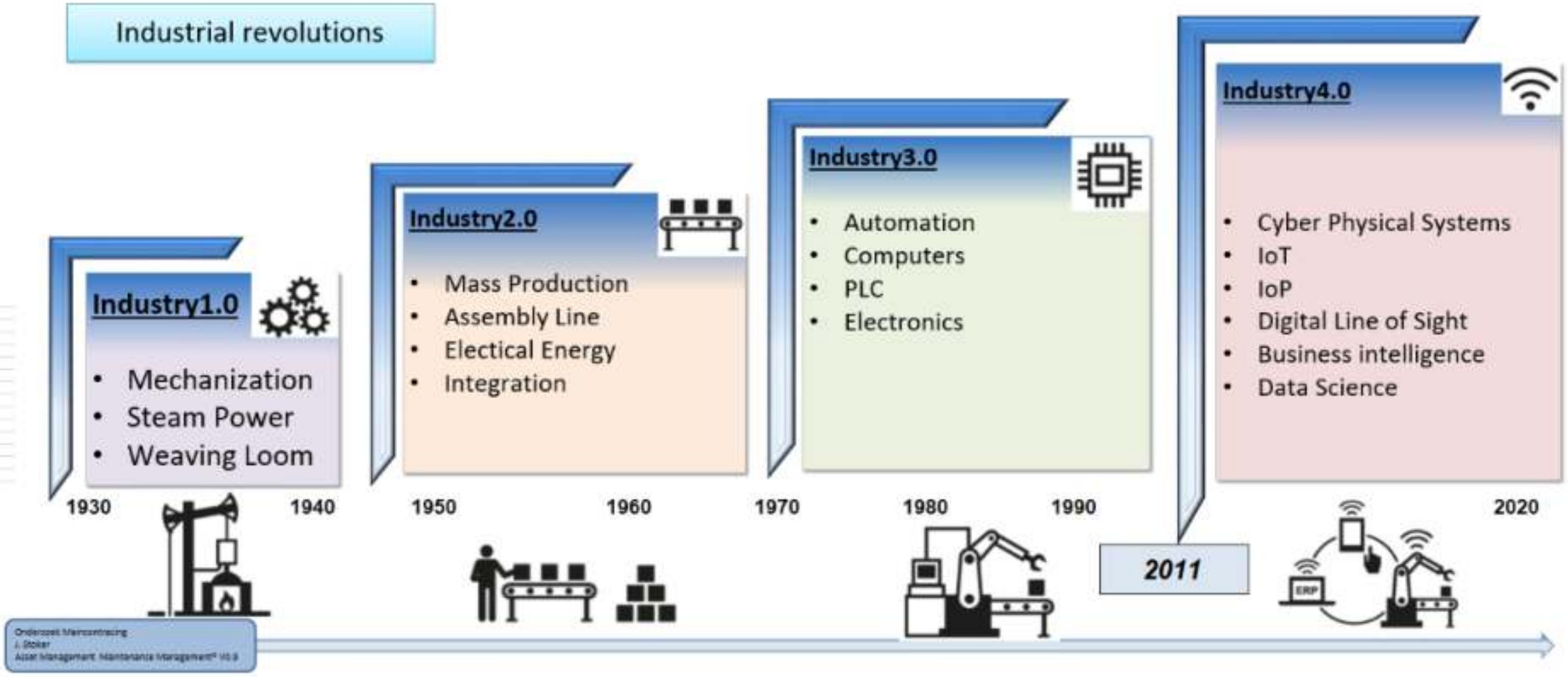
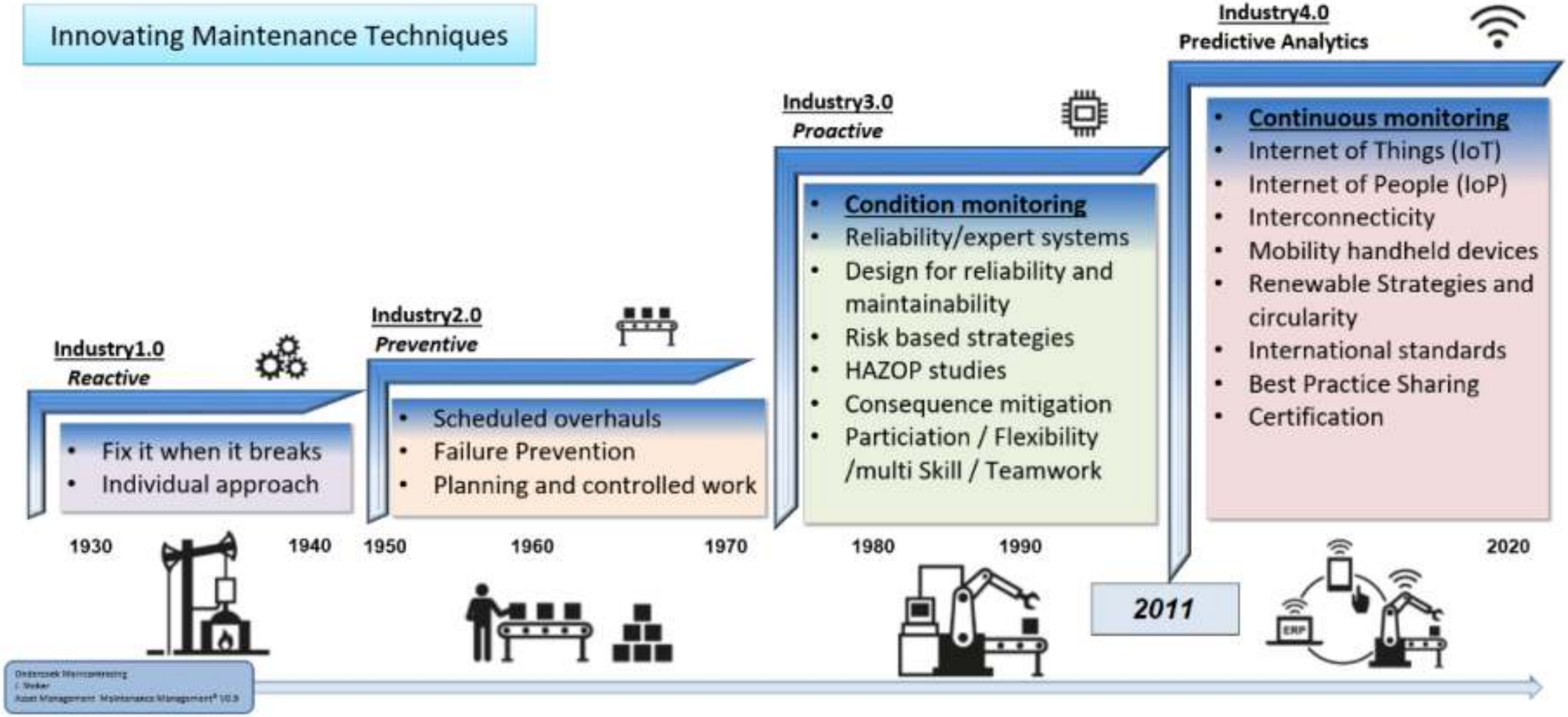

LULEÅ
UNIVERSITY
OF TECHNOLOGY
Sisteplant
Dream Innovate Challenge
5.0
5.0
Industry 4.0 to 5.0
Ten years of Digitization to
Human Centric Industry
Prof. Diego Galar
Luleå University of Technology
Director R&D Sisteplant

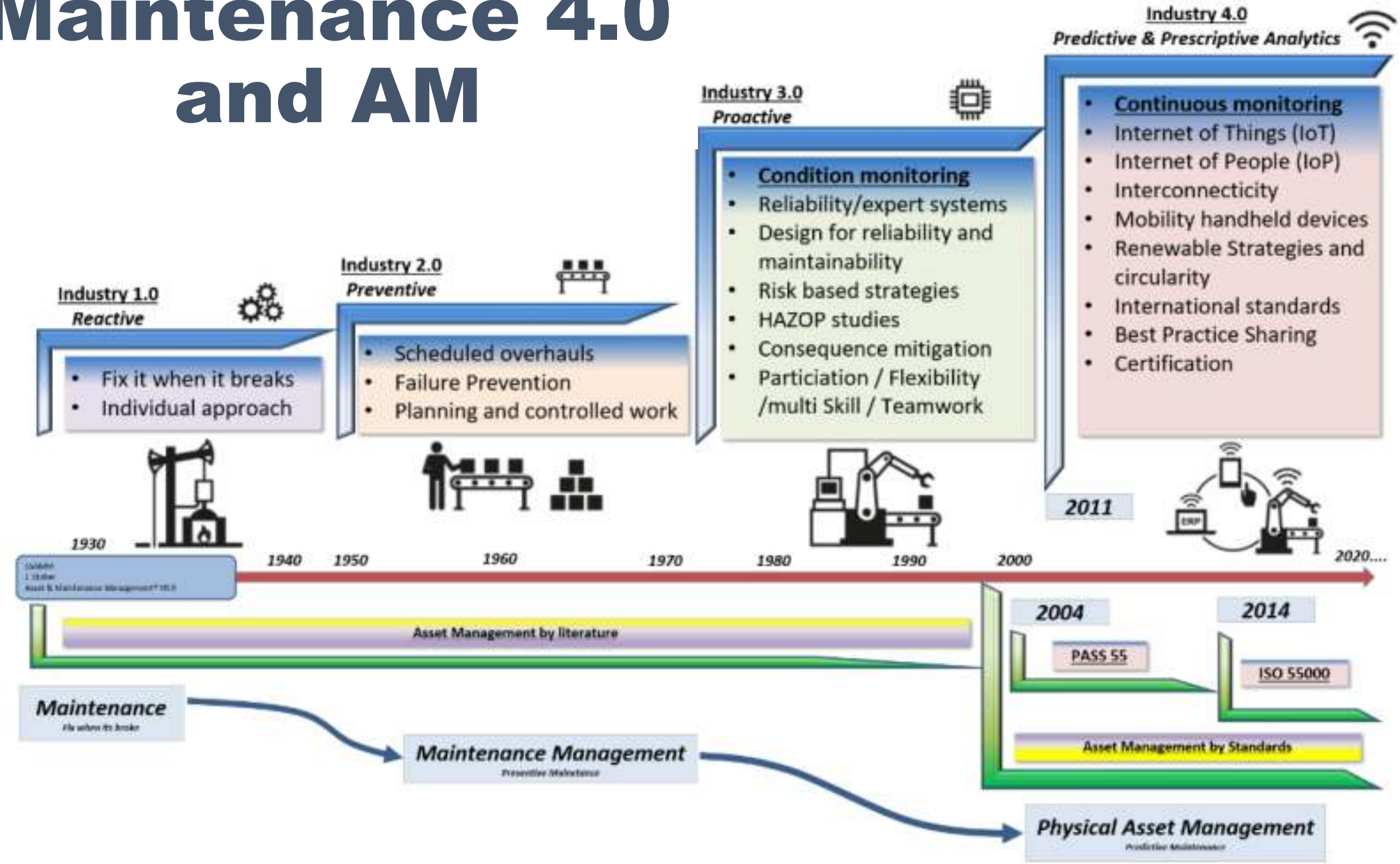
When did it happen?



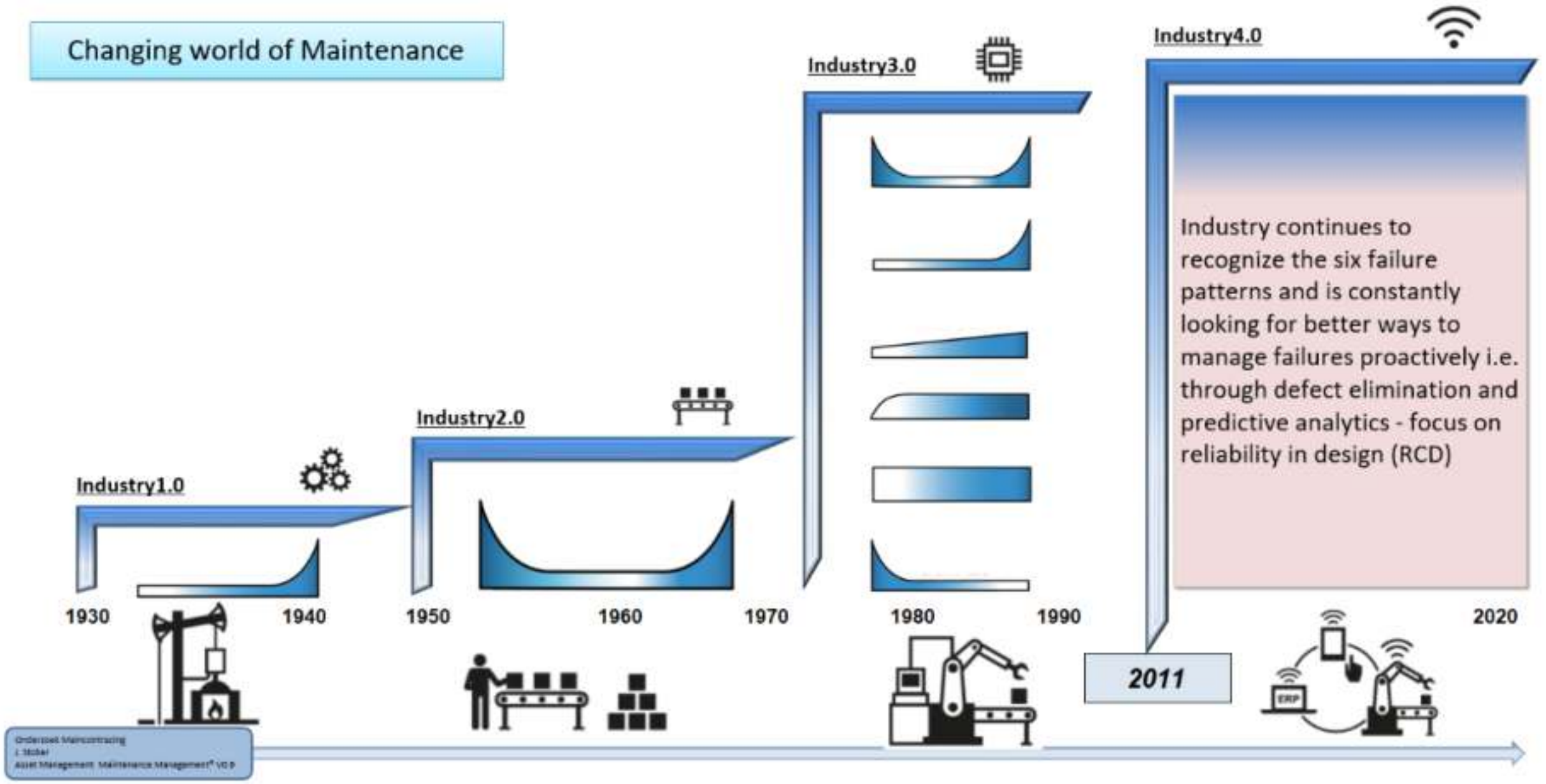
Maintenance 4.0?

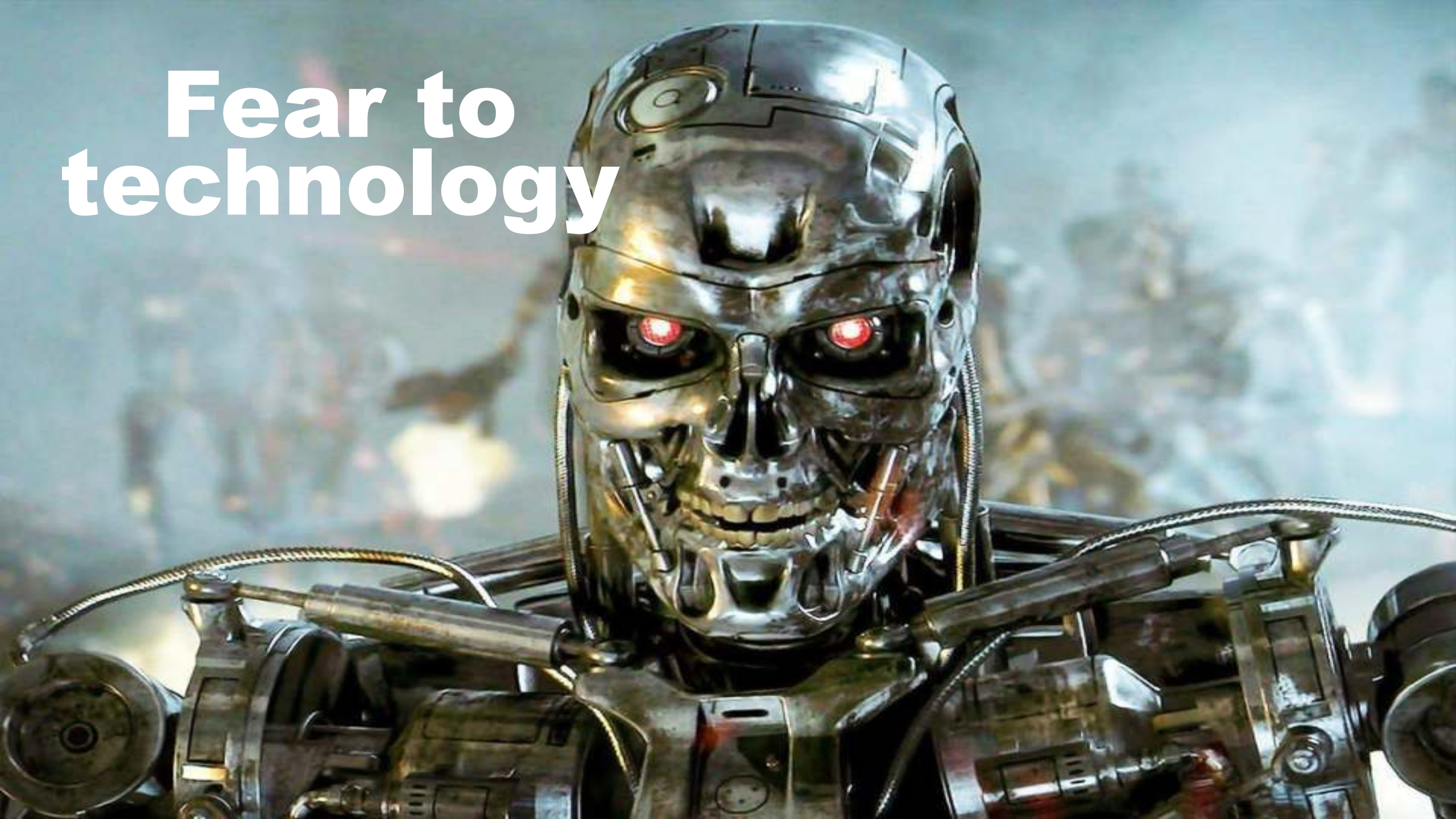


Maintenance 4.0 and AM



What to do with AI on maintenance data?



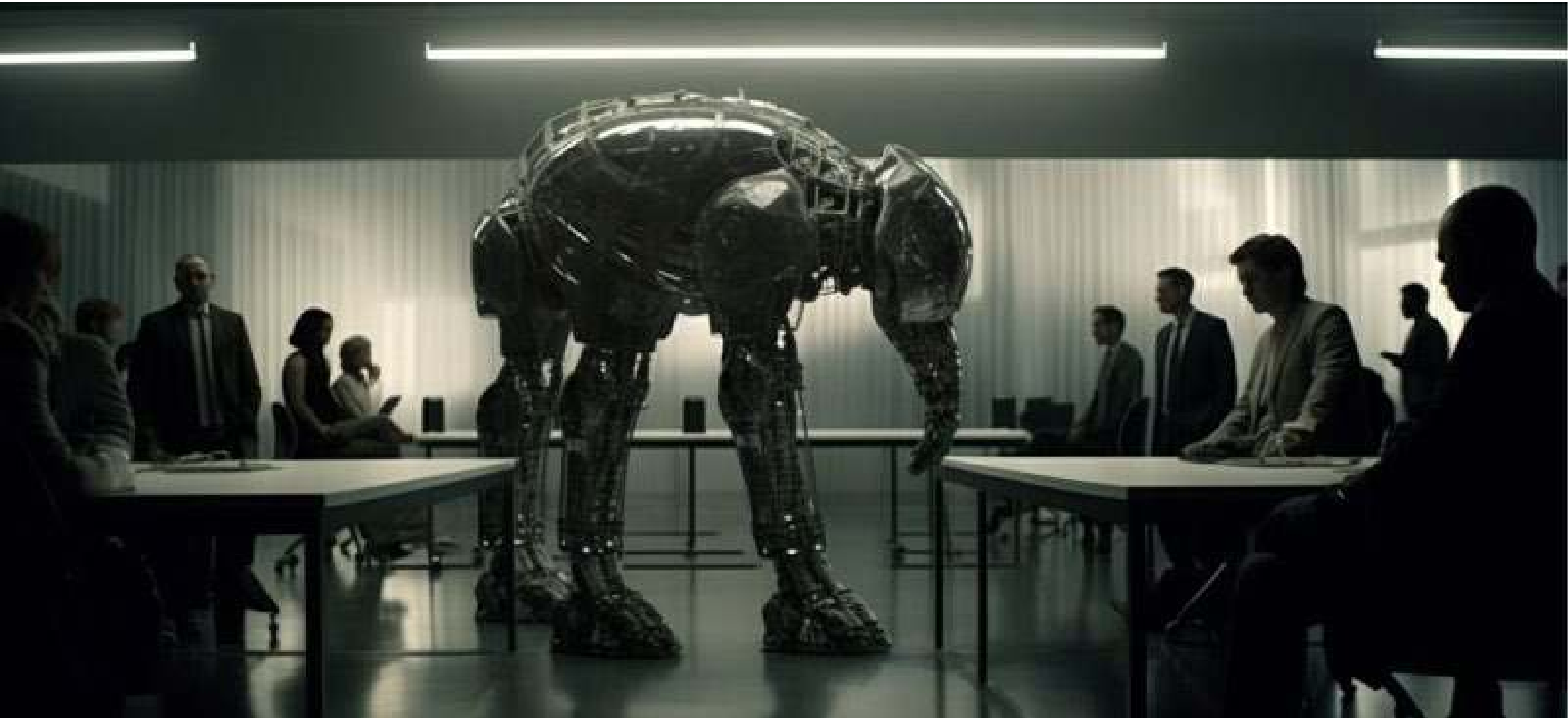

Fear to
technology

Dark Factory

- Dark Factory (Lights out manufacturing)
- Characterised by
  - High level of autonomy
  - Digitalisation
  - AI
  - Robotics
  - Low liveware intervention

Technology is 'The Elephant' in the room

Not always organizations embrace new innovations or are aligned with the latest timeframe Industry 5.0



European Commission

From shareholder
to stakeholder value

INDUSTRY 5.0

human-centric, sustainable
and resilient

IR4.0 to IR 5.0

Industry 5.0 ...

HUMAN-CENTRIC

... promotes talents, diversity and empowerment

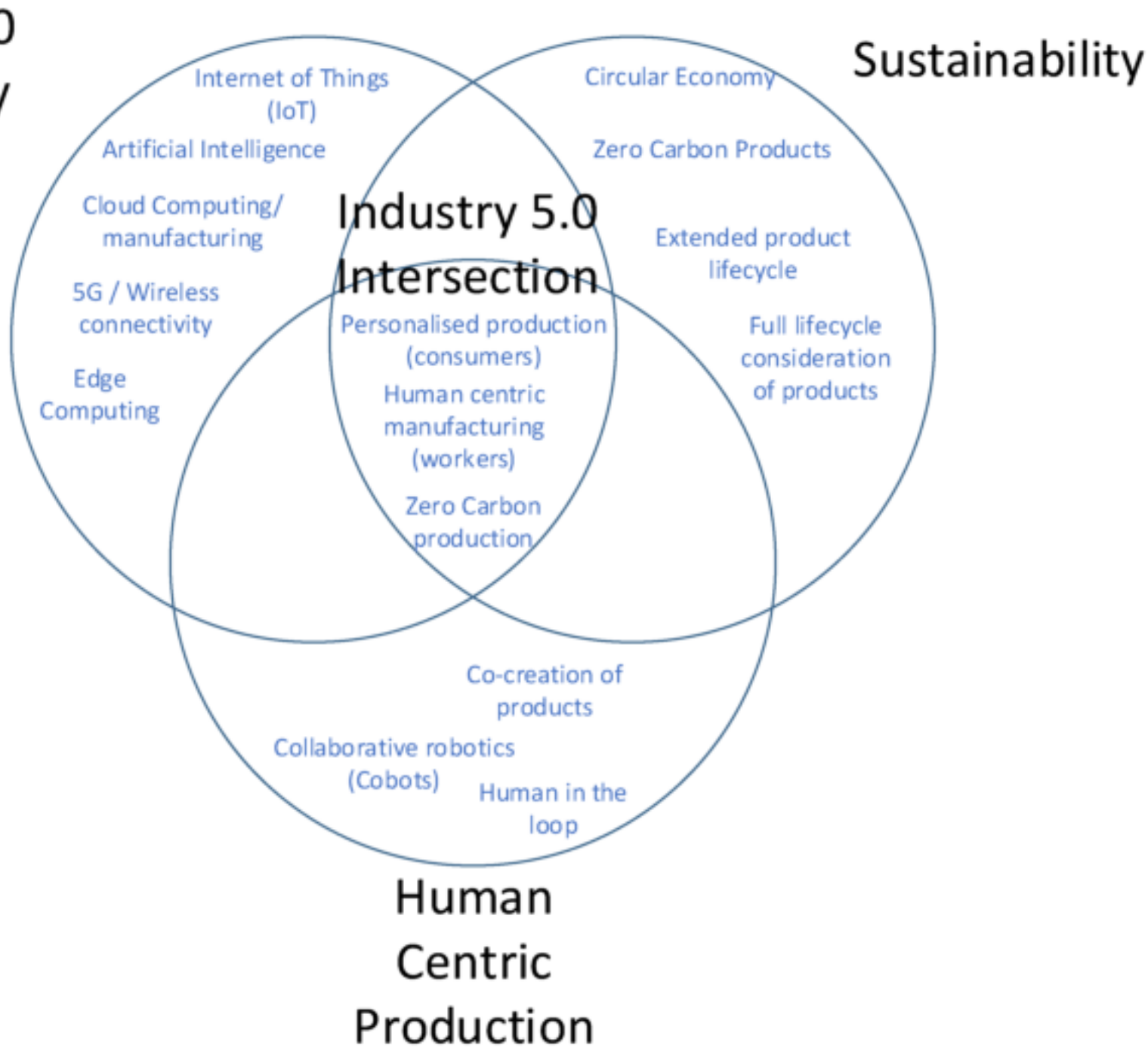
RESILIENT

... is agile and resilient with flexible and adaptable technologies

SUSTAINABLE

... leads action on sustainability and respects planetary boundaries

IR4.0 to IR 5.0


Industry 4.0
Technology
Sustainability
Internet of Things (IoT)
Artificial Intelligence
Cloud Computing/ manufacturing
5G / Wireless connectivity
Edge Computing
Circular Economy
Zero Carbon Products
Extended product lifecycle
Full lifecycle consideration of products
Industry 5.0 Intersection
Personalised production (consumers)
Human centric manufacturing (workers)
Zero Carbon production
Co-creation of products
Collaborative robotics (Cobots)
Human in the loop
Human Centric Production


SUSTAINABILITY

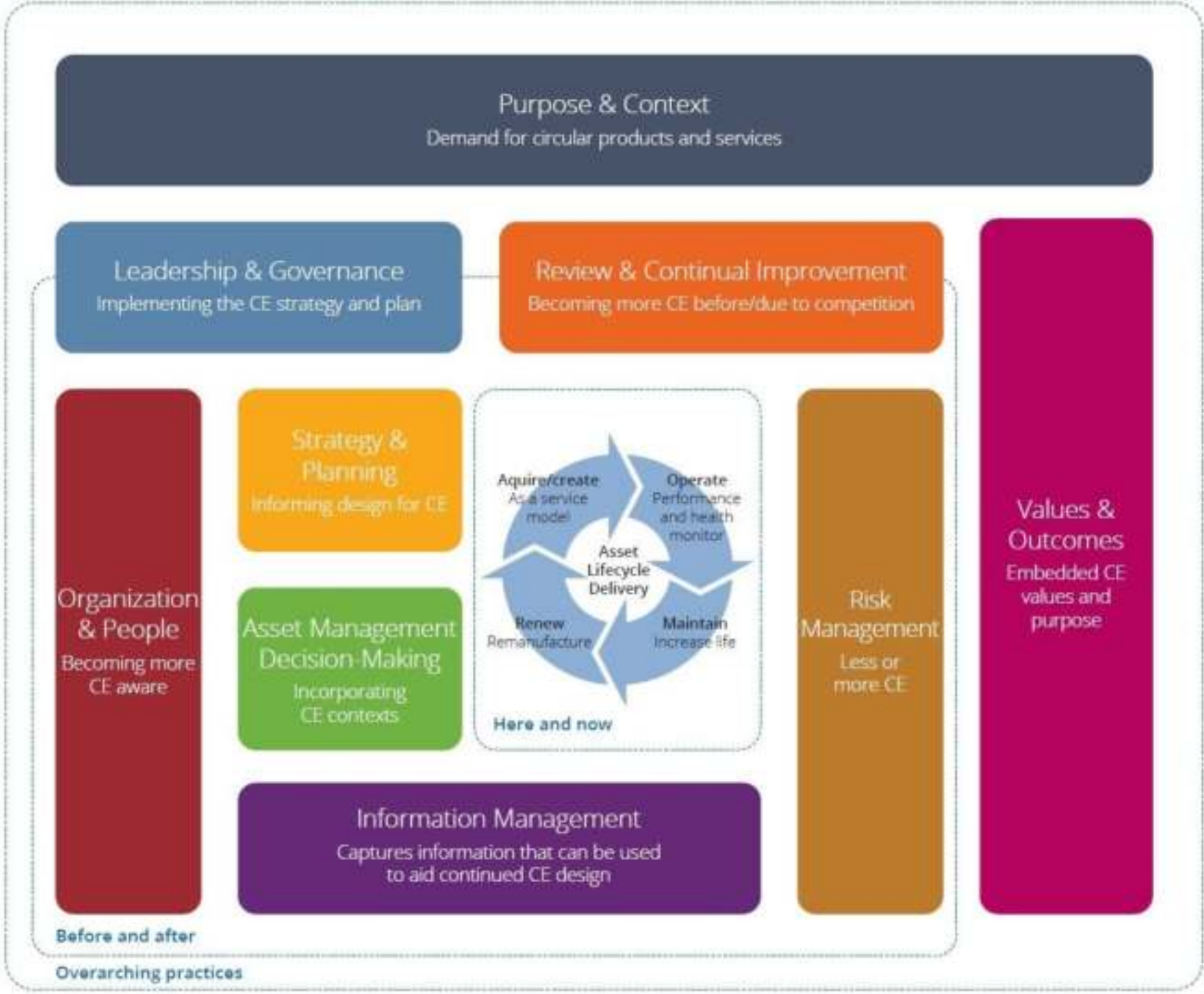
For industry to respect planetary boundaries, it needs to be **sustainable**. It needs to develop circular processes that re-use, re-purpose and recycle natural resources, reduce waste and environmental impact. Sustainability means reducing energy consumption and greenhouse emissions, to avoid depletion and degradation of natural resources, to ensure the needs of today's generations without jeopardising the needs of future generations. Technologies like AI and additive manufacturing can play a large role here, by optimising resource-efficiency and minimising waste.

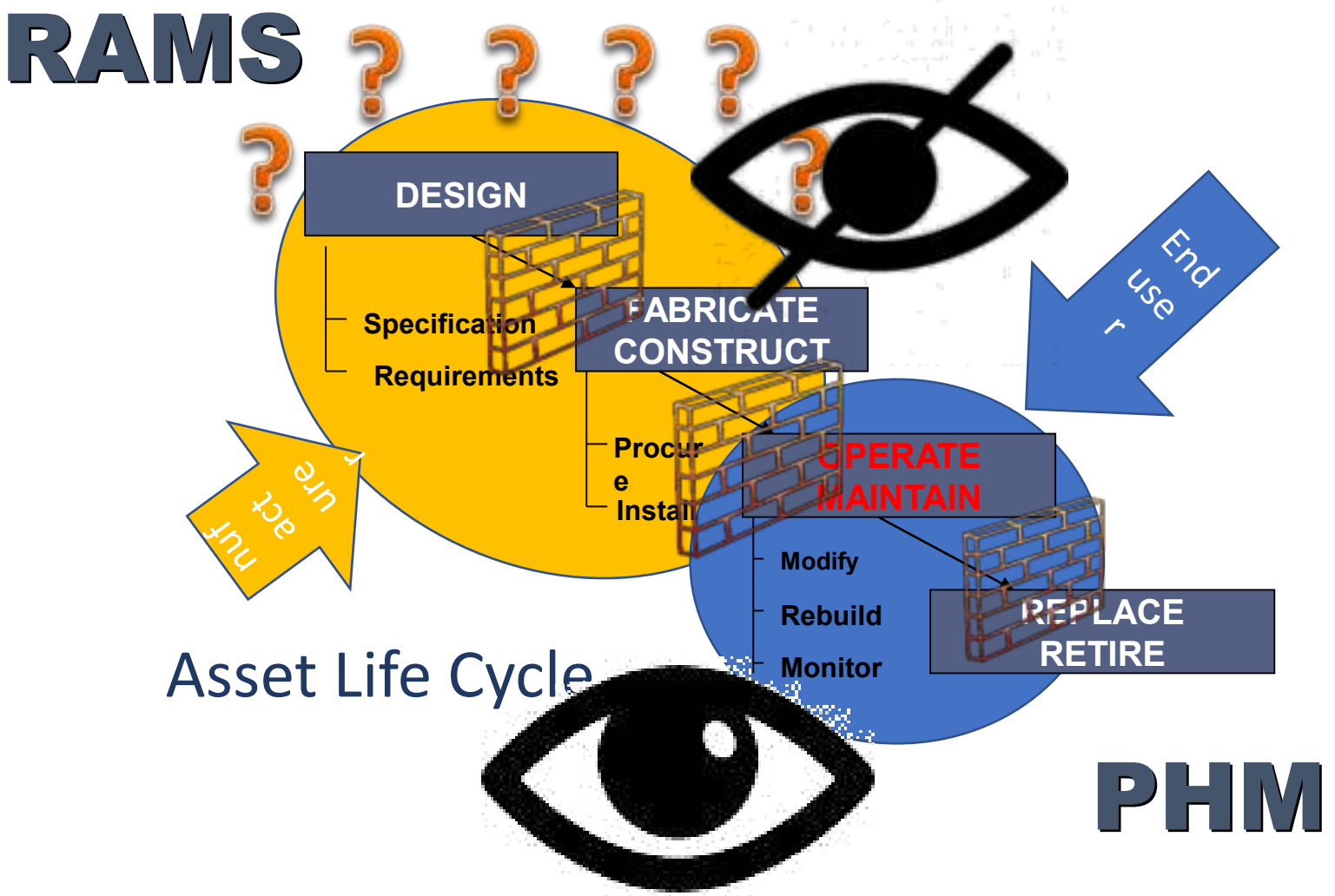
RAM4S

- Reliability
- Availability
- Maintainability
- **S**afety
- **S**ecurity
- **S**upportability
- **S**ustainability

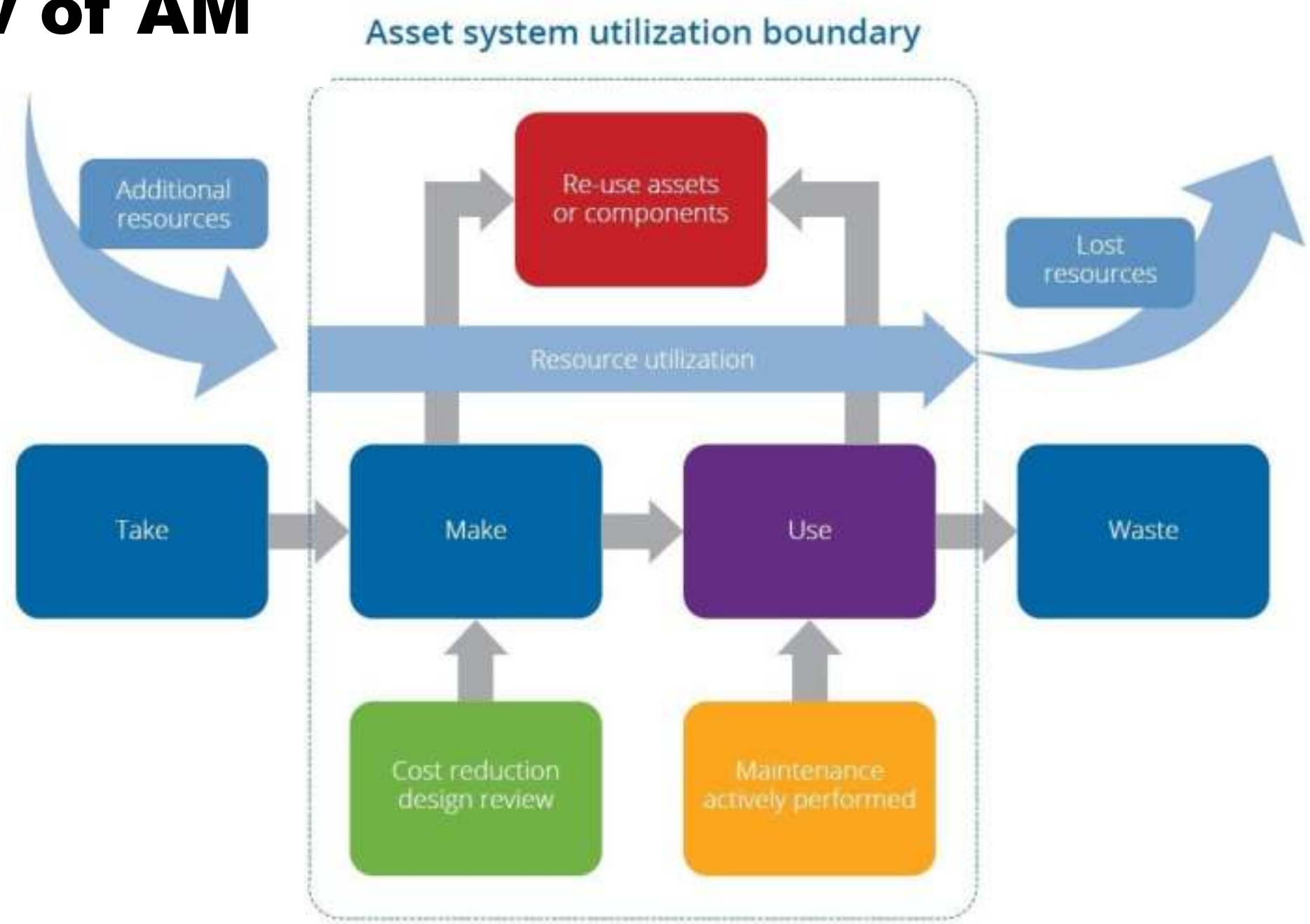
Asset management ISO55000

New Asset management

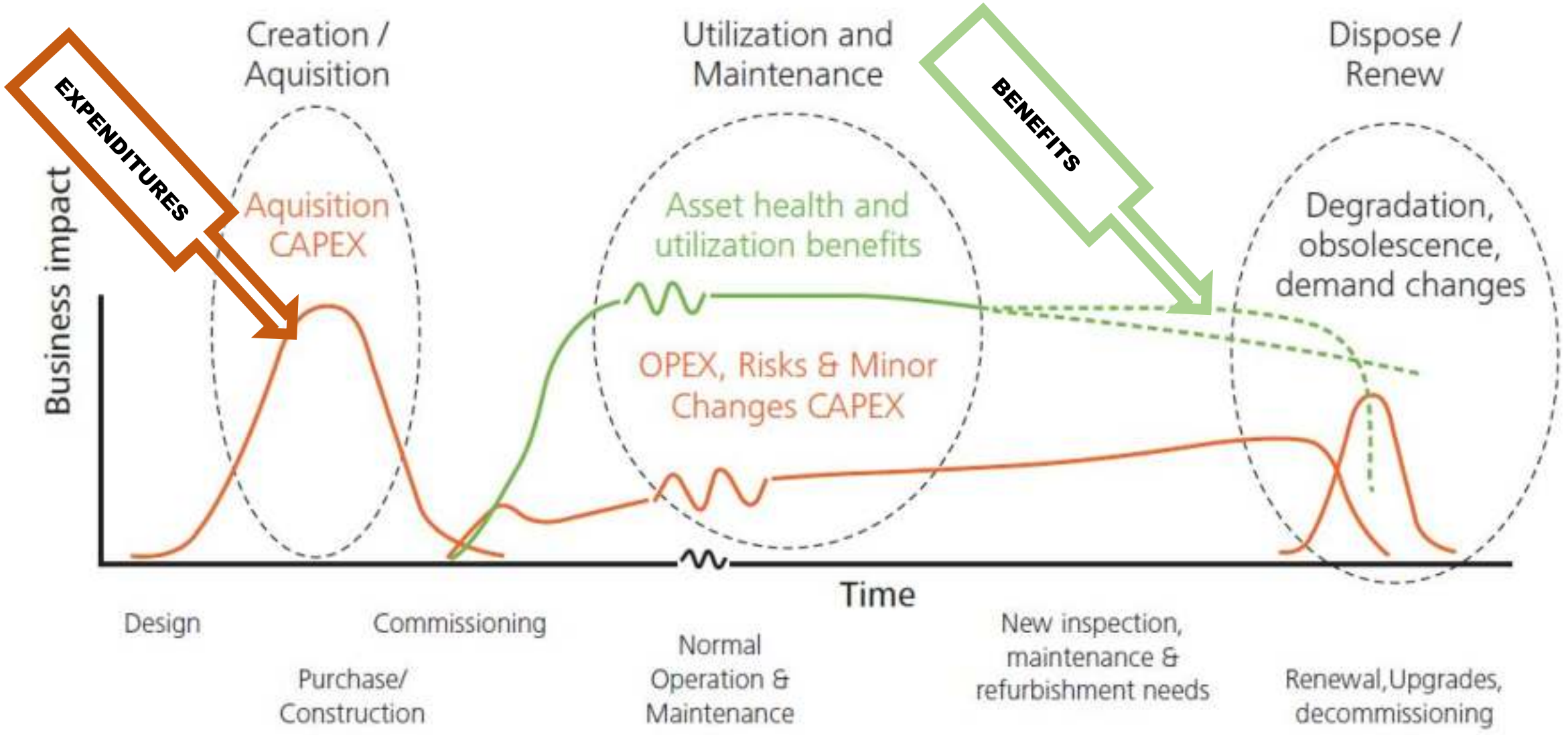



RAMS
DESIGN
Specification
Requirements
FABRICATE
CONSTRUCT
Procur
e
Instal
OPERATE
MAINTAIN
Modify
Rebuild
Monitor
REPLACE
RETIRE
End
use
r
nuf
act
ure
r
Asset Life Cycle
PHM

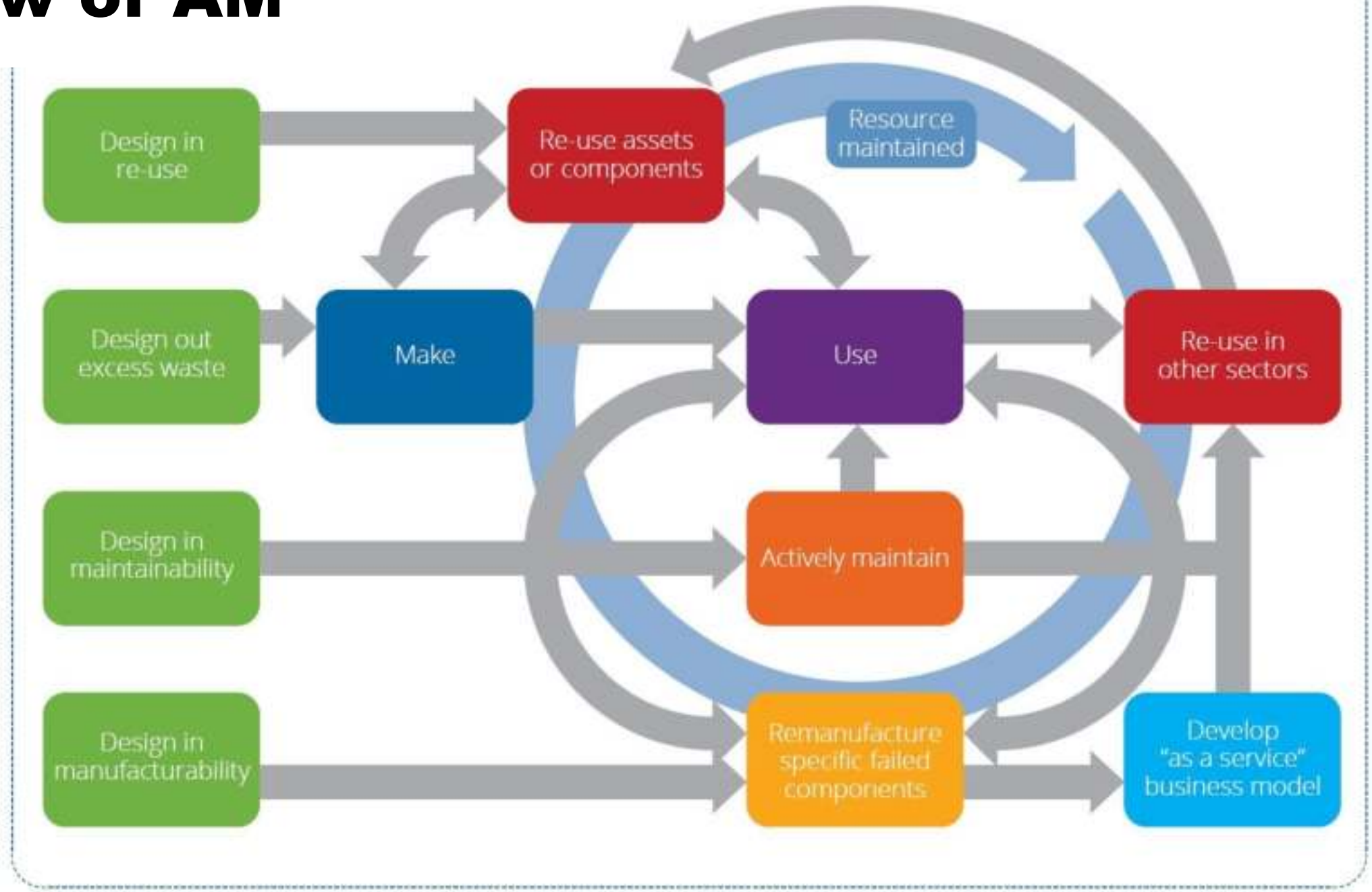
OLD view of AM



Business impact in a PLM approach



NEW view of AM



Design for.....

- Design for reliability
- Design for maintainability
- Design for maintenance
- Design for failure

Obsolescence

- Condition of being antiquated, old-fashioned, or out-of-date
- No longer meets current needs or expectation levels
  - Aging, technology, standard change
  - 2-yr old computers good example
- Inability to meet changing performance requirements

Obsolescence & Service Life

- “Always remember that someone, somewhere is making a product that will make your product obsolete”

  Georges Doriot

- “Planned obsolescence” by Vince Packard’s The Waste Makers
  - Practice of deliberately designing products to last for a shorter period of time
  - Systemically doing this leads to inferior products

Service vs. Physical Lives

- Physical Lives: time it takes for infrastructure to wear out/fail
  - **Predicting this may be irrelevant**
- Service life: time actually used
  - In general these 2 are different

Planned Obsolescence

- Products needing replacement before they should because they are obsolete

- Producers who **influence consumer** concepts of acceptable styles

- Intentionally **holding back attractive functional features**, then introducing them later to make old model obsolete.

Designing products to wear out or become outdated quickly

MAINTENANCE OR REPAIRMENT AR NOR VALID OPTIONS

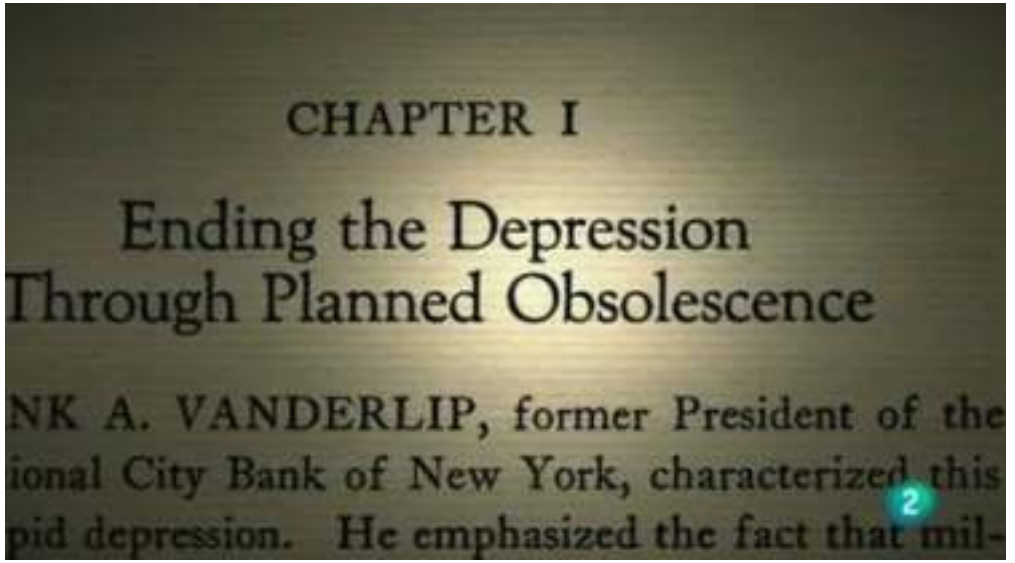

NO
MORE
DISPOSABLE
PRODUCTS
RIGHT TO
REPAIR
REPAIR FOR FUTURE
REPAIR FOR FUTURE
RIGHT TO REPAIR
IFIXIT
patagonia

What Causes It?

- Technological change
- Regulatory change
- Forced or “suggested” upgrades
- **Economic / social changes**
- Value / behavior changes

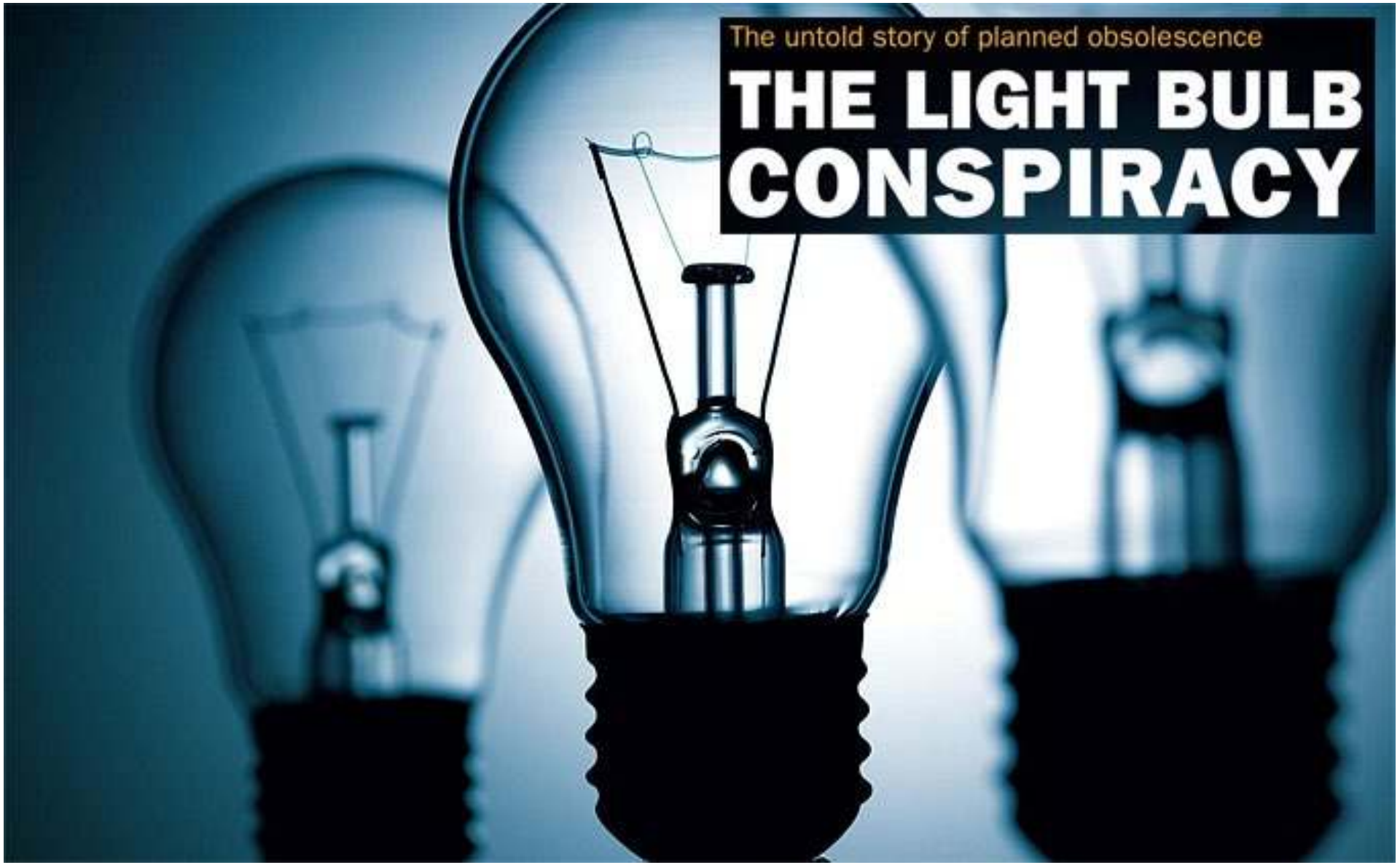
Design to fail?

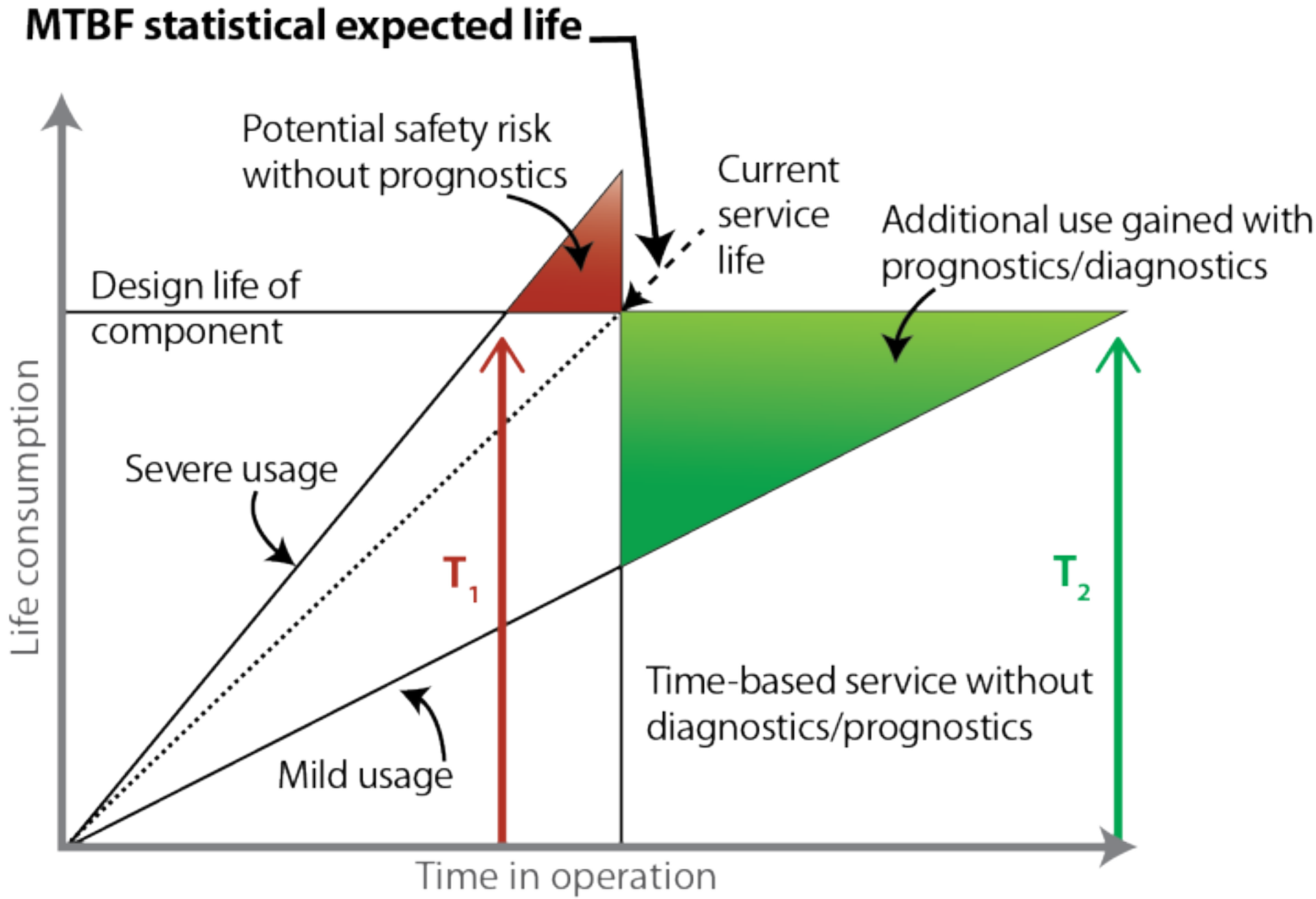
Bernard London (1932)



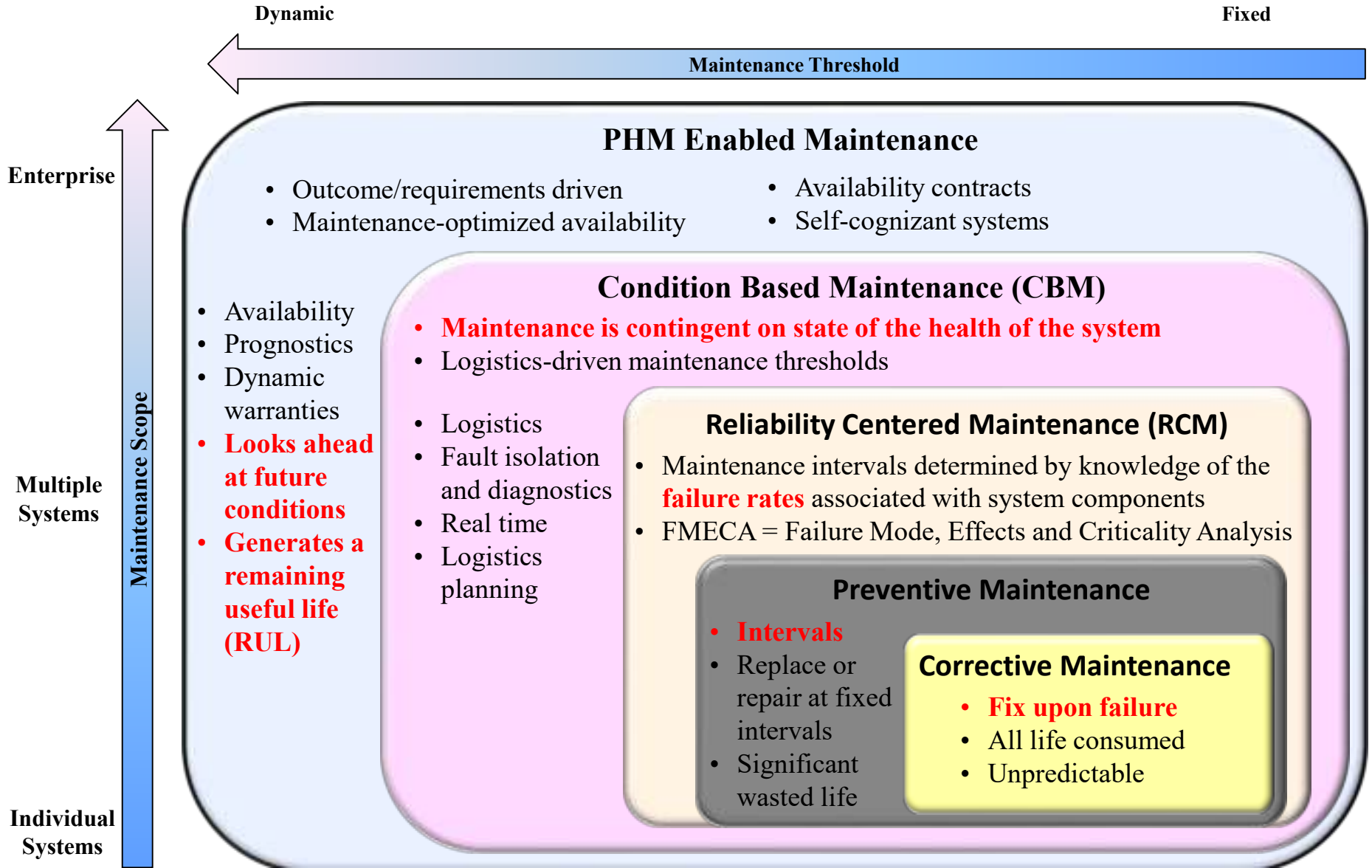
Capitalism is sustained on obsolescence?

The main in White suit

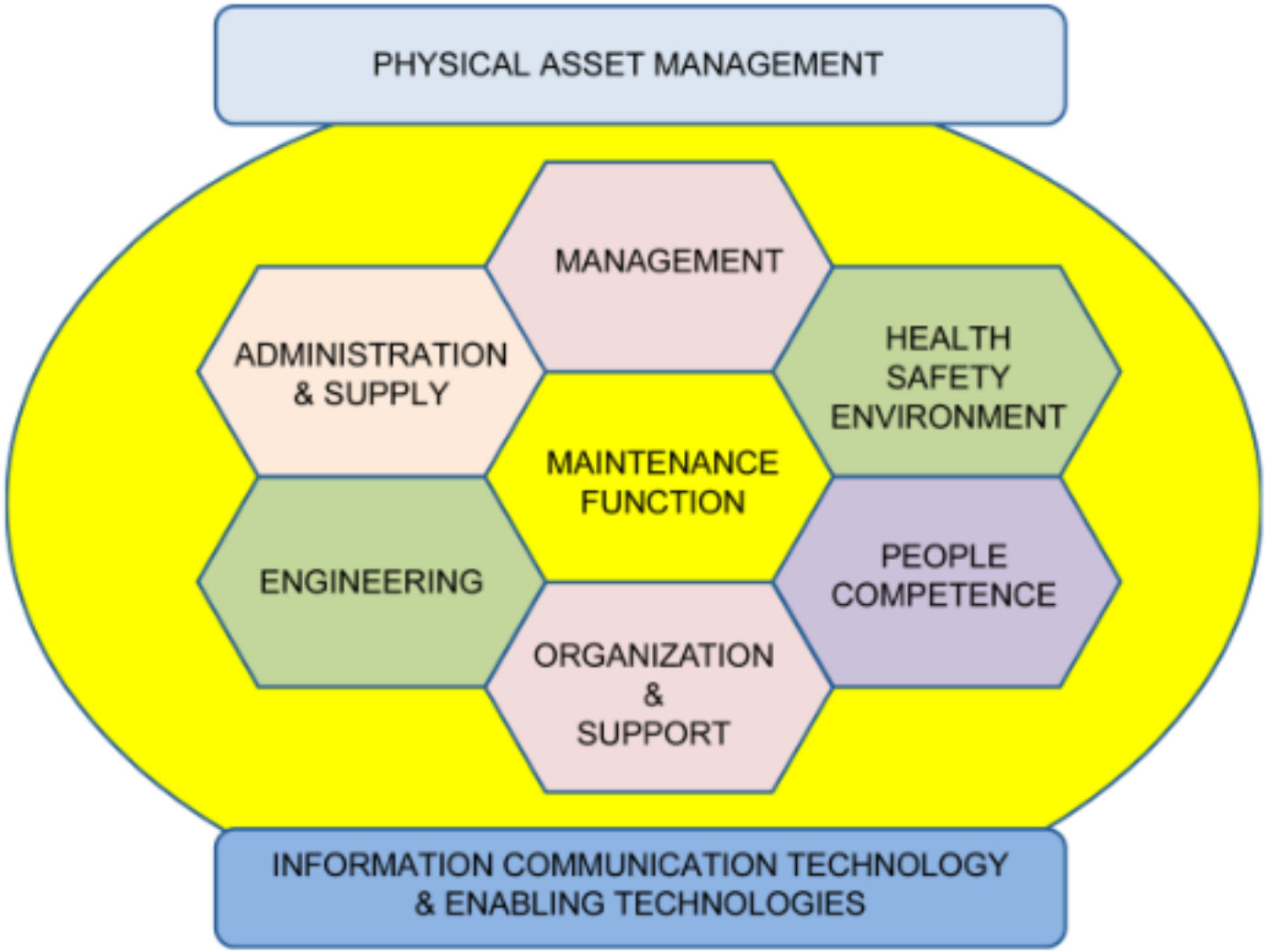

The untold story of planned obsolescence
THE LIGHT BULB CONSPIRACY


MTBF statistical expected life
Potential safety risk without prognostics
Current service life
Additional use gained with prognostics/diagnostics
Design life of component
Severe usage
T1
T2
Time-based service without diagnostics/prognostics
Mild usage
Life consumption
Time in operation

Evolution of Failure Response Paradigms



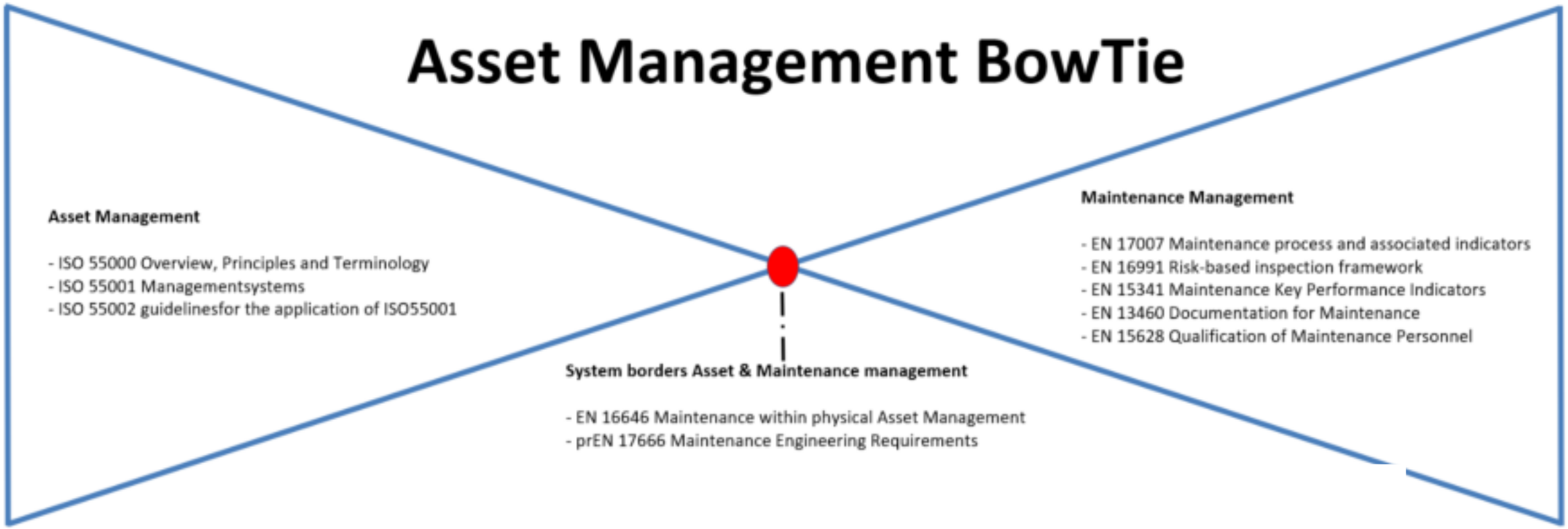
15341:2020


PHYSICAL ASSET MANAGEMENT
MANAGEMENT
ADMINISTRATION & SUPPLY
HEALTH SAFETY ENVIRONMENT
MAINTENANCE FUNCTION
ENGINEERING
PEOPLE COMPETENCE
ORGANIZATION & SUPPORT
INFORMATION COMMUNICATION TECHNOLOGY & ENABLING TECHNOLOGIES

15341:2020

SUB FUNCTIONS, TOOLS AND METHODOLOGIES	KPIs	MAIN AREAS			
Maintenance within physical asset management	PHA_i	Sustainability i = 1 to 3	Capacity Effectiveness Integrity i = 4 to 11	Service Level i = 12 to 13	Economics i = 14 to 20
Sub-function 1 Health - Safety Environment	HSE_i	Laws- Rules conformity i = 1 to 3	Statistical Records i = 4 to 12	Safe Practice i = 13 to 17	Prevention and Improvements i = 18 to 22
Sub-function 2 Maintenance Management	M_i	Strategy i = 1 to 3	Function i = 4 to 10	Technical Assessment i = 11 to 16	Continuous Improvement i = 17 to 22
Sub-function 3 People Competence	P_i	Maintenance Manager i = 1 to 3	Maintenance Supervisor/ Maintenance Engineer i = 4 to 9	Maintenance Technician Specialist i = 10 to 12	Education i = 13 to 21
Sub-function 4 Maintenance Engineering	E_i	Capability Criticality i = 1 to 3	Durability i = 4 to 9	Preventive Maintenance i = 10 to 16	Engineering Improvements i = 17 to 19
Sub-function 5 Organization and Support	$O\&S_i$	Structure and Support i = 1 to 8	Planning and Control i = 9 to 22	Productivity Effectiveness i = 23 to 28	Quality i = 29 to 30
Sub-function 6 Administration and Supply	$A\&S_i$	Economics i = 1 to 6	Budget &Control i = 7 to 19	Outsourcing services i = 20 to 25	Materials and spare parts i = 26 to 29
Information Communication Technology, Enabling technologies	ICT_i	Management i = 1 to 6	Administration and Supply i = 7 to 10	Organization and Support i = 11 to 13	Engineering i = 14 to 20 TEC 18.20

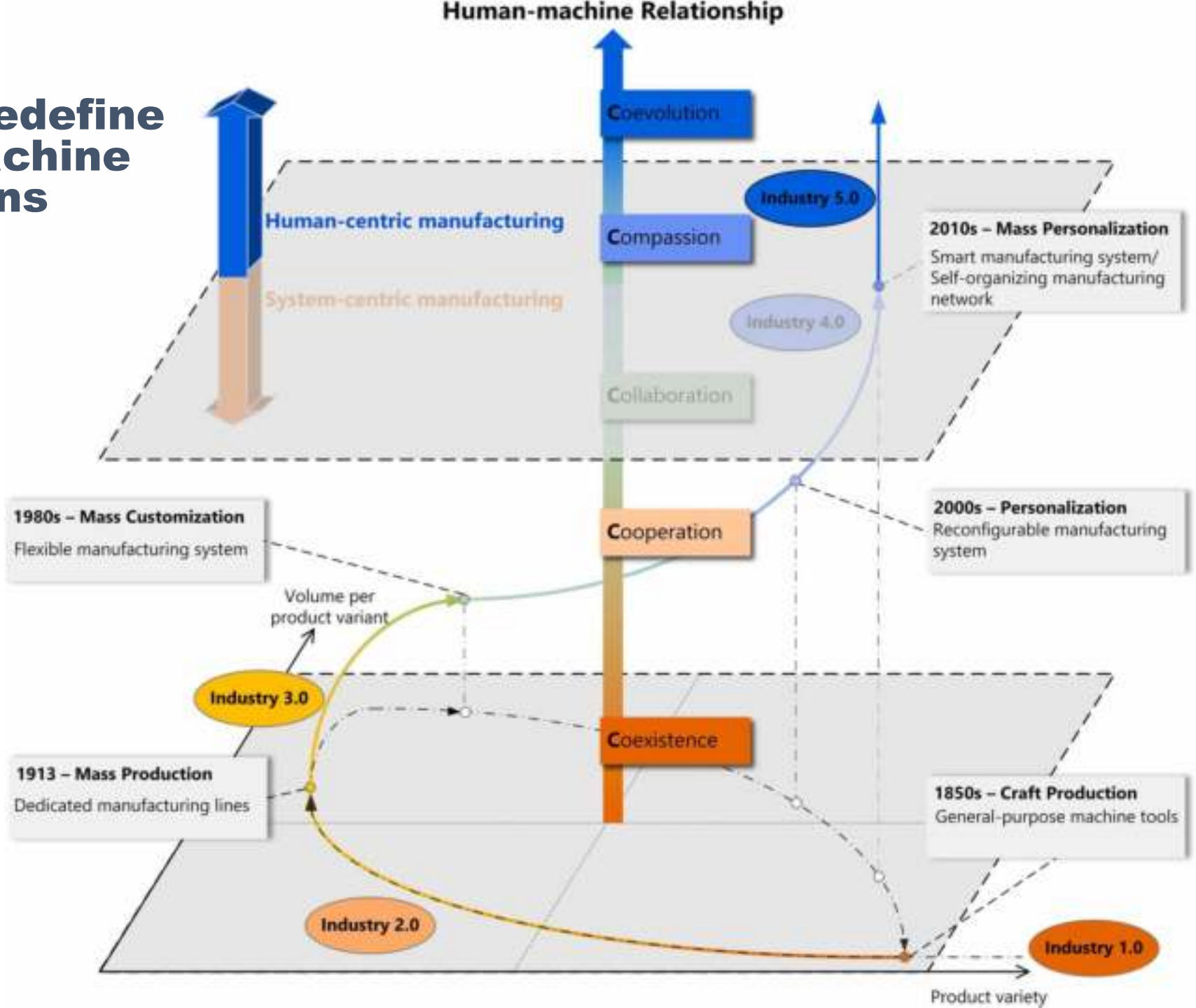
Asset Management BowTie




Human Centric

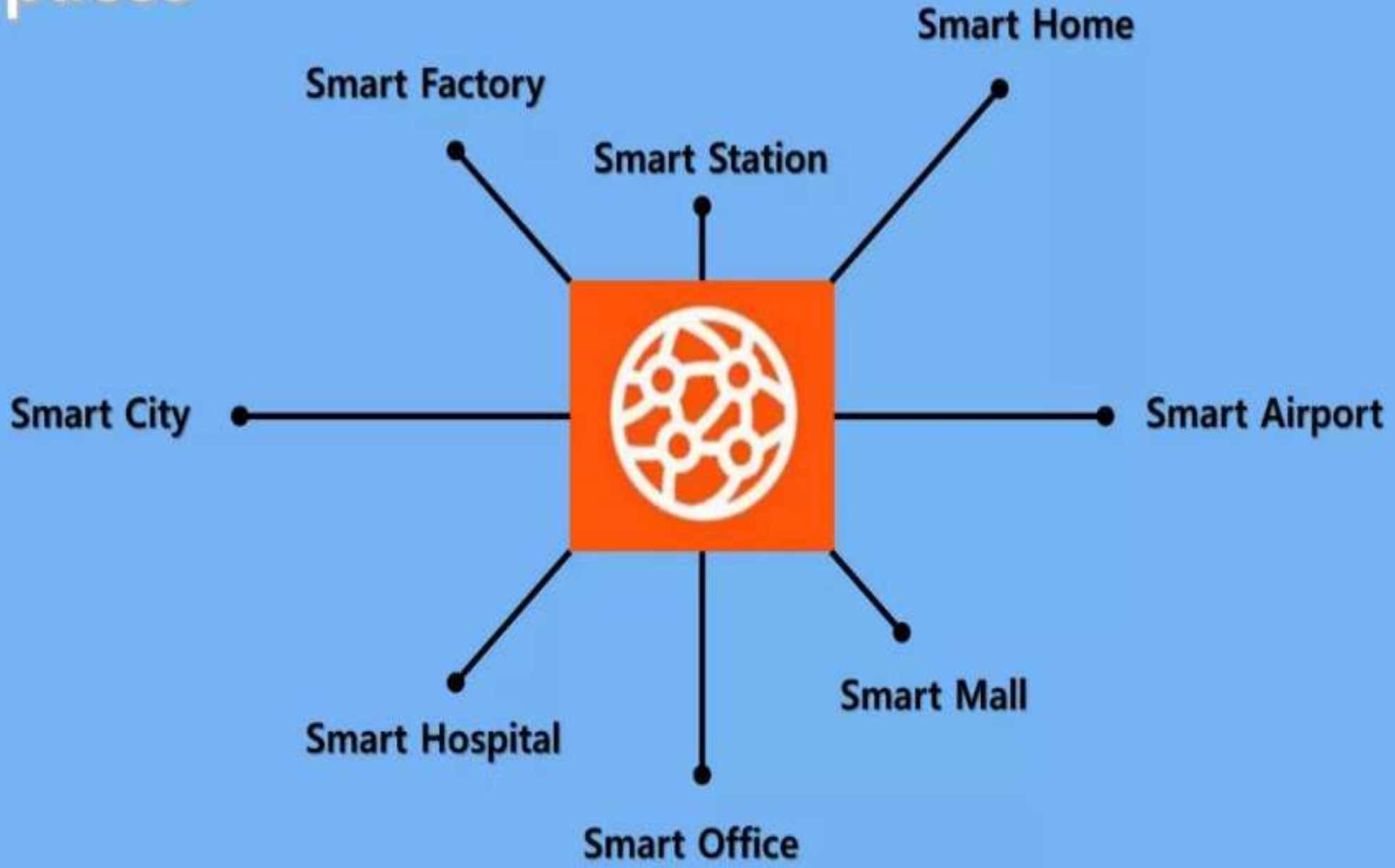
Rather than taking emergent technology as a starting point and examining its potential for increasing efficiency, a **human-centric approach** in industry puts core human needs and interests at the heart of the production process. Rather than asking what we can do with new technology, we ask what the technology can do for us. Rather than asking the industry worker to adapt his or her skills to the needs of rapidly evolving technology, we want to use technology to adapt the production process to the needs of the worker, e.g. to guide and train him/her. It also means making sure the use of new technologies does not impinge on workers' fundamental rights, such as the right to privacy, autonomy and human dignity.

5.0 Let us redefine human machine relations

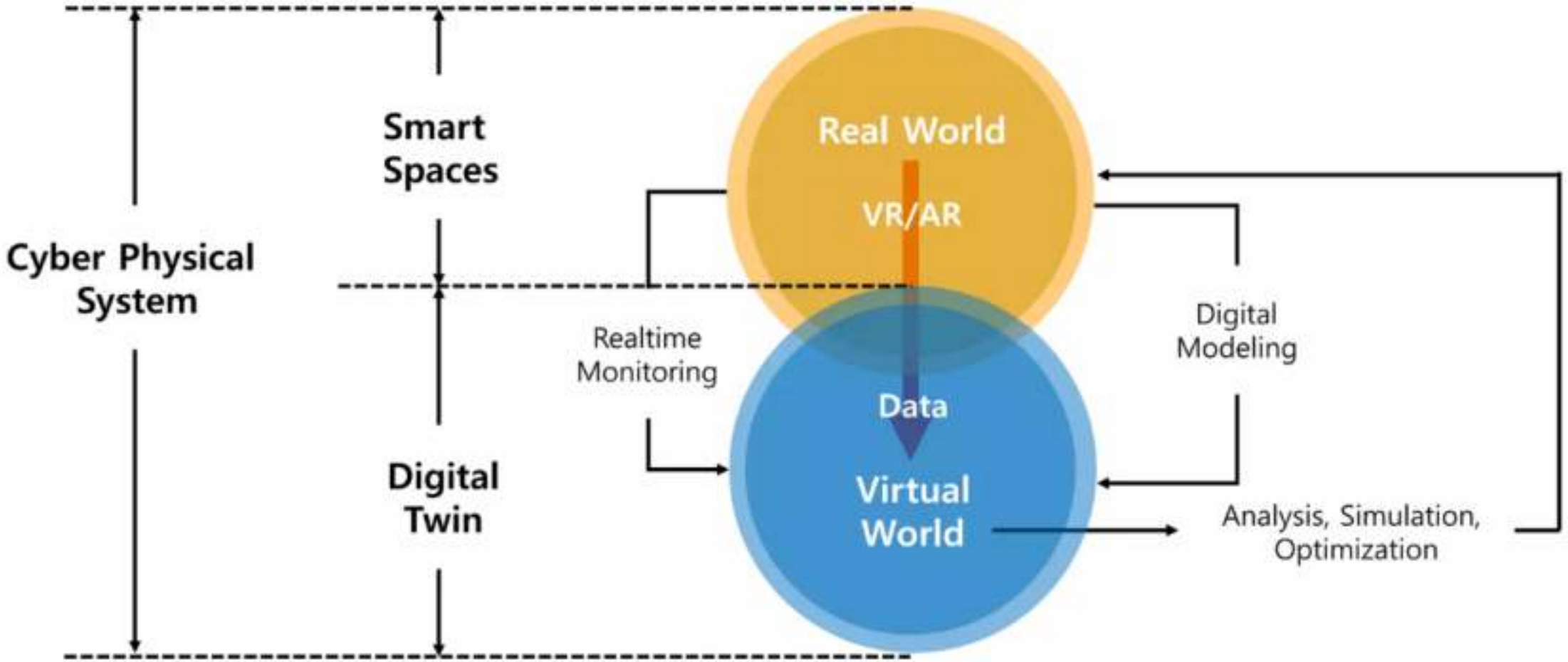


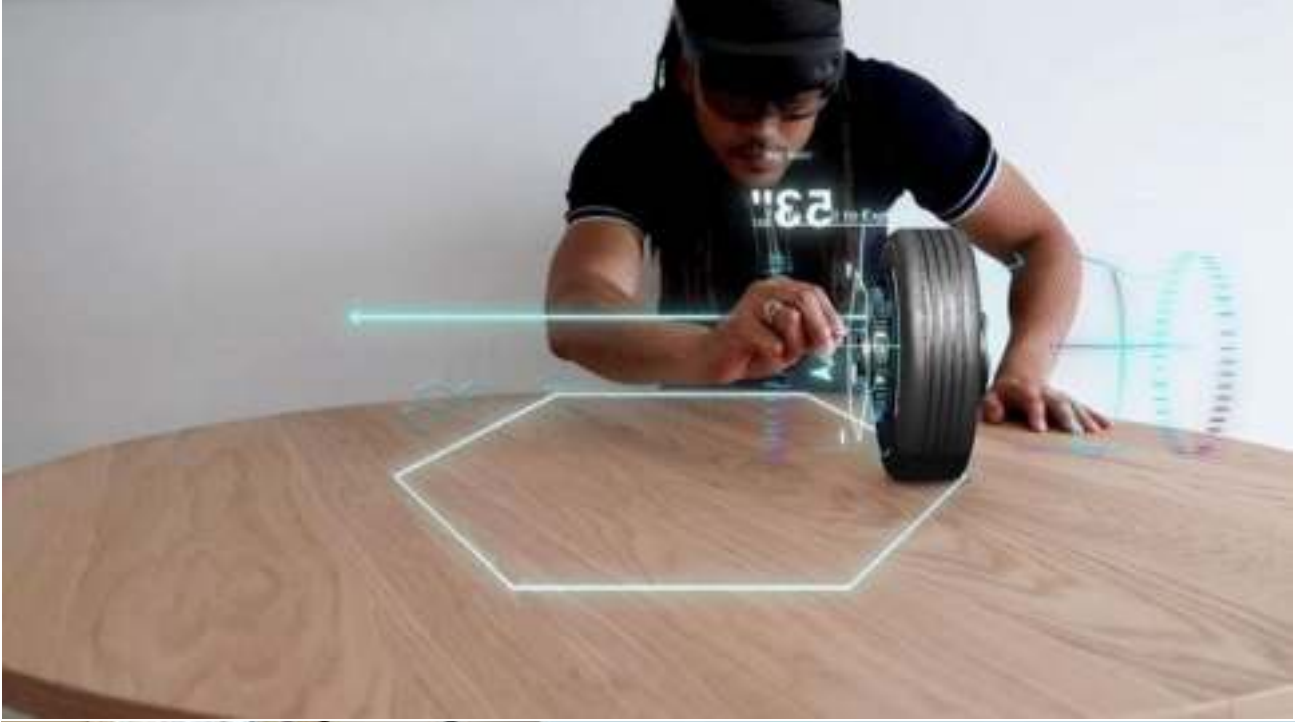

MAINTENANCE

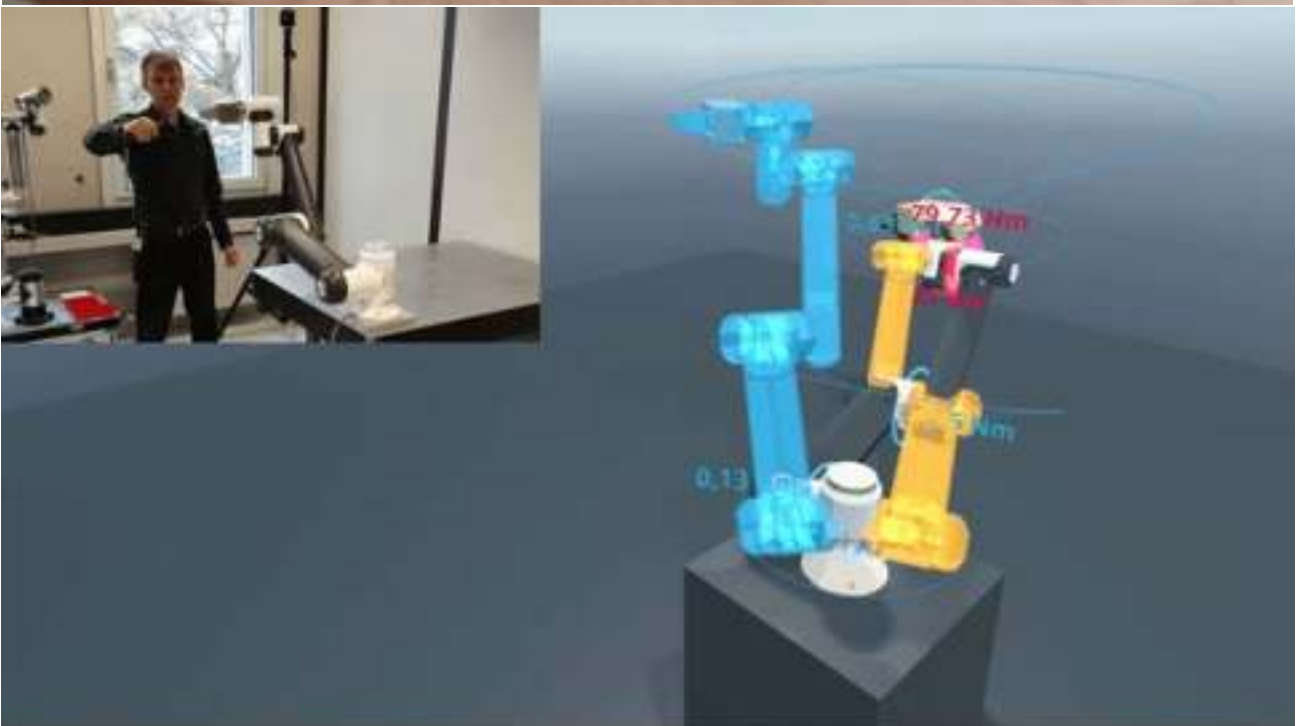
Smart Spaces



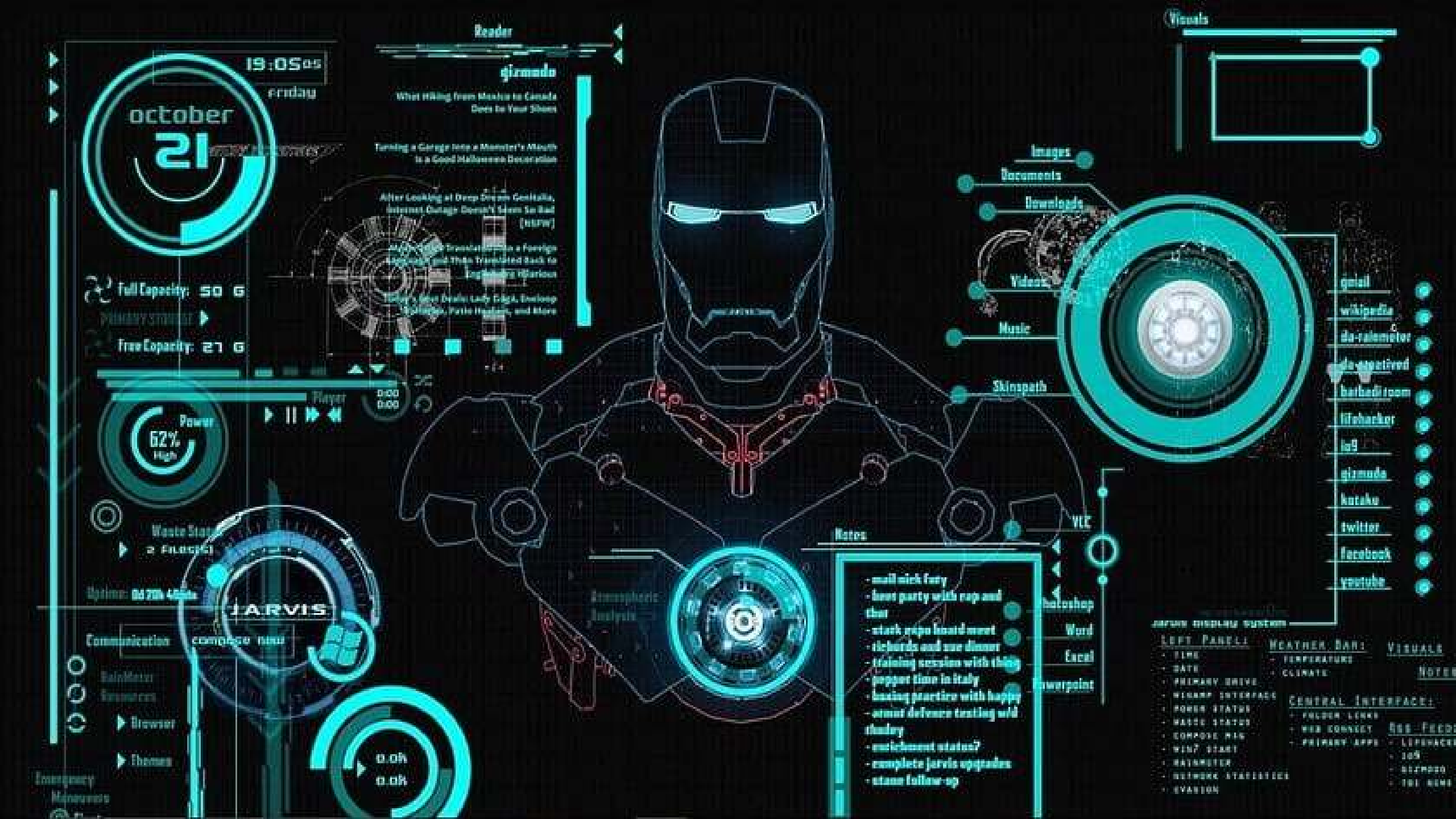
Digital Twin and SMART







We want to be Alice


Reader
gizmodo
What Hiking from Alaska to Canada Does to Your Shoes
Turning a Garage into a Monster's Mouth is a Good Halloween Decoration
Visuals
Images
Documents
Downloads
Videos
Music
Skinspath
gmail
wikipedia
da-rainmeter
da-deviantart
baiduditeam
lifehacker
io9
gizmodo
kotaku
twitter
facebook
youtube
19:05
friday
october
21
Full Capacity: 50 G
Free Capacity: 27 G
Power
62%
High
Player
Notes
- mail nick fury
- have party with rap and thor
- stark expo board meet
- tickards and sue dinner
- training session with thing
- pepper time in italy
- boxing practice with happy
- armor defence testing w/d thunder
- enrichment status?
- complete jarvis upgrades
- stane follow-up
VLC
Photoshop
Word
Excel
Powerpoint
JARVIS
Communication
Browser
Themes
Emergency Maneuvers
0.0k
0.0k
Left Panel:
Time
Date
Primary Drive
Weather Interface
Power Status
Mass Status
Compose Mail
Win7 Start
Rainmeter
Network Statistics
Evasion
Weather Bar:
Temperature
Climate
Central Interface:
Folder Links
Web Connect
Primary Apps
Visuals
Notes
Sub Feeds
Lifehacker
io9
Gizmodo
TBI News


J.A.R.V.I.S
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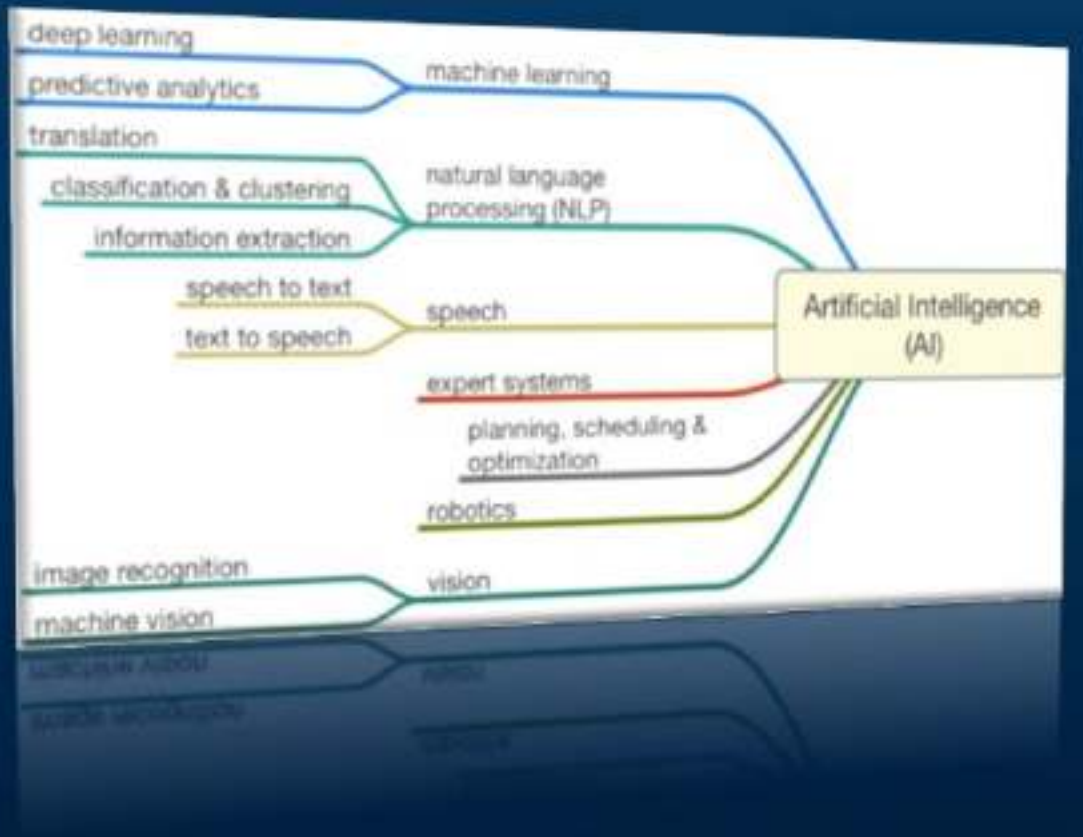
21 Tuesday


AI IN THE INDUSTRY

AI DEFINITION

Artificial intelligence (AI) is the ability of a computer or computer-controlled system to perform tasks commonly associated with intelligent beings.



LULEÅ UNIVERSITY OF TECHNOLOGY

What is Intelligence?

- Common definition of artificial intelligence:
  - AI is a field which attempts to build intelligent machines and tries to understand intelligent entities.
- But what is intelligence?
  - Learning, manipulating with facts, but also creativity, consciousness, emotion and intuition.
- Can machines be intelligent?
  - Up to the present day it is not sure whether it is possible to build a machine that has all aspects of intelligence.
  - This kind of research is central in the field of AI.

Artificial Intelligent Systems

- We can debate endlessly about whether a certain system is intelligent or not …

- SW programs or SW/HW systems designed
  - to perform complex tasks
  - employing strategies that mimic some aspect of human thought
  - the key is evolution: it is intelligent if it can learn (even if only a limited sense) and/or get better in time

Artificial Intelligence (AI) vs Machine learning (ML)

- AI:
  is the broader concept of machines being able to carry out tasks in a way that we would consider “smart”.

- ML:
  an application of AI based around the idea that we should really just be able to give machines access to data and let them learn for themselves.

ML in a metaphor

It's like gardening

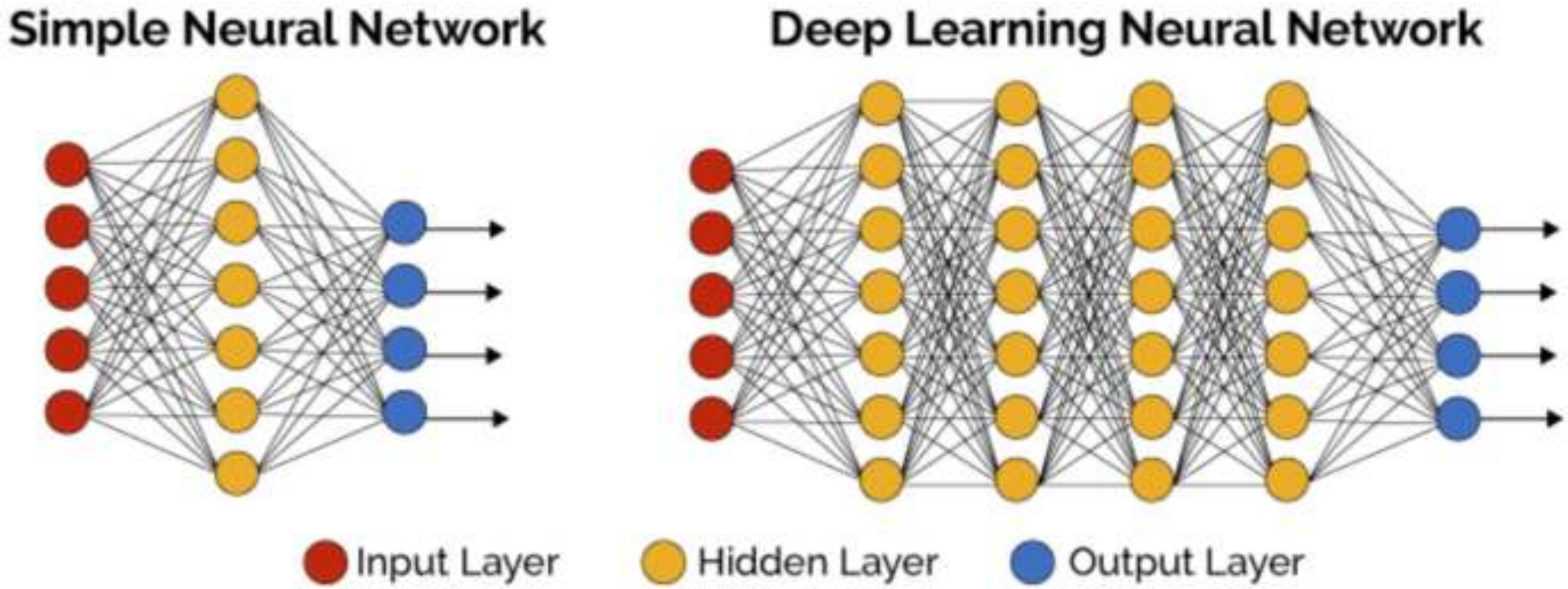
- Seeds = Algorithms
- Nutrients = Data
- Gardener = You
- Plants = Programs/ trained models


AI
AI
AI

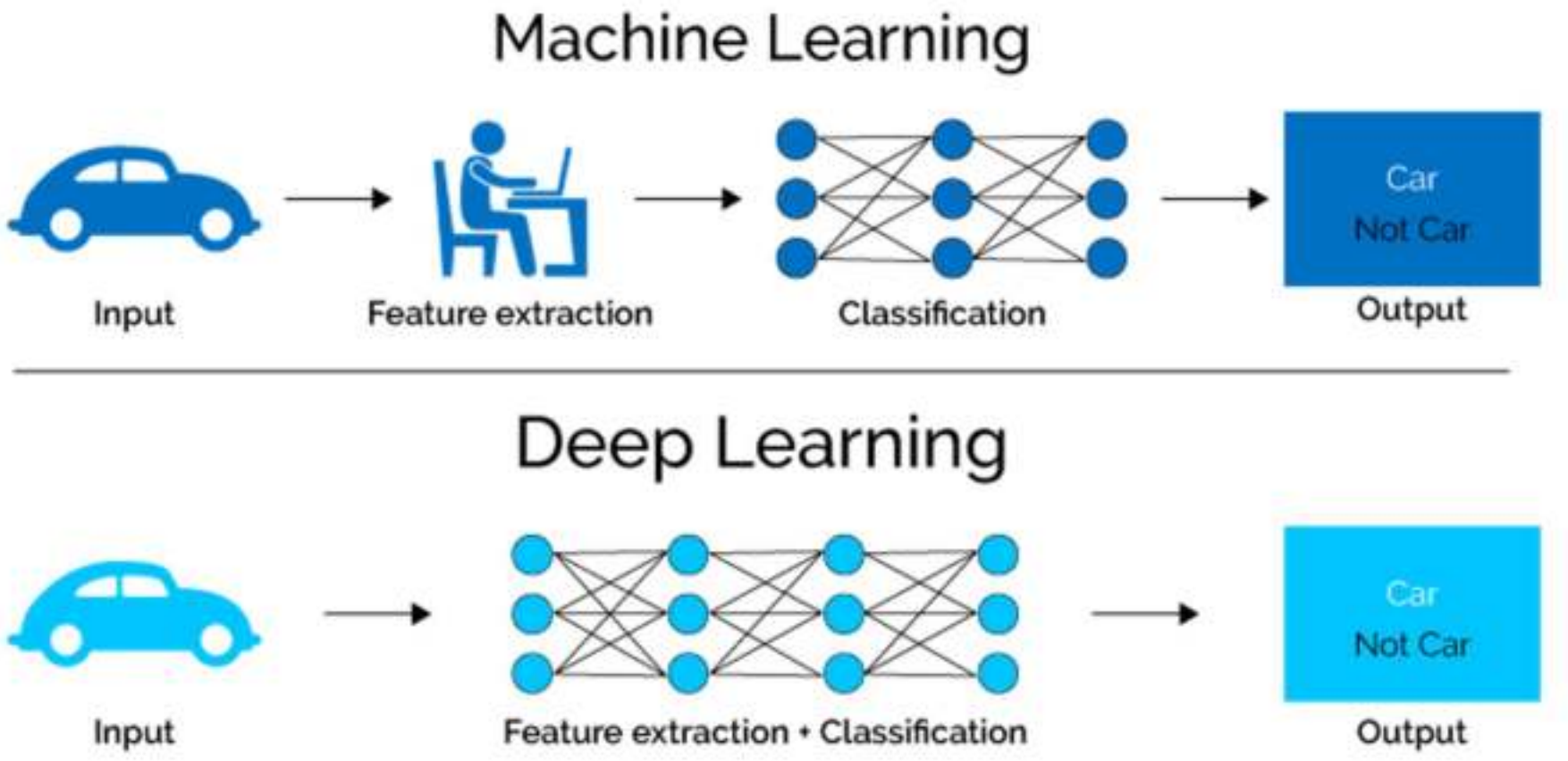
Not for all applications..

- IF
  - the nature of computations required in a task is not well understood
  - or there are too many exceptions to the rules
  - or known algorithms are too complex or inefficient
- THEN
  - AI can be considered as a possible solution

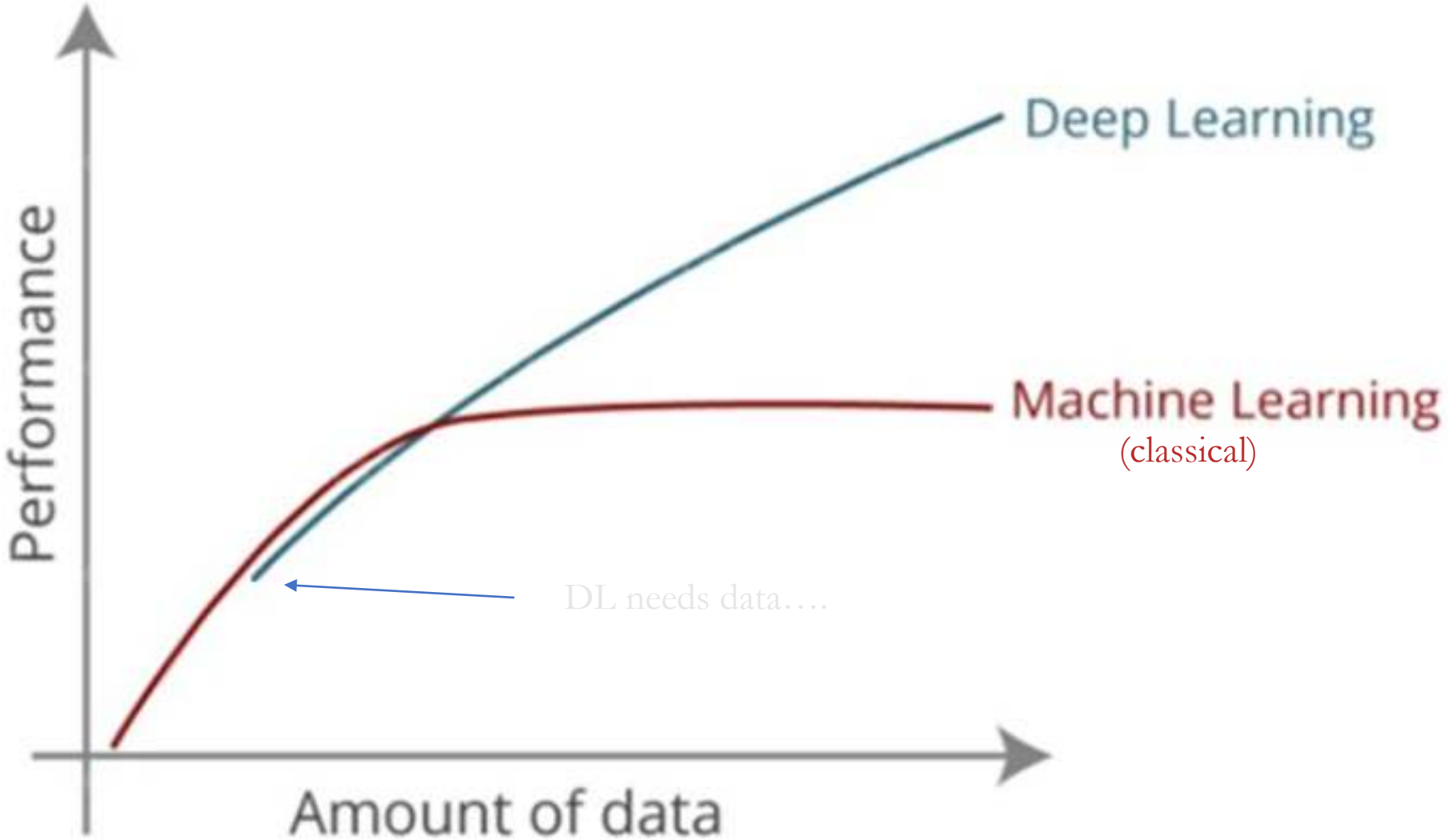
Traditional and Deep Learning networks

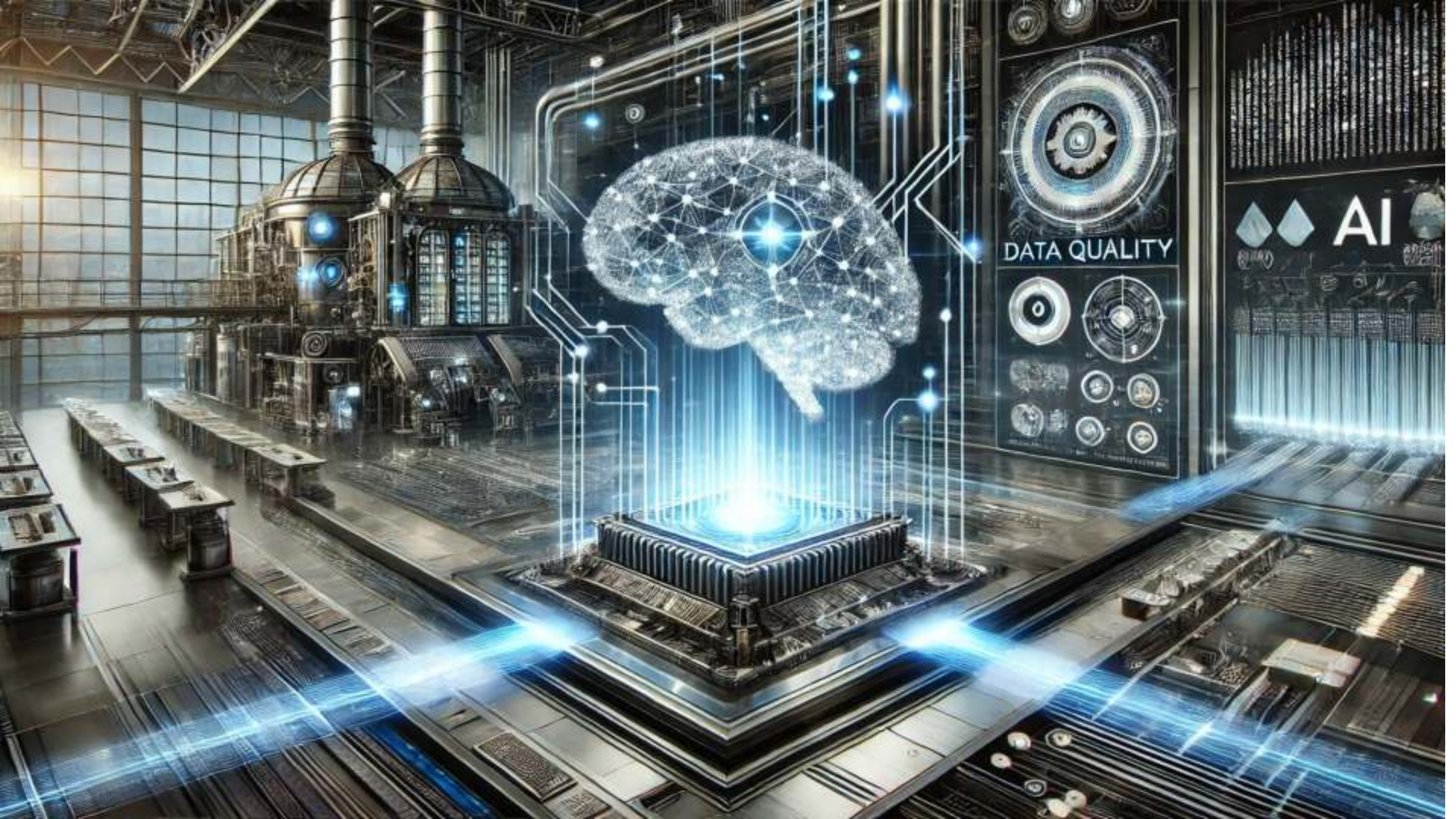


Traditional ML vs Deep Learning

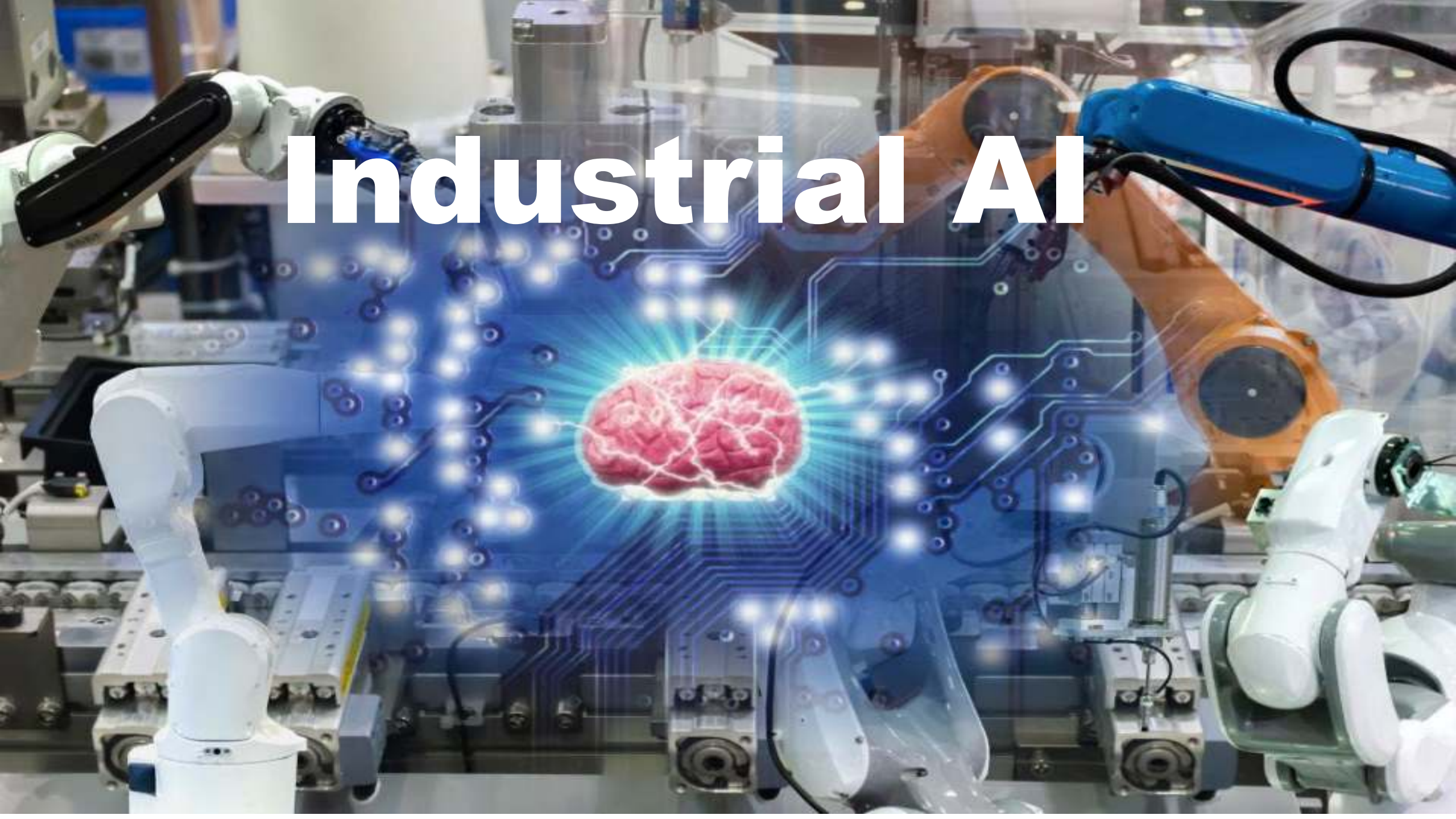


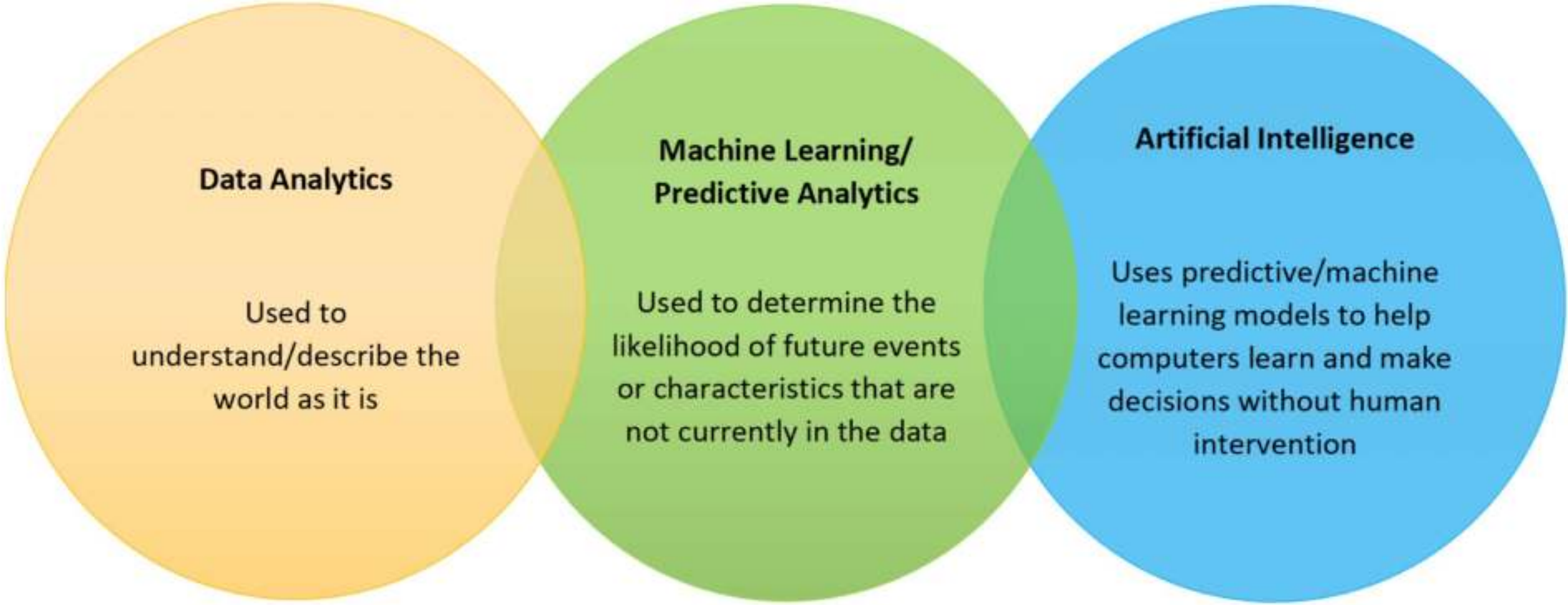
Classical ML vs DeepLearning




DATA QUALITY
AI

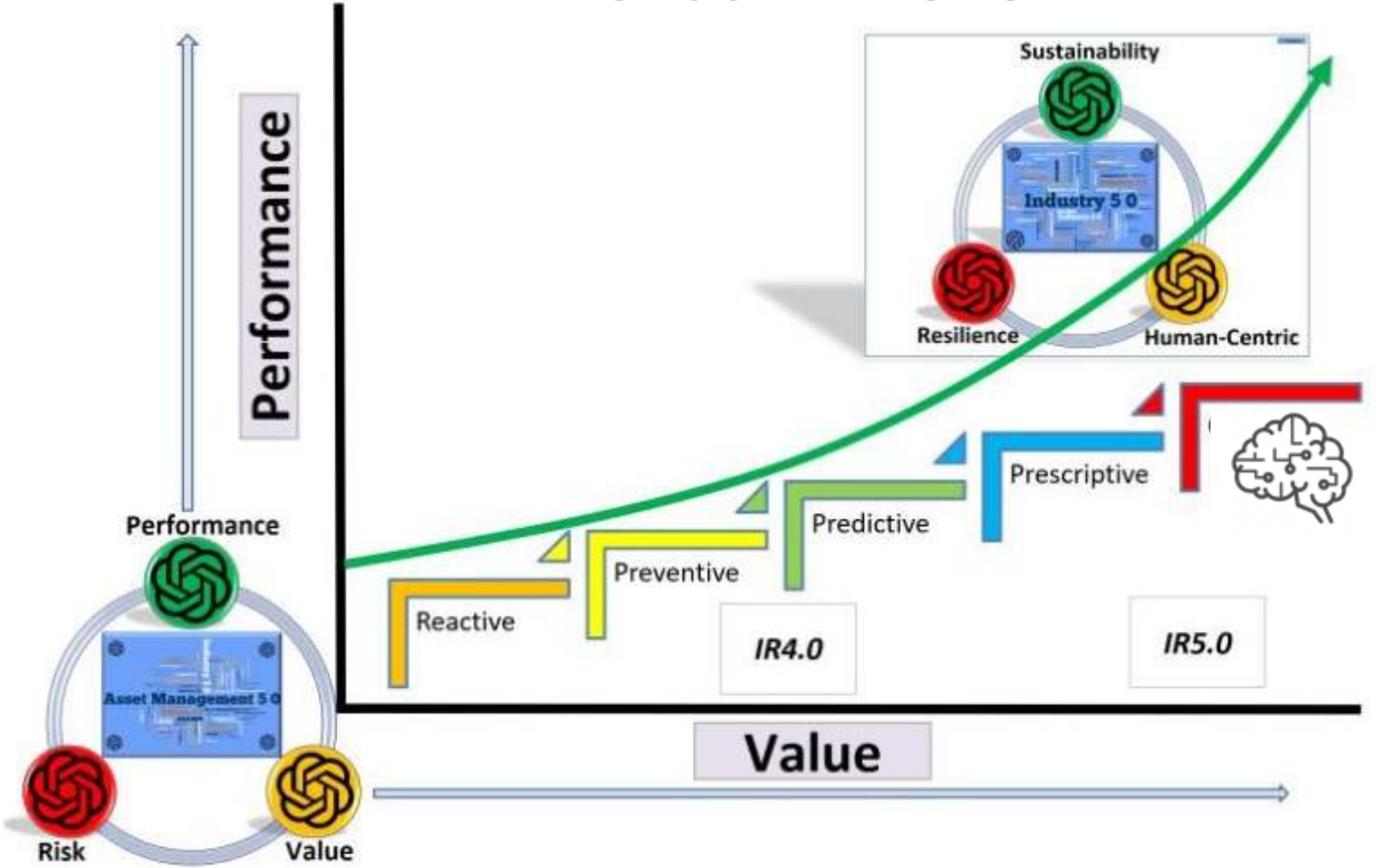
Industrial AI





Artificial Intelligence vs Machine Learning vs Data Analytics

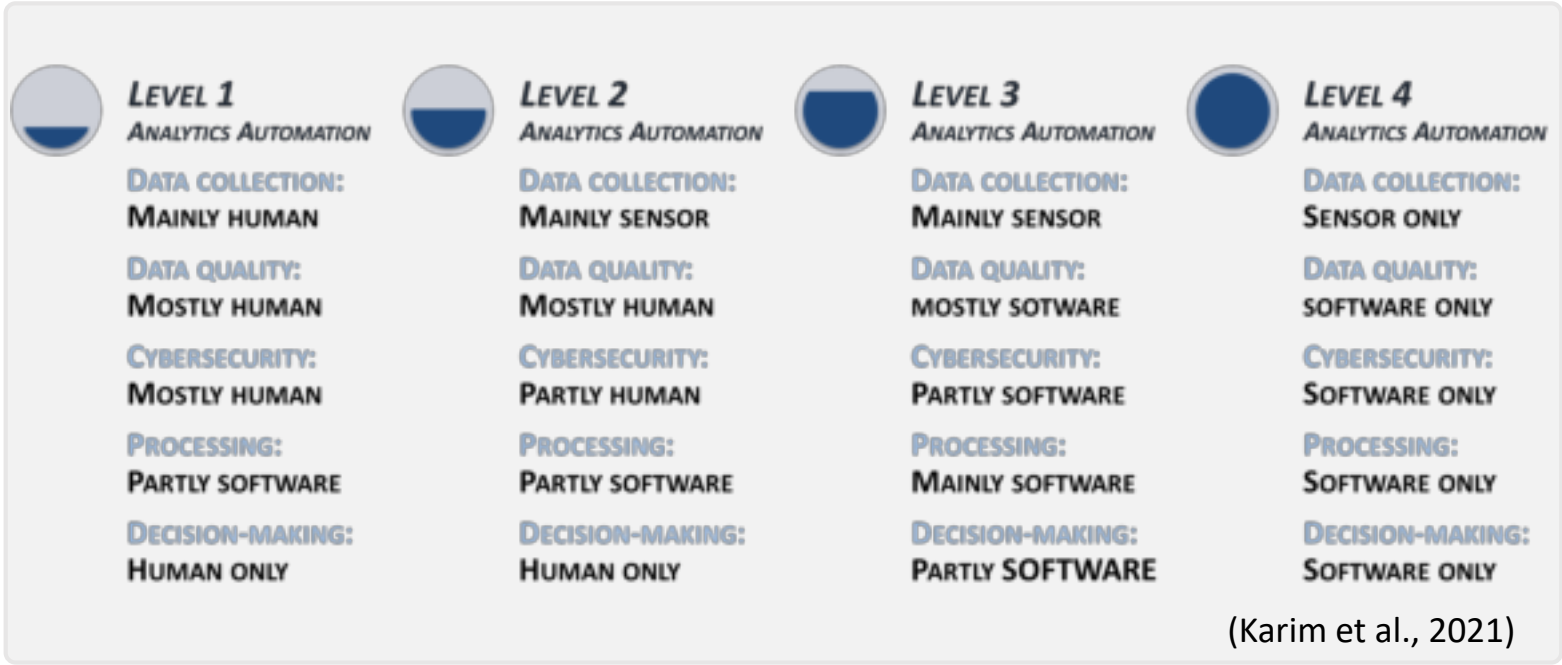
IR4.0 to IR 5.0


Performance
Sustainability
Industry 5 0
Resilience
Human-Centric
Prescriptive
Predictive
Preventive
Reactive
IR4.0
IR5.0
Value
Performance
Asset Management 5 0
Risk
Value

AI & Automation

- **Automation** can be defined as the technology by which a process or procedure is performed without human assistance

- **Autonomy** refers to a state of equipment in which it can perform the programmed operations under defined conditions without human input or guidance



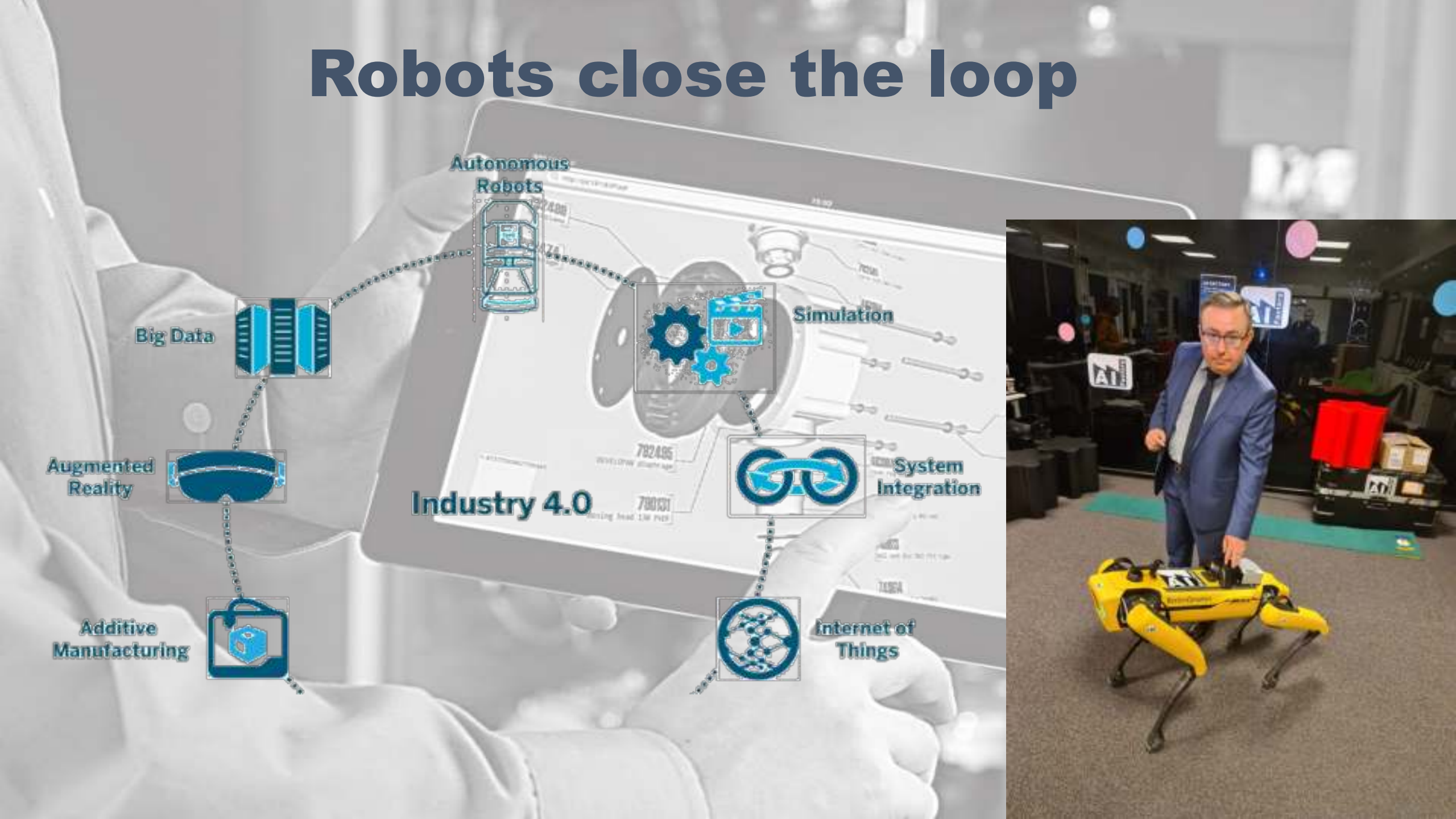
(Karim et al., 2021)

AI: Digital Governance

- eGovernance
  - The three rules (Isaac Asimov, professor and writer, 1920-1992)
    1. A robot may not **injure a human being** or, through inaction, allow a human being to come to harm.
    2. A robot must **obey the orders given it by human** beings except where such orders would **conflict** with the **First** Law.
    3. A robot must **protect its own existence** as long as such protection does not **conflict** with the **First** or **Second** Laws.

AI - multi-dimensionality

Robots close the loop



Cobots who mimic humans

Cobots with 2 arms?

Robot grippers to mimic humans

ADAPTIVE ROBOT GRIPPERS

2-FINGER 85

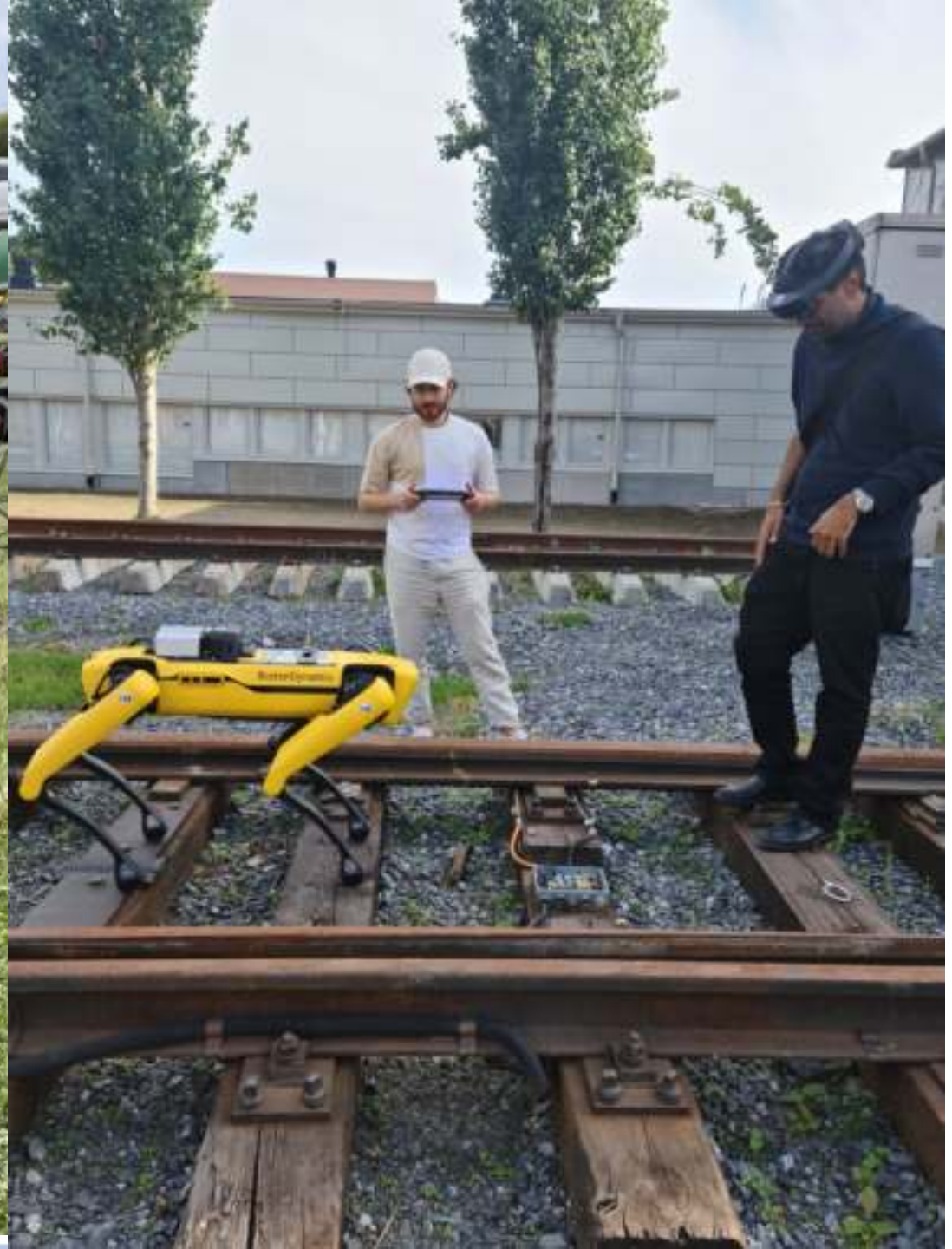
With a stroke of 85 mm and a payload of 5 kg, this programmable gripper can handle all your parts. Compatible with all major industrial robots. Easy Integration Packages are available on robots such as Universal Robots, ABB, Yaskawa and Fanuc.

3-FINGER

Get maximum flexibility for robotic R&D. This robot hand is compatible with all major industrial robots. Easy integration packages are also available for industrial robots like: Universal Robots, ABB and Yaskawa. A ROS stack is also available.

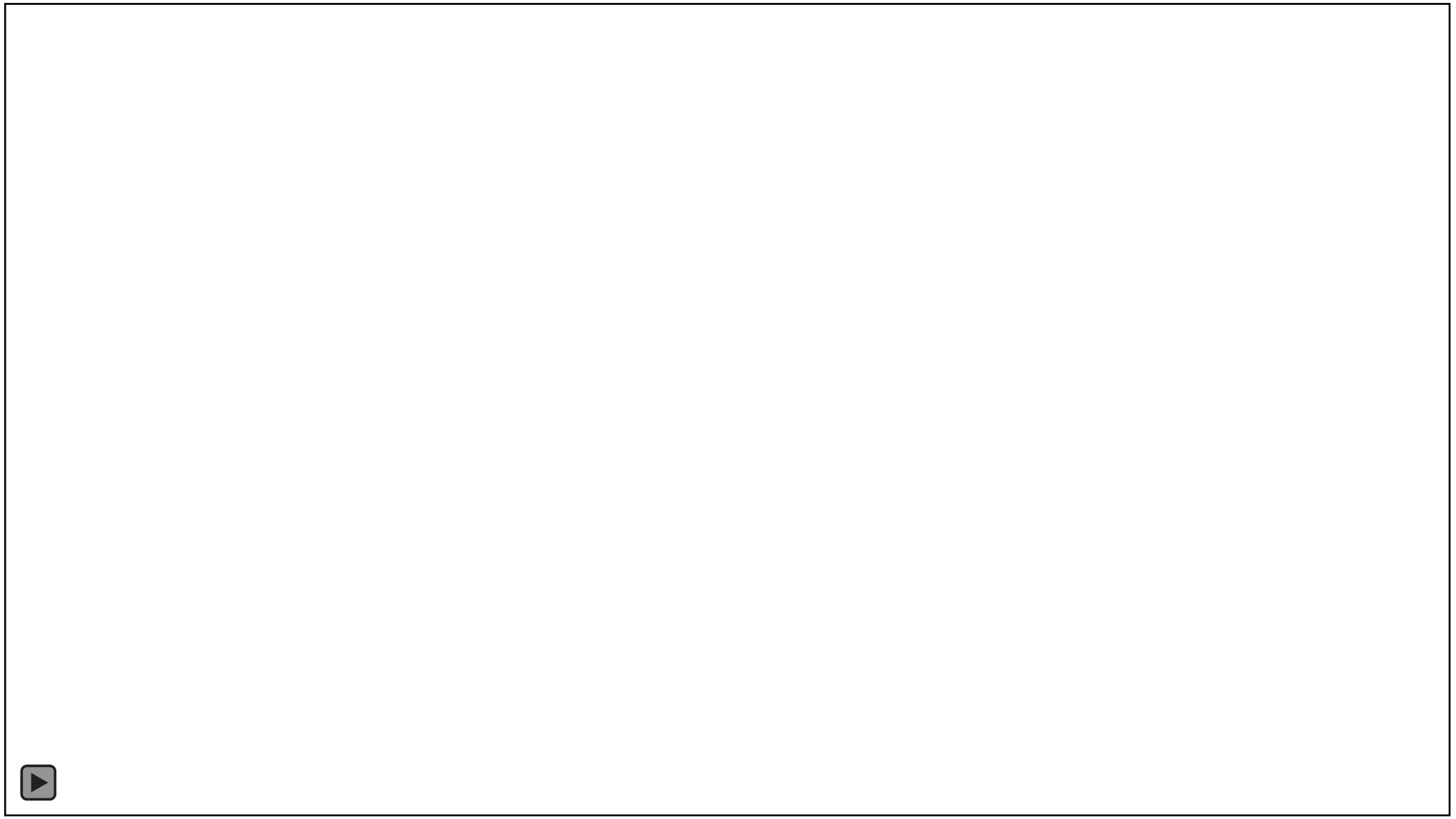
2-FINGER 140

With a stroke of 140 mm, this programmable gripper can handle all your parts. Compatible with all major industrial robots. Easy Integration Packages are available on robots such as Universal Robots, ABB, Yaskawa and Fanuc.



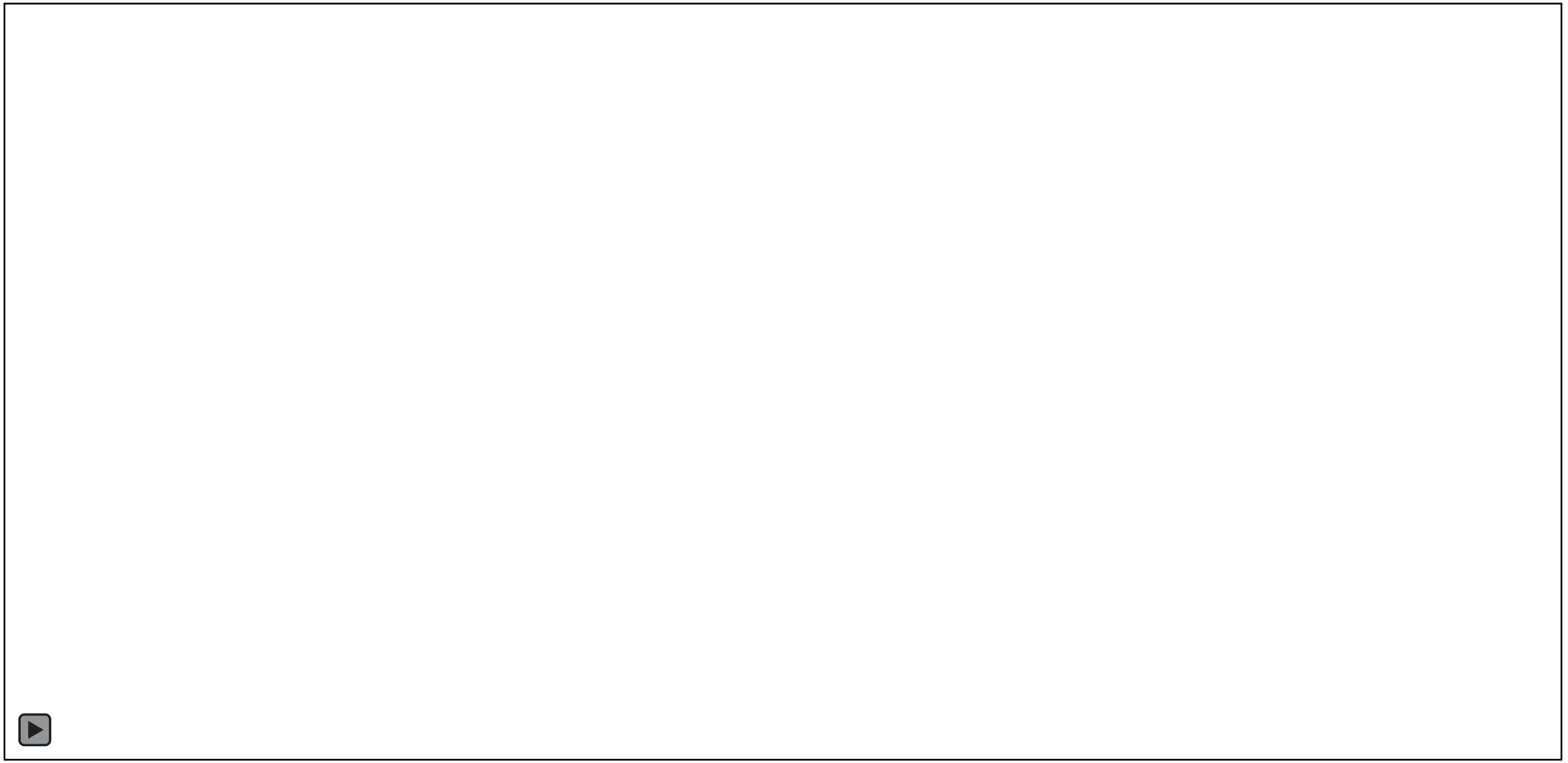
Robots in railway

Robots in aircraft inspection

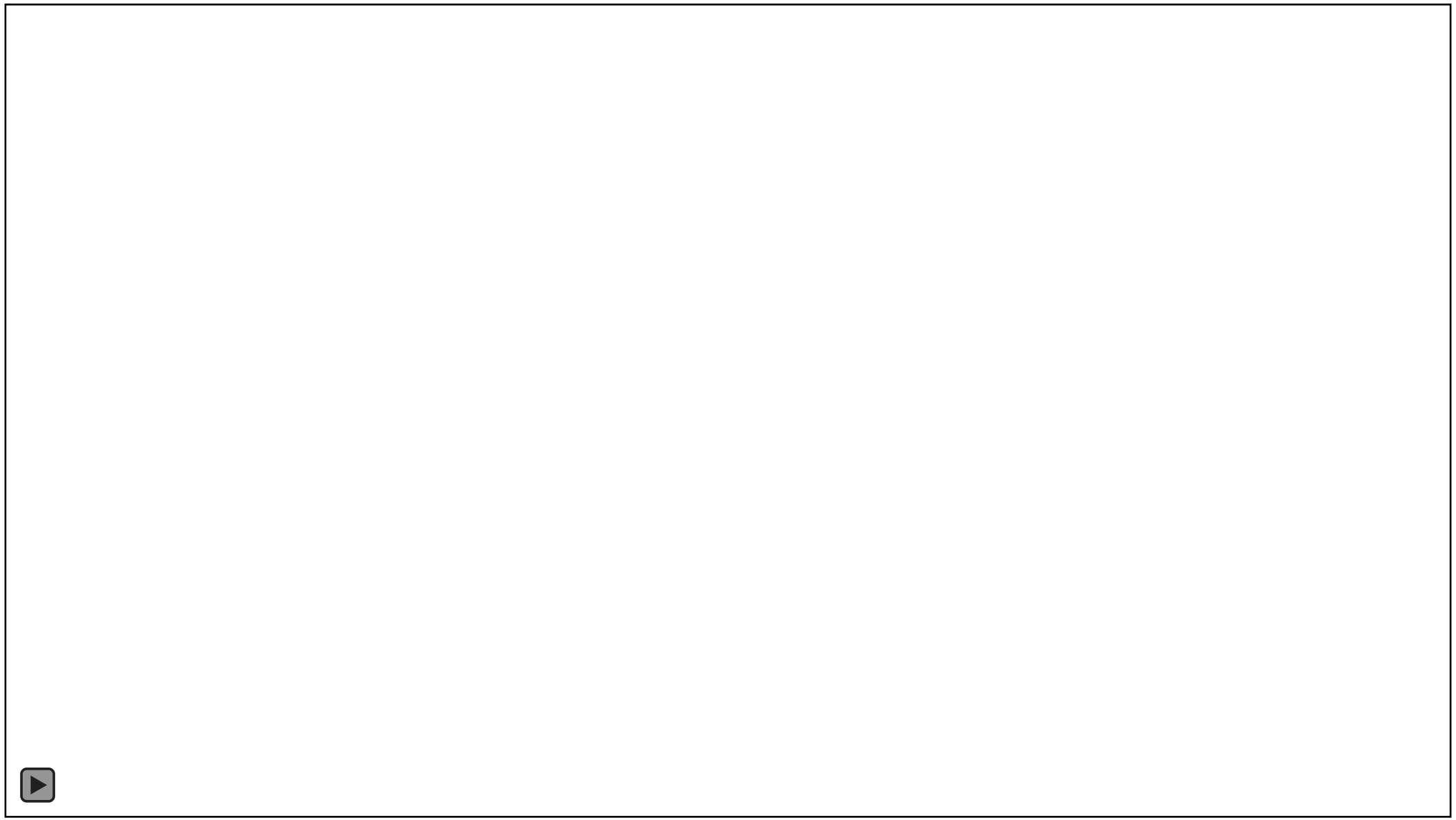


Robots in mining

Robots in mining



Oil & Gas



Social networks of robots


RESILIENCE

Resilience refers to the need to develop a higher degree of robustness in industrial production, arming it better against disruptions and making sure it can provide and support critical infrastructure in times of crisis. Geopolitical shifts and natural crises, such as the Covid-19 pandemic, highlight the fragility of our current approach to globalised production. It should be balanced by developing sufficiently resilient strategic value chains, adaptable production capacity and flexible business processes, especially where value chains serve basic human needs, such as healthcare or security.

As indicated earlier, our concept of Industry 5.0 is an open and evolving concept, providing a basis for further development of a collaborative and co-creative vision of the European industry of the future. Nonetheless, we believe the core of Industry 5.0 can be defined as follows:

Common links between reliability and resilience

- Reliability encompasses the rate of occurrence of events, the management as well as the recovery.
- Resilience appears to be more focused on adopting to the event as well as the recovery process. The rate of occurrence is not part of resilience.
- Most views recognize the interlink of reliability and resilience although some would like to believe these are disjoint.

Relationship between reliability and resilience

- There are three phases in both reliability and resilience
- Before event : Build resilience or strengthen the system
- During event : Manage events
- After event : Restoration to normal

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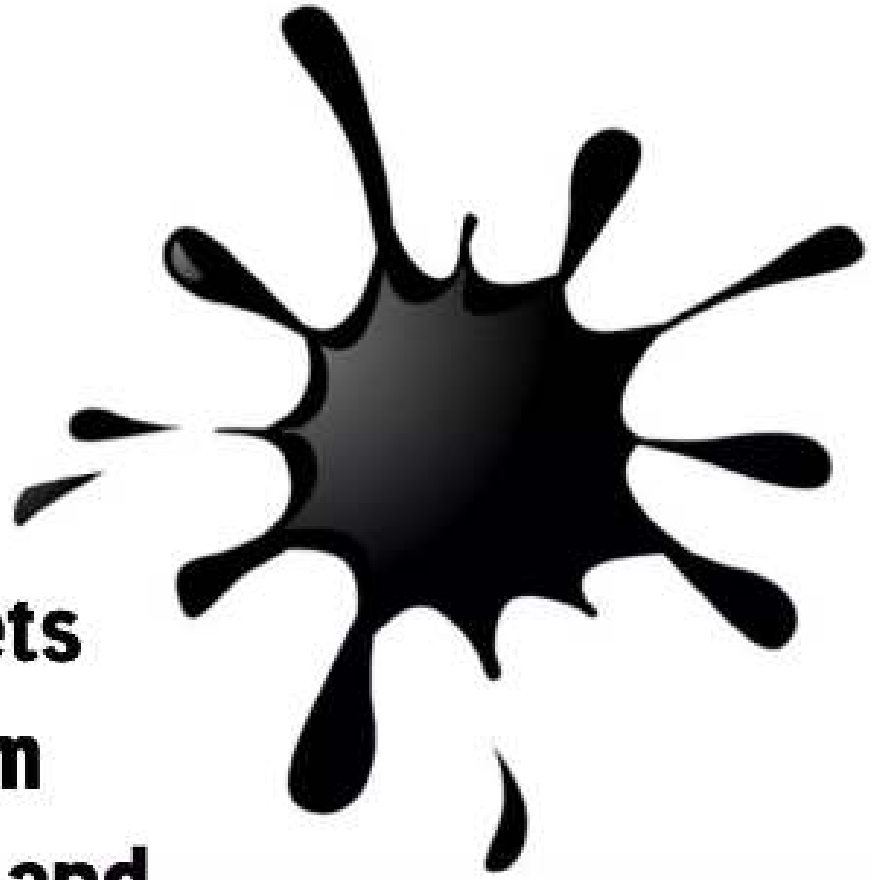
What's the **opposite** of fragile?

Mosaic war vs Platforms


MOSAIC WAR
Resilience as a networked system
Bakup

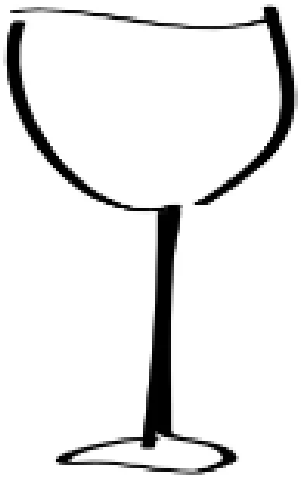
Robust?

Wrong!

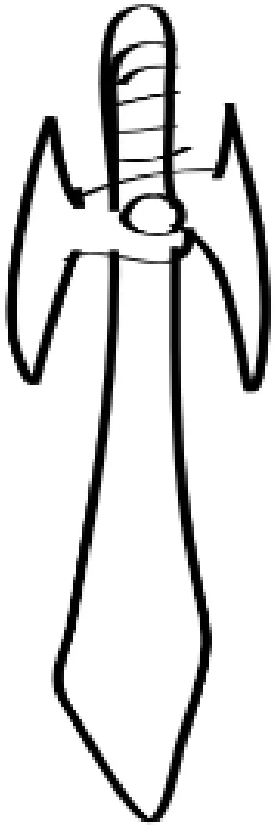


Antifragile gets benefits from random events and gain from disorder

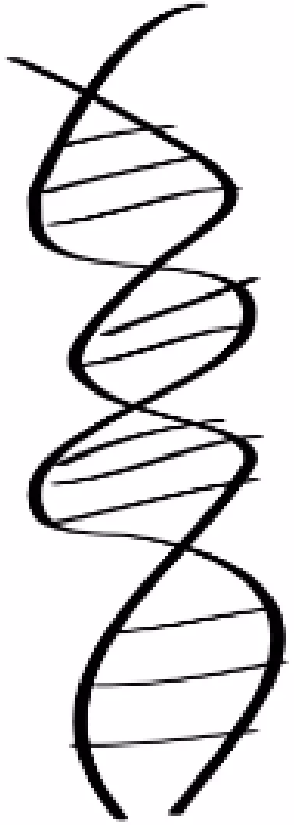
Fragile



Robust



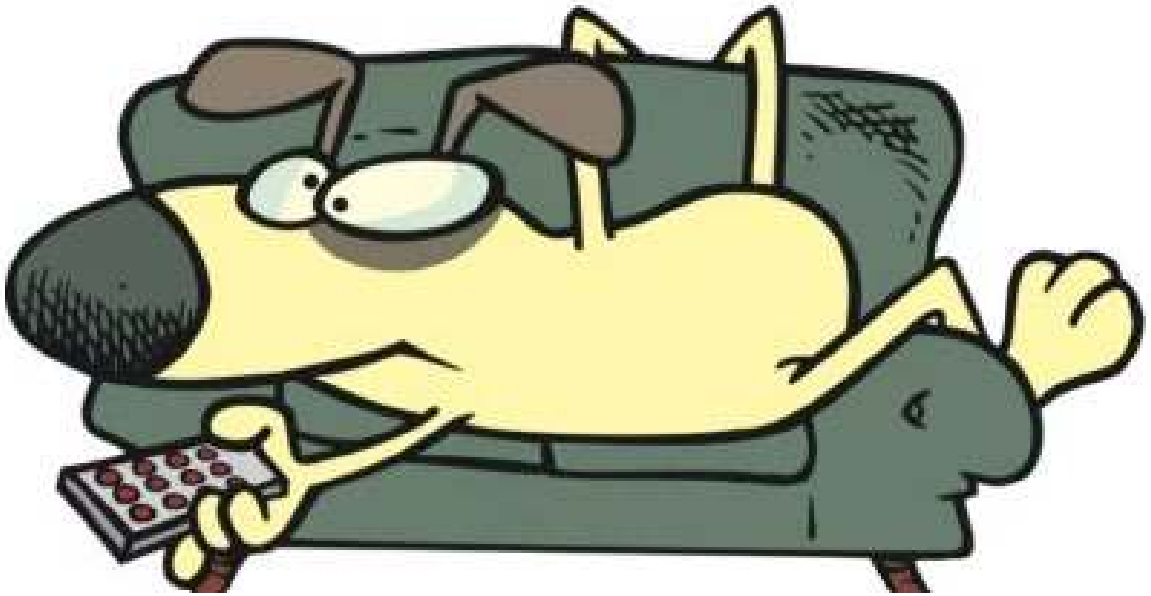
Anti-Fragile



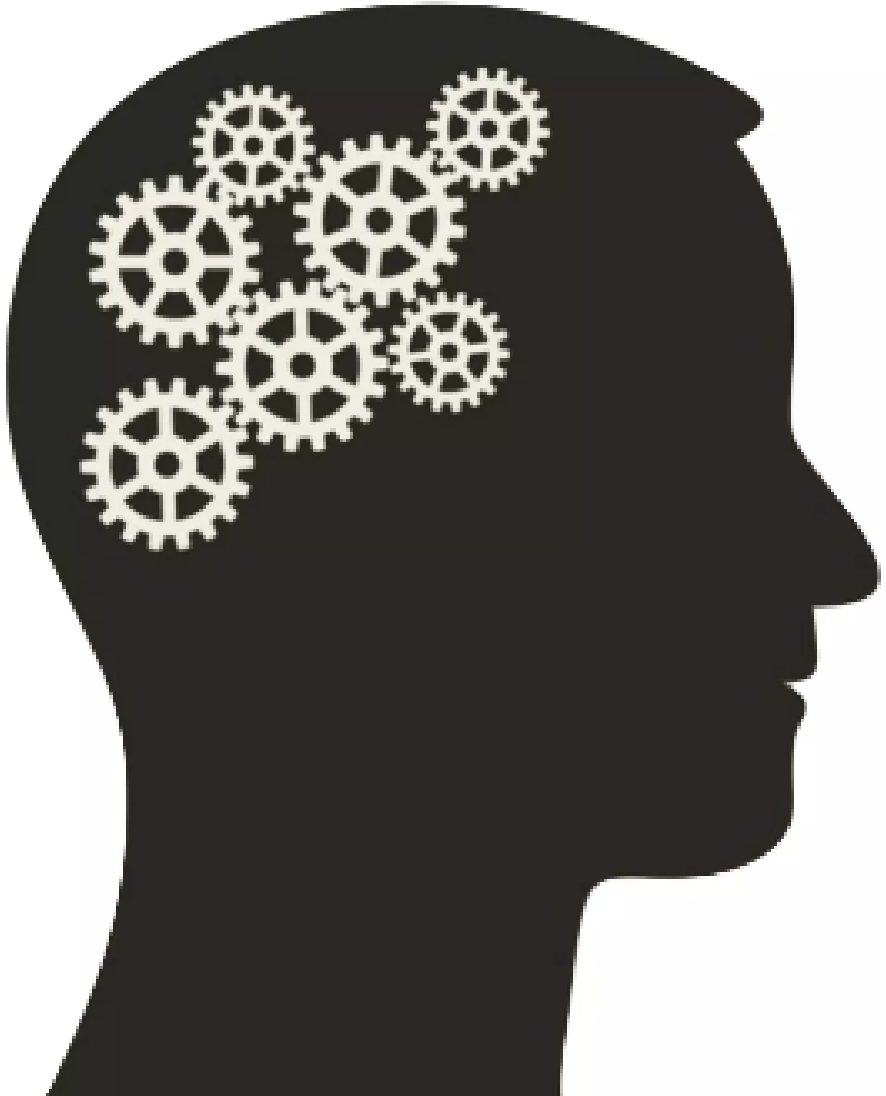
Mithridatization

An organism can gain a tolerance to a poison by way of being exposed to the poison in small doses

Not only do bodies get stronger when they are met with periodic stress, but, conversely, the lack of this periodic stress tends to lead to **degeneration** and **atrophy**.



The single most significant way that we fragilize the body, is by stepping in with medical intervention far more often, and far sooner than is truly necessary or beneficial



Antifragile systems are necessarily complex, and a certain amount of randomness is a natural (and necessary) part of complex systems.

@EUScienceInnov #Industry5.0 #ResearchImpactEU

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