AI FOR MANUFACTURING

Chaired by:

Maurizio Gattiglio
CEO, Partner and Co-Founder of ARCA, Chairman of Manufuture

Antonio Emilio Calegari
CEO at Artificialy

Marta Candeias
Head of Research Funding Support Unit at IST-ID

Andreas Graichen
Group Manager Digitalization of AM at Siemens Energy

Daniel Engel
Data Scientist at BASF SE

Sotiris Makris
Senior Research Scientist at Laboratory for Manufacturing Systems and Automation, University of Patras

Ind Tech 2022

Industry 4.1

Antonio Calegari
Artificialy SA
June 29,

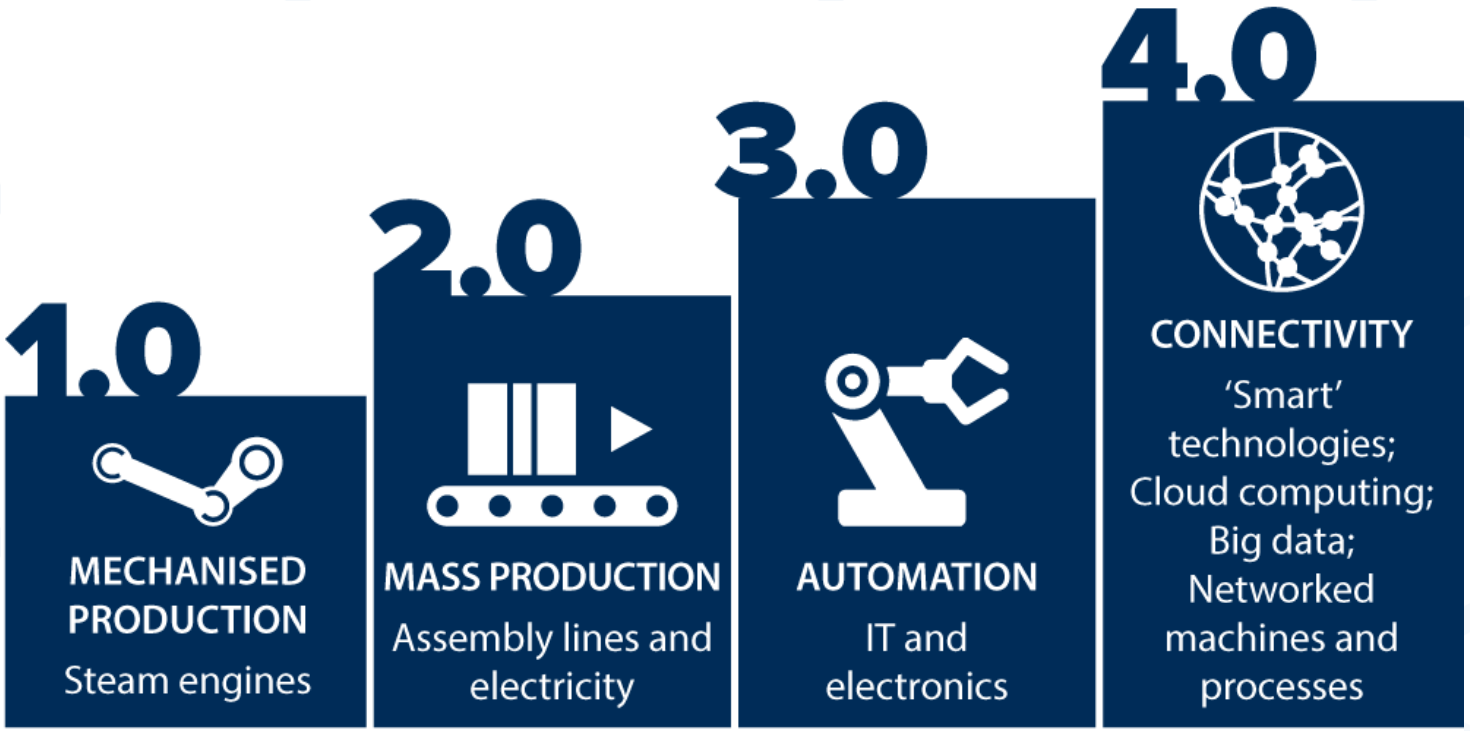
Who are we?

ARTIFICIALY

Centre of excellence
delivering
custom AI solutions

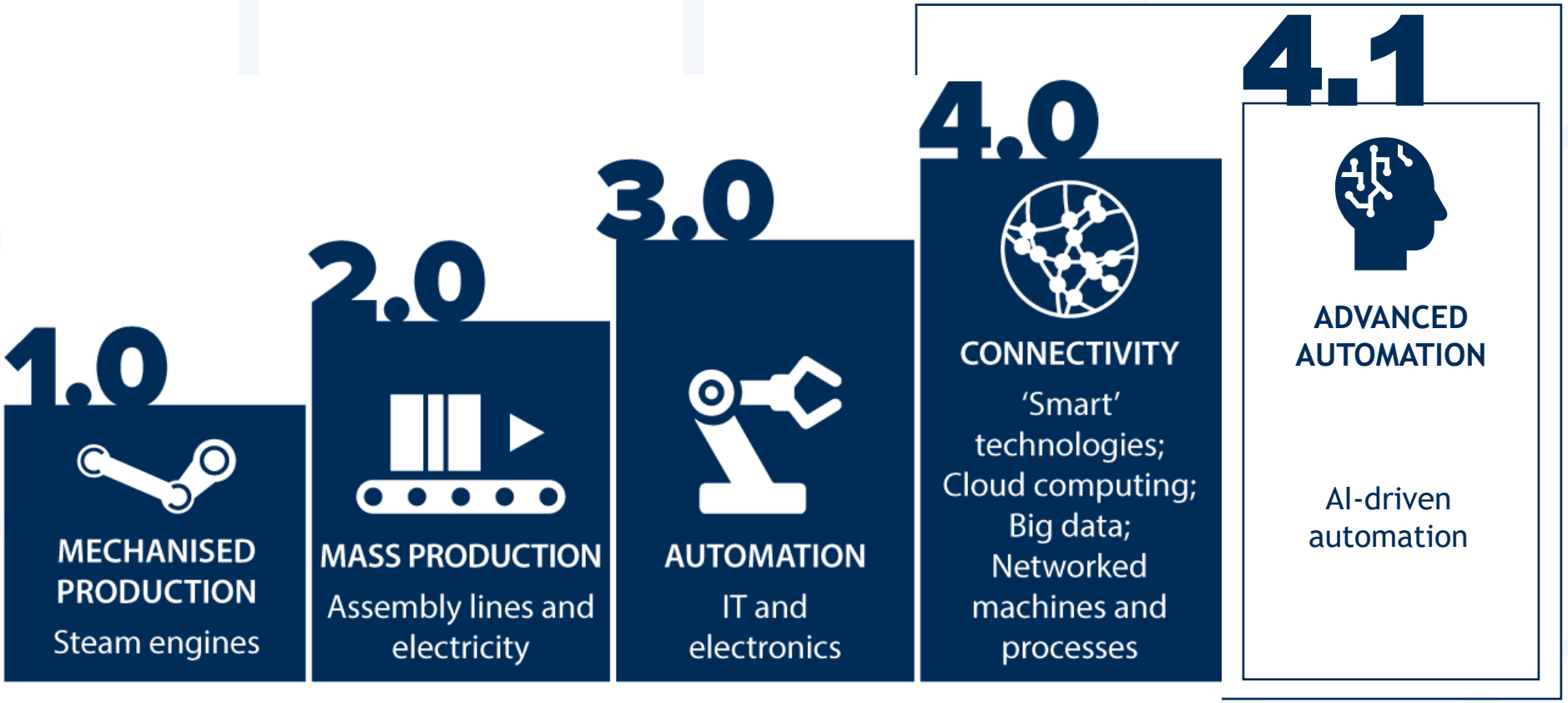
www.artificialy.com

A short history of manufacturing



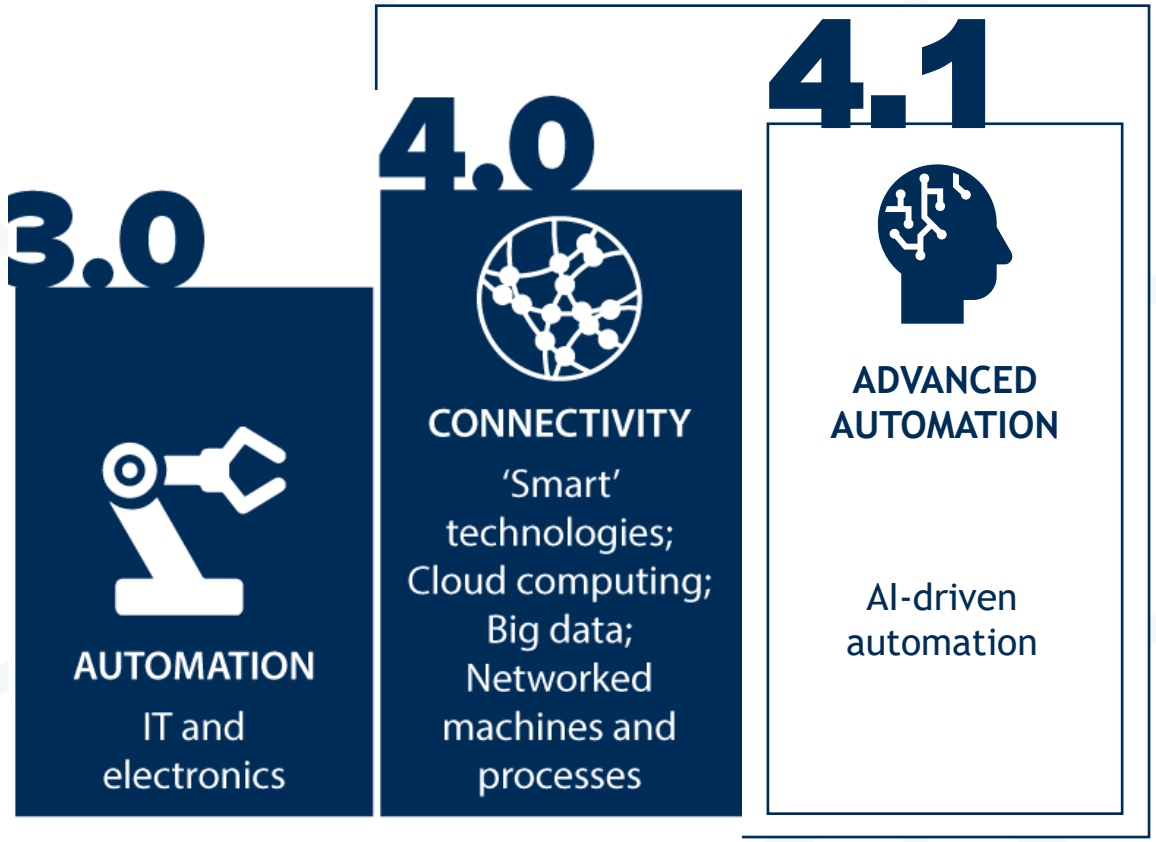
The stages of industrial development
Source: Oxford Analytica

A history of manufacturing



The stages of industrial development
Source: Oxford Analytica

A short history of manufacturing



- AI is bringing automation to a next level
- Sometimes even leap-frogging established Ind 4.0
- Industrial AI is now!

AI manufacturing use cases

	INDUSTRY	USE CASE	GOAL
Bystronic	Laser cutting	Machine-assisted human interface	Reduce machine **idle-time** Guide and simplify **operators'** activities
MIKRON	Hi-performance transfer machining	Predictive maintenance	Reduce maintenance **down-time** Reduce **waste**
GALVOLUX	Production of architectural products	Automated quality control	Reduce **defect** rate

Human-machine interface

Human-machine interface

THE PROBLEM

VARIABILITY. Metal characteristics vary enormously from job to job: metal type, quality, thickness, geometry level of details, …

MULTI-PARAMETER. Each variation of material and geometry requires the tuning of several inter-twined parameters (power, speed, gas pressure, …)

LENGTHY. Finding the optimal combination of parameters is a trial&error **lengthy procedure** (DoE), often performed only by **experienced staff**

long machine idle-time

and **suboptimal configurations**

Human-machine interface

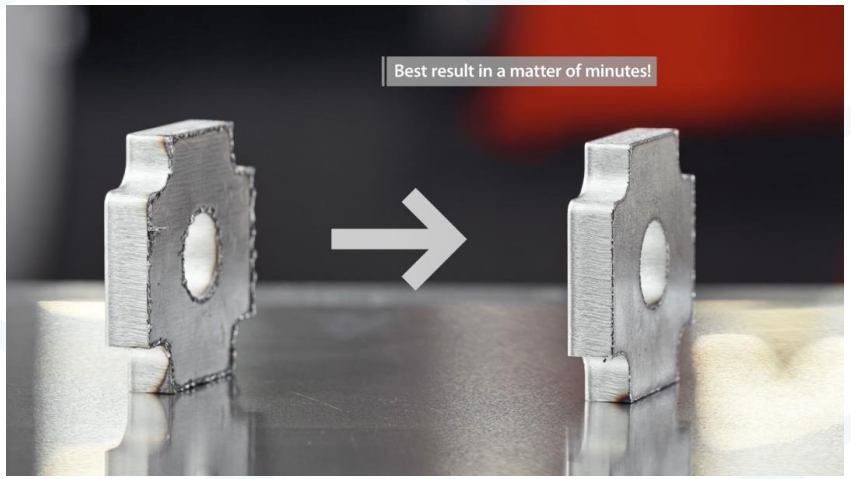
THE SOLUTION

AI-based calibration system (Bayesian optimization) that **auto-sets parameters** based on operators **qualitative** or quantitative feedback.

Human-machine interface

THE RESULTS

Up to **80% reduction in machine calibration time** + independence from **skilled resources,** with up to **20% increase in machine ROI.**



Live free demo at:
https://optimizer.artificialy.com

AI manufacturing use cases

	INDUSTRY	USE CASE	GOAL
Bystronic	Laser cutting	Machine-assisted human interface	Reduce machine **idle-time** Guide and simplify **operators'** activities
MIKRON	Hi-performance transfer machining	Predictive maintenance	Reduce maintenance **down-time** Reduce **waste**

Predictive Maintenance

THE PROBLEM

MULTIPLE TOOLS. Transfer machines feature multiple machining tools **working in sequence**

UNEVEN LIFETIME. Each tool wears differently and has a **different life-time,** causing multiple machine stops

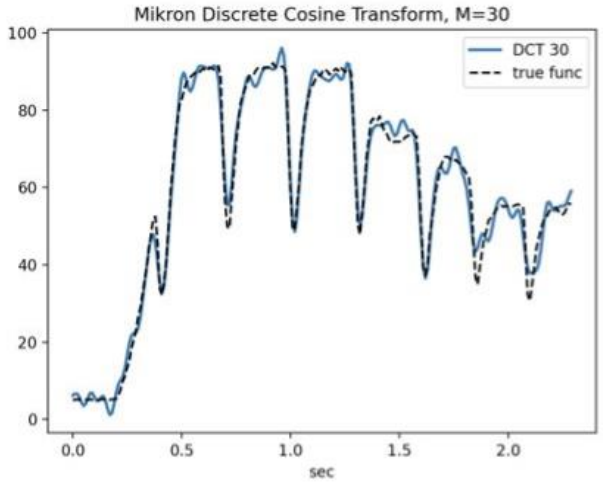
UNPREDICTABILITY. Tools wears differently depending on **piece characteristics** (and unknown intrinsic material quality)

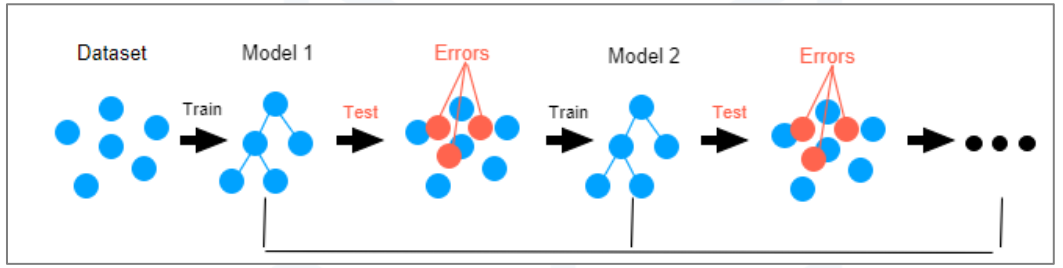
long machine idle-time

and **waste**

Predictive maintenance

THE SOLUTION **AI-based** allows for an **accurate** estimation of real **residual life-time** of each tool by monitoring easily available signals such as current absorption





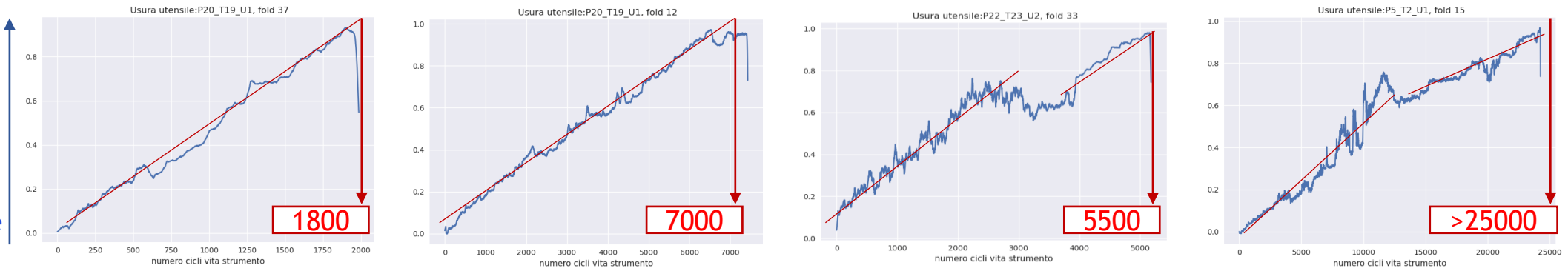
Predictive maintenance

THE RESULT

Up to **7% reduction in idle time** thanks to **planned tool replacement**

Estimated real wear

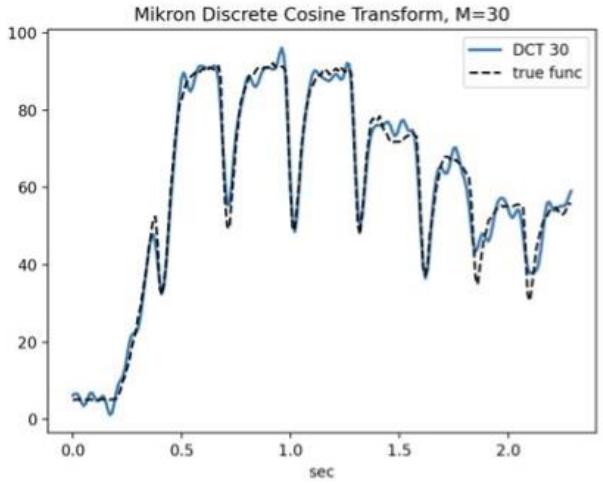
(% of total lifetime cycles)

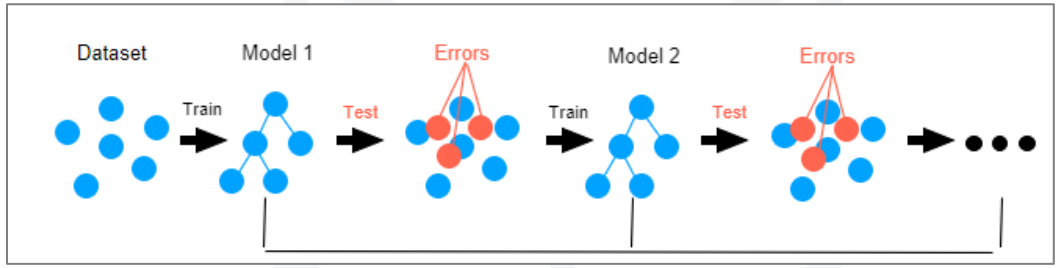


# of counted cycles

Predictive maintenance

THE SOLUTION **AI-based** allows for an **accurate** estimation of real **residual life-time** of each tool by monitoring easily available signals such as current absorption





Human-machine interface

	INDUSTRY	USE CASE	GOAL
Bystronic	Laser cutting	Machine-assisted human interface	Reduce machine **idle-time** Guide and simplify **operators'** activities
MIKRON	Hi-performance transfer machining	Predictive maintenance	Reduce maintenance **down-time** Reduce **waste**
GALVOLUX	Production of architectural products	Automated quality control	Reduce **defect** rate

Quality Control

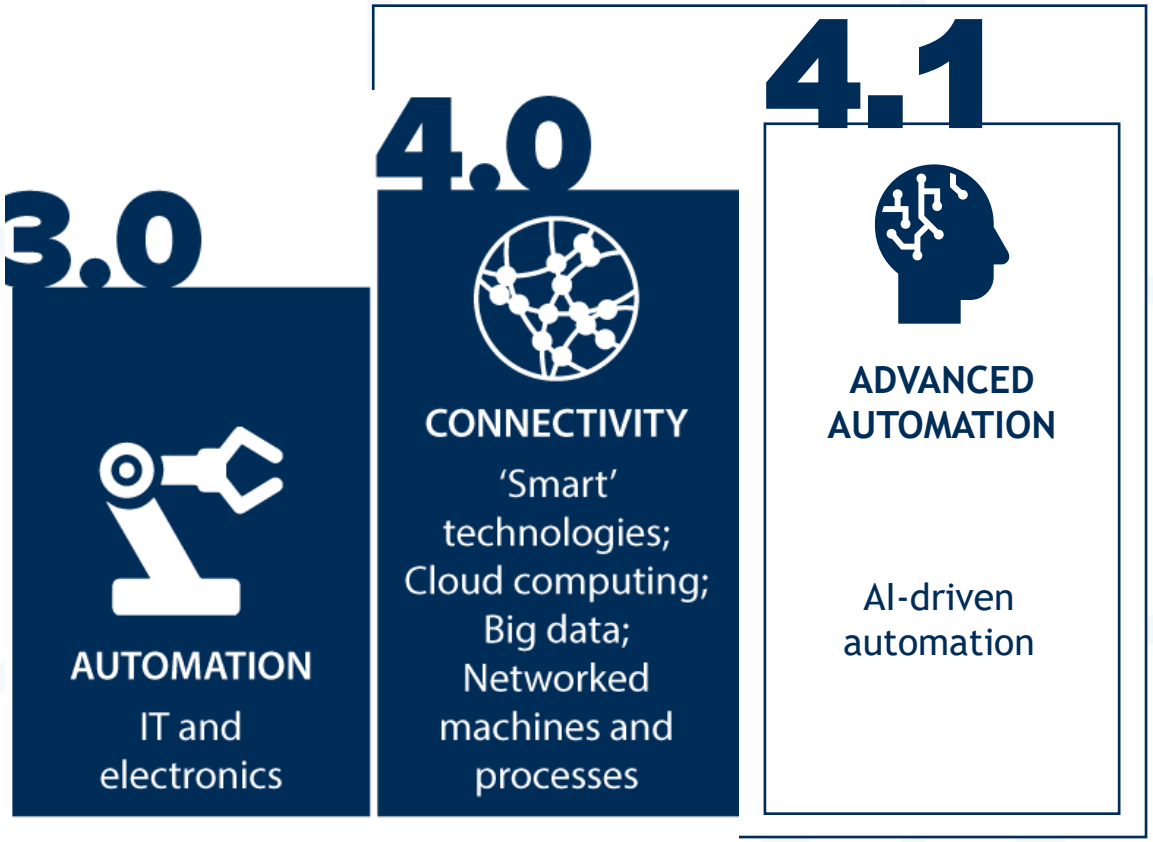
GALVOLUX

Glass and mirror technology

Quality Control

THE SOLUTION **Assembly line** quality is controlled by an AI module interpreting **cheap camera** images

A short history of manufacturing



- AI is bringing automation to a next level
- Sometimes even leap-frogging established Ind 4.0
- Industrial AI is now!

Thank you very much!

Ind Tech 2022

IST-ID
Associação do Instituto Superior Técnico para a Investigação e Desenvolvimento

Implications of Artificial Intelligence - examples from the Portuguese automotive sector

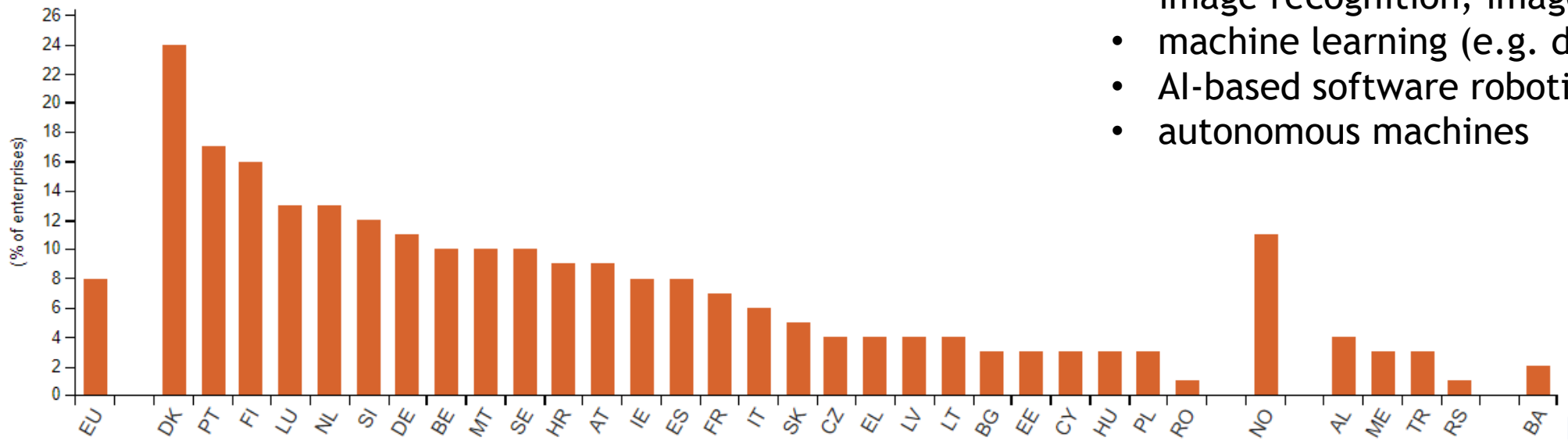
Marta Candeias
Instituto Superior Técnico's Association for R&D
28/06/2022, Grenoble

8% of EU enterprises used AI in 2021

In 2021, 8% of enterprises in the EU used at least one of the following AI technologies:

- text mining
- speech recognition
- natural language generation
- image recognition, image processing
- machine learning (e.g. deep learning)
- AI-based software robotic process automation
- autonomous machines

Enterprises using AI technologies, 2021



Note: North Macedonia: data confidential

Source: Eurostat (online data code: isoc_eb_ai)

eurostat

7% of Manufacturing enterprises used AI technologies in 2021

Enterprises using AI technologies by economic activity, EU, 2021
(% of enterprises)

Source: Eurostat (online data code: isoc_eb_ai)

eurostat

Use and Purpose of Use of AI technologies in Manufacturing

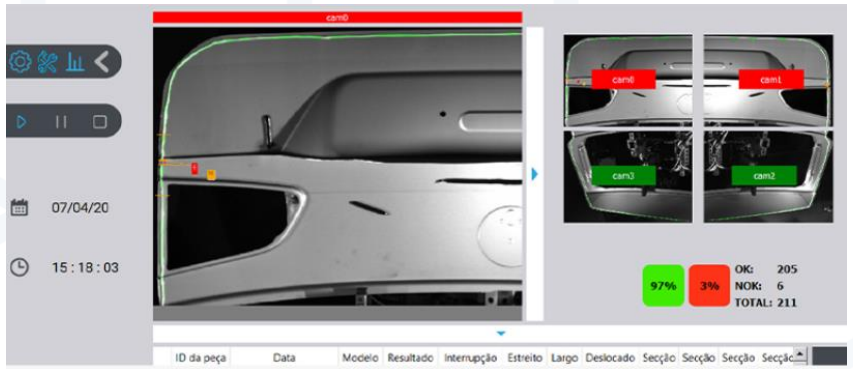
Enterprises using AI technologies by type of AI technology and economic activity, EU, 2021 (% of enterprises)

Use of AI technologies	Manufacturing (%)
Text mining	2
Speech recognition	1
Natural Languange generation	1
Image recognition/image processing	2
ML for data analysis	2
AI-based software robotic process automation	3
Autonomous machines	2

Enterprises using AI software and systems by type of purpose and economic activity, EU, 2021 (% of enterprises using at least one AI technology)

Purpose of Use	Manufacturing (%)
Marketing/Sales	14
Production Process	39
Organization of business administration process	17
Management of Enterprises	13
Logistics	13
ICT security	24
Human resources management and recruiting	5

Example - Automated glue bead inspection systems at rear gates in an OEM in Portugal

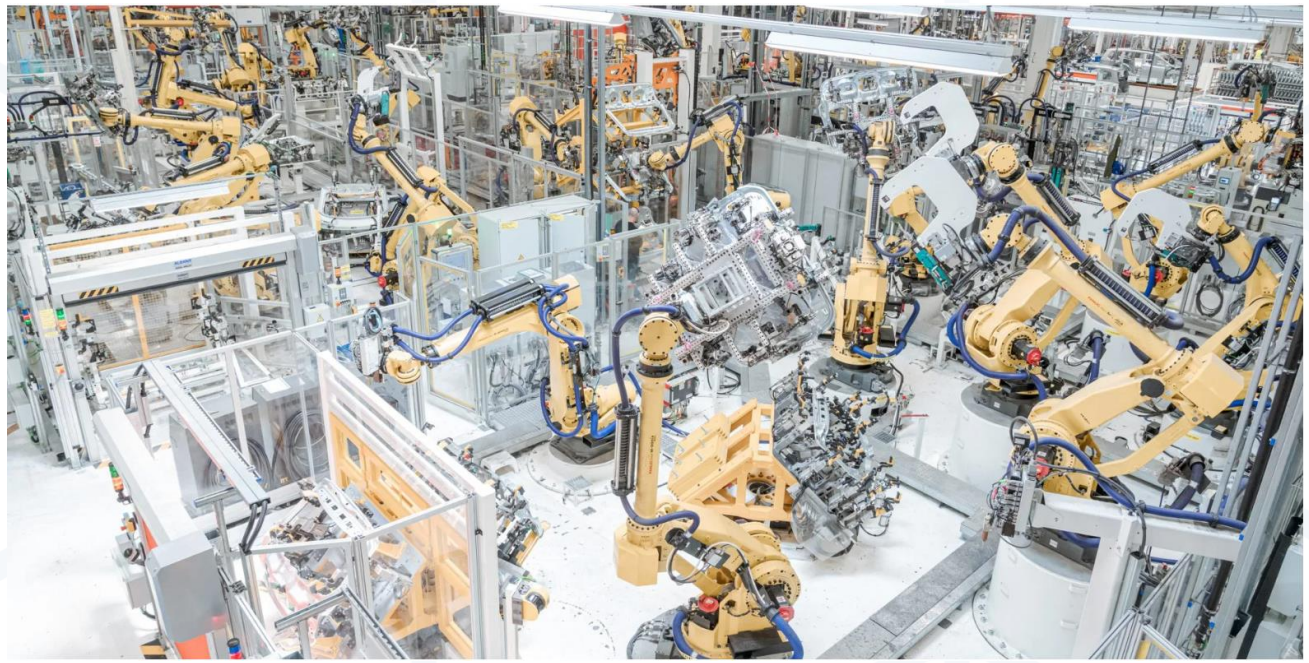


- computational vision and predictive analysis
- Increased efficiency and productivity
- Reduction of waste
- Reduction of process time

Boavida, Nuno and Candeias, Marta, “Recent Automation Trends in Portugal: Implications on Industrial Productivity and Employment in Automotive Sector”; *Societies* **2021**, *11*(3), 101; https://doi.org/10.3390/soc11030101

Example – New technologies, processes and innovative systems in a production line of an OEM in Portugal

New mobile elements in the assembly line to assembly the rear gate to the bodywork with automatic screwing



Integration of new equipment into existing lines:
141 new robots
72 new pneumatic welding
16 new electric welding
80 grippers

Production capacity increase from 32 to 45 units per hour in the body work area.

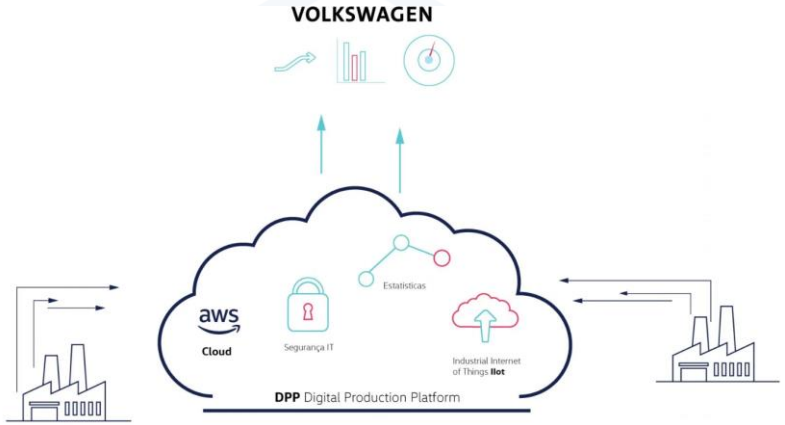
Example - Automation technologies in components and parts company for the automotive sector in Portugal

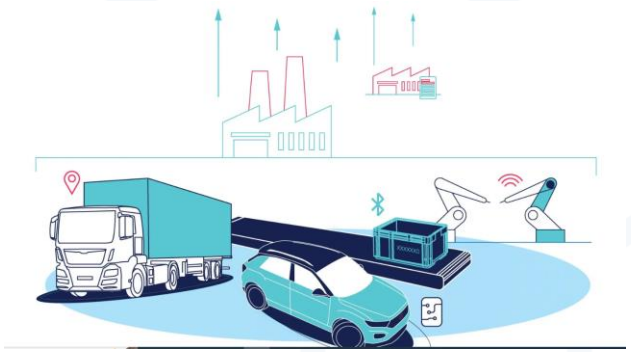
- Automation systems implemented only in high quality products
  - Automated quality inspection system of part,
  - Automatic rejection of the part,
  - Registration of the part in a database
  - Allows efficiency, traceability and parts' remanufacturing leading to an increase in productivity and reduction of costs.
- New process design, new equipment and robots programming
  - Increased the production line capacity
  - Increased production volume
  - Process design and robots programming done internally
- Welding Robot Cell
  - Automation systems lack flexibility
  - A worker can fix an unforeseen ocurrence

Moniz, A.B, Boavida, Nuno and Candeias, M., 2022 "Changes in productivity and labour relations: Artificial Intelligence in the automotive sector in Portugal" in International Journal of Automotive Technology and Management 22(2):1; DOI: 10.1504/IJATM.2022.10046022

Example - Industrial cloud pilot project on an OEM in Portugal

The industrial cloud is foreseen to increase productivity by 30% by 2025 with a strategy for a more agile production, using a combination of cloud computing, machinery equipped with sensors, big data and machine learning.





How?

- Digital platform with solutions focused on the production process with interfaces common to various operations: quality control, shop floor management, maintenance of equipment to energy efficiency management.
- All plants will converge on this platform.
- In the long run, it should also integrate its suppliers into the industrial cloud.

Why?

- Data used to develop and train learning models, based on AI
- Optimization of predictive maintenance and predictive quality control
- Efficiency of the supply chain and logistics operations
- Effective and real-time communication

Conclusions

- AI technologies improve **efficiency and productivity**
- Different AI technologies will have different rates of adoption
- Robotics, artificial vision, predictive analysis will have widespread adoption in one to two year; cloud, plug & produce, blockchain and artificial intelligence will take longer to be implemented as they involve connectivity, monitoring, data collection and automated decision making.
- Implementation of AI technologies is resulting in **changes in organization of work rather than in dismissal of workers.**
- AI **is not replacing workers but augmenting their capacity** to perform their tasks.
- AI adoption may be hindered by **lack of skills**, resistance of managers, costs, low level of modernization, jobs displacement and boosted by **lack of human resources**, competitiveness, quality and efficiency gains

Thank you!

Machine Learning Enters Additive Manufacturing at Siemens Energy in Sweden

“Not as simple as paper printing….yet!”

Siemens Energy is a trademark licensed by Siemens AG.

Unrestricted © Siemens Energy, 2021

Table of contents

1	Introduction & Background: Siemens Energy and Additive Manufacturing (AM)	xxx
2	After a ‘Hype of Inflated Expectations’, we fell into a pit…	xxxx
3	How we intend to use AM and Machine Learning	xx
4	Outlook into the Future & “…as simple as paper printing!”	x

Unrestricted © Siemens Energy, 2021

Disclaimer

Subject to changes and errors. The information given in this document only contains general descriptions and/or performance features which may not always specifically reflect those described, or which may undergo modification in the course of further development of the products. The requested performance features are binding only when they are expressly agreed upon in the concluded contract.

All product designations may be trademarks or product names of Siemens Energy Global GmbH & Co. KG or other companies whose use by third parties for their own purposes could violate the rights of the owners.

© Siemens Energy 2021
Main entity (global):
Siemens Energy Global GmbH & Co. KG
Otto-Hahn-Ring 6
81739 München
Germany

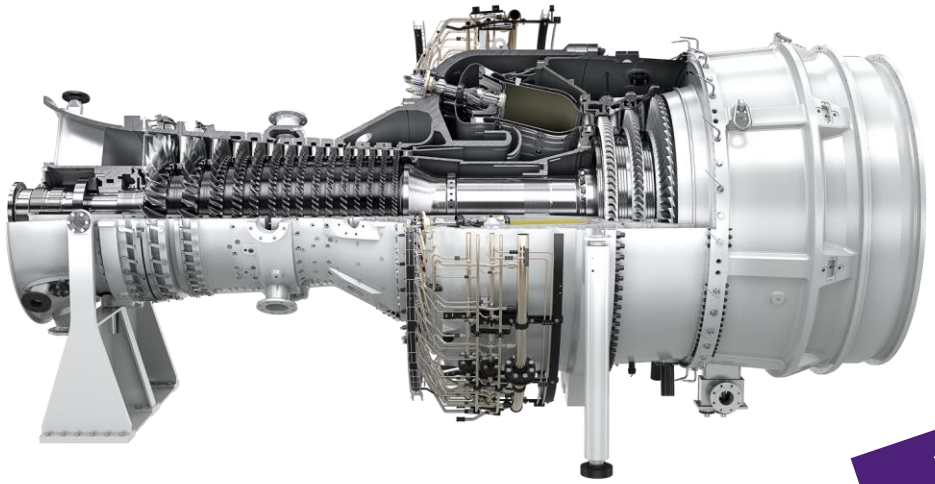
Unrestricted © Siemens Energy, 2022

Gas Turbines are similar to aero-engines, but meant to last longer between service intervals

High Temperatures

Extreme Forces

Complicated Atmosphere



Critical for Society and Grid Stability

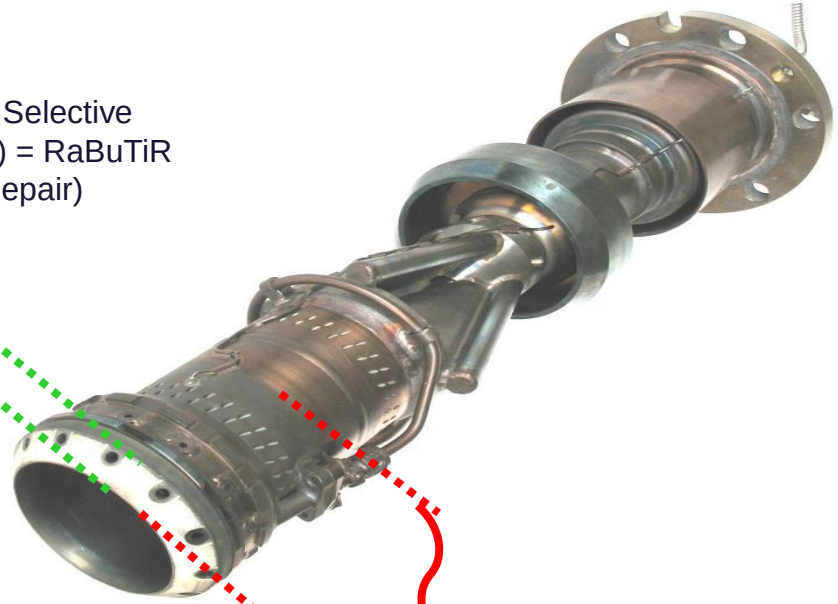
Push for Efficiency Drives New Materials

Decarbonization requires Additive Manufacturing for Better Mixing, Cooling etc.

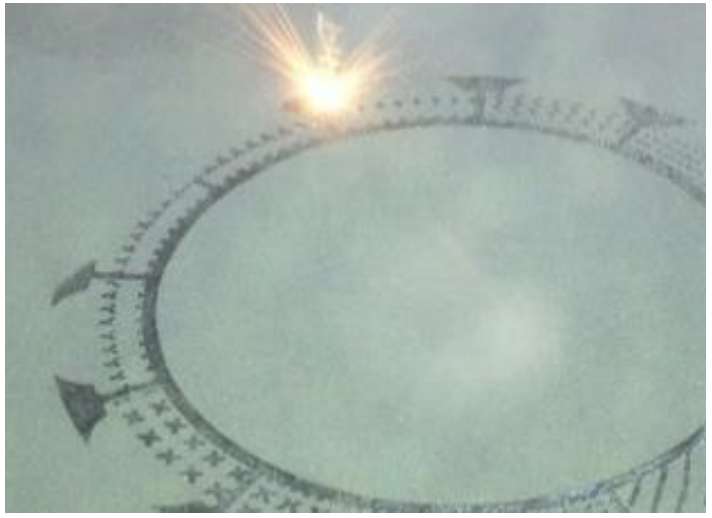
Unrestricted © Siemens Energy, 2022

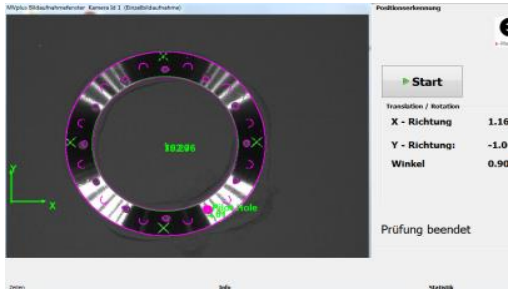
Additive Manufacturing lends itself for Machine Learning, because it is already per definition ’predominantly digital’

Repair Volume with Selective Laser Melting (SLM) = RaBuTiR (Rapid Burner Tip Repair)



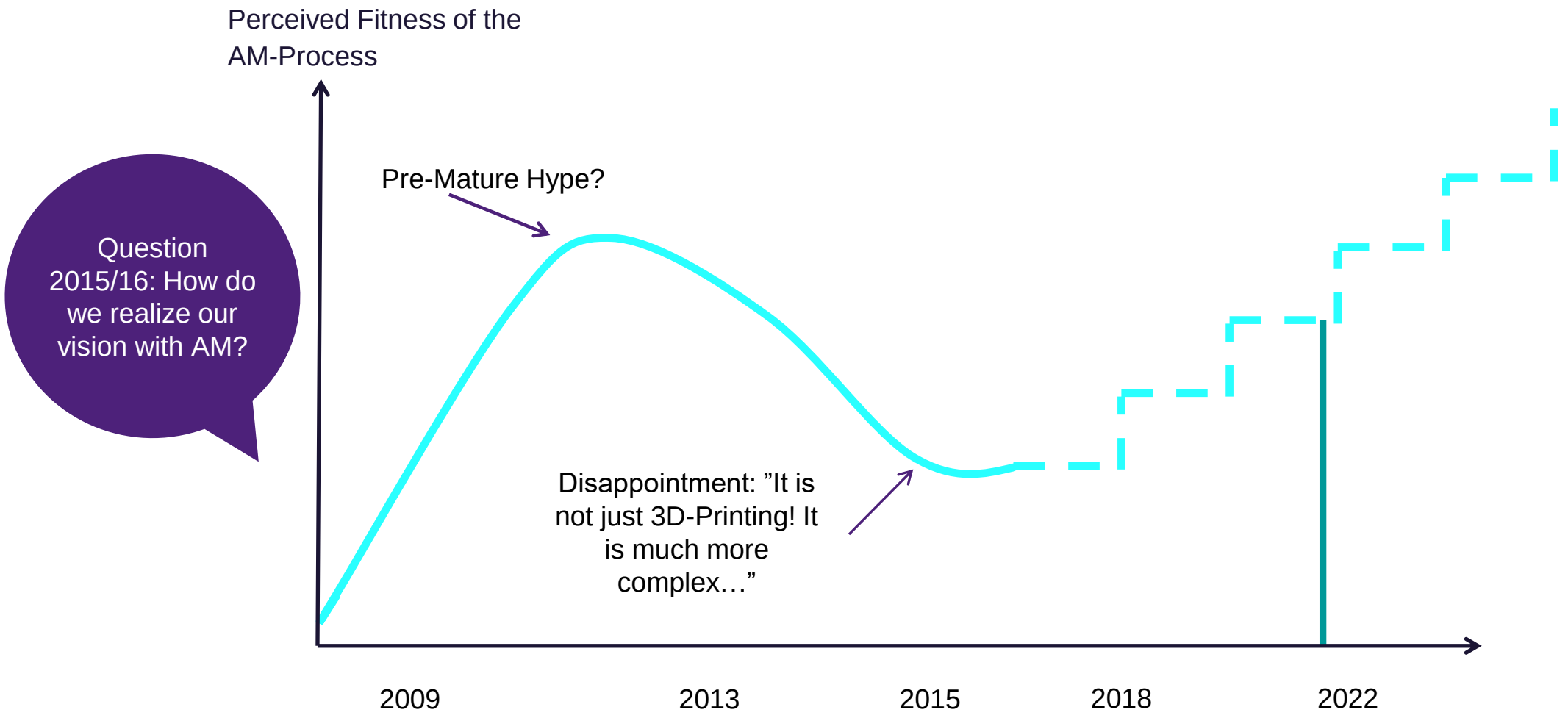
Traditional Repair through Replacement and TIG-welding





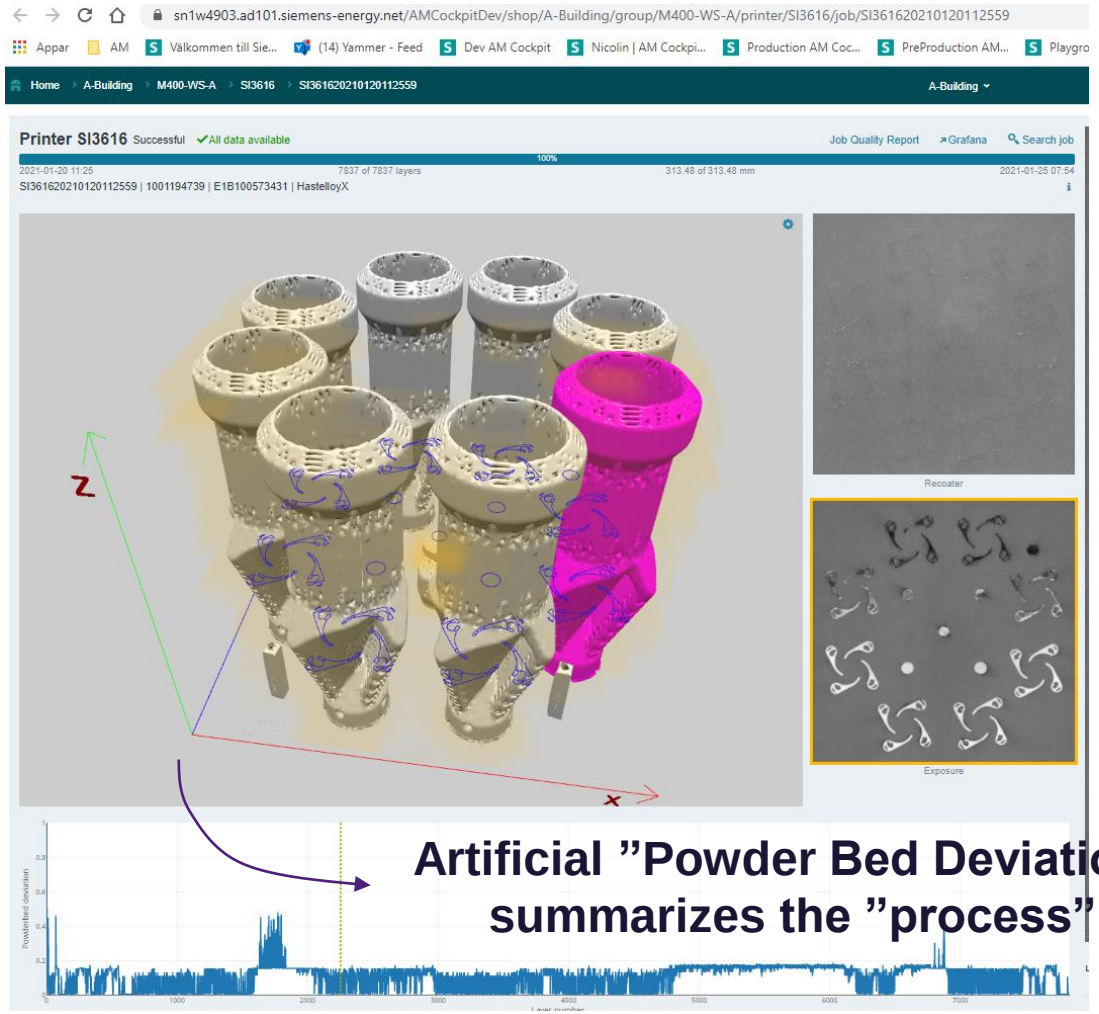
Unrestricted © Siemens Energy, 2022

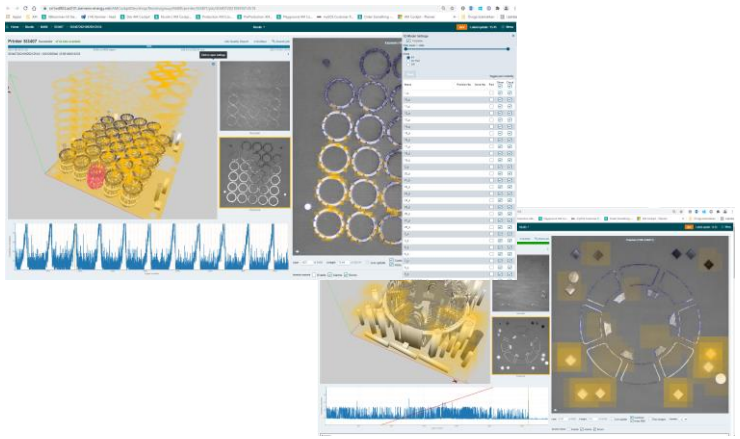
The Hype and the “Valley of Tears”: Digitalization and Machine Learning are the Tools for Quality Improvement



Unrestricted © Siemens Energy, 2022

The ”AM Cockpit” Collects ’All’ Sensor Data and Makes It Accessible for Data Analytics





8700 x2 pictures to check!

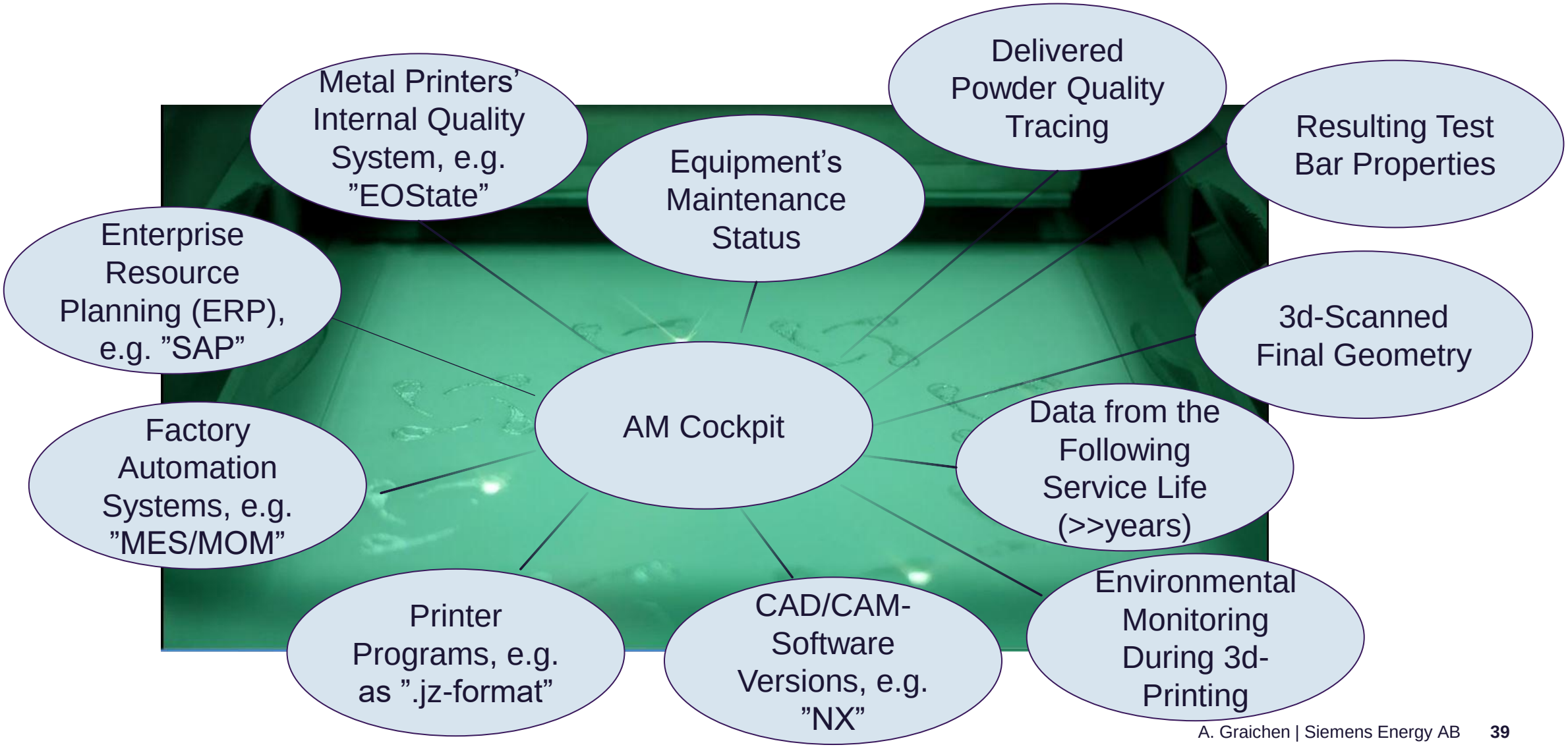
Machine Learning algorithms judge each layer and allocate a Powder Bed Severity Index

Artificial ”Powder Bed Deviation” summarizes the ”process”

Overlaying many build jobs compares process quality

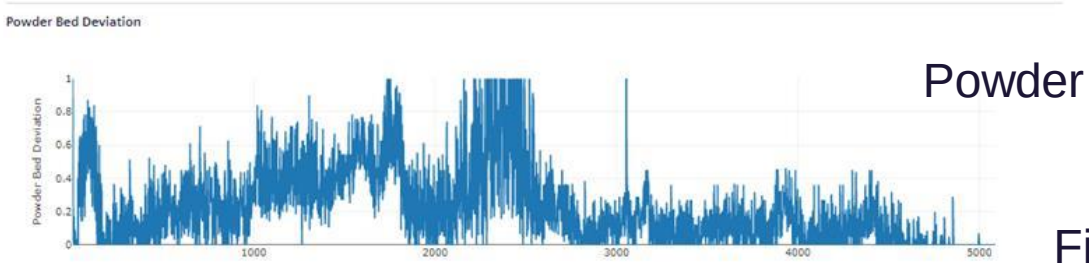
Unrestricted © Siemens Energy, 2022

More Challenges Remain, Often Starting with Data Format, Data Availability and Data Reliability, also Data Ownership

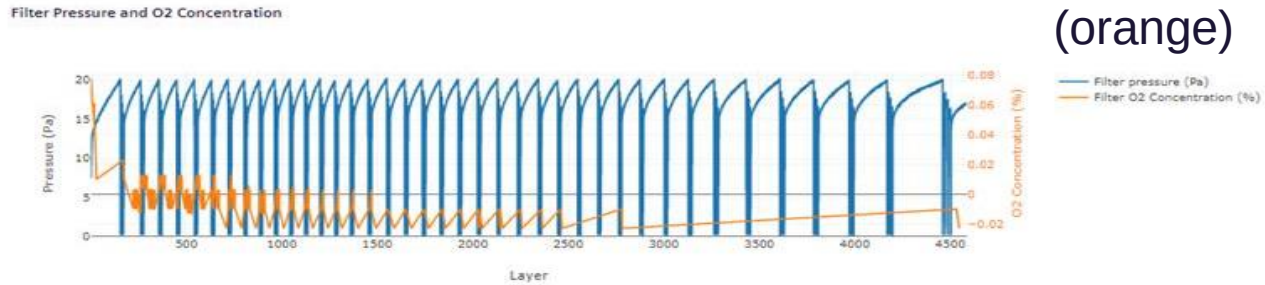


Unrestricted © Siemens Energy, 2022

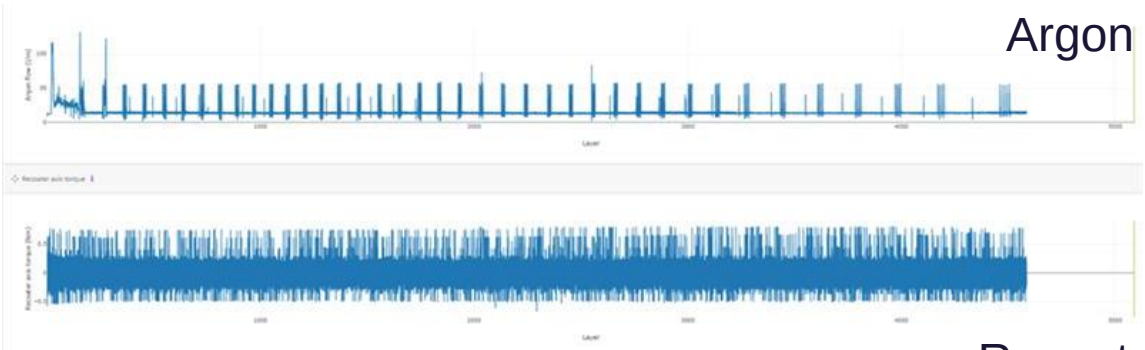
Pattern finding among 30+ completely different physical sensors is not yet successful (1)



Powder Bed Deviation

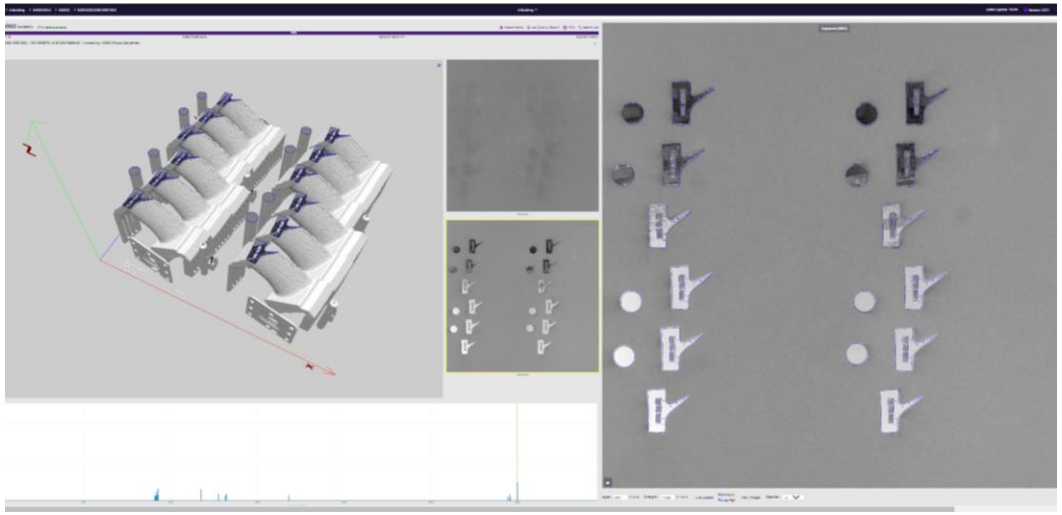


Filter Pressure and Filter O2 content (orange)



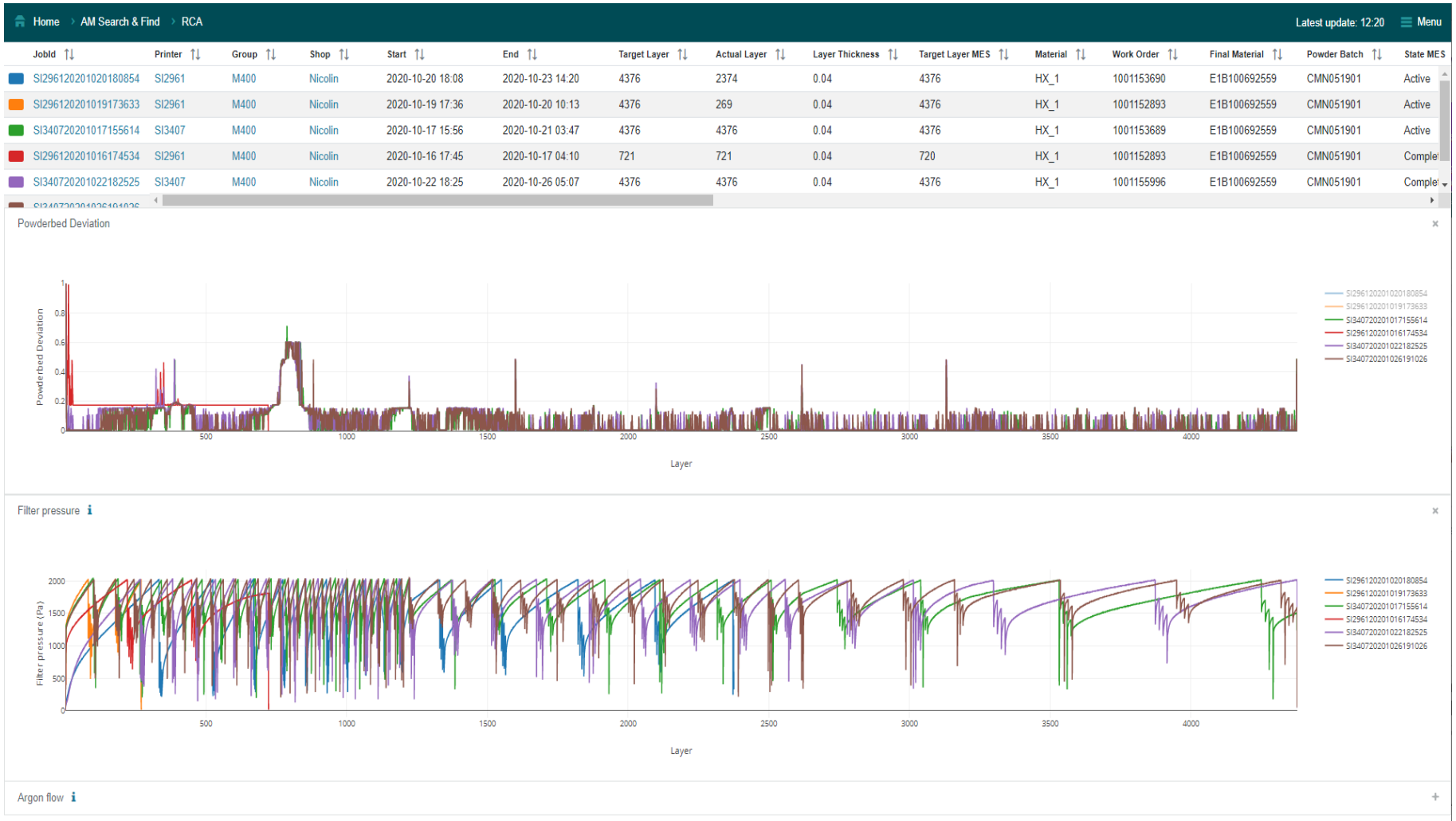
Argon flow

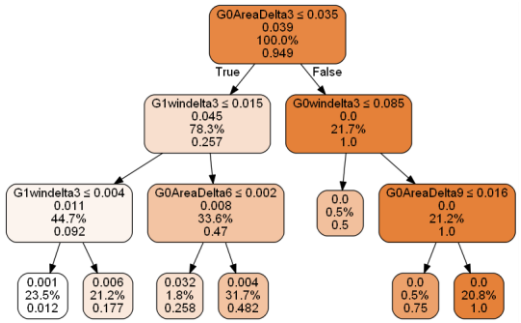
Recoater Torque



Unrestricted © Siemens Energy, 2022

Pattern finding among 30+ completely different physical sensors is not yet successful (2)





- Regression Tree
- Case Based Reasoning (like gas turbines!)

Powder Bed Deviation (several jobs)

Filter Pressure (several jobs)

Unrestricted © Siemens Energy, 2022

Summary: Observations Concerning the Introduction of Machine Learning in a Formerly ”Traditional” Machine Builder Industry

1. Former experts need to start learning again
2. Recruiting of the right data science competences is difficult
3. **Without big amounts of data there is no Big Data Analytics!**
4. Monitoring of data quality important
5. Collaboration over company size borders wanted

I consider us soon ready with the preparations –
then we can further embark on the journey to…

Unrestricted © Siemens Energy, 2022

Establishing an Industry
Where are we now?

Traditional Workshop

Connected Workshop

"MES/QMS
Build Job Simulations

Learning Workshop

"Big Data Analytics and
Machine Learning

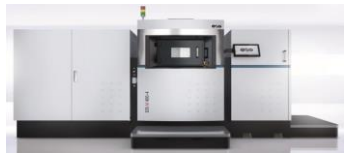
Intelligent Workshop

Robots
VR/AR and
AI

IoT for Industrial AM

Autonomous Workshop

Closed Loop & Self Healing Processes, gas turbines order spare parts by themselves

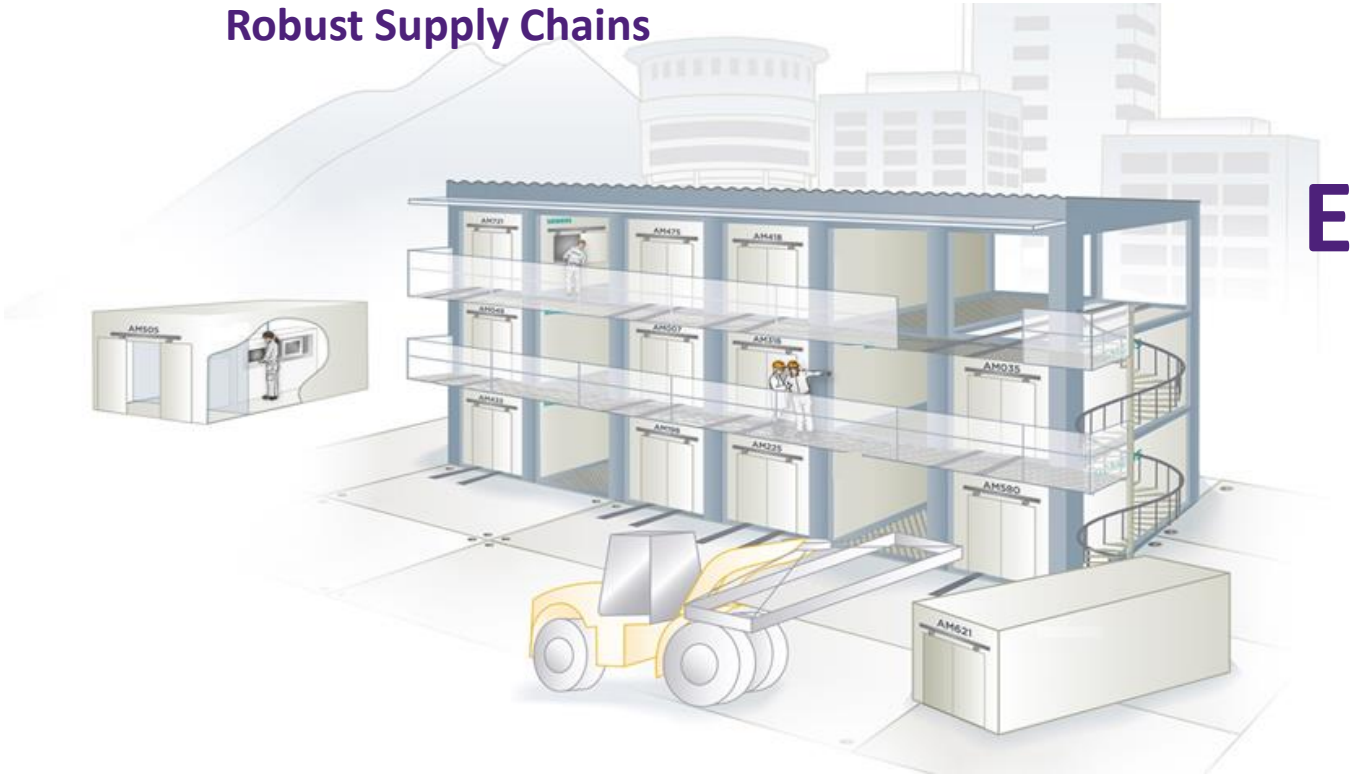


Unrestricted © Siemens Energy, 2022

“…as simple as paper printing!”

Remote Manufacturing

Robust Supply Chains



Enabling Hydrogen Combustion

Unrestricted © Siemens Energy, 2022

Zero Emission Hydrogen Turbine Center
The future energy system

Develop the gas turbine test facility towards a zero-emission demonstrator plant by:

- Utilize power from turbine test runs to produce hydrogen in an electrolyzer
- Installing solar panels for continuously hydrogen production
- Use produced hydrogen as turbine fuel to reduce LNG consumption
- Operation started in 2021

Demonstration plant at Siemens Energy test facilities in Finspong, Sweden

FINSPÅNG

LÄNSSTYRELSEN ÖSTERGÖTLAND

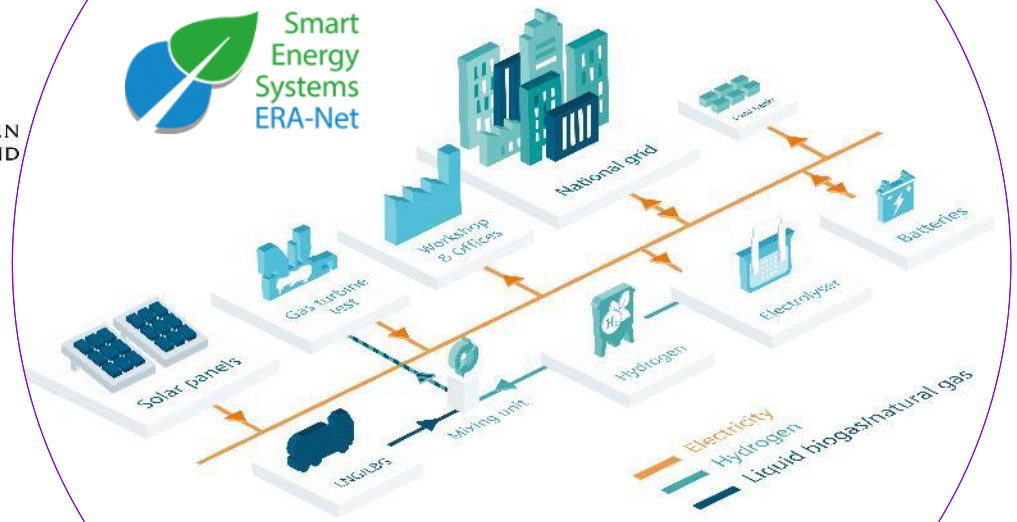
CHALMERS UNIVERSITY OF TECHNOLOGY

ALMA MATER STUDIORUM UNIVERSITÀ DI BOLOGNA

Linde

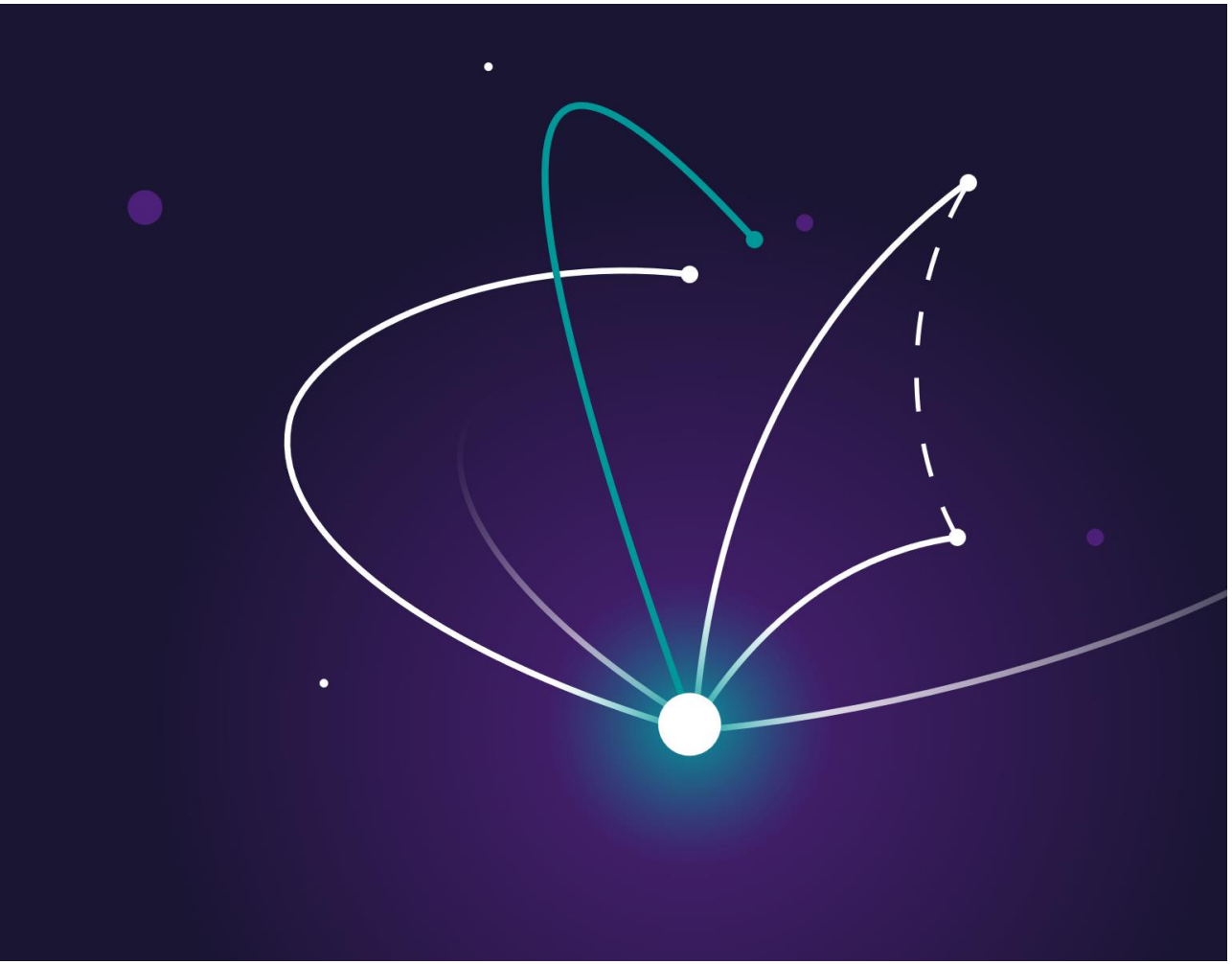
Funding gratefully acknowledged
Swedish Energy Agency and EU
ERA-Net Smart Energy System

Smart Energy Systems ERA-Net



Swedish Energy Agency

Unrestricted © Siemens Energy, 2022



Andreas Graichen

Group Manager Industrialization & Digitalization

Additive Manufacturing

Siemens Energy AB

Siemens Energy is a trademark licensed by Siemens AG.

Unrestricted © Siemens Energy, 2022

Additional Material

https://www.siemens-energy.com/global/en/offerings/power-generation/gas-turbines/sgt-800.html

https://www.youtube.com/watch?v=fr5eDxiYqEs&list=PL98wx66MtSODR13zytiNNNUbp3YsasAc4&index=2

Unrestricted © Siemens Energy, 2022

Ind Tech 2022

BASF
We create chemistry

Artificial Intelligence in process industry

Dr.-Ing. Daniel Engel
BASF SE
June 28, 2022, Grenoble

BASF – We create chemistry

- Our chemistry is used in almost all industries.
- We combine economic success, social responsibility and environmental protection.
- Sales 2021: €78.6 billion
- EBIT before special items 2021: €7.8 billion
- Employees (as of December 31, 2021): 111,047
- 6 Verbund sites and 232 other production sites
- Around 90,000 customers from various sectors in almost every country in the world

BASF
We create chemistry

BASF's segments

Chemicals

Petrochemicals

Intermediates

Materials

Performance Materials

Monomers

Industrial Solutions

Dispersions & Resins

Performance Chemicals

Surface Technologies

Catalysts

Coatings

Nutrition & Care

Care Chemicals

Nutrition & Health

Agricultural Solutions

BASF
We create chemistry

Our way to net zero 2050

- We are a **key enabler** in the net zero transformation of base chemicals and downstream value chains
- Globally, we want to reduce our absolute CO_2 emissions **by 25% by 2030 compared with 2018**
- We aim to achieve **net zero CO_2 emissions at BASF by 2050**
- We are a **front-runner** in offering customers a portfolio of **products with lower carbon footprints** to enable their decarbonization

BASF
We create chemistry

BASF Corporate Commitments

Our Corporate Commitments cover every part of our value chain and operations to deliver long-term business success.

Suppliers | BASF operations | Customers | And along the way…

We source responsibly

We produce safely for people and the environment

We produce efficiently

We drive sustainable solutions

We value people and treat them with respect

BASF
We create chemistry

BASF Corporate Commitments

Our Corporate Commitments cover every part of our value chain and operations to deliver long-term business success.

Suppliers | BASF operations | Customers | And along the way…

We source responsibly

We produce safely for people and the environment

We produce efficiently

We drive sustainable solutions

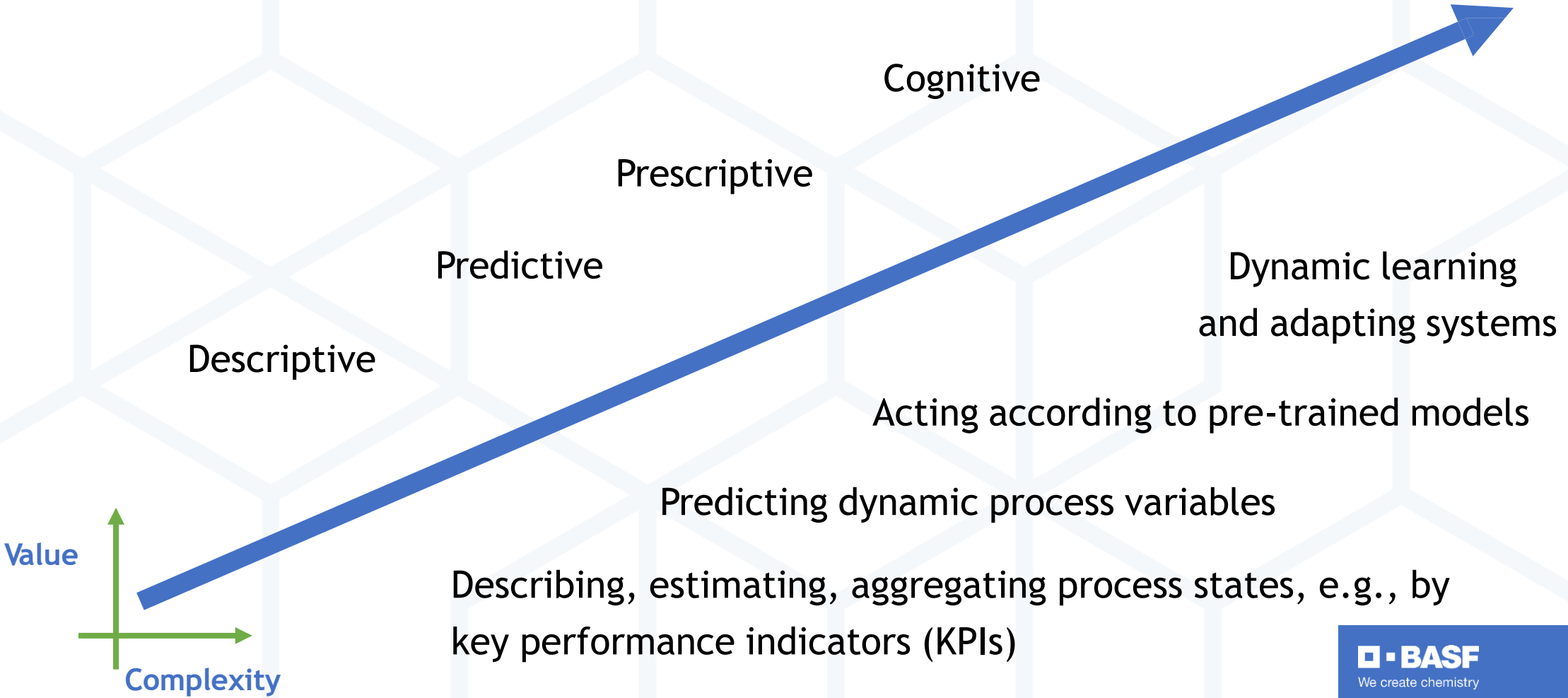
We value people and treat them with respect

Leverage key technologies, such as

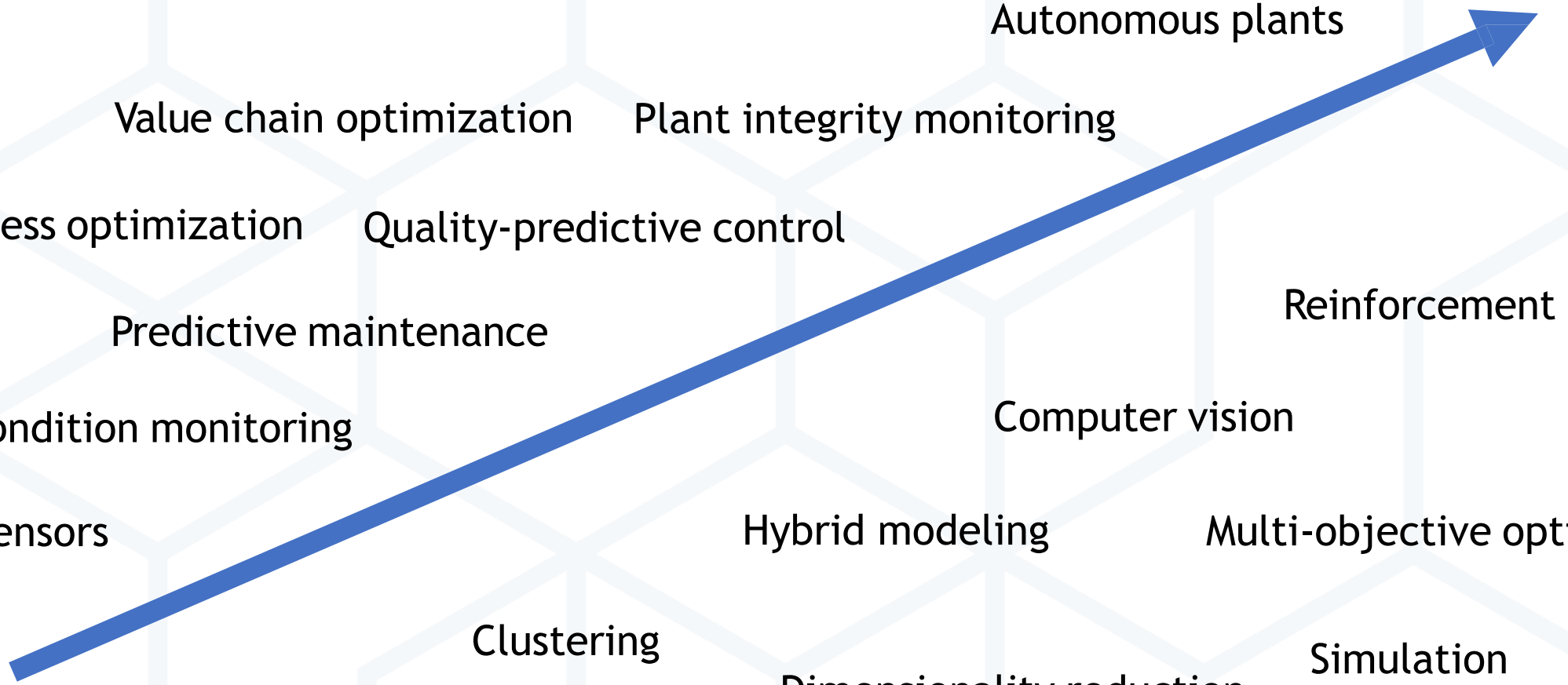
Artificial Intelligence

BASF
We create chemistry

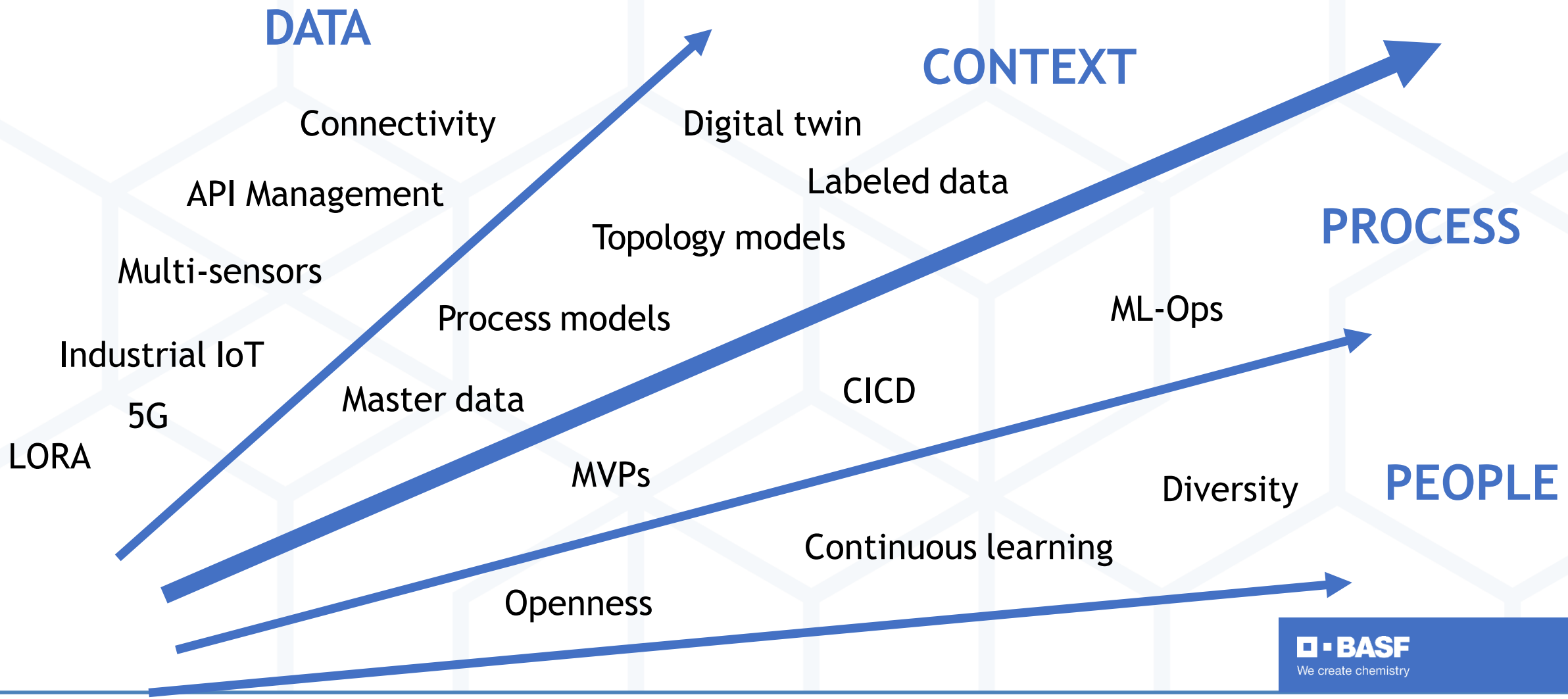
Evolution of Artificial Intelligence



Methods & applications of artificial intelligence



Challenges & opportunities for research and supplier industry



Thank you!

Ind
Tech
2022
INDUSTRIAL

3.0
4.0
AUTOMATION
IT and electronics
CONNECTIVITY
'Smart' technologies; Cloud computing; Big data; Networked machines and processes
Ind
Tech
2022

7% of Manufacturing enterprises used AI technologies in 2021
Enterprises using AI technologies by economic activity, EU, 2021
Ind
Tech
2022
INDUSTRIAL
TECHNOLOGIE
CONFERENCE