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Manufacturing Technologies
for Europe's Prosperity

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Outline

- Manufacturing at the Core of Europe's Prosperity
- Manufacturing Levels & Technologies
- The Dual/Common Use opportunity
- Key takeaways

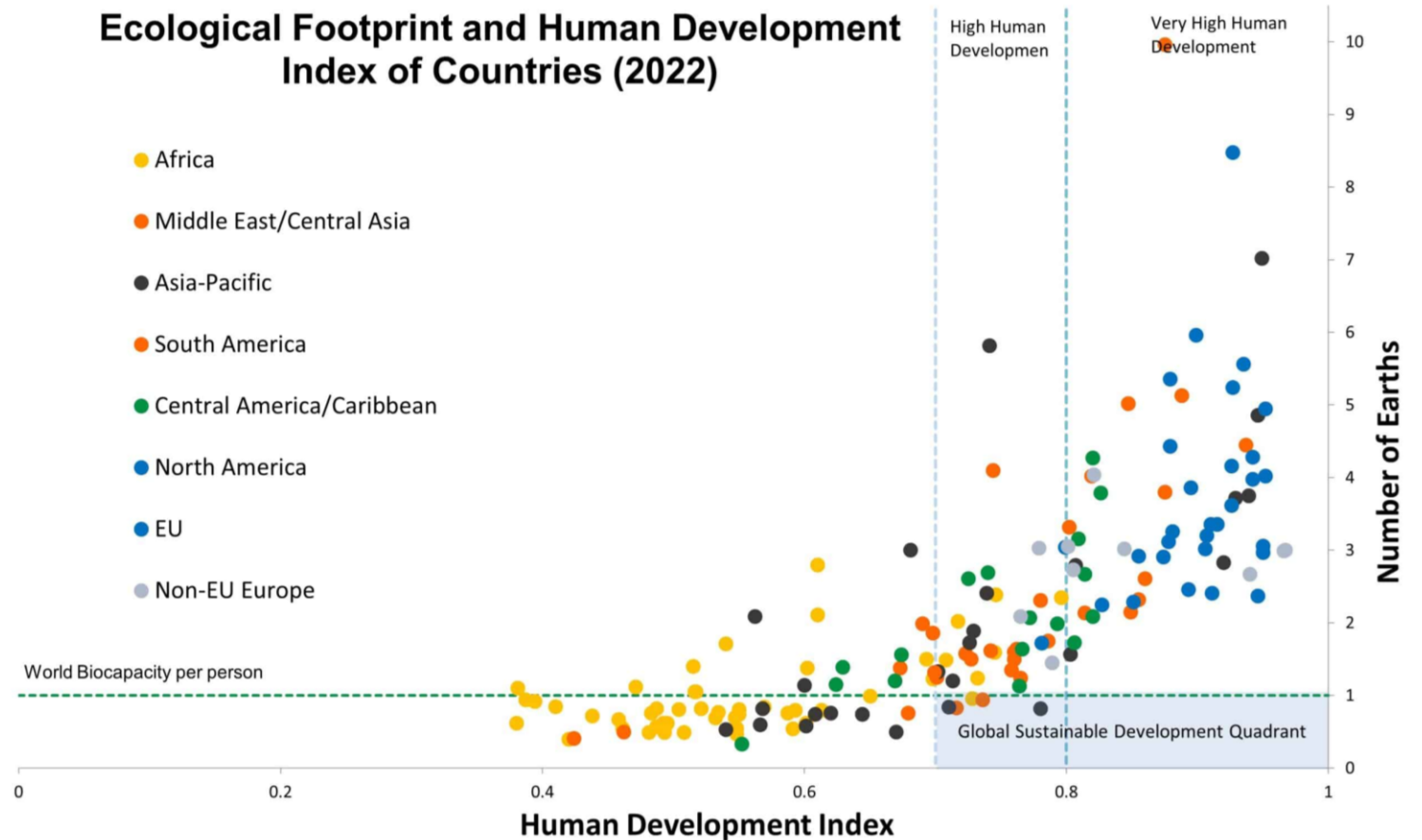
The **UNDP** framework shows a relationship:

- Human Development Index (HDI) - quality of life.
- “Earths used” - resources needed to sustain it.

Manufacturing is key

- it enables us to produce more with less through innovation, circularity, and efficiency.

Ecological Footprint and Human Development Index of Countries (2022)

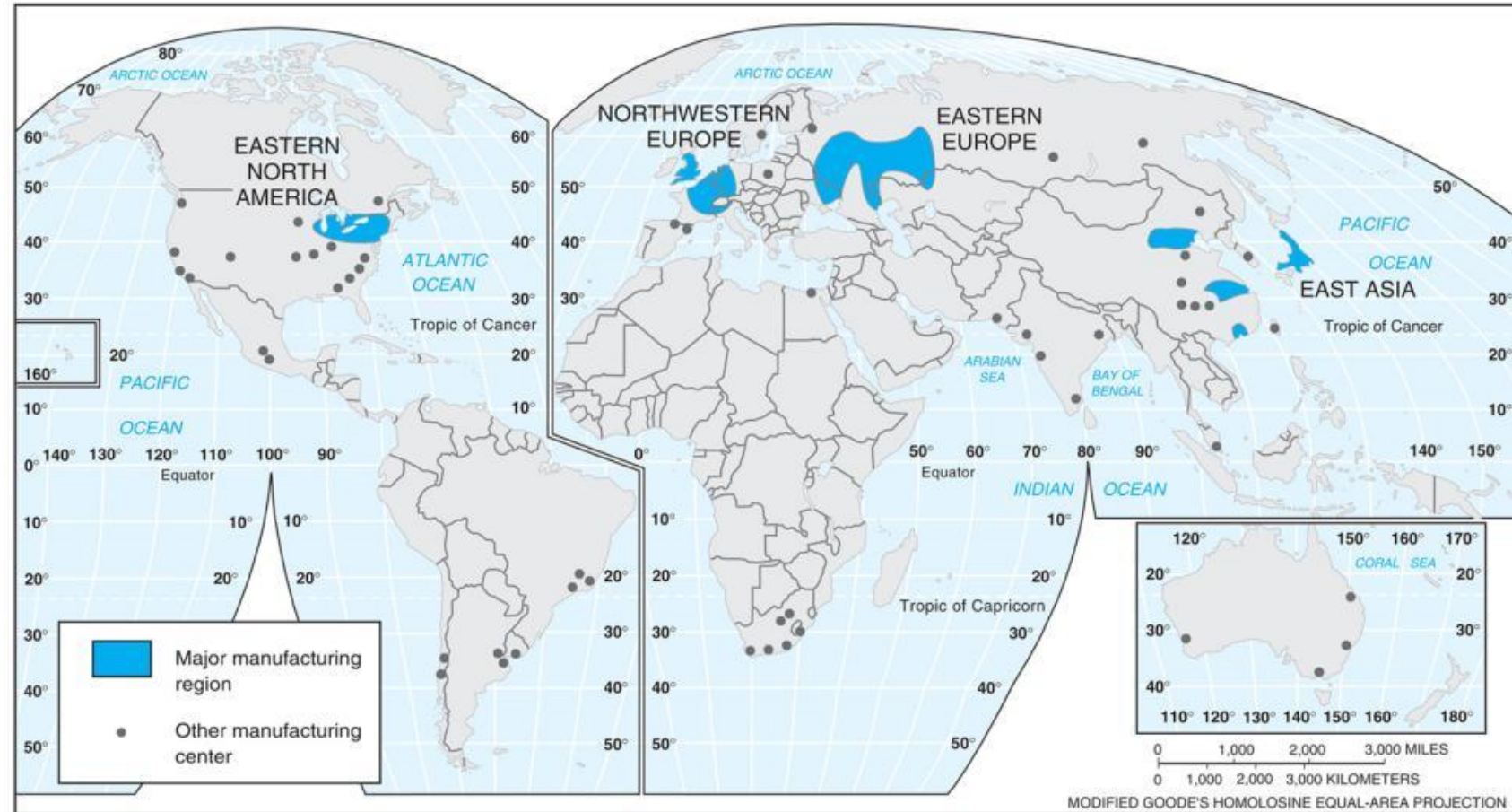


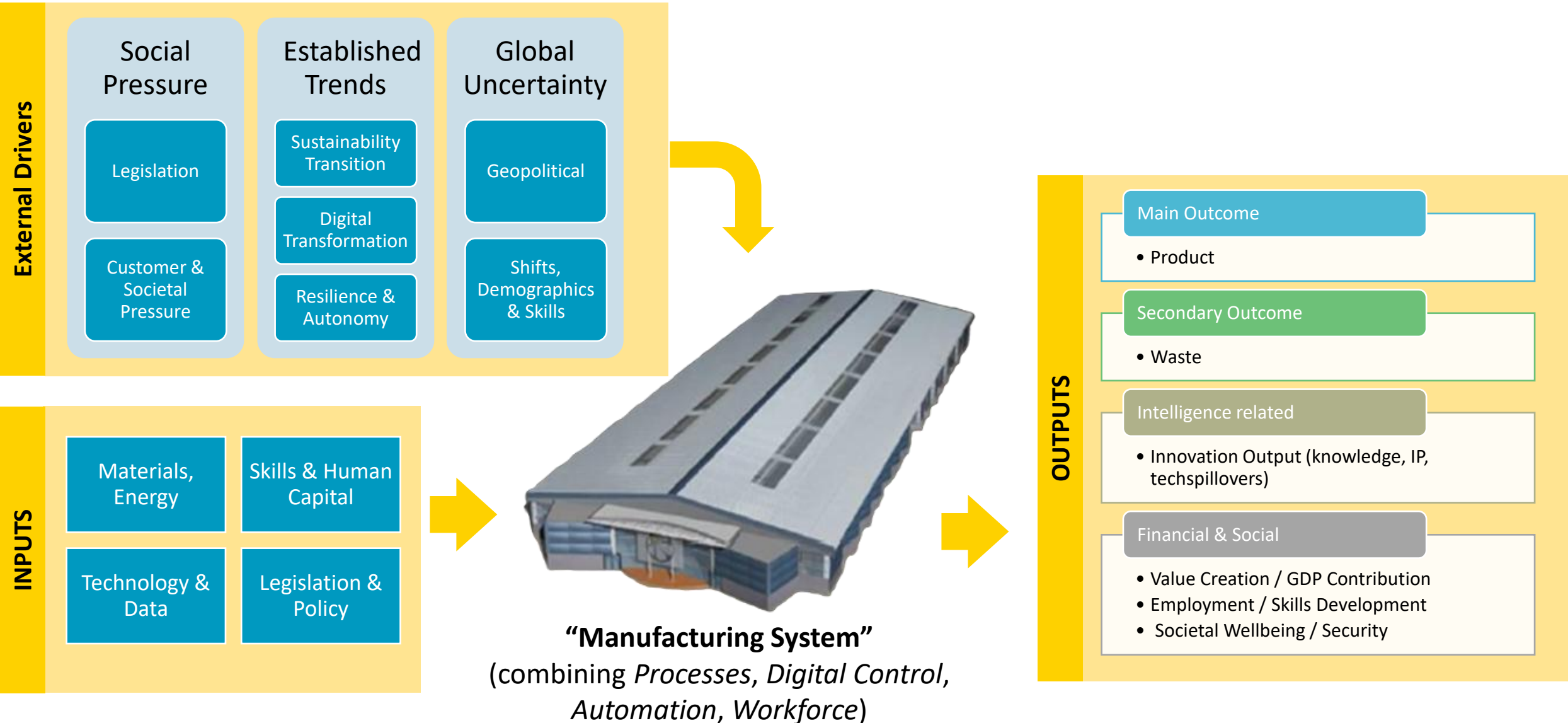
Source: Ecological Footprint: York University Ecological Footprint Initiative & Global Footprint Network. National Footprint and Biocapacity Accounts, 2025 Edition. Human Development Index: Human Development Report, 2025, UNDP.

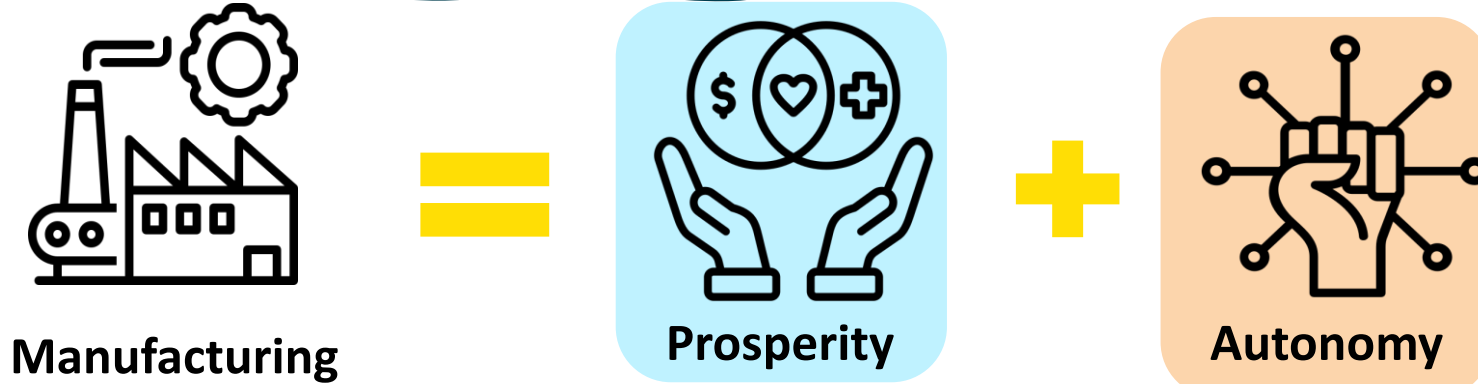
“very few countries come close to achieving these basic conditions for global sustainable development”

Manufacturing is a Global Game

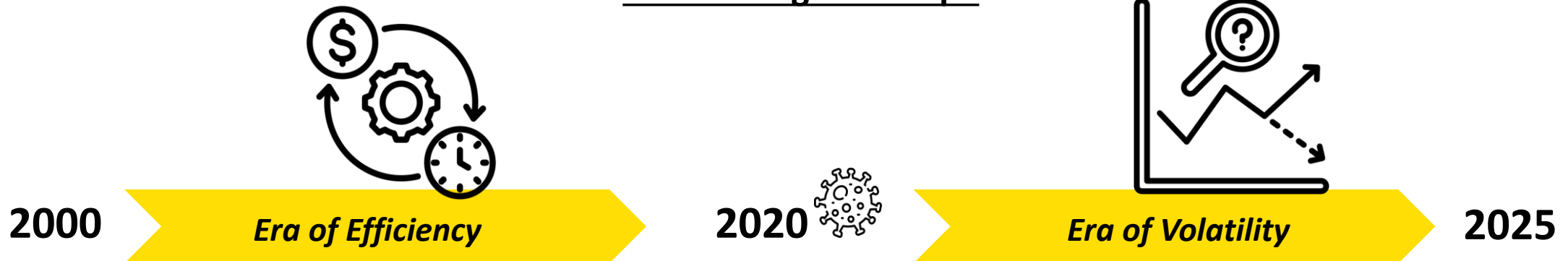
- Industrialized world
- Commodities
- Contributes to well being







An evolving landscape



To stay competitive, Europe must manufacture **faster, smarter, and greener** — shifting from **efficiency** to **resilience and strategic autonomy**.

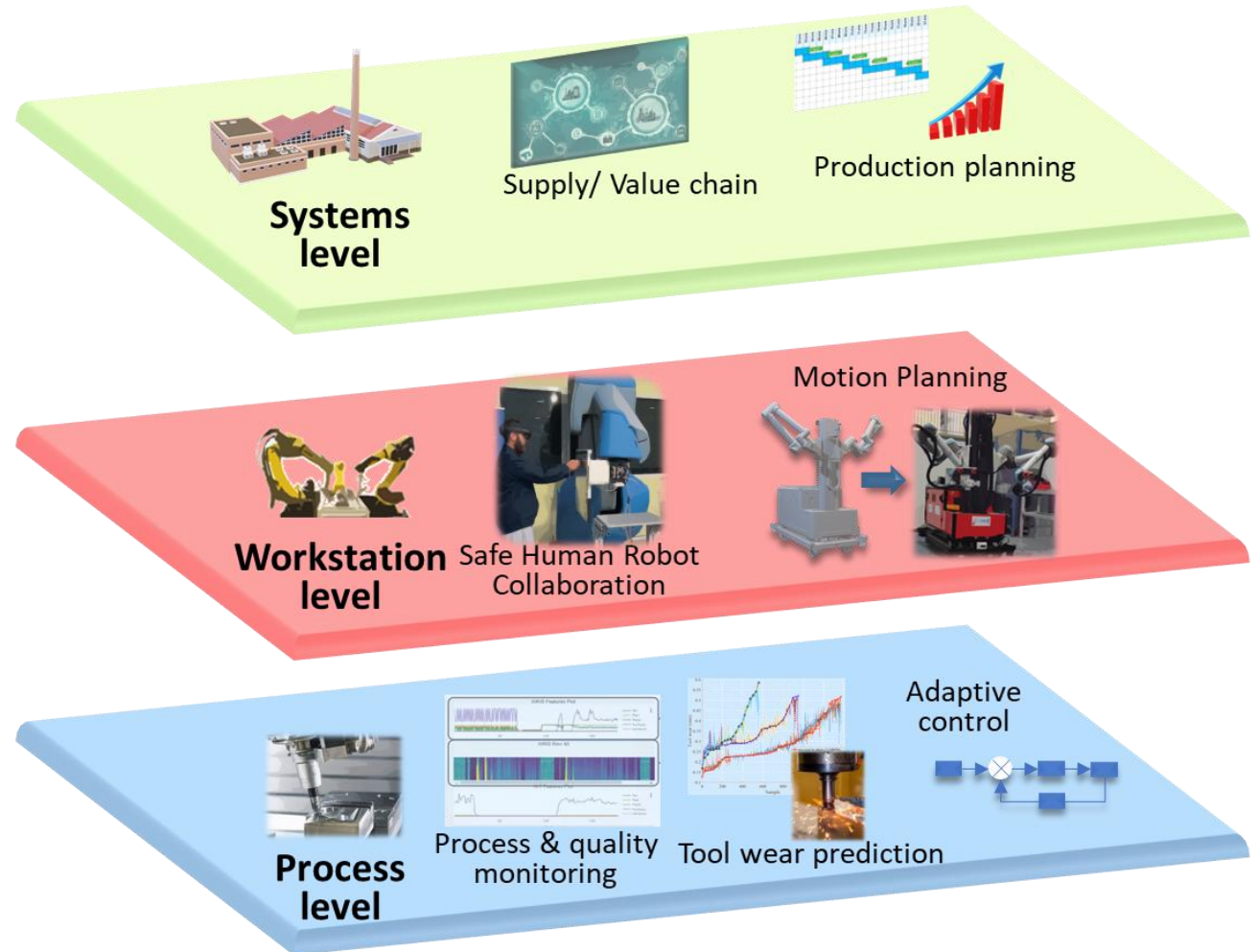
Manufacturing Research and Technologies

Three levels:

- Process – The Foundation
- Robotics & Automation – The Enabler
- Systems – The Integrator

Conceptual modelling

- Facilitating optimization
- Communicating with each other heavily





Scalability and agility/resilience — crucial for quick time-to-market, high productivity and EU safety.



Sustainable production: multi-purpose machines that can be reconfigured to serve different purposes



Consistent quality and traceability across complex value chains



Configurable level of human engagement: undertaking difficult tasks while leaving space for human craftsmanship and ingenuity



Competitiveness will strongly depend on how fast Europe can **industrialize digital and AI enabled robotics and automation**

EU Strengths:

- World class R&I in manufacturing (process, workstation, level)
- Instruments for advancing robotics R&I already in place (HE, EFFRA, ADRA, EIT-M)
- Leadership in collaborative robotics, machine perception, DTs, operations optimization, processing twinning and safety standards
- Human centric automation

Gaps:

- Lack of pan-European deployment strategy
- Limited industrial data sharing
- Slow / overly complex / over restrictive standardization
- Uneven distribution of key technological competences around Europe



Robots



AGVs



Automation



Humans



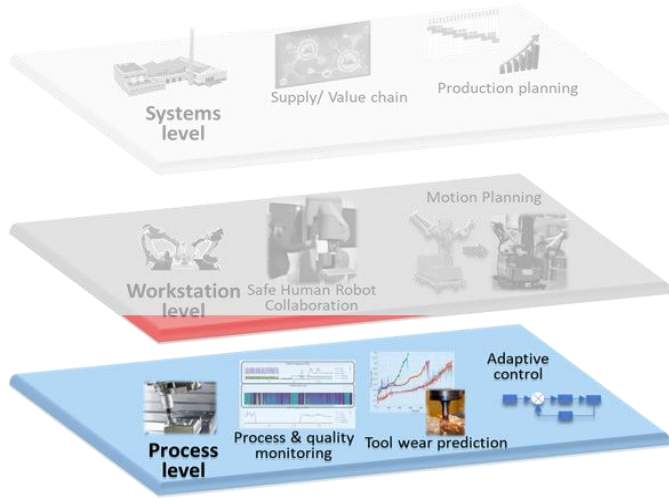
Sensors



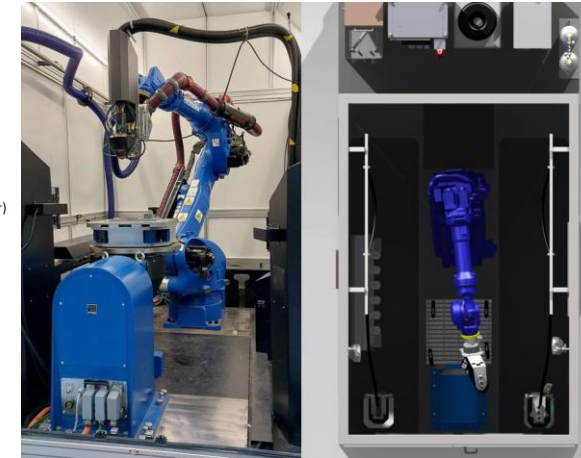
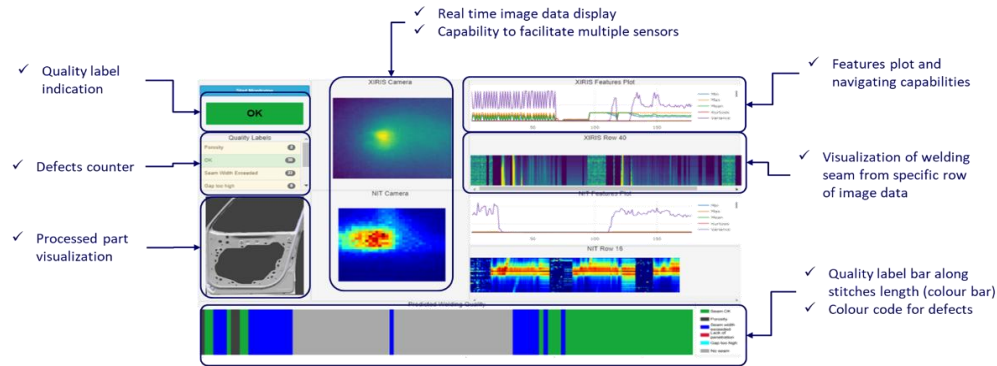
Digital Tech.

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Process level – The foundation



Stavropoulos, P., Papacharalampopoulos, A., Stavridis, J., & Sampatakakis, K. (2020). A three-stage quality diagnosis platform for laser-based manufacturing processes. *The International Journal of Advanced Manufacturing Technology*, 110(11), 2991-3003.



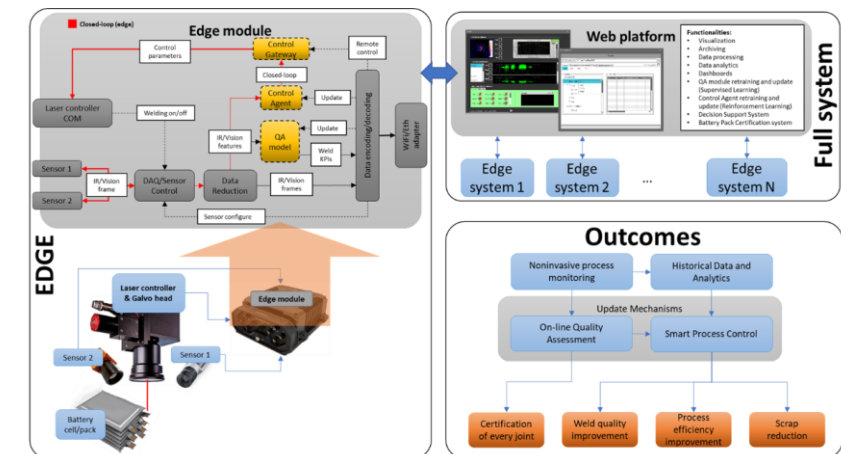
Stavropoulos, P., Papacharalampopoulos, A., Athanasopoulou, L., Kampouris, K., & Lagios, P. (2022). Designing a digitalized cell for remanufacturing of automotive frames. *Procedia CIRP*, 109, 513-519.

Key Enabling Technologies

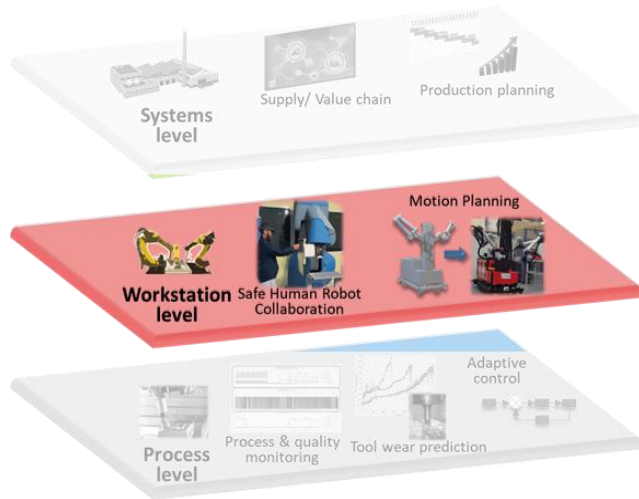
Flexible & adaptable manufacturing processes	AI-driven optimization towards zero-defect	Unused data
Skills & human centric approaches	Material & process integration for sustainability	AI-driven design for circularity
	Digital security & traceability	

Research Challenges & Priorities

Zero-Defect and Adaptive Manufacturing	Sustainable Process Integration
Traceable and Trustworthy Data	Human-Machine Synergy



C. Gkournelos, C. Konstantinou, S. Makris, "An LLM-based approach for enabling seamless Human-Robot collaboration in assembly", *CIRP Annals – Manufacturing Technology*, Volume 73, Issue 1, pg. 9–12, (2024)



Key Enabling Technologies

AI & Robotics Cognition	Collaborative workplaces design	Novel industrial & collaborative robotics
Digital Twin enabled planning and control	GenAI for perception & interaction	AI/ XR for Upskilling & Reskilling

Research Challenges & Priorities

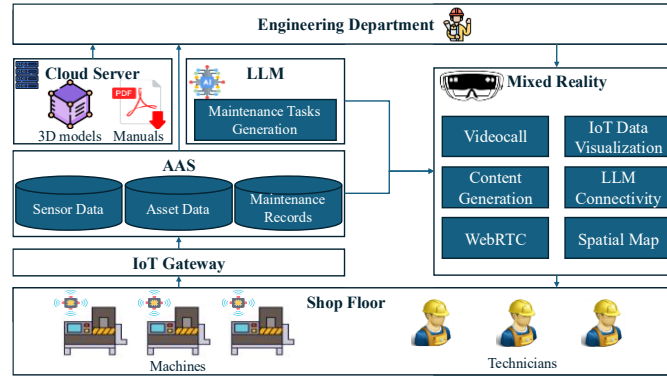
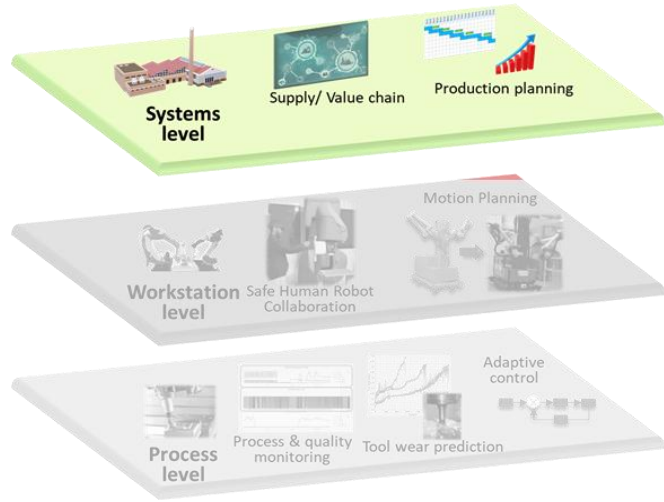
Financially Viable & Scalable Automation	Sustainable & Resource-Efficient Robotics
Deploy trustworthy, cost-effective systems integrating AI, robotics, and data spaces.	Leverage automation to reduce waste, energy, and resource use.

Dimosthenopoulos, D., Basamaklis, F. P., Glykos, C., Bavelos, A. C., Mountzouridis, G., & Makris, S. (2024). A Digital Twin-based paradigm for programming and control of cooperating robots in reconfigurable production systems. *International Journal of Computer Integrated Manufacturing*, 1-21.

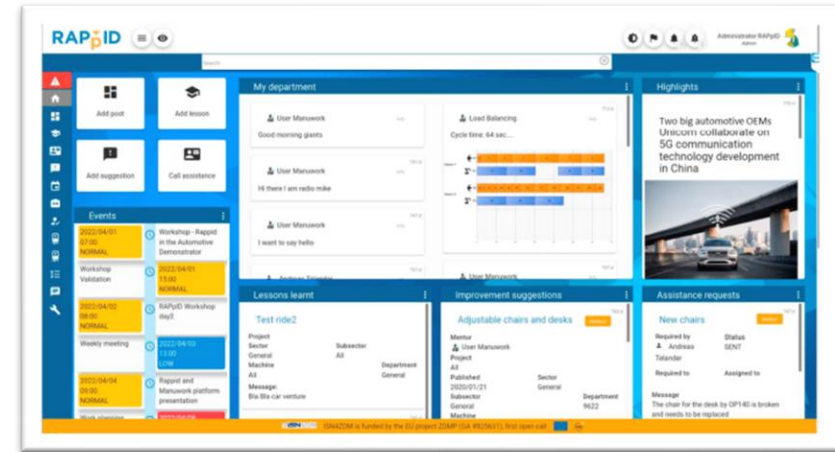


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Systems Level – The Integrator



Alexopoulos, K., Tsoukaladelis, T., Dimitrakopoulou, C., Nikolakis, N., & Eytan, A. (2023). An approach towards zero defect manufacturing by combining IIoT data with industrial social networking. *Procedia Computer Science*, 217, 403-412.



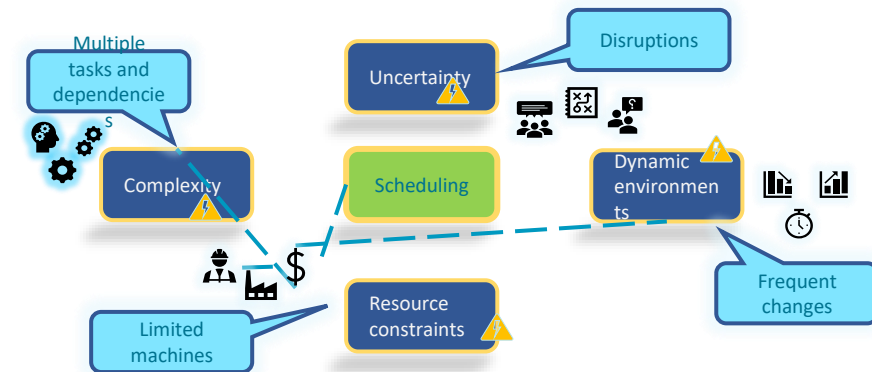
Chrysolouris, G., Alexopoulos, K., & Arkouli, Z. (2023). A Perspective on artificial Intelligence in Manufacturing (Vol. 436, pp. 1-135). Cham, Switzerland: Springer.

Key Enabling Technologies

Simulate & optimize scheduling / supply chain management	Digitalize and Networking of agents	Human Inclusion in decision making
Manage Maintenance and enhance traceability towards Zero Defect	Augment Workforce	Connect to and utilize dataspace
	Federate workflows and link to business aspects	

Research Challenges & Priorities

Systemic Integration and Interoperability	Cognitive and Resilient Decision-Making Systems
Data Sovereignty and Trusted Collaboration	Sustainable and Adaptive Value Networks





- Resilient, reconfigurable production systems
- Digital twins for process & asset adaptation
- Dynamic reconfiguration of factories & supply chains
- Interoperable data layer via AAS



- Data spaces for resilient manufacturing networks
- Dynamic reconfiguration of production ecosystems
- Resilience assessment & decision-support tools
- Secure, sovereign data exchange based on Gaia-X



- Zero-defect manufacturing through open platform
- AI-driven process monitoring & adaptation
- Digital twin-based reconfiguration of production lines
- Energy- and waste-efficient resilient processes



CONVERGING



- Smart, reconfigurable cyber-physical production systems
- AI enabled multi-level cognition
- Human robot collaboration
- Advanced Digital Twins



- Flexible robotic manipulation
- AI-driven advanced control & perception
- Workforce-centered design
- Rapid reconfiguration for new product variants







- AI-driven diagnosis & classification
- Digital infrastructure & Digital Twin for remanufacturing
- Flexible robotics & human-centric production modules
- Resource resilience

Sustainability equals Security

Embedding Dual/Common Use Resilience in European Manufacturing:

- ✓ Cross-cutting tech (digital twins, AI-predictive, circularity) boosts **BOTH** efficiency & security
- ✓ Design for common-use at **technology level** – not product level
- ✓ Circular supply chains cut import dependence & **reinforce sovereignty**

Key Enablers

-  Secure digital manufacturing networks
-  Modular / reconfigurable production for rapid response
-  Advanced process control towards high-precision & zero-defect
-  Closed-loop supply chains recovering critical materials & reducing dependencies

Common-use is a resilience agenda, not a defense agenda!

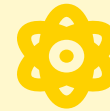
Coordinate EU research with defence R&I—leverage synergies without merging agendas.

Manufacturing at the Center



Manufacturing should be the horizontal layer binding all sectors, acting as Europe's security backbone

Integrated R&I agenda is Key



Research must integrate processes, robots, and systems to deliver technologies that are sustainable, resilient and sovereign

Security through Efficiency



Resource efficiency, circularity, and resilience can make Europe safer by shielding it from external shocks

Invest in Skills



Human capital must evolve with technology — skills for digital, green and resilient manufacturing are strategic assets

Bridging civil and, where relevant, defence needs is crucial for a resilient future.



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