MADE IN EUROPE

Priorities in relation to the Strategic Plan and the Horizon Europe Work Programme 25-27

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Made in Europe and inclusive productivity: doing better (creating more added value) with less.

European Industry and society is facing many challenges:

- Manufacturing value networks need to operate in a context of open strategic autonomy, lowering the dependence on other international regions, while continuing to operate competitively in a global market.
- Increasing scarcity of natural resources and the urgent need to stop climate change and achieve net-zero industry requires that industry is capable of rising productivity with less input (material, energy).
- The demographic evolution, leading to less people entering the job market, and the need competence shifts that are taking place in manufacturing, increases the need for highly resource-efficient manufacturing automation and physical as well as cognitive augmentation of humans.
- Limited financial resources and increasing costs pushes industry to innovative quickly and efficiently, both from the technological as from the business perspective.

This context requires strong investments in research, development and innovation in Europe.

The Made in Europe Partnership is addressing these challenges by exploiting the opportunities offered by emerging and maturing technologies, new business models and growing markets – such as the green tech sector – and by building on the strong European Manufacturing Ecosystem that the Partnership has been developing over the past years.

This document describes how these ambitions translate into priorities for the Made in Europe Partnership for the Work Programme 25-27.

Excellent productive and flexible Manufacturing automation for open strategic autonomy

- Manufacturing engineering and time-to-market of manufacturing products will be shortened by factory automation approaches, from order processing automation to the automation of difficult-to-automate-processes, in particular for high-mix low-volume production, supporting workers, technicians, engineers and developers.
- Productivity will be increased in high quality manufacturing, both on the shop floor and in engineering/business processes, addressing the UN Sustainable Development Goal 8 “Sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all”.
- ‘Zero-X’ smart manufacturing approaches and capabilities will be developed and deployed across value networks.

Sustainable value network resilience and competitiveness through robust and flexible production technologies

- Faster and more collaborative product-process design and innovation is required to keep up with global competition. In order to obtain robust, resilient and competitive value networks, the manufacturing ecosystems require data spaces with standardised data formats for the exchange of design, manufacturing, logistics and other (digital twin) product/component data to allow for real-time deep-chain planning and control for logistic information and design modifications.
- Artificial Intelligence and digital twins need to support trusted decision making by humans when reallocating manufacturing capabilities within the factory or along the value network. This includes the quantitative assessment of resilience (KPIs).
- Complex manufacturing challenges and unforeseen disruptions need to be addressed with the rapid reconfiguration and deployment of flexible production systems while assuring digitally enabled compliance to quality and value network standards, achieving robust performance. The logistics aspects (planning, delivery...) as well as production engineering aspects need to be addressed.

Recovering and preserving the European leadership in strategic and high value added products

- Europe needs to increase the knowledge and manufacturing capabilities to design and produce sophisticated and high quality products that are essential for the European economy and society. This includes in particular products that are key for sustainable and renewable energy generation and storage, such as solar panels, batteries, hydrogen solutions, e-fuels solutions, sustainable mobility, wind energy solutions and critical machinery components that save energy consumption.
- While operating in synergy with initiatives that focus on the design and engineering of such (green-tech) key products and solutions, the Made in Europe Partnership will focus on key manufacturing technologies that Europe needs in order to be a manufacturing leader in strategic sectors.
- All levels needs to be addressed: process, machine, production line, plant and value network level, product design, covering material shaping and processing as well as advanced automation and digitalisation approaches, including re-manufacturing capabilities and digital product passport implementation.

Circular, connected manufacturing ecosystems

- The new circular economy will need to be underpinned by innovative business models and servitisation approaches where industrial actors establish solid and sustainable partnerships. This adds an additional dimension to the need for realising resilient value networks, where reusing and remanufacturing of components and resources will be both a key capability in view of achieving open strategic autonomy and environmental sustainability. The value network dimension of circular economy also has a strong logistics component, where the ecological impact of transport will also need to be considered.
- The realisation of circular economy requires not only the physical collection, disassembly and re-manufacturing of products and components, it also requires the collection and sharing of product data along complex value networks, including digital product passport and digital twin implementations as well as the connection to data spaces.
- Setting up circular manufacturing value networks is a complex process. Decision-making regarding the routes that used products and components need to follow across a circular value network, requires support from digital decision-making solutions and quantitative assessment of sustainability KPIs combined with advanced equipment, including for instance advanced vision systems, scanners, etc.

The next level of circular economy through scalable, highly productive and zero-defect re-manufacturing technologies

- The transition to circular economy on an industrial scale needs to be accelerated by realising the repair, reconditioning and transformation of products into new ones. The first and preferred option is to retain or even upgrade the function and the value of a product or system along its life-cycle and make the circular loop as short as possible, before opting for instance for material recycling routes.
- This transition requires the development and deployment of a range of innovative and automated de- and re-manufacturing operations, including the physical collection of products, disassembly, separation and sorting. These operations are shaping a new circular manufacturing and business eco-system, establishing a new economy, creating innovative business cases.
- Products need to be (re-)designed for remanufacturing: modular design, design for remanufacturing needs to be reinforced from the beginning. However also the co-existence of actual and future products needs to be supported, requiring for instance mixed model assembly, where the complexity is increasing.
- Along the manufacturing/re-manufacturing operations, information about what has happened with products along their extended lifetime needs to be collected. Measurement and inspection approaches need to assure high quality, traceability and compliance with quality standards.

Manufacturing with new/ limited raw materials availability

- Manufacturing industry needs to find alternatives for materials that are either scarce or that have a high ecological foot or handprint along their lifecycle. Manufacturing industry also needs to be capable to integrate recycled materials into their production processes. Highly productive recycling processes and value chains need to be put in place or need to be further developed in order generate recycled materials in a sufficient volume and with a sufficient quality. Also, industry needs to optimise and minimise the use of materials along the manufacturing process chains (which is also associated to the scope 3 reductions of emissions).
- Addressing these challenges, require re-defining the operation of manufacturing processes, machines and production lines and the development of innovative manufacturing processes in order to produce (new) products based on new or recycled materials. Integration of product design and manufacturing needs to be strengthened.

Solutions for energy-efficiency for realising net-zero discrete manufacturing processes and value chains

- As described above, European manufacturing industry can play a strong role in achieving a net-zero industry/society through producing green-tech products and systems as well as by realising circular economy (The production of green products can be allocated to scope 3 emissions). In order to increase resilience to strong fluctuations in energy prices and energy supply variations/disruptions, European manufacturing can address more elements of reducing scope 1, scope 2 and scope 3 emissions, through:
    - Reduction of the use of fossil fuels in manufacturing (scope 1)
    - Reduction of the electric energy consumption by manufacturing (scope 2)
    - Adapt to the use of renewable energy in manufacturing (scope 2)
    - Replacement of materials that require a lot of energy in the production phase (scope 3)
    - Waste reduction in manufacturing (scope 3)
    - Reduction of water or other technical fluids consumption (scope 3)
- This involves the following approaches:
    - Standardised monitoring of energy-consumption and CO2-emissions in manufacturing sites and value chains, KPI measurement and management
    - Optimal scheduling (minimize heat waste, demand flexibility), waste heat reduction approaches, power consumption predictability (energy digital twin of production)
    - Optimization of energy and CO2-footprint in supply chains (supply security, costs, sustainability, flexibiity, value-chain integration). This involves energy storage/recovery in production environments. Industries thar are more integrative within an industrial ecosystem and also city infrastructures (water, electricity, oil/H2, etc.) into a sustainable and green ecosystem.

  - Supporting the use of renewable energy, by for instance on-site production of renewable energy or use of DC in industrial production.

Quick response service deployment for maintaining optimal manufacturing operations using trusted AI and digital twins

- Manufacturing equipment or associated service providers need to provide continuous support to manufacturing companies in obtaining the best possible performance from their manufacturing assets, even in changing conditions (such as deviating characteristics of materials).
- The continuous optimal use of manufacturing assets needs to be addressed from the manufacturing process level up to the workplace and factory level, requiring the development and integration of digital technologies for quality control, machine/artificial/computing vision for autonomous/predictive quality and advanced prognostics, including energy consumption management.
- “Virtualization” and “Dematerialisation” using next generation sensors, digital twins and artificial intelligence will support virtual commissioning, repair and maintenance, while reducing the need for “physical” fine-tuning and on-site interventions.

Life-cycle management of manufacturing solutions and associated services for flexible, productive and sustainable manufacturing industry

- Manufacturing systems are progressing along the transition towards circular economy. Key components of manufacturing systems (such as electrical motors or control systems) also are part of the circular economy industrial ecosystem.
- In the meantime, the ongoing servitisation trend where manufacturing companies deploy manufacturing equipment as a “product-service” increases the creation of long-term partnerships between manufacturing system providers and manufacturing companies, associated to the application of innovative business models.
- Services can be associated to the modification of the behaviour of machinery, repurposing, reconfiguration, customising, energy efficiency... and the integration in the manufacturing process and equipment in the work flow of the manufacturing company.
- While services can have a ‘short-term’ component (as described under the priority ‘*Quick response service deployment for maintaining optimal manufacturing operations using trusted AI and digital twins*’), there is also a longer term component, where the full life-cycle orientation includes circular aspects of the manufacturing system
- These services and the associated enabling technologies are evolving along the (extended) lifecycle of these manufacturing systems.

Data spaces and cloud/edge solutions for responsive and robust manufacturing

- The exchange of data and the manufacturing data spaces will be one of the most important drivers for progress in manufacturing supporting smart factories in sharing data with other factories and organisations such as service providers, supporting better and faster decision making. Even if related calls will take place in Digital Europe, activities should be closely coordinated.
- Crucial is the delivery and diffusion of open standards enabling the wide digitalization of industry from design to manufacturing and (remote) services, considering the manufacturing industry fragmentation with a large % of SMEs.
- Manufacturing Data spaces should feature: openness, decentralization, sovereignty, interoperability, scalability, transparency, integrity, security and trusted data exchange, technologies to secure data sovereignty, low latency and improved data economics (for example through "Edge AI")
- IT/OT convergence should be addressed, connecting different systems and levels:
  - Hardware tools (sensors, Cyber Physical Systems, smart mechatronics, cognitive robotics)
  - Digital tools (data analytics, AI, distributed ledger technology, digital product passports for tracking along lifecycle, IoT, fog/edge/cloud, Asset Administration Shell, standardised ontologies and semantics ...)
- Hybrid digital twins, multidomain modelling & simulation (digital twins at factory automation levels) will support optimisation across the life cycle of manufacturing assets.

Digitally enabled compliance and integration of innovative manufacturing solutions

- Industry is progressing with the development and production of digitally enabled products and systems. Supply chains are transforming to digitaly supported flexible and collaborative value networks. However there is still an analogue approach to getting manufacturing products on the market requiring certification and compliance to regulation.
- Digitally enabled certification/qualification of processes will save resources and will drive the uptake on new production technologies. This applies to several situations that include not only quality and fit for purpose of a specific manufacturing system, associated manufacturing services and the manufactured product, but also circularity of products and systems.

Understanding the transformation of the factory work and organisation

- A number of technologies as for example AR, VR, human-robot cooperation, advance HMIs were developed, demonstrated and tested during the past years and these developments should continue.
- However, there is a need to speed up the technology uptake and speed up the change with actions that focus on the transformation of the way of the work itself.
- The transformation of manufacturing jobs should be observed (the operation of equipment, planning, quality control, maintenance, engineering, etc...) including manufacturing innovation/design/development processes and ways of collaboration inside the companies and/or networks.
- There is a need to identify how the technology has changed the work (and the associated job profle and if/how the workplace became more attractive/inclusive.
- Linking back to industrial competitiveness and excellence, it should be demonstrated how human-centred innovations in manufacturing will not only have a positive impact on the well-being of workers, but also how these developments will reduce the non-value added time, increase the quality, productivity, efficiency etc.

Physical and cognitive augmentation of human capabilities for inclusive and socially sustainable manufacturing

- The demographic evolution reinforces the need to continuously improve the well-being of factory workers and the attractiveness and inclusiveness of manufacturing workplaces. Human-centred developments should also Increase overall factory throughput, energy efficiency, use of resources, etc...
- Physical augmentation should reduce efforts of people to cooperate with machines, reduce human strain and stress through
  - advanced mechatronics and robotics allowing for safe, seamless and natural human-machine cooperation and interaction
  - wearables
- Cognitive augmentation will be brought about by
  - shifting the focus to the people bringing value in manufacturing, including collaborative working environments
  - data engineering so that AI works for humans (who are in this case expert domains) and not the opposite.
  - advanced information sharing and personalised digital work instructions
  - advanced visualisation technologies at factory/machine/process level
  - advanced data models, synthetic data generation and semantics
  - intuitive interaction with AI and data analytics technologies
- Human augmentation goes beyond technologies , it is about increasing human impact and capabilities addressing organisational and management approaches.

Digitally enabled upskilling, qualification and job transformation

- There is a competence shift in manufacturing processes which is accelerated by the transition towards a zero-net industry (see also the priorities '*Recovering and preserving the European leadership in strategic and high value added products*' and '*The next level of circular economy through scalable, highly productive* and zero-defect re-manufacturing technologies'.
- This competence shift requires the upskilling and/or reskilling of personnel and the empowerment of young professionals in manufacturing. Similar to the priority '*Digitally enabled compliance and integration of innovative manufacturing solutions*', the upskilling and the qualification of workers should be further supported by digital technologies, while respecting privacy aspects associated to personal information. For instance, augmented reality solutions can be used to quality workers remotely.
- Digital tools can support career development of workers by providing guidance towards new opportunities in manufacturing and matching workers' capabilities with job profiles.

Bio-intelligent Manufacturing

- The vision of bio-intelligent manufacturing is to not only copy but integrate and interact with biological systems in man-made technical and information systems. It is about the harnessing of nature's design principles and manufacturing capabilities to design and operate at the atomic level of organic and inorganic matter.
- Examples of bio-intelligent manufacturing:
    - Biosensors in manufacturing systems: A new class of biosensors interacting with the living organs and brains (including human) will conceivably change the way micro and nano-manufacturing is combined with biomaterial science and bioprinting to create a new class of solutions.
    - Bioactuators in manufacturing systems: For about 15 years, applied research has tried to simulate bioactuators with carbon nanotubes, electroactive polymers, and other controllable materials. Now, science has started to employ muscular cells directly to compose biotechnical actuators.

Note: Research on Bio-intelligent manufacturing would be covering significantly lower Technology Readiness level, compared to the other priorities described in this document. It is not clear if Horizon Europe will create funding opportunities outside the Made in Europe Partnership where such more upstream research is covered. This needs to be further investigated.