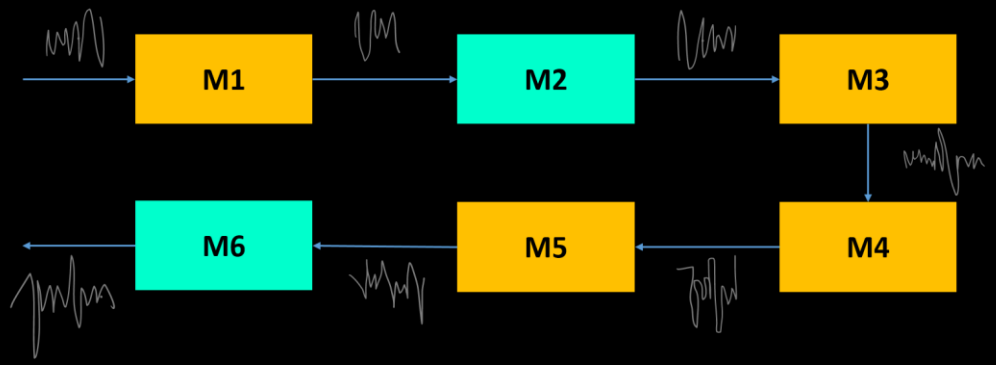
Basic indicators

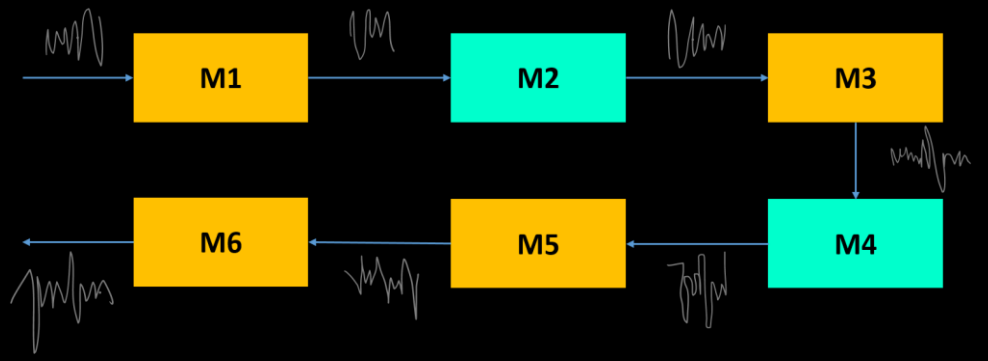
- High utilization
- Seldom blocked or starved
- High buffer levels upstream
- Resources blocked upstream
- Resources starved downstream

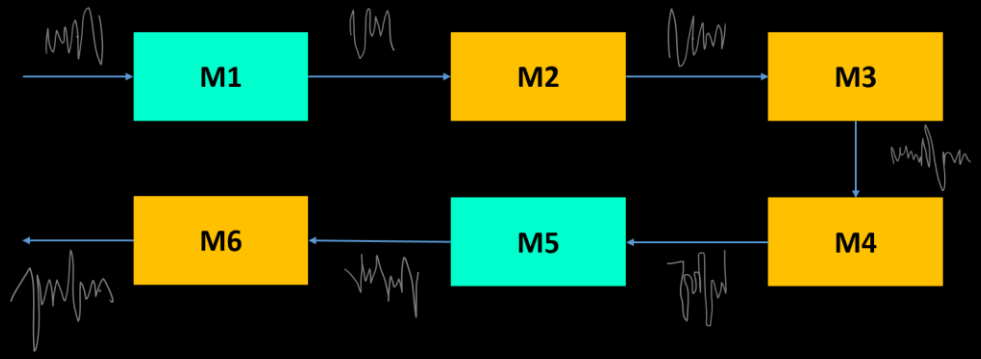
To identify bottlenecks…

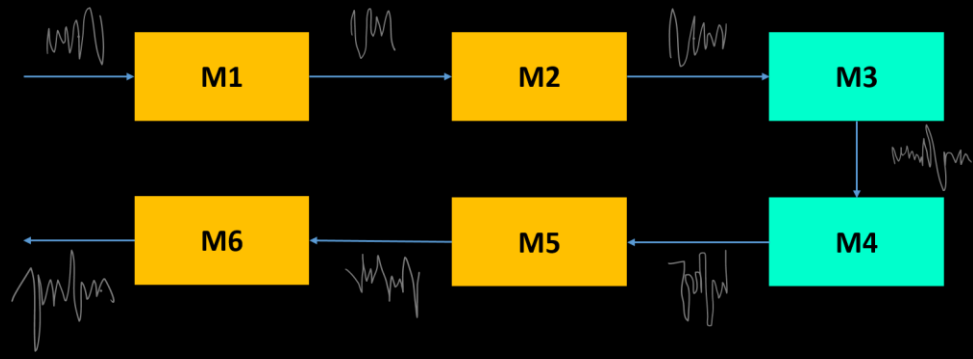


Shifting bottlenecks…





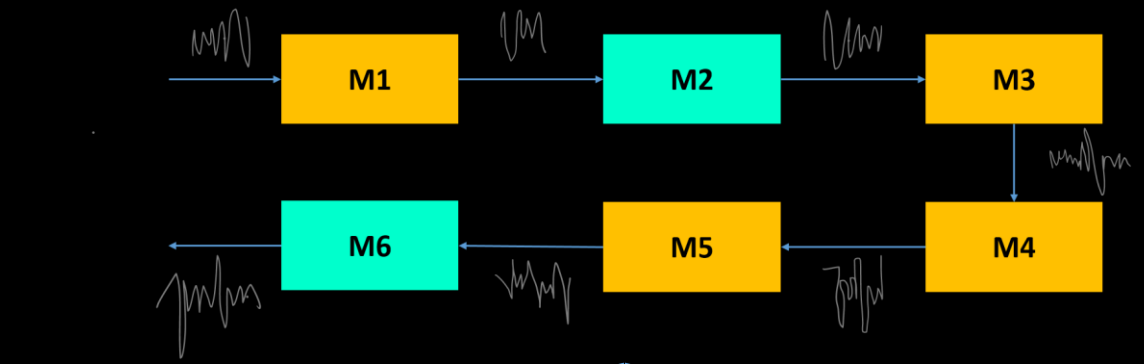




Improvements, products being produced, people working, variations changing over time…

"Change is the only constant in the universe" (Heraclitus)

To identify bottlenecks…

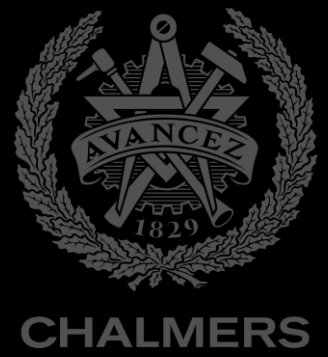


Analytical approaches
(1990)

Simulation models
(2000)

Shop floor digital data
(Industry 4.0)

Agenda



Why we need to prioritise?

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Technology towards more proactive systems

Some reflections about task 2

Industry 4.0 is characterized by 4 foundational technologies applied along the value chain.

1. Connectivity, data, computational power

Sensors

Internet of Things

Cloud technology

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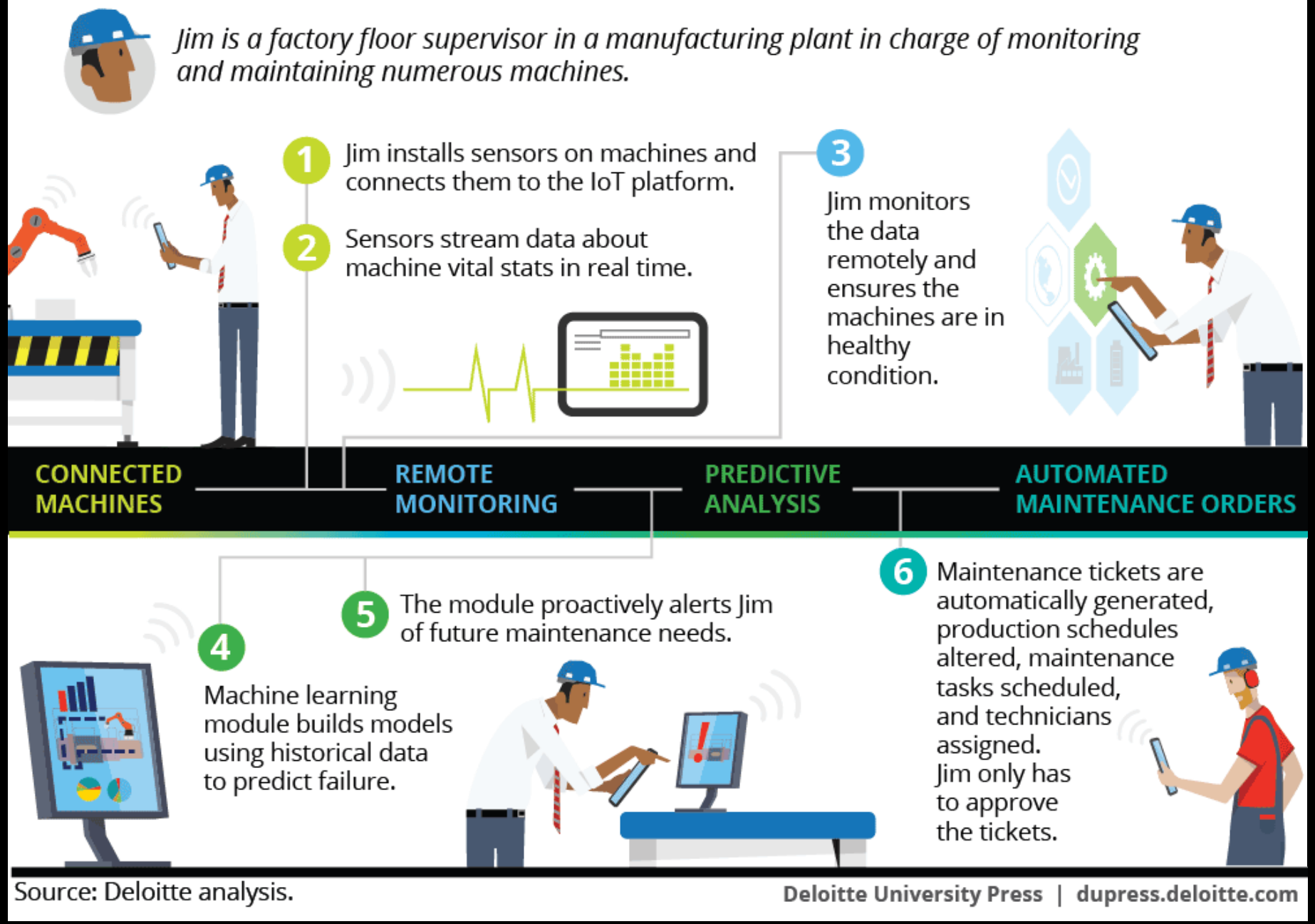
https://www.mckinsey.com/business-functions/operations/our-insights/industry-40-reimagining-manufacturing-operations-after-covid-19

Figure 4. The predictive maintenance process



Source: Deloitte analysis.

Deloitte University Press | dupress.deloitte.com

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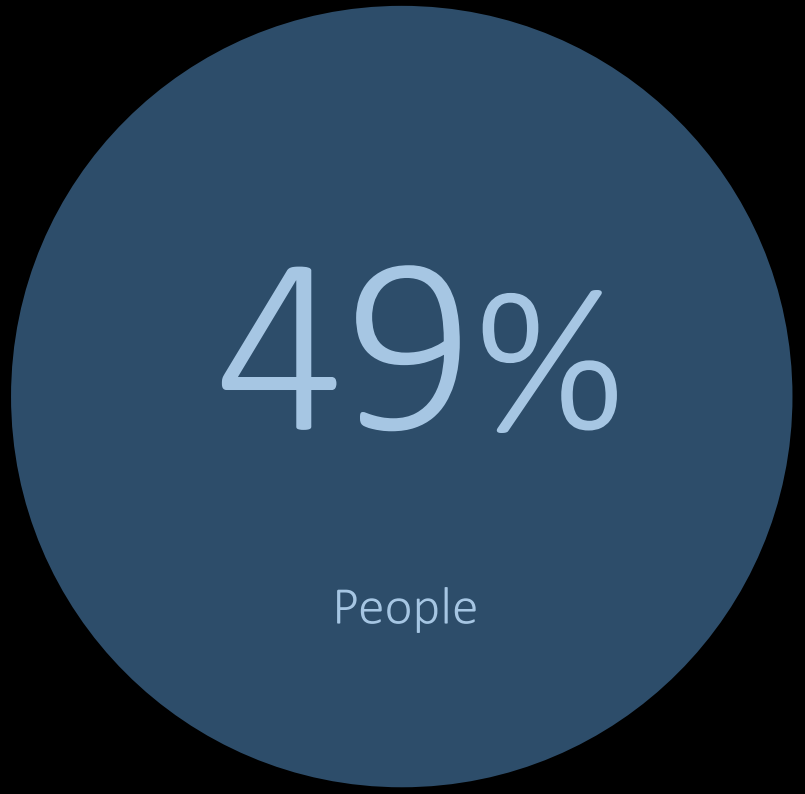
If this is so nice why are we not doing it?

https://www2.deloitte.com/us/en/insights/focus/industry-4-0/using-predictive-technologies-for-asset-maintenance.html

Biggest challenge to becoming proactive?



32%

Process

19%

Technology

"I want to exercise more example"

Survey respondents: Executives from 58 companies within different business areas
Survey done in 2018 by NewVantage Partners LLC

Agenda

Why we need to prioritise?

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Some reflections about task 2

To reflect…

How can you estimate the expected production? What methods can you use?

	Cycle time (sec)	Set-up time (sec)	MTBF (min)	MTTR (min)	PM interval (hours)	PM time (hours)	Scrap rate
Cutter 1	240	600	100	15	60	2	1%
Cutter 2	240	600	130	17	60	2	1%
Welding 1	300	420	130	16	40	3	--
Welding 2	300	420	180	20	40	3	--
Painting 1	60	120	500	10	150	1	--
Painting 2	60	120	650	15	150	1	--
Painting 3	120	120	360	12	150	1	--
Drying 1	120	0	600	15	100	1	--
Drying 2	120	0	660	13	100	1	--
Drying 3	120	0	560	11	100	1	--
Sticker	120	240	800	10	200	2	---
Heat 1	100	0	--	--	100	5	1%
Heat 2	100	0	--	--	100	5	1%
Qual. insp.	120	0	--	--	--	--	4%

How could you introduce some variability?

Do you think the system will perform like this? Can you make other assumptions?

To reflect…

What criteria did you choose to set priorities? Is this the best one?

Table 2: Simulation results for a year of production

	Working (%)	Reactive downtime (%)	Idle (%)	Set-up (%)	Prev. maintenance (%)
Cutter 1	53,1	17,1	19,9	7,8	2,1
Cutter 2	51,6	19,1	19,9	7,5	1,9
Welding 1	64,2	13,4	15,6	3,2	3,6
Welding 2	64,5	12,9	15,1	3,3	4,2
Painting 1	24,1	6,7	68,6	0,2	0,4
Painting 2	24,2	8,2	66,8	0,3	0,5
Painting 3	48,3	6,7	44,2	0,2	0,6
Drying 1	48,3	6,6	44,2	0	0,9
Drying 2	48,2	5,4	45,3	0	1,1
Drying 3	47,9	5,5	45,7	0	0,9
Sticker	47,9	3,8	46,4	1	0,9

Is life this static?

How could you introduce some variability?

Is these data enough to set priorities? Is these data good?

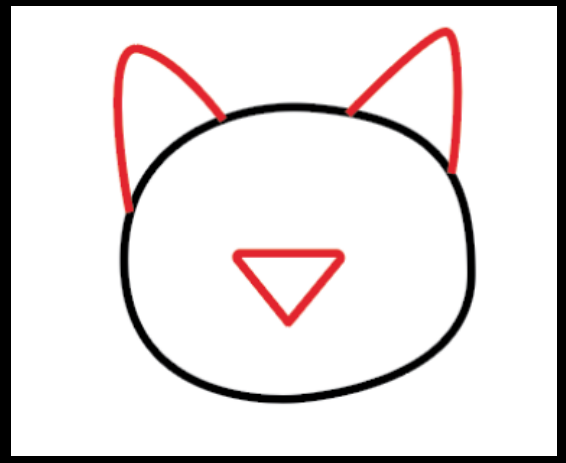
Do priorities change with time?

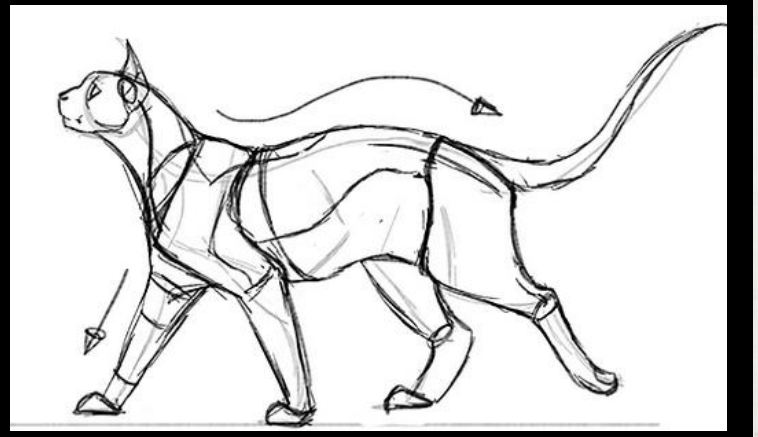
Grading

3 – Obvious answers

4 – Critical reflections

5 – Insightful answers and reflections. You went deeper than what was presented in the course.





THANK YOU!