

# **H2020 STAR: ENABLING INDUSTRY 5.0 WITH TRUSTED ARTIFICIAL INTELLIGENCE**

**John Soldatos**

**EFFRA Manufacturing Partnership Day**

**September, 26<sup>th</sup>, 2023**

**[www.star-ai.eu](http://www.star-ai.eu)**



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# STAR PARTNERS

- Start date: 1 January 2021
- End date: 31 December 2023
- Overall budget € 5 999 253,75

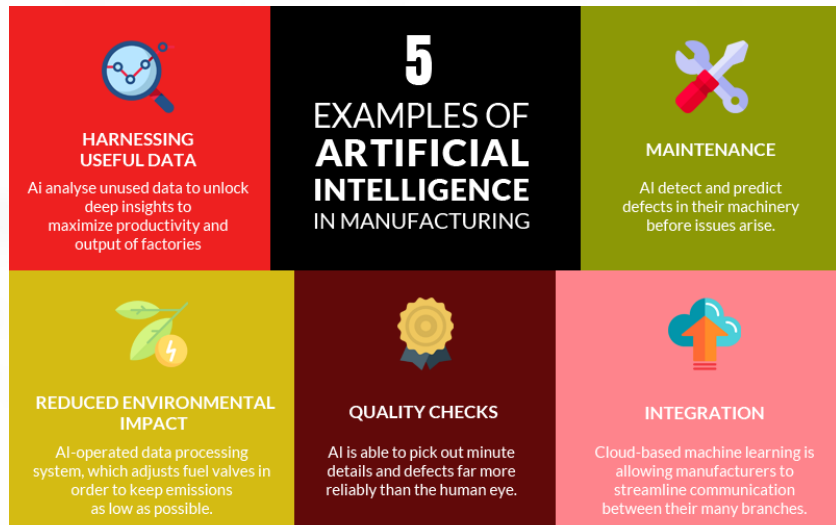


Project Coordinator

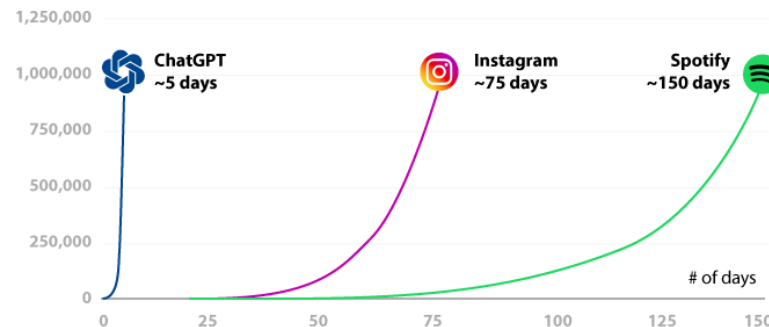


# RISE OF ARTIFICIAL INTELLIGENCE IN A DATA ECONOMY

## AI set to transform Manufacturing



~ Path to 1 million users\* (# of days from launch)



Sources: Google, Subredditstats, Media Reports

Source: Tyrone Systems

## Data is the New Oil





# THE REALITY ABOUT AI IN MANUFACTURING

Manufacturing Enterprises are drowning in data, but still starving for insights & intelligence

AI must be Human-Centric and Acceptable by Workers (Industry 5.0 Vision)



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## Why Should Humans Trust AI?

**Insights**

- Explainable AI is an important approach to make it possible for humans to trust AI.
- Explainable AI is a diverse, multi-disciplinary area. Both users and developers of business-critical systems usually need to understand why the AI does what it does. This lack of understanding can create confusion, frustration and mistrust. One of the main goals of explainable AI is to provide a clear, understandable explanation of the AI's decision-making process. A popular way to think about this is the idea of "white box" AI, where the internal workings of the AI are visible and understandable to humans.

AI is increasingly used in manufacturing to optimize production, predict equipment failure, and improve quality control. However, workers may be skeptical of AI's ability to make decisions that affect their jobs. This is where explainable AI comes in. By providing clear, understandable explanations of AI's decisions, manufacturers can help workers understand and trust the technology. This is essential for the successful implementation of AI in manufacturing.

# STAR PERFORMS WORLD-CLASS RESEARCH ON HUMAN-CENTRIC AI

Explainable AI

Why did you do this?: Explain to Factory Workers the AI systems operation – Increase transparency & trust

Active Learning

Robot-to-Human: Is this piece defected? Query human when not sure and accelerate Knowledge Acquisition for AI

Simulated Reality

Shorten Reinforcement Learning Cycle through Simulation – Useful for Safety

Human Centric Digital Twins

What-if-Analysis with the Human in Loop


Safety Zones Detection

Optimal Deployment of Automated Mobile Robots


(Cyber)Security for AI Systems

Protection of AI Systems against Adversarial Attacks


### STAR: ENABLING SAFE, SECURE & ETHICAL AI IN MANUFACTURING




Explainable & Transparent AI Systems




Active Learning & Simulated Reality for Human-AI Collaboration



Virtualized Digital Innovation Hub for Safe & Secure AI in Manufacturing



Cyber Security Solutions for AI Systems in Manufacturing



Human-Centric Simulations for Safe AI in Manufacturing

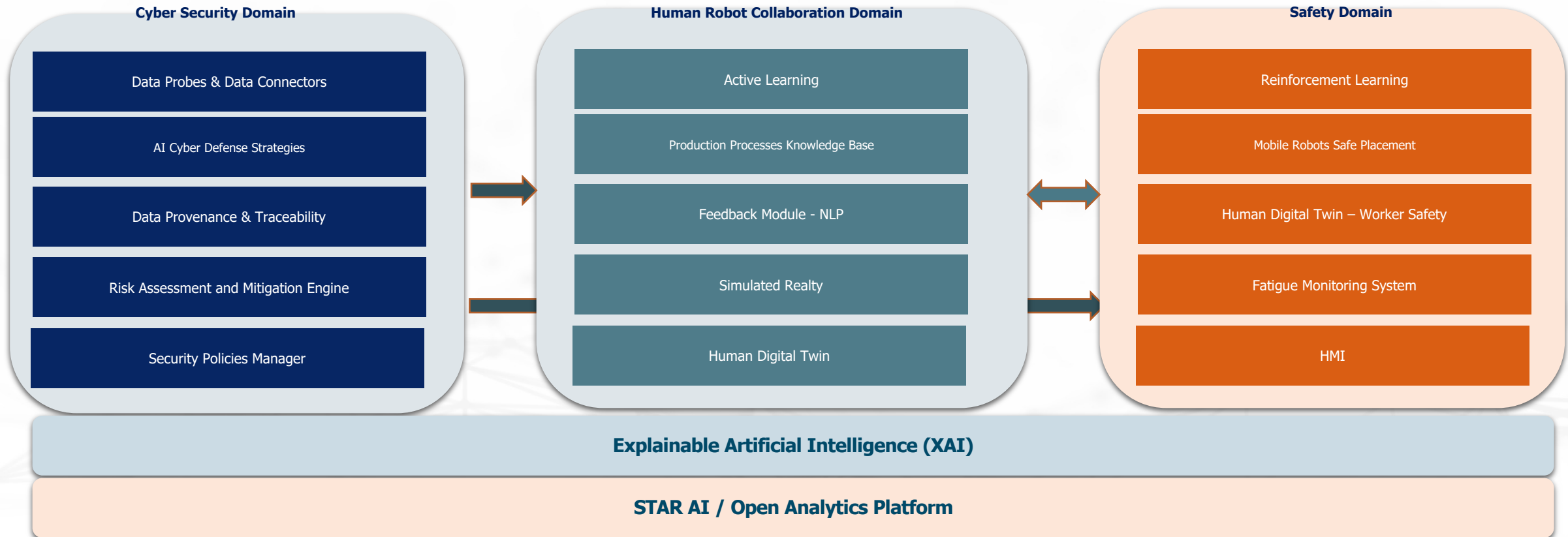
### EXPECTED IMPACT

- INCREASED INTELLIGENCE & FLEXIBILITY OF PRODUCTION LINES
- SAFE HUMAN-ROBOT COLLABORATION AT SCALE
- FASTER UPTAKE OF AI SOLUTIONS (QUALITY4.0, CO-BOTS)
- ETHICAL IMPACT IN MANUFACTURING IN-LINE WITH HLEG RECOMMENDATIONS
- RESEARCH (E.G., SIMULATED REALITY, ACTIVE LEARNING, EXPLAINABLE AI) PLACING EU AT FOREFRONT OF GLOBAL AI R&D

Safe and Trusted Human Centric Artificial Intelligence in Future Manufacturing Lines

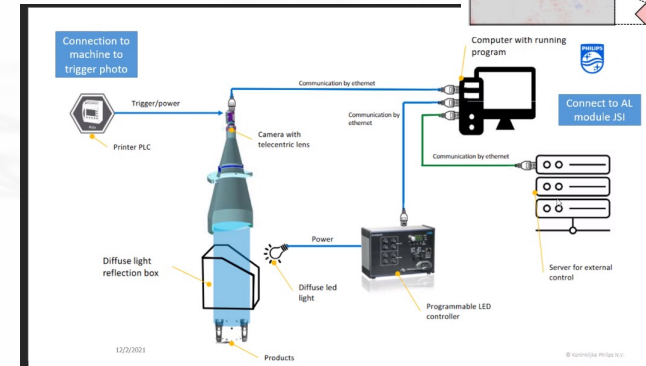
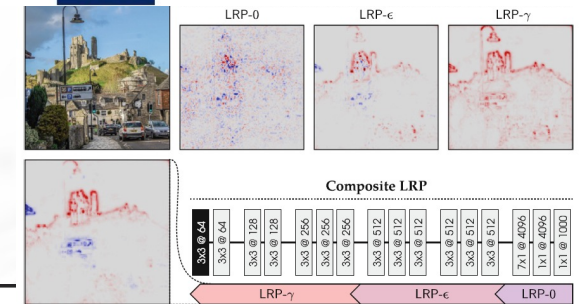
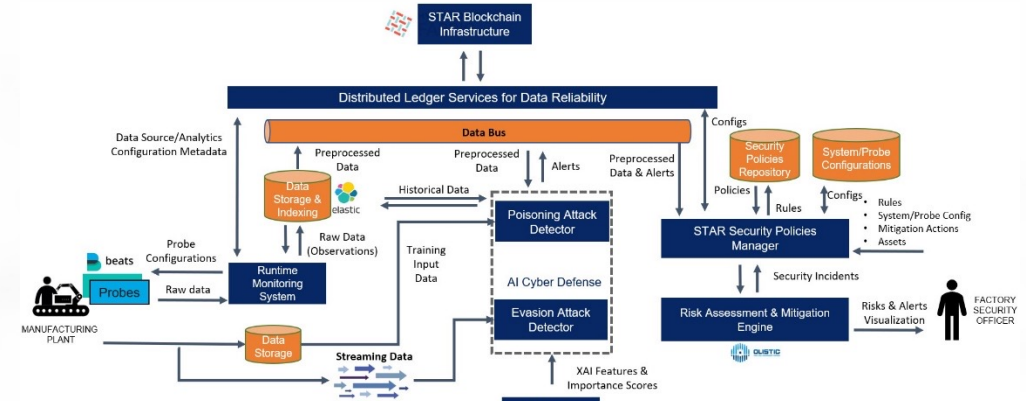
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# STAR HIGH LEVEL REFERENCE MODEL



# STAR PROVIDES TRUSTED INDUSTRIAL DATA

- Cybersecurity Layer
- Runtime Monitoring System - Probes
- Blockchain Network
- AI Cyber Defence
- Security Policy Manager
- Cyber-Resilience against attacks (poisoning, evasion)







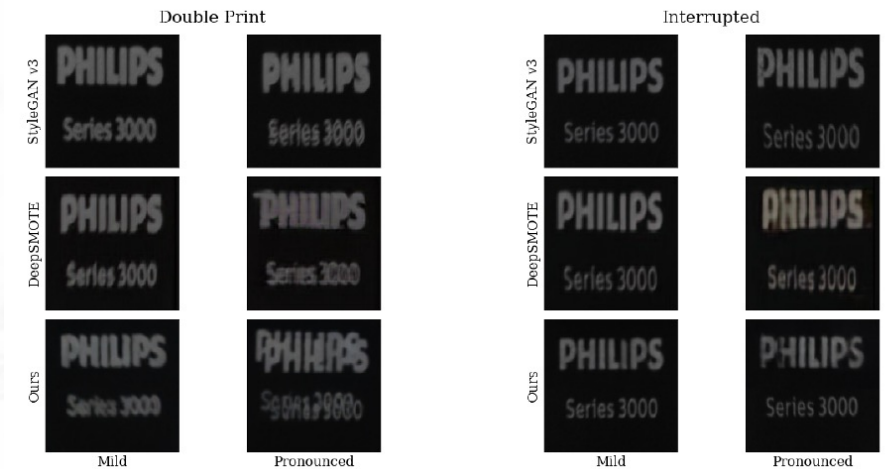
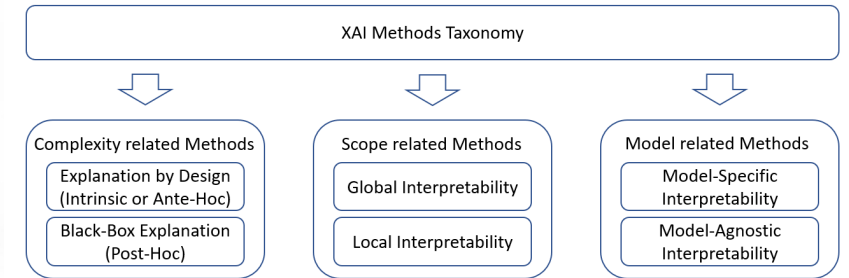
# STAR EXPLAINS HOW AI SYSTEMS WORK

## Explainable AI(XAI)

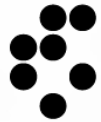
- E.g., Explaining important parts of an image

## Simulated Reality and Synthetic Data Generation

- E.g., for under-populated (defect) classes for the PCL shaver shell data
- Increased robustness to inputs both unknown defects and unknown products



# Example: Explainable Artificial Intelligence in STAR



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Ljubljana, Slovenia

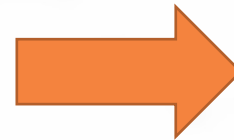
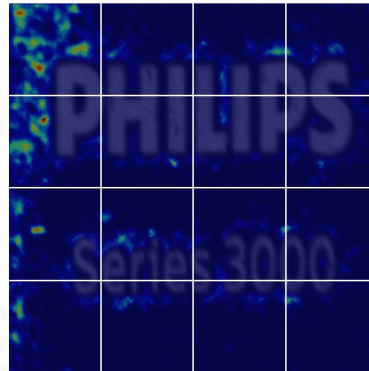


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Use XAI to facilitate the annotation of images and enhance the explanations obtained through explainable artificial intelligence approaches.



- Machine learning models aim to detect defects when presented with a product image
- Explainable Artificial Intelligence is used to understand what does the model look for to determine the defect
- Human feedback can provide valuable information where defects are observed
- Human feedback can provide valuable information how to improve explainable artificial intelligence outcomes

**Use collected information to create adaptive explanations.**

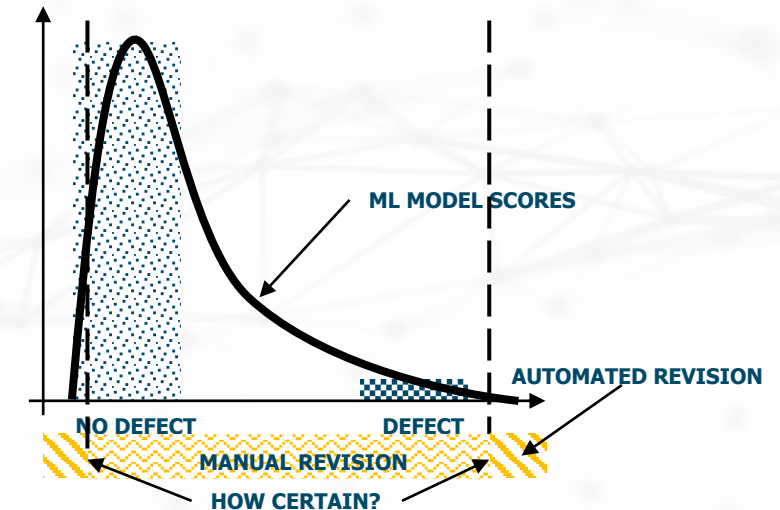
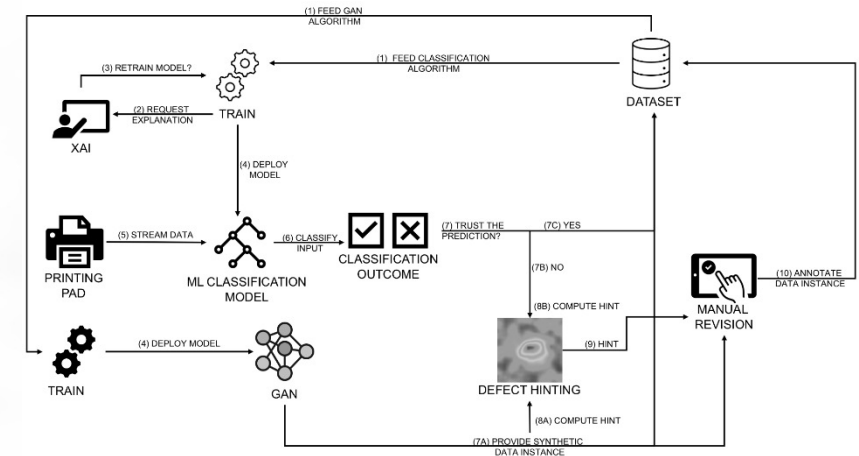
# STAR FOSTERS HUMAN-AI COLLABORATION

## Active Learning for Quality Inspection

- Defect Detection
- Data Labelling

## Active Learning for Fatigue Monitoring

## Active Learning for Cyber Defence



# Example: Quality Inspection and Active Learning

- Changing **job profiles**: Towards Synergies of humans with AI.
- STAR provides an Active-Learning based approach to foster **human – AI synergies**:
  - Interpreting inspection outcomes
  - Labeling inspection image data
  - Correcting AI mistakes
  - Providing hints to operators (training/help)
  - Recognise operators' (cognitive) fatigue
- Benefits:
  - AI and humans **benefit from each other**
  - **Joint** human-AI synergy **outcomes** improved over AI or humans alone
  - Proactively take mitigation actions to enhance the **workers' well-being**

1 Login  
Username  
Enter email  
We'll never share your email with anyone else.  
Password  
Password  
Sign in

2 EXPERIMENTS  
Experiment 1  
Experiment 2  
Experiment 3  
Experiment 4  
Experiment 5

3 Does the current piece have any kind of defect?  
Good sample  
PHILIPS Series 3000  
Current piece  
PHILIPS Series 3000  
Hints on possible defect  
PHILIPS Series 3000  
NO DEFECT DOUBLE PRINT INTERRUPTED PRINT OTHER DEFECT NEXT

QLECTOR

PHILIPS

IBER-OLEFF

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Ljubljana, Slovenia  
University of Applied Sciences and Arts of Southern Switzerland

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Input-image Explanation Explanation



# STAR OFFERS HUMAN CENTRIC DIGITAL TWINS AND OTHER HUMAN CENTRIC SYSTEMS



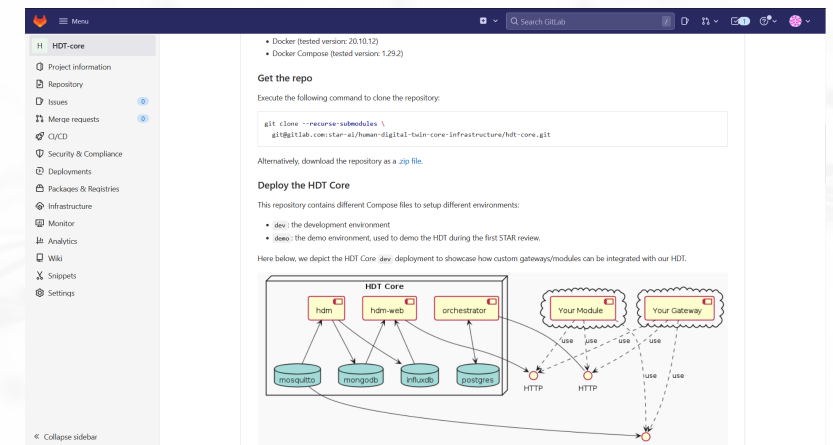
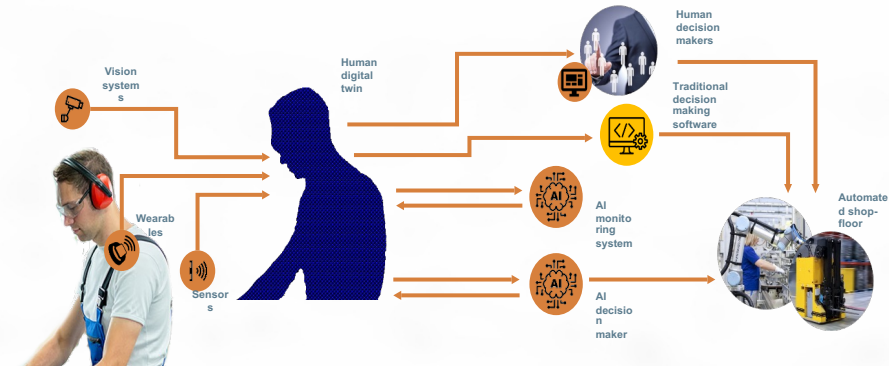
Fatigue Monitoring System,

Worker's Intention Recognition Module

AMR Fleet Optimizer

Safety Zones Detection System

Worker Training Platform



## Applications

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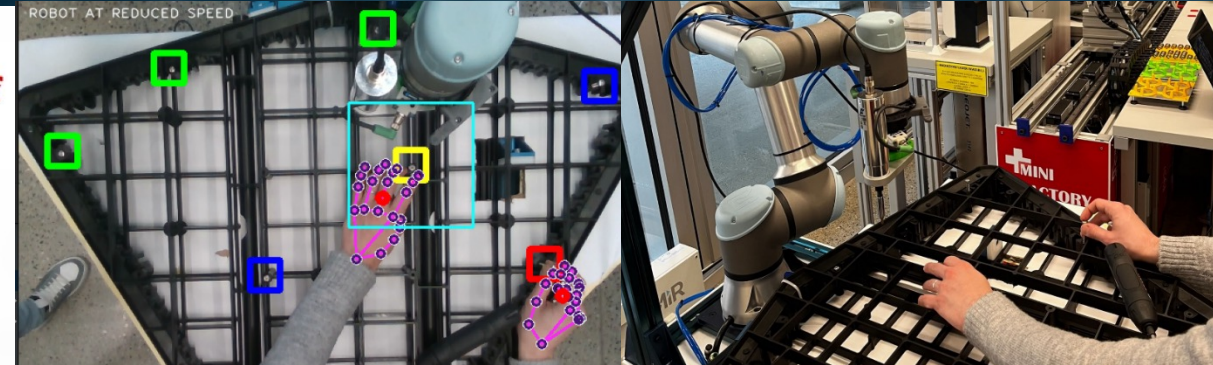
**Motivation:** Most Cobot applications are not fully collaborative (out of ~40 applications we analysed only 3 are collaborative).

**Cause:** System integrators and end-users fail to implement factors like human awareness, training and ethics

**Solution:** Human Digital Twins (HDTs) increase human awareness in HRC systems and model humans, to support simulation, control, decision-making, and monitoring.

**STAR** developed an **extensible and flexible platform** that:

- Supports **customised data representations** (including human data)
- Provides a **modular infrastructure** with interchangeable components for easy instantiation and commissioning.



HDT in  
screwdriving

HDT in machines  
tending



To start the production process, operator activates the COMPLEMENT system, logs in and connects his/her devices.

# STAR Safety: Video Analytics & Reinforcement Learning for Autonomous Mobile Robots (AMRs)



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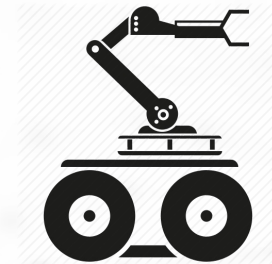
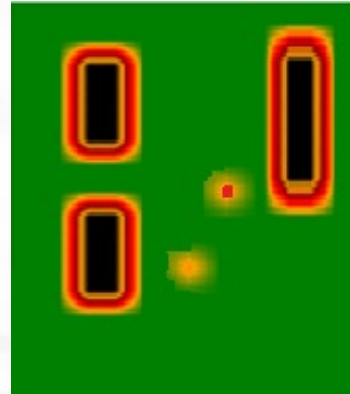
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The goal is to optimize the control a whole fleet of AMRs, taking into account a dynamic environment, in particular human presence, thanks to Video Analytics



From video...



...to robot anticipation

Thanks to:

- ML Video Analytics for humans and objects detection (robotino, and obstacles) / human & robotino localization in real world
- ML for aggregated pedestrians' positions anticipation
- Pathfinding
- RL to avoid collision with anticipated detours



# Workers' Training and Continuous Learning



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Create a Workers' Training/Upskilling System, link to media content and training materials, inform about the platforms and tools developed within the project

## Functionalities (ongoing):

- CV analysis
- Virtual Interviewers (using NLP and voice interaction)
  - Replaces the old Multilevel self-assessment questionnaire
- Chatbot for getting information about occupations
- Training recommendation engine
  - Linked to project and external training materials

## Worker oriented:

- Compare occupations (find similarities)
- Discovering paths, training materials
- Understanding details about current or future occupations (tasks,

**Templates**

**Query Types**

1. Alternate names of jobs
2. [Abilities | Knowledge | Skills | Tasks | Tech-Skills | Tools used | Work activities] that are important or necessary in any job
3. Description of a job
4. The similarities between a couple of jobs
5. Which jobs require a specific [Ability | Knowledge | Skill | Task | Tech-Skill | Tool | Work activity]
6. Recommendations on how to improve one [Ability | Knowledge | Skill | Task | Tech-Skill | Tool | Work activity]
7. Anything on the internet

**Examples of query templates**

1. List alternate names for taxi drivers
2. Tell me other designations for developers
3. List tools for programmers
4. List some skills that actors need
5. Tell me some work activities performed by actors
6. Describe the work of a taxi driver
7. Describe the work of the actors
8. Compare the jobs of pilots and actors
9. What are the similarities between surgeons and nurses?
10. What job requires servers?
11. Which professions require medical masks?
12. Can you teach me something about python?
13. How can I improve my speech clarity
14. When was the web born?
15. When did men land on the Moon?

**Onet Database Entities**

**StarBot**

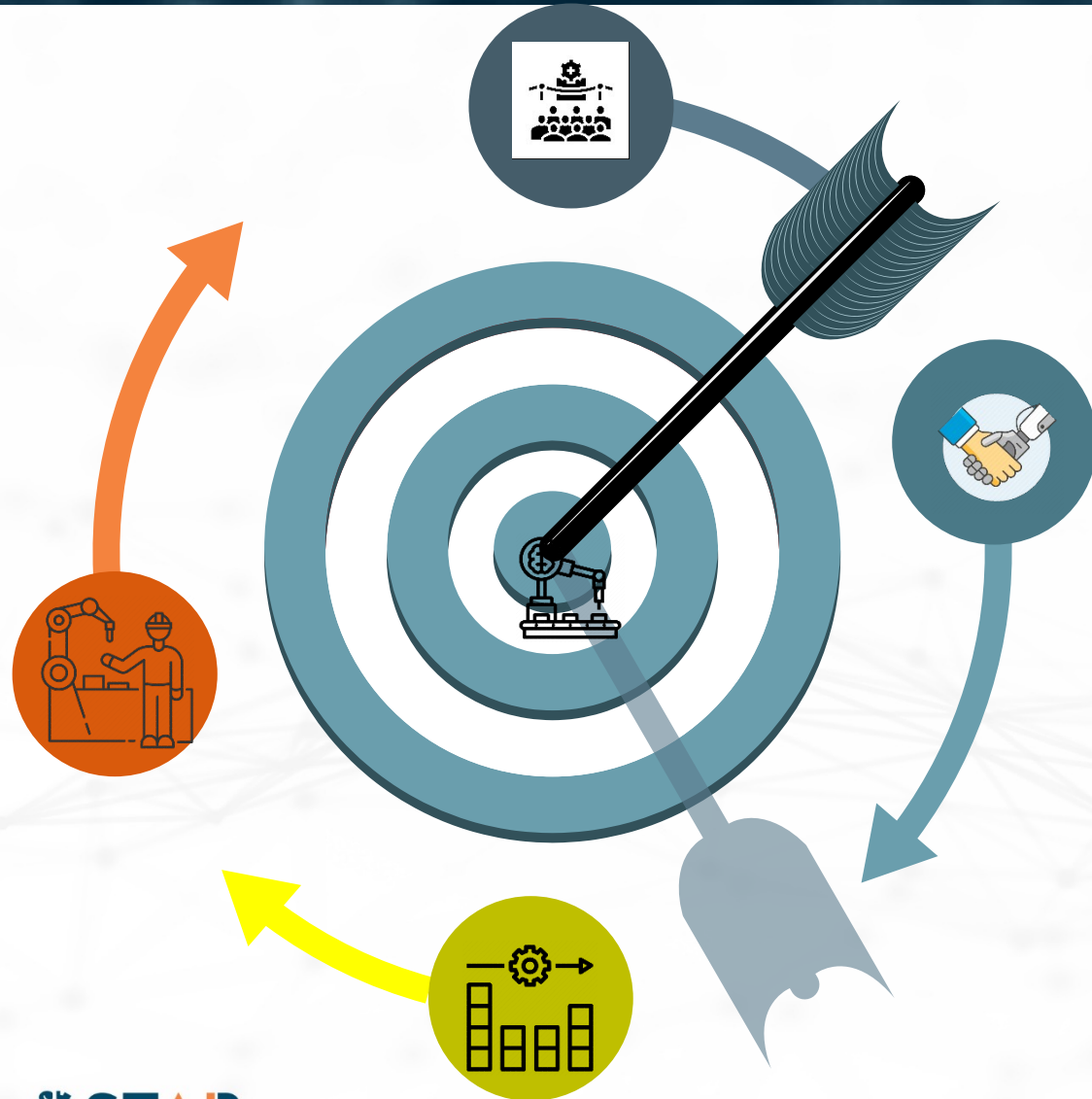
Welcome! I'm StarBot, your personal assistant. What can I do for you?

Tell me other designations for developers

Some alternative names for Developer are: Database Architects, Analytics Manager, Automatic Data Processing Planner (ADP Planner), Big Data Engineer, Cloud Architect, Computer Architect, Data Analyst, Data Architect, Data Base Design Analyst, Data Center Manager



# LESSONS WE LEARNT FROM STAR



## 1. INVOLVE STAKEHOLDERS (FROM THE START)

STAR's Co-Creation Approach; Boost a Cultural Shift in Manufacturing Enterprises

## 2. DESIGN FOR HUMAN-AI COLLABORATION

Humans remain the most flexible resource; Design AI models that benefit from their ability, rather than replacing them (e.g., Active Learning, HDT)

## 3. DATA IS NEVER PERFECT & NEVER ENOUGH

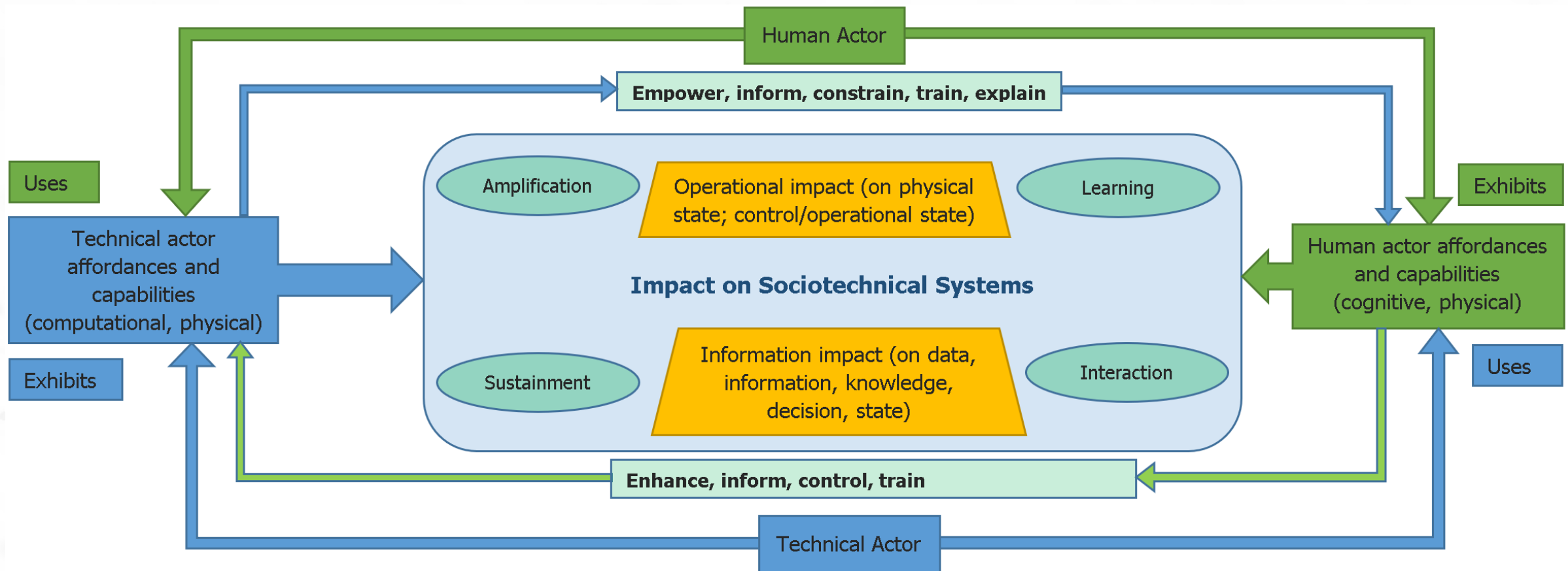
Ensure data quality; Try to be Data Efficient; Design resilient and unbiased systems

## 4. CONTINUOUS TRAINING, SKILLS DEVELOPMENT AND SUPPORT

Workers, Managers, Operators must be all confident to use and fully leverage the AI technology

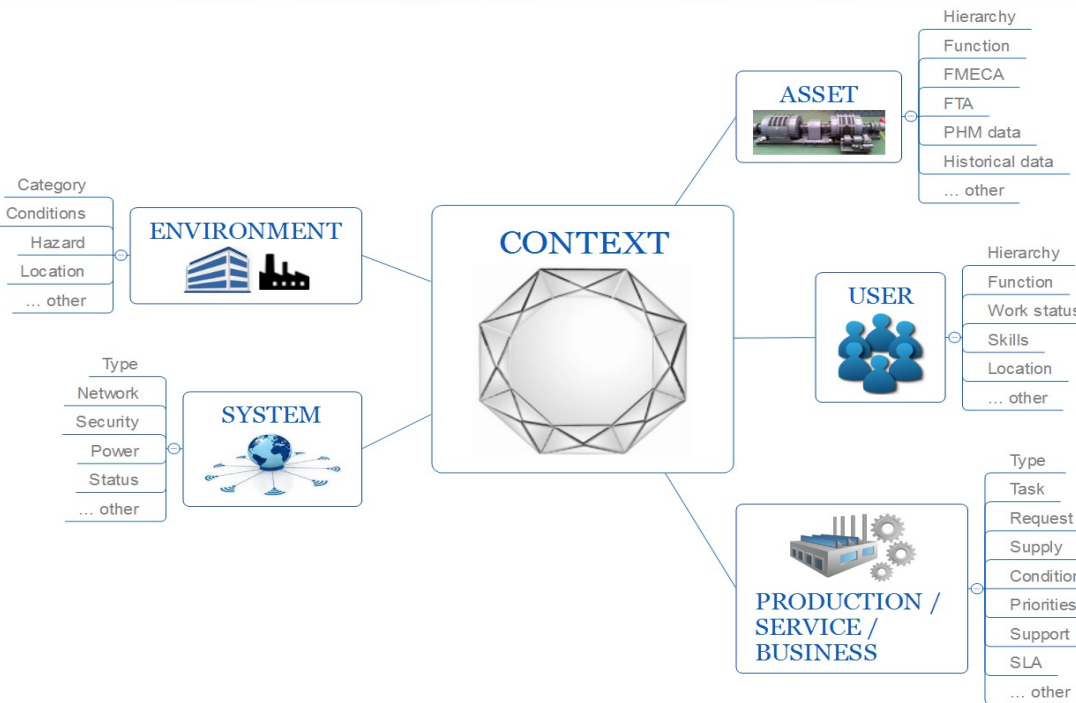
# LESSONS ON HOW TO DELIVER HUMAN-CENTRIC AI

Human – AI synergies deliver more than the sum of individual parts

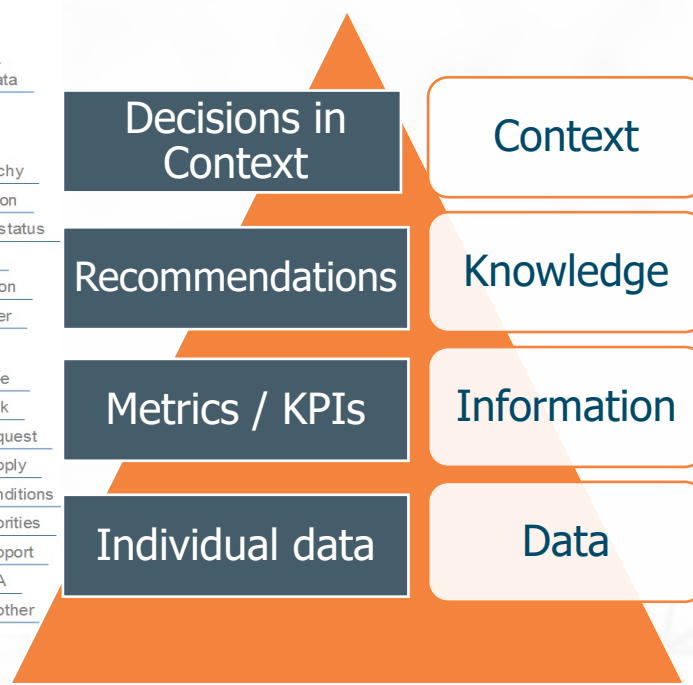


# LESSONS ON HOW TO DELIVER HUMAN-CENTRIC AI

## Use Data in Context



## Enhanced value



Production machinery quality affects performance of finished part; production load at maximum limit for several weeks; changed supplier of parts a few months ago; order to be delivered within 2 weeks; avoid production interruption is possible with advance context-based action

Perform inspection within a week

Data indicates throughput drops below average and production machinery quality deteriorates faster than expected

Data taken on a specific date, location/production asset, production throughput of specific line is calculated

D1	2018:7:23:12:01	577.5	1	0.123
D2	2018:7:23:12:02	574.3	0	0.099
D3	2018:7:23:12:03	568.1	1	0.021
D4	2018:7:23:12:04	564.7	1	-0.012
D5	2018:7:23:12:05	543.2	0	-0.055
D6	2018:7:23:12:06	548.1	1	-0.132

# PUBLISHED AND UPCOMING BOOKS

## Open Access Books

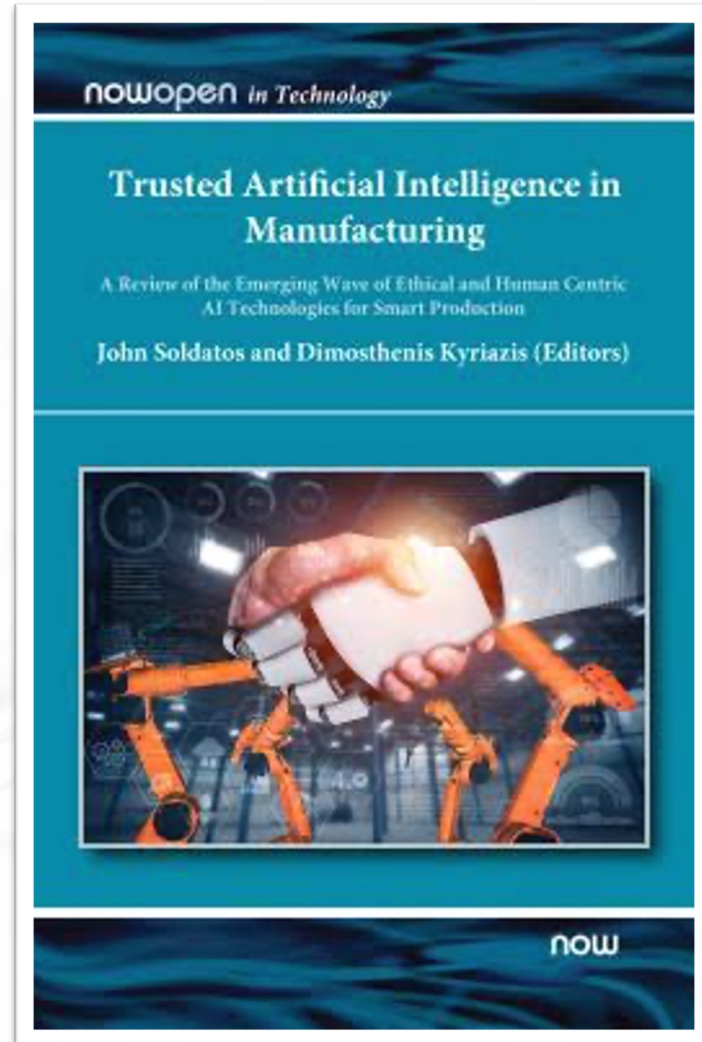
- Published: Trusted AI in Manufacturing (STAR Book) (>40000 downs)
- Upcoming: "AI in Manufacturing", AI4Manufacturing Cluster Book, to be published by Springer Nature, Q4 2023



### AI in Manufacturing: Enabling Intelligent, Flexible and Cost-Effective Production Through AI



**AI4MANUFACTURING**





# QUESTIONS?

