

TENFORCE
elisa company



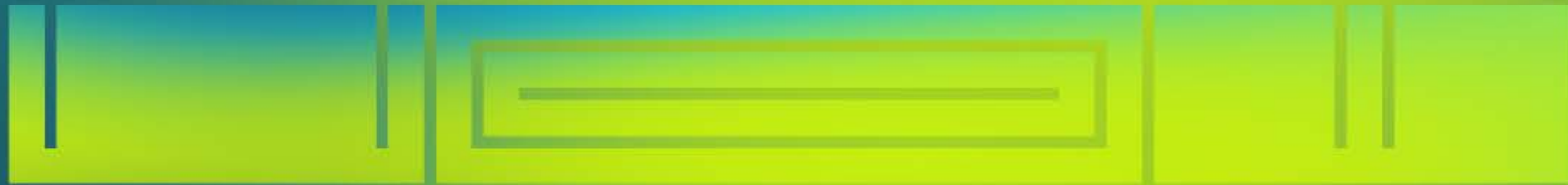
AI-PROFICIENT

Artificial Intelligence
for improved production efficiency,
quality and maintenance

JUNE 8TH, 2023

FUTURE

THE FUTURE IS WOW 2023



BRINGING AI TECHNOLOGY TO THE PRODUCTION LINE





AI-PROFICIENT

Artificial intelligence
for improved *production efficiency*,
quality and maintenance



Introduction to **AI-PROFICIENT** project : Artificial Intelligence for Improved Production Efficiency, Quality, and Maintenance

Pr. Benoît IUNG (Lorraine University – UL) - Benoit.iung@univ-lorraine.fr

Introduction connected to several presentations planned Today

<https://ai-proficient.eu/>



<https://www.linkedin.com/company/ai-proficient-eu/>



<https://twitter.com/AiProficient>



This product is part of a project that has received funding from the European Union's
Horizon 2020 research and innovation program under grant agreement No 957391.

06/07/2023

About us ... AI-PROFICIENT Identity

Artificial Intelligence for improved **PRO**duction **efFICI**ency, quality and **maiNT**enance

PROJECT FUNDED IN **ICT-38 « AI FOR MANUFACTURING » CALL**

BUDGET: 5,47 M€

TYPE: **RIA (RESEARCH AND INNOVATION ACTION)**

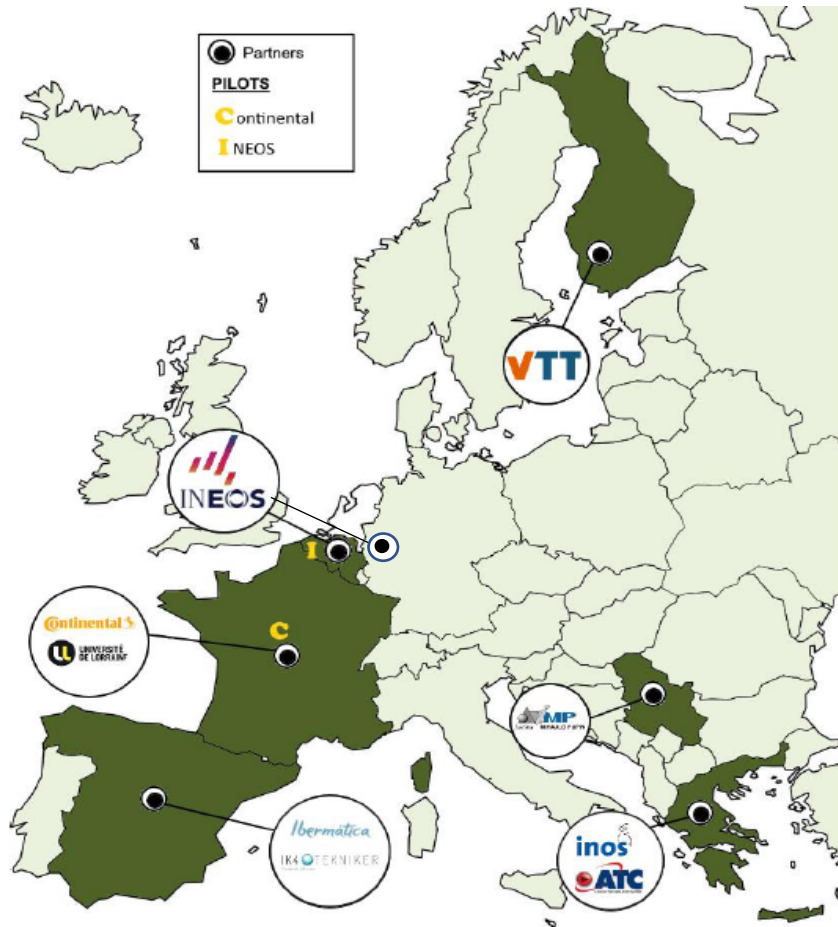
DURATION: **3 YEARS (STARTED 1ST NOVEMBER 2020)**

PILOT SITES: **3 (TYRE MANUFACTURING;
POLYETHYLENE/POLYPROPYLENE)**

MAN/MONTH: **718**

TRL: **3 – 7**

P.O: **ELENA ANGIOLINI**



1 UNIVERSITY (UL- COORDINATOR) – 3 RESEARCH CENTRES



6 INDUSTRIAL COMPANIES (2 END-USERS; 2 LARGE ENTERPRISES – 2 SMES)



Using advanced
AI technologies to
improve manufacturin

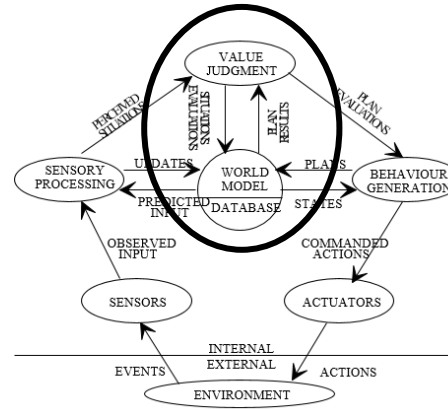
AI Consideration ... in general ...

- Learning
 - Develop a knowledge system and be able to integrate new knowledge
- Reasoning, deducting, anticipating
 - From the knowledge system and experience, data can produce new knowledge
- Own a story
- Have a conscience
- Having feelings

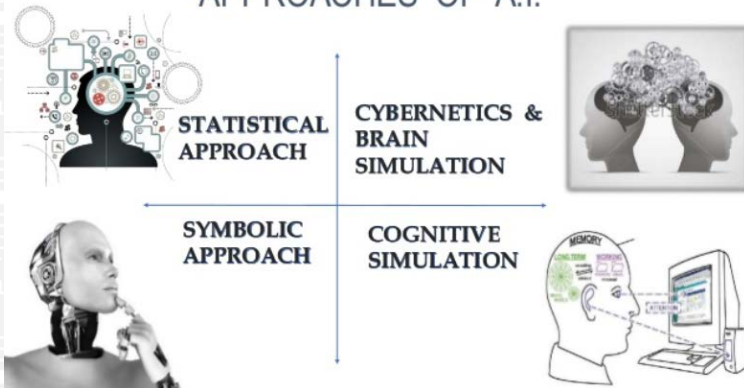
What is artificial intelligence?

Artificial intelligence (AI) refers to systems that display intelligent behaviour by analysing their environment and taking actions – with some degree of autonomy – to achieve specific goals.

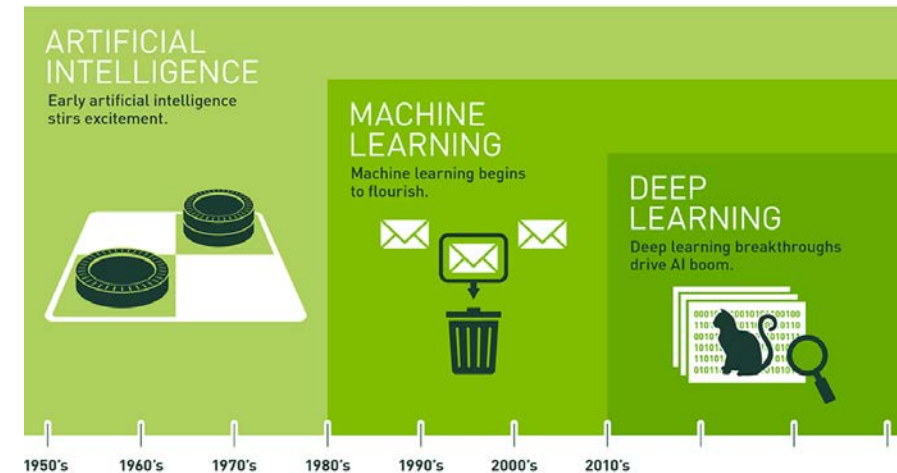
AI-based systems can be purely software-based, acting in the virtual world (e.g. voice assistants, image analysis software, search engines, speech and face recognition systems) or AI can be embedded in hardware devices (e.g. advanced robots, autonomous cars, drones or Internet of Things applications).



APPROACHES OF A.I.



AI = Theories + Techniques → Programme having to simulate ... **Human Intelligence**

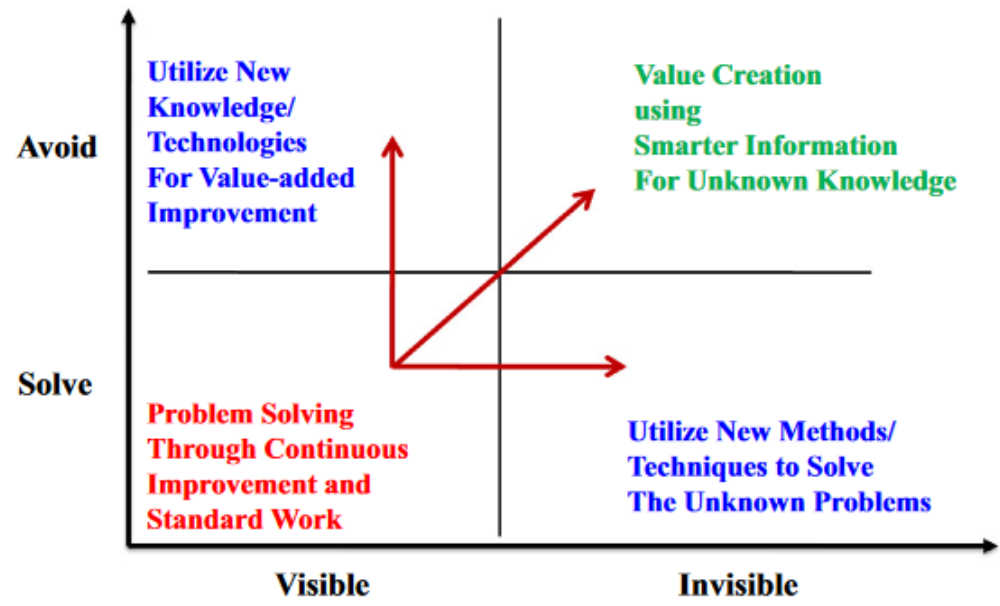
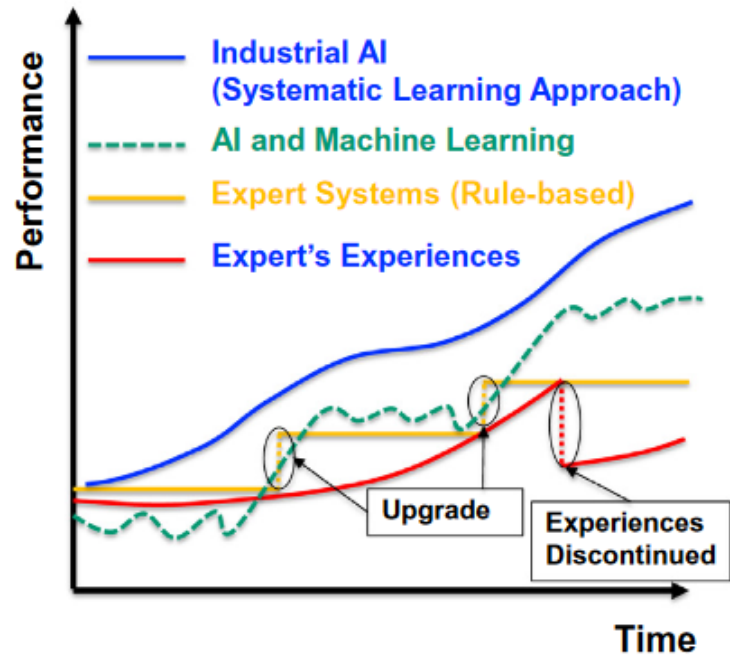


... Industrial AI (Jay Lee, 2018) ...

Artificial intelligence (AI) is a popular branch of computer science that concerns with building "intelligent" smart machines capable of performing intelligent tasks.

With rapid advancements in deep learning and machine learning, tech industry is transforming radically.

- (A) – Analytics Technology; (B) Big Data Technology; (C) Cloud or Cyber Technology;
- (D) Domain KnowHow; (E) Evidence

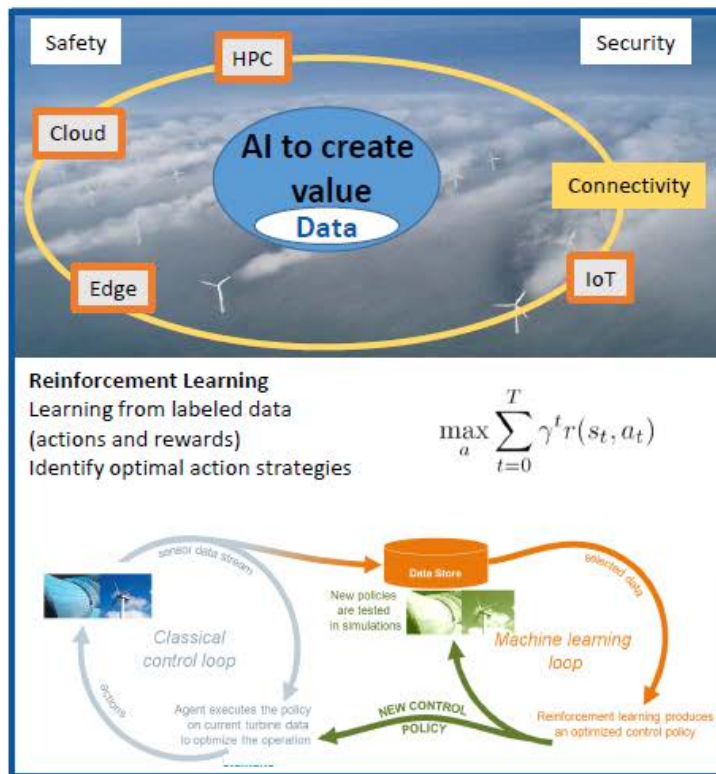


a) Comparison of Industrial AI with other learning systems; b) The impact of Industrial AI: from solving visible problems to avoiding invisible

... Industrial AI (Siemens in 2019) ...

Workshop on AI for Manufacturing, 2nd July 2019, Brussels

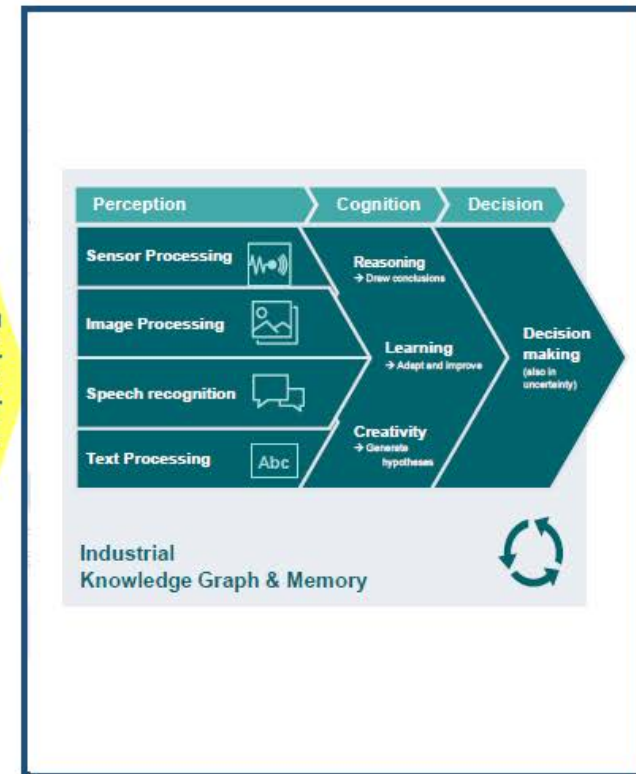
SIEMENS
Ingenuity for life



Definition

From an industrial point of view, AI means **algorithm-based and data-driven computer systems** that enhance machines and people with digital capabilities such as **perception, reasoning, learning and even autonomous decision making.**

Technology



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... Industrial AI (Siemens in 2019) ...

Workshop on AI for Manufacturing, 2nd July 2019, Brussels

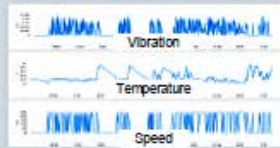
Perception/Cognition/Decision/Knowledge are key!
... especially in manufacturing environment!

SIEMENS
Ingenuity for life

Perception

Signals and data

e.g. temperature, acceleration, pressure, force, magnetic field, ...

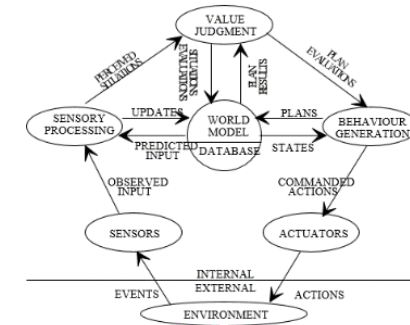


Cognition



Decision

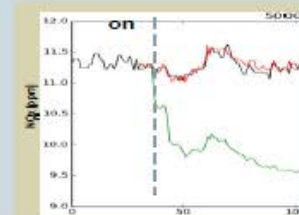
- Speed
- Flexibility
- Quality
- Efficiency



Knowledge

AI for industrial applications – data and know-how feed algorithms

Machine data



Domain Know-How



Context Know-How



(Few) public data



... Industrial AI and « AI in Manufacturing » European Vision



- 2018 Communication “AI for Europe” emphasizes the importance of AI in European manufacturing, reflected in the EUR 1.5 billion for AI research provided in the H2020 programme

https://eur-lex.europa.eu/resource.html?uri=cellar:01ff45fa-a375-11eb-9585-01aa75ed71a1.0001.02/DOC_1&format=PDF

- Report on “Fostering a European approach to Artificial Intelligence” (May 2021) – Coordinated Plan on AI 2021 Review

<https://digital-strategy.ec.europa.eu/en/library/coordinated-plan-artificial-intelligence-2021-review>

- **The co-programmed European Partnership ‘Made in Europe’** will be the driving force for sustainable manufacturing in Europe, including through AI, contributing to a competitive and resilient manufacturing industry in Europe and ...
 - first calls (in 2021-2022) focused on the following identified sectors: **manufacturing**, health, agri-food, smart communities and edge AI. The estimated budget per sector will be around EUR 20-75 million
 - January 2020 - **Call H2020 ICT-38 “AI for Manufacturing”**
- European AI Alliance
- European AI-on-Demand Platform



... Industrial AI and « AI in Manufacturing » European Vision



- January 2020 - **Call H2020 ICT-38 “AI for Manufacturing [2021-2023]”**



- Some other European projects in AI-based Manufacturing

– Robotics

An.Dy; Rossini; Symbiotic; Collaborate
Imagine; Resibots; Thomas; Robotics4EU

– Maintenance

Programs; Serena

– Production/Logistics

Aideas; Logistar; Epic

– Sustainability

Enerman; Circular TwAI, Engine, Re4Dy

– New Business model

Converging; Ultimate

– Human/Machine

Kyklos 4.0; ManuWork



AI-PROFICIENT
Artificial intelligence for improved production efficiency, quality and maintenance

Artificial Intelligence for improved PROduction eFFICIency, quality and maintenance.

Grant Agreement N° 957391

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leArning and robuSt deciSIon Support systems for agile mANufacTuring environments.

Grant Agreement N° 101000165

[VISIT WEBSITE](#)



COgnitive Assisted agile manufacturing for a Labor force supported by trustworthy Artificial Intelligence.

Grant Agreement N° 957391

[VISIT WEBSITE](#)



Multi-Agent Systems for Pervasive Artificial Intelligence for assisting Humans in Modular Production Environments.

Grant Agreement N° 957204

[VISIT WEBSITE](#)



Towards AI powered manufacturing services, processes, and products in an edge-to-cloud-knowlEdge continuum for humans [in-the-loop].

Grant Agreement N° 957331

[VISIT WEBSITE](#)



Safe and Trusted Human Centric Artificial Intelligence in Future Manufacturing Lines.

Grant Agreement N° 956573

[VISIT WEBSITE](#)



Advancing Collaboration and Exchange of Knowledge Between the EU and Japan for AI-Driven Innovation in Manufacturing.

Grant Agreement N° 957339

[VISIT WEBSITE](#)



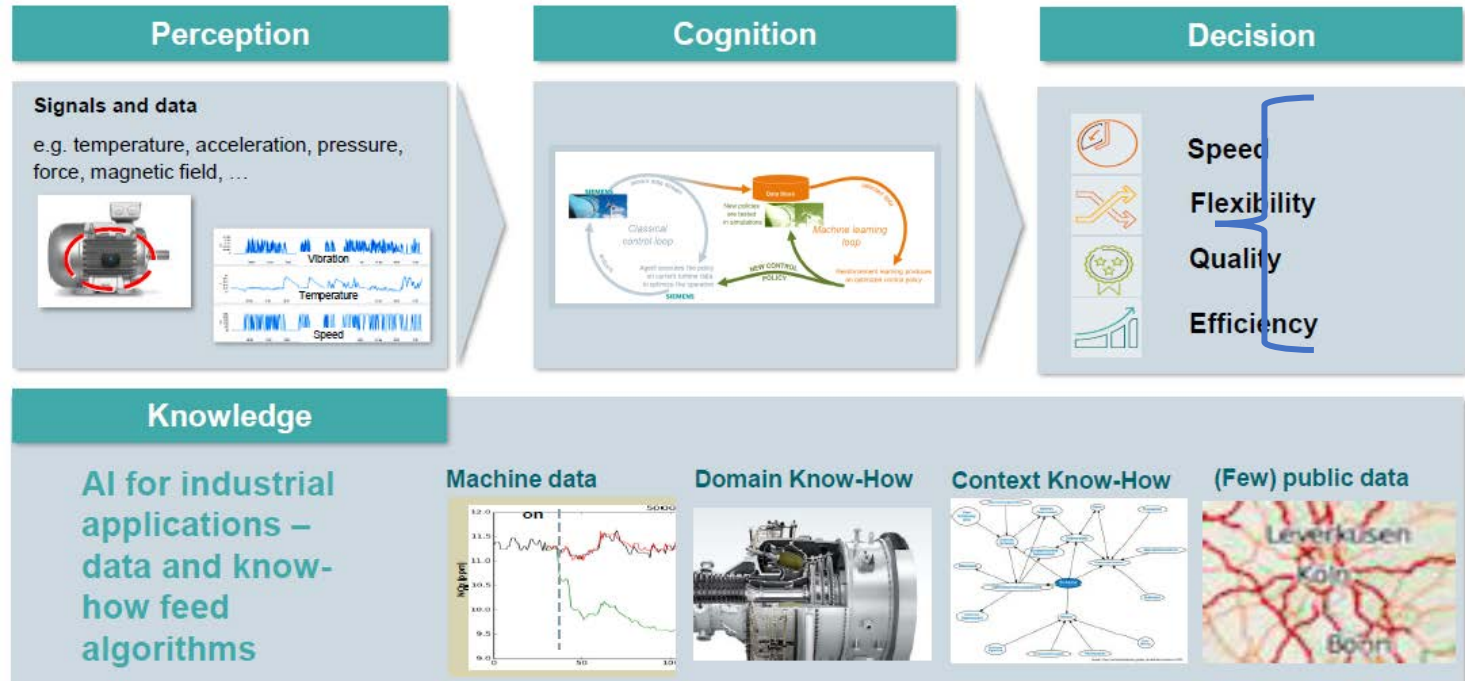
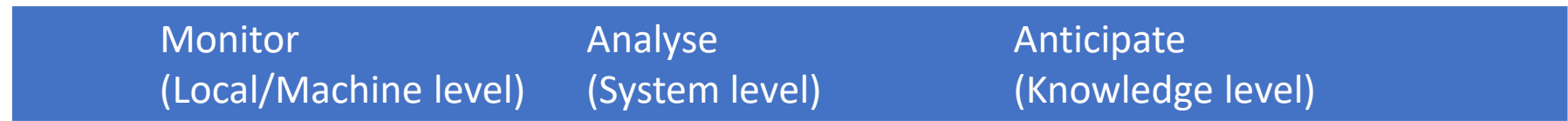
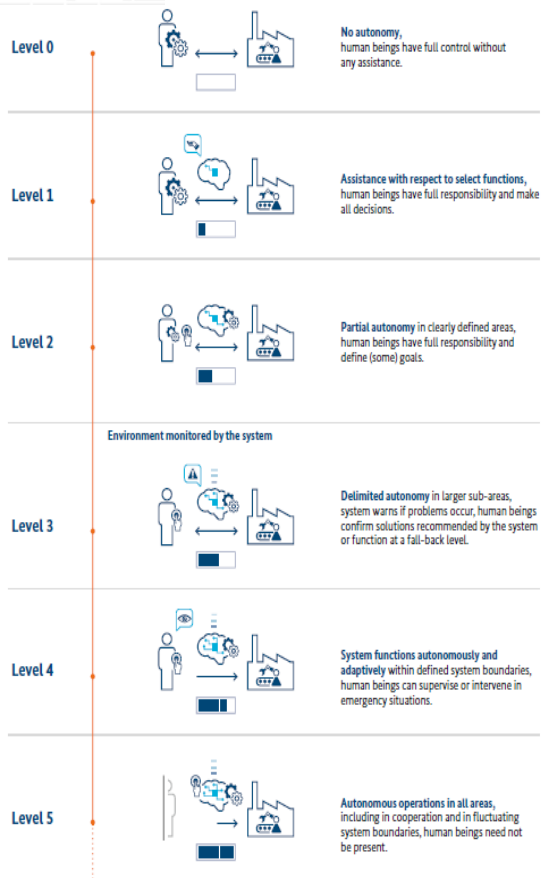
Human-AI Teaming Platform for Maintaining and Evolving AI Systems in Manufacturing.

Grant Agreement N° 957402

[VISIT WEBSITE](#)

... AI-PROFICIENT concept related to industrial AI

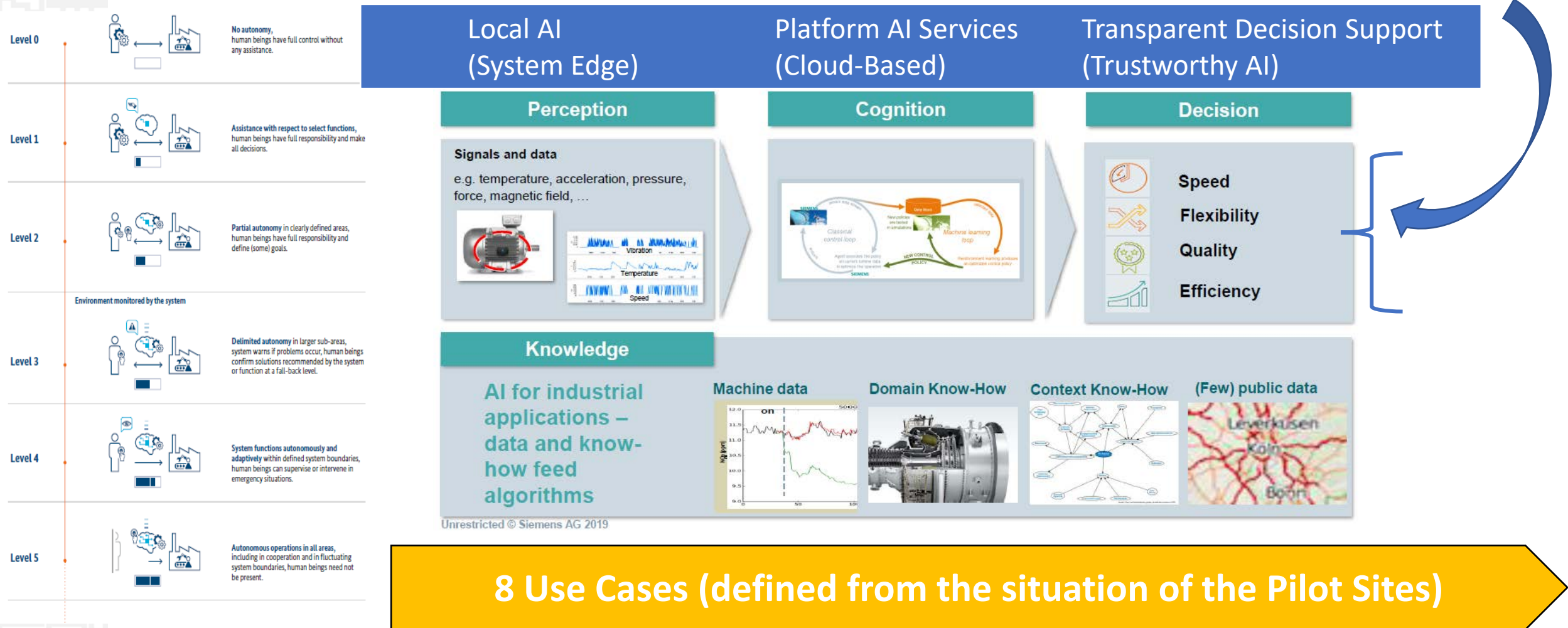
In AI-PROFICIENT, AI-Technology is referring to any data-driven, model-based or knowledge-based system or service, that can provide advanced reasoning, self-learning and/or autonomous decision support capabilities. AI-PROFICIENT is considering AI for providing advanced capabilities (Self-X) to production process and assets while considering the human-in-the loop, human-on-the-loop and human-in-command scenarios.



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8 Use Cases (defined from the situation of the Pilot Sites)

... AI-PROFICIENT concept related to industrial AI



From AI-PROFICIENT concept ... to objectives

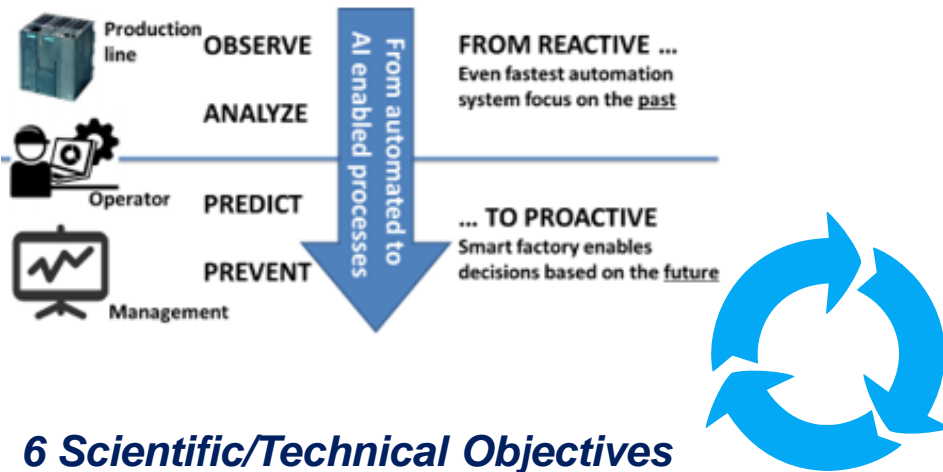
- Investigating **disruptive technological solutions** by introducing **AI** for the implementation of optimised strategies in the frame of **agile production and predictive maintenance...** to face challenges of adaptability, agility and resilience of **Cyber Physical Production System**
- Placing **the human being** at the centre of the implementation of these solutions by considering the **ethical aspects** in relation to the work of each operational actor

3 General Objectives

1. Integrating existing and emerging **AI technologies** to create the **AI-PROFICIENT platform ...**
2. Piloting the **AI-PROFICIENT** solution in **3 production plants** which operate under different use case scenarios, ...
3. Identifying the effective means for **human-machine collaboration**, while respecting the privacy, safety and security requirements and following the ethical principles ...

By bringing the advanced AI technologies to production lines and facilitating the cooperation between humans and machines ...

... Promote an evolution from hierarchical and reactive decision

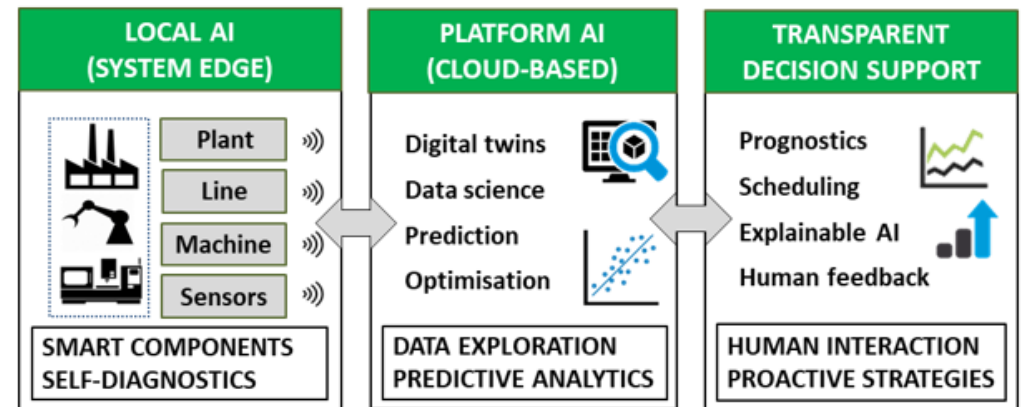


6 Scientific/Technical Objectives

1. Integration of **Advanced AI technologies** with production process in IIoT environment
2. AI for early **detection** of the process anomalies and provision of **fault diagnostics and prognostics**
3. AI-based decision support for **proactive maintenance at component and system level** (PHM consideration)
4. **Joint human-machine approach** to improve production planning and execution
5. **Demonstrators** as case studies and early adopters
6. **Ethical and legal aspects recommendation** for effective human-machine collaboration

Ethics by Design

HUMAN IN COMMAND
HUMAN IN THE LOOP
HUMAN ON THE LOOP



From AI-PROFICIENT concept ... to objectives

- Investigating **disruptive technological solutions** by introducing **AI** for the implementation of optimised strategies in the frame of **agile production and predictive maintenance...** to face challenges of adaptability, agility and resilience of **Cyber Physical Production System**
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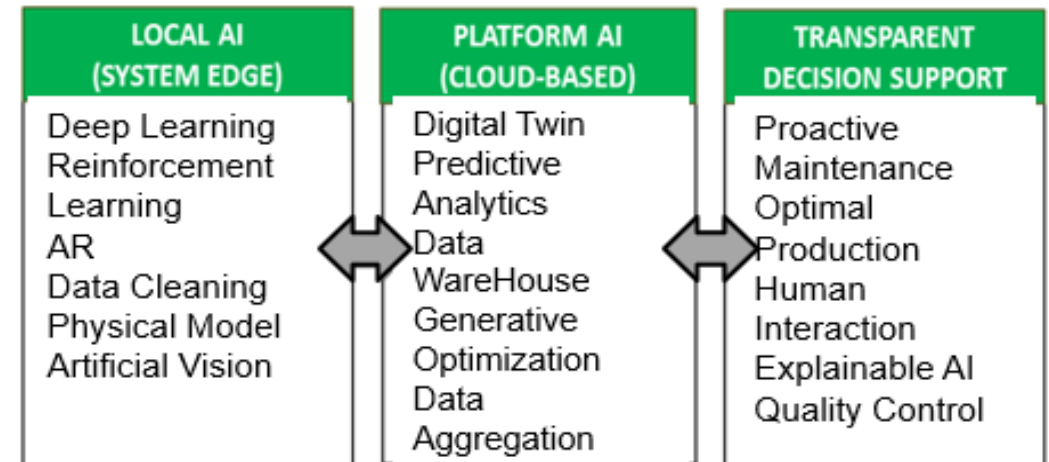
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Ethics by Design

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HUMAN IN THE LOOP
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From AI-PROFICIENT concept ... to objectives & results

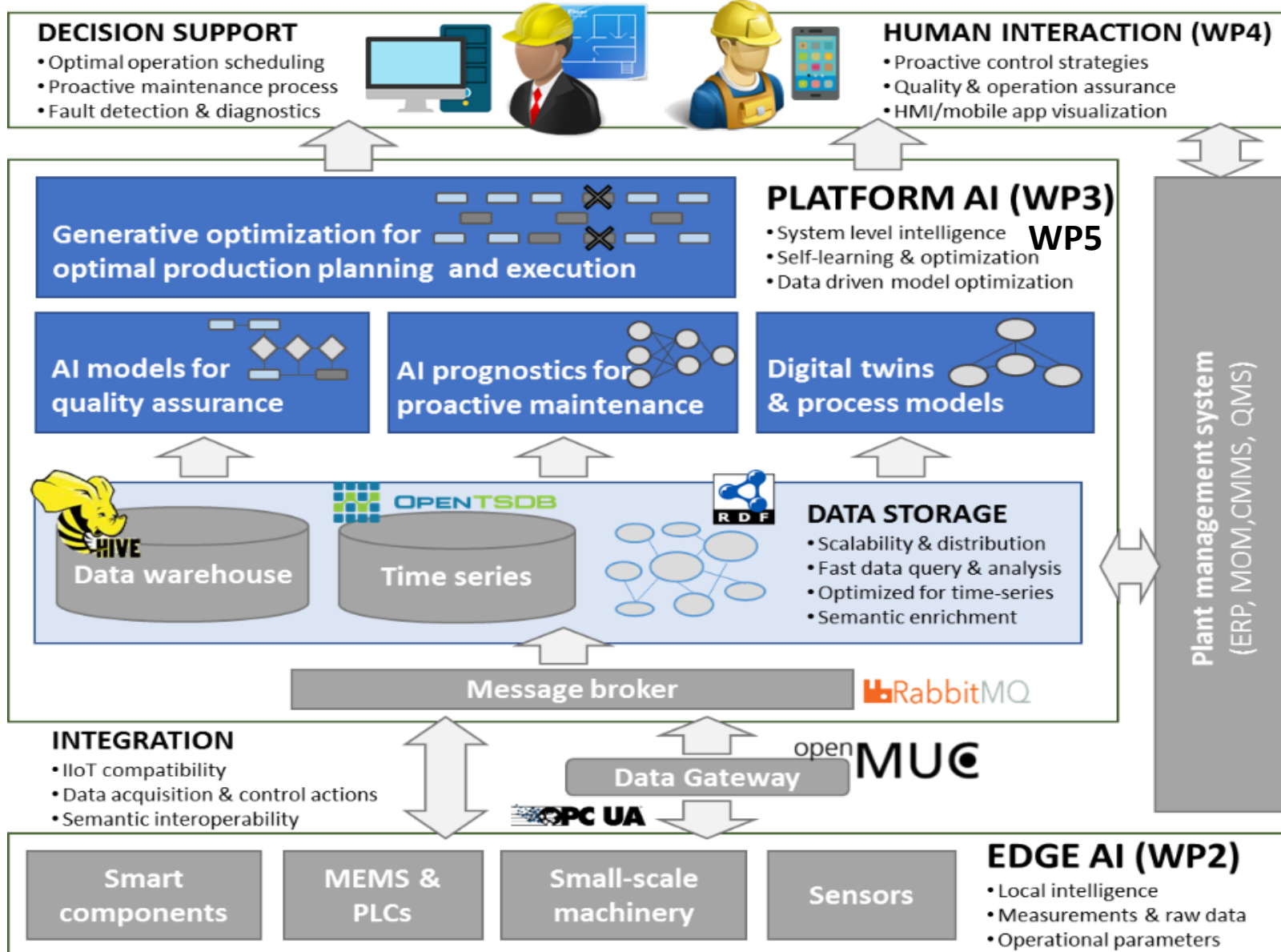
Digital challenges

- **Edge AI & Smart Components**
 - Smart components for embedded AI at system edge
 - AI detection, diagnostics and prognostics for system degradation and health state assessment
- **System integration & HMI Interfacing**
 - Semantic lifting and model agnostic techniques for XAI
 - IIOT for smart component integration and interoperability
- **Process Modelling & DT**
 - Hybrid Digital Twins and Process Modelling
- **Platform AI & Process Optimization**
 - AI-enabled decision making for Quality Assurance
 - Generative optimization of production processes (Human In The Loop)
- **Plant Management System**
 - Role-specific visualization for transparent AI decision support

Innovations and achievements

- Integration of Advanced AI technologies with production process in IIoT environment
- AI for early detection of the process anomalies and provision of fault diagnostics
- AI-based decision support for proactive maintenance at component and system level
- Joint human-machine approach to improve production planning and execution
- Demonstrators as case studies and early adopters
- Ethical and legal aspects recommendation for effective human-machine collaboration

AI-PROFICIENT organisation to achieve objectives & results

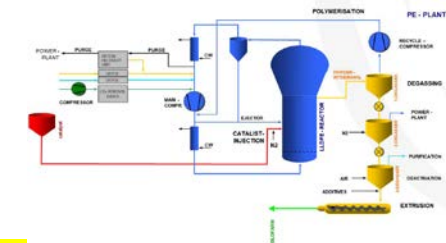
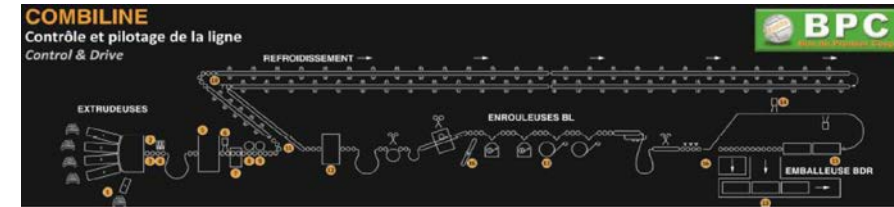


AI-PROFICIENT organisation to achieve objectives & results

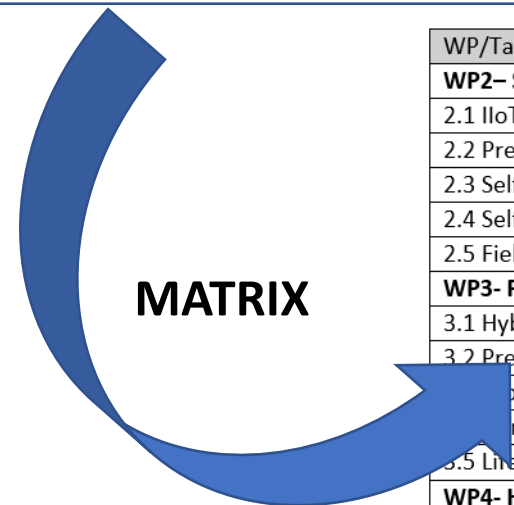


8 Uses Cases (UC) Defined (5 for CONTI – 3 for INEOS)

- UC Conti 2 - Restart Set up
- UC Conti 3 – Released extrusion optimization
- UC Conti 5 – Tread Blade wear
- UC Conti 7 – Tread alignment
- UC Conti 10 – Quality analysis
- UC Ineos 1 – Reactor stability [At Geel Plant]
- UC Ineos 2 – Image recognition [At Geel Plant]
- UC Ineos 3 – Rheology drift [At Cologne Plant]



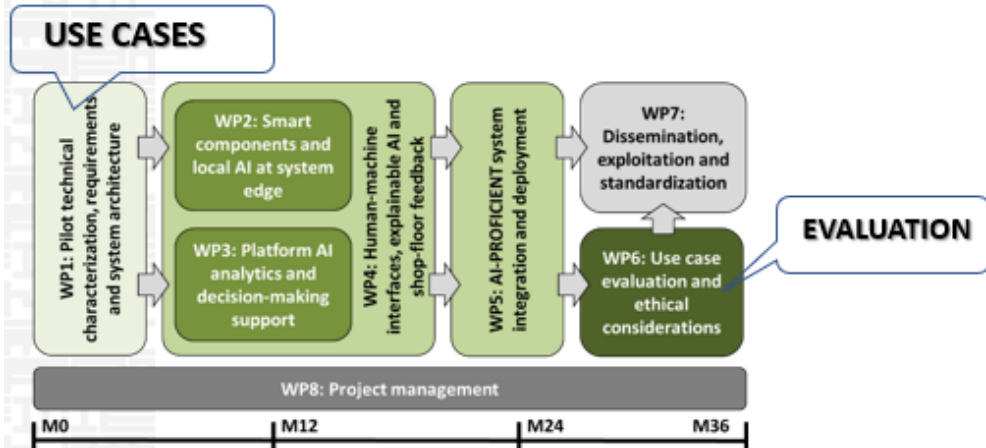
Mapping WP/Task/Services



MATRIX

WP/Task	CONTI-2	CONTI-3	CONTI-5	CONTI-7	CONTI-10	INEOS-1	INEOS-2	INEOS-3
WP2- Smart components and local AI at system edge								
2.1 IIoT environment		CONTI	CONTI/INOS	CONTI/INOS	CONTI	INEOS		INEOS
2.2 Pre-processing	TEK		TEK/INOS	CONTI/INOS	**	**		**
2.3 Self diagnostics	TEK	UL	TEK/UL/IBE	INOS	TEK/IBE			
2.4 Self prognostics	TEK	UL	TEK					UL
2.5 Field Automation			TEK*	INOS/TEK*				
WP3- Platform AI analytics & decision-making support								
3.1 Hybrid models/twins	TEK					VTT		VTT
3.2 Predictive AI	TEK		TEK/INOS	INOS/UL	TEK	TEK/IBE/INEOS	UL/INOS/IMP/ATC*	INOS
3.3 Predictive Maintenance		UL	UL/TEK/IBE	INOS/UL	INOS/IBE			
3.4 Generative optimization					IMP	IMP		IMP
3.5 Lifelong self-learning	TEK		TEK/IBE					UL
WP4- HMI, explainable AI and shop-floor feedback								
4.1 Feedback/reinforc.	TEK/TF*		TEK/IBE/CONTI		IBE/IMP	IMP*	INOS/ATC/NEOS	IMP
4.2 Role specific HMIs	TEK/TF	ATC/TF	TEK/TF	INOS/TF	TF/IBE	IBE/TF*	TF/ATC/INEOS	TF
4.3 XR and conversational					TF/IBE	IBE/TF*	TF/INEOS/ATC	TF
4.4 Explainable AI	TEK*		IMP/TEK/IBE	TEK*	IMP/IBE*			IMP

AI-PROFICIENT Pilots and industrial requirements

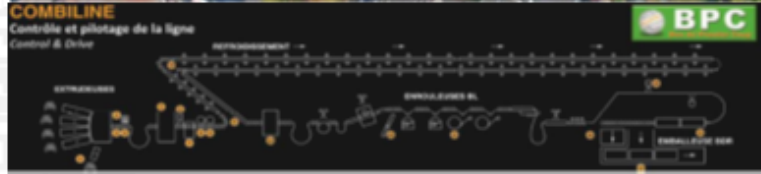


AI-based expected improvements:

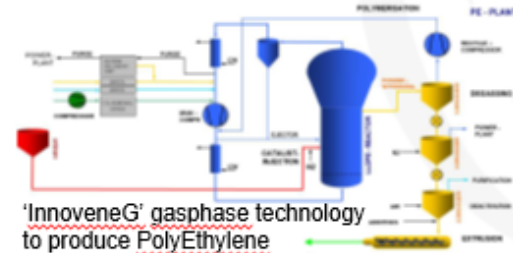
- Reduce production failures due to system breakage or disturbance
- Reduce low-quality products due to system degradation
- Optimize machine control setting and product set-up
- Increased product quality through drift identification and operator-in-the-loop
- Achieve increased raw material conversion
- Optimize use of raw materials through intelligent image recognition ...



Continental
TYRE MANUFACTURING
SARREGUEMINES
- FRANCE



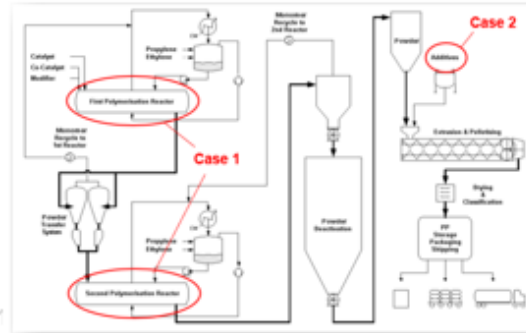
A quintuplex extruder producing 2 kinds of semi products : treads and sidewall



'InnoveneG' gasphase technology to produce PolyEthylene



INEOS - POLYETHYLENE,
COLOGNE - GERMANY



'InnoveneP' gasphase technology to produce PolyPropylene



INEOS - POLYPROPYLENE
GEEL - BELGIUM

AI-PROFICIENT Pilots and industrial requirements

AI-based expected improvements:

Reduce production failures due to system breakage or disturbance

Reduce low-quality products due to system degradation

Optimize machine control setting and product set-up

Increased product quality through drift identification and operator-in-the-loop

Achieve increased raw material conversion

Optimize use of raw materials through intelligent image recognition

...

KPIs to be generalised to underline Innovation in general from the solutions proposed

- **System breakage (STO2, STO3):** 50% reduction (baseline (2019) 4.0%, target 2.0%)
- **Production of scrap (STO2):** reduction by 0.05% (from 4.55% to 4.5% comparing to all extrusion lines)
- **Low-quality products (STO2, STO4):** reduction by 50% (comparing to share of final product with defects)
- **Number of trial loops before release (STO4):** 12.5% improvement
- **Off spec production (STO2):** lower amount of off spec product (target 1M€ saving per annum, Cologne plant)
- **Reduction of human errors (STO1, STO4):** reduction by at least 50% (using wrong raw materials leads to downgrading the product at the final quality check) (Geel plant)
- **Increase plant availability (STO2, STO4):** by at least 0,5% (equalling a value uplift of 550k€ per annum) (Geel plant) ...

Main Key Exploitable Results (KER) expected

SMART COMPONENTS FOR EMBEDDED AI AT SYSTEM EDGE

- CPUs / GPUs
- Edge computing
- Keras, Pytorch, Tensorflow
- SDKs Deep learning + ANN

HW/SW system to support AI → Smart EDGE component + ML

AI PROGNOSTICS FOR SYSTEM DEGRADATION AND HEALTH STATE ASSESSMENT

Component performance: Predicting, Stopped, Degradation mode reparation, Substitution between degradation modes.

Degradation mode (1): Predicting, Degradation mode (2): Predicting, Degradation mode (3): Predicting, Failed.

Substitution between degradation modes.

Operating conditions: Maintenance, Environmental conditions.

Component performance: Degradation mode (1), Degradation mode (2), Degradation mode (3), Failed.

Co-FACTOR X

Edge AI & Smart Components [WP2]

SEMANTIC LIFTING AND MODEL AGNOSTIC TECHNIQUES FOR XAI

IIOT FOR SMART COMPONENT INTEGRATION AND INTEROPERABILITY

Platform AI (AI services & digital twins)

- influxdata
- RabbitMQ

Communication middleware

openMUE Data Gateway

Vendor protocols

Smart components, PLCs, Small-scale machinery, Sensors

Plant management system

System integration & HMI Interfacing [WP5 & WP4]

HYBRID DIGITAL TWINS AND PROCESS MODELLING

Process Modelling & DT [WP3]

AI ENABLED DECISION-MAKING FOR QUALITY ASSURANCE

sample data + quality → model

new data + model → quality

GENERATIVE OPTIMISATION OF PRODUCTION PROCESSES (HUMAN IN THE LOOP)

Constraints, Objective function, Interface, CPU, Resolutions, Optimization results, Process model & algorithms, Model interface, Reinforcement learning, OUTPUT (set of control parameters), Selects output, Plant operator, Respects intended output.

Platform AI & Process Optimisation [WP3]

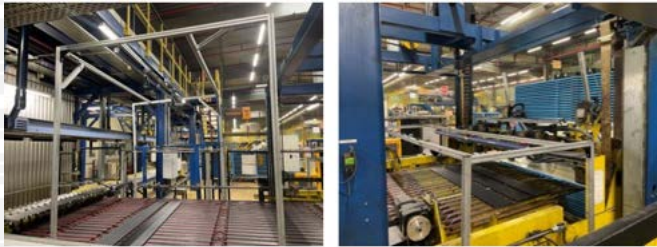
ROLE-SPECIFIC VISUALIZATION FOR TRANSPARENT AI DECISION SUPPORT

Plant Mng. System [WP3 & 4]

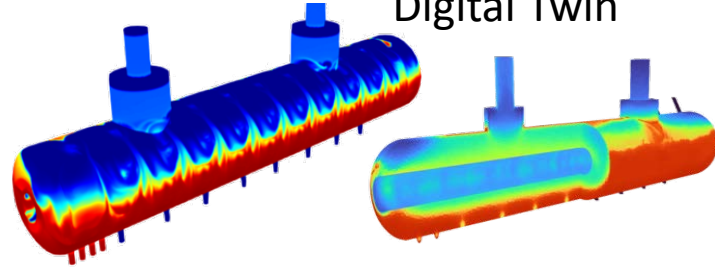
Main Key Exploitable Results (KER) in progress

CONTI UC7

Cabinet and belt camera installation



INEOS UC1 Digital Twin

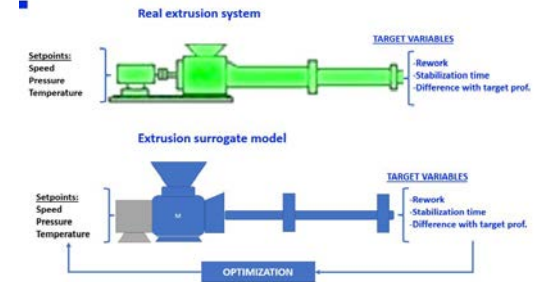
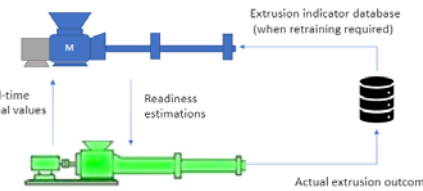


CONTI UC2

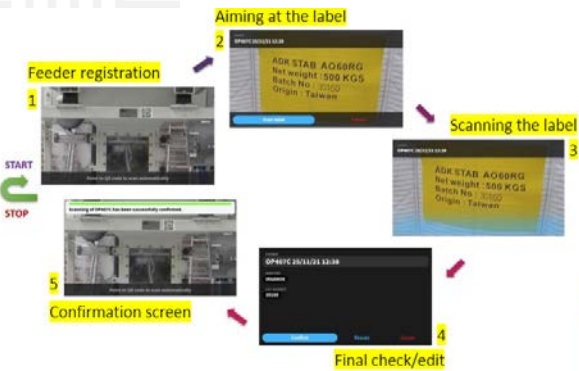
Reduce the quantity of rework by detecting readiness of extrusion and providing operators with optimal extrusion setup speed settings

Model 2
Surrogate based Optimization model

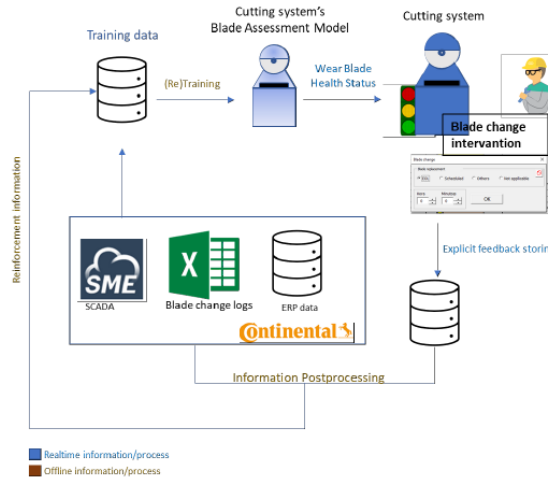
DIGITAL TWIN BASED ON A SURROGATE MODEL



INEOS UC2



INEOS use case demonstration video: https://youtu.be/Z_I5w5NxakQ

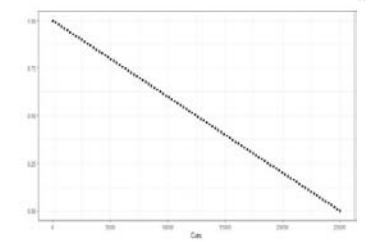
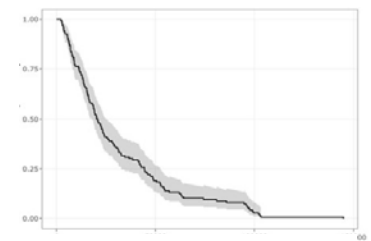


CONTI UC5

Wear of the blade
Prediction Service

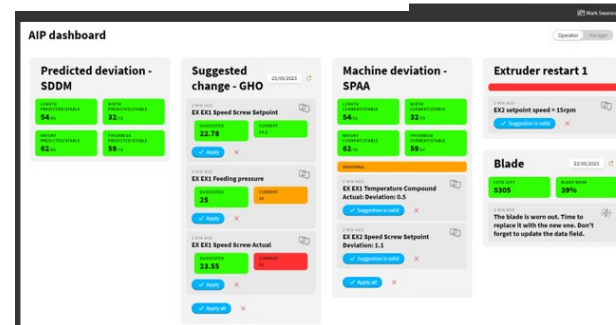
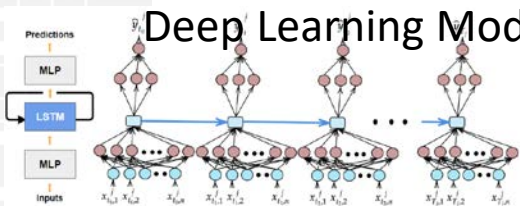


FinalCutsPoint



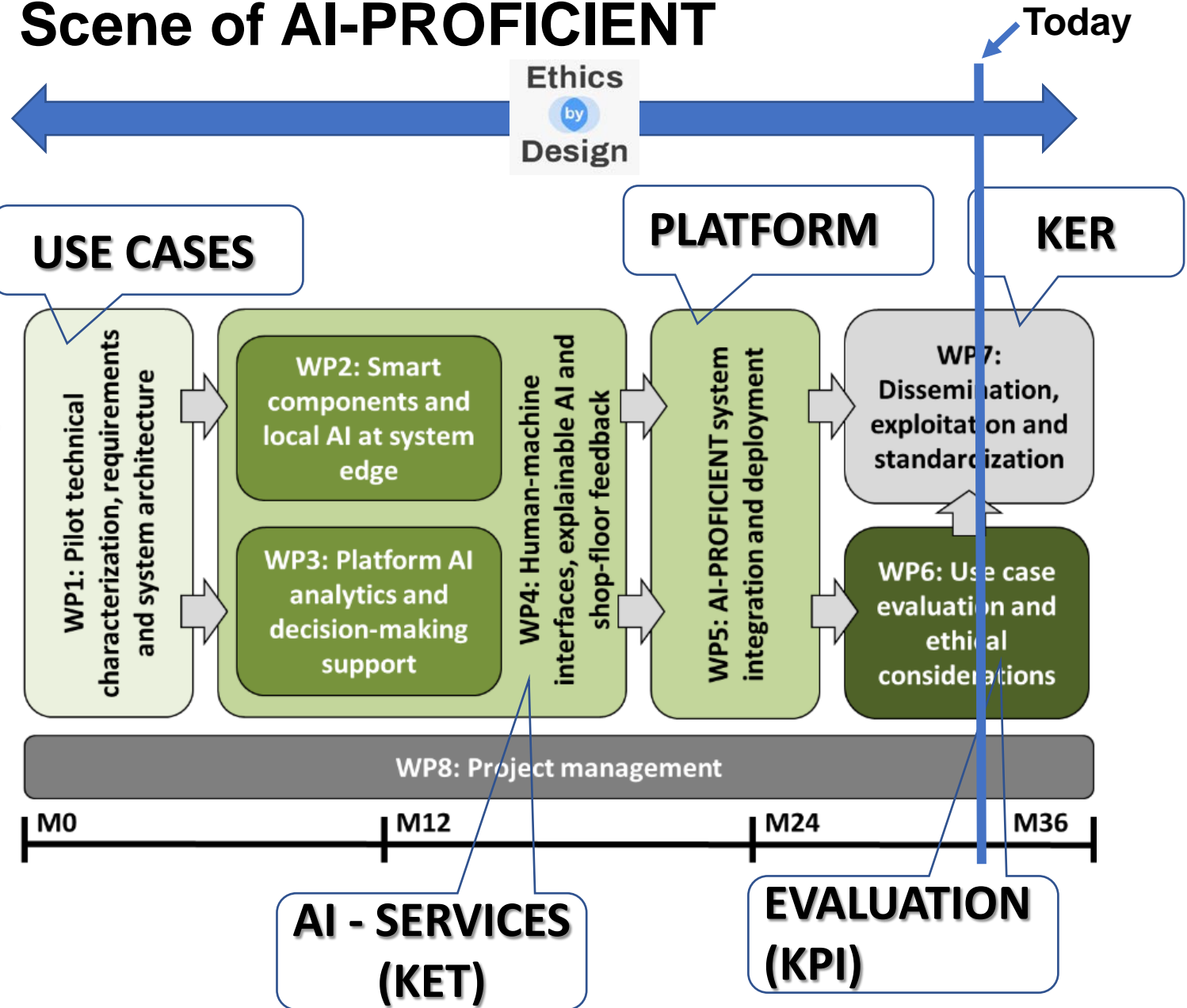
CONTI UC3

Deep Learning Model



Common
Dashboard

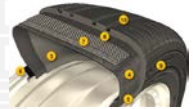
Set-up the global Scene of AI-PROFICIENT



- Design platform requirements and specifications
- KPIs
- Demo scenario



TYRE MANUFACTURING
SARREGUEMINES



INEOS

POLYETHYLENE,
COLOGNE

POLYPROPYLENE
GEEL



AI4MANUFACTURING

AI4EU



EUROPEAN FACTORIES OF THE FUTURE
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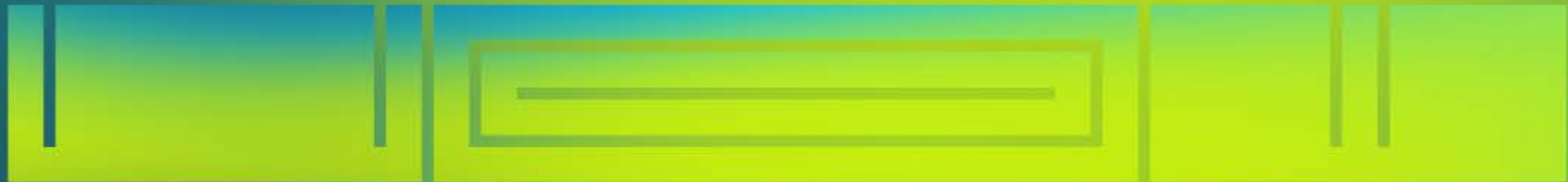
AI-PROFICIENT

Artificial intelligence
for improved production efficiency,
quality and maintenance

JUNE 8TH, 2023



THE FUTURE IS WOW 2023



BRINGING AI TECHNOLOGY TO THE PRODUCTION LINE