MASTT2040

# MaaS Roadmap
# Manufacturing Vision

# Summary of MASTT2040 Project Aims

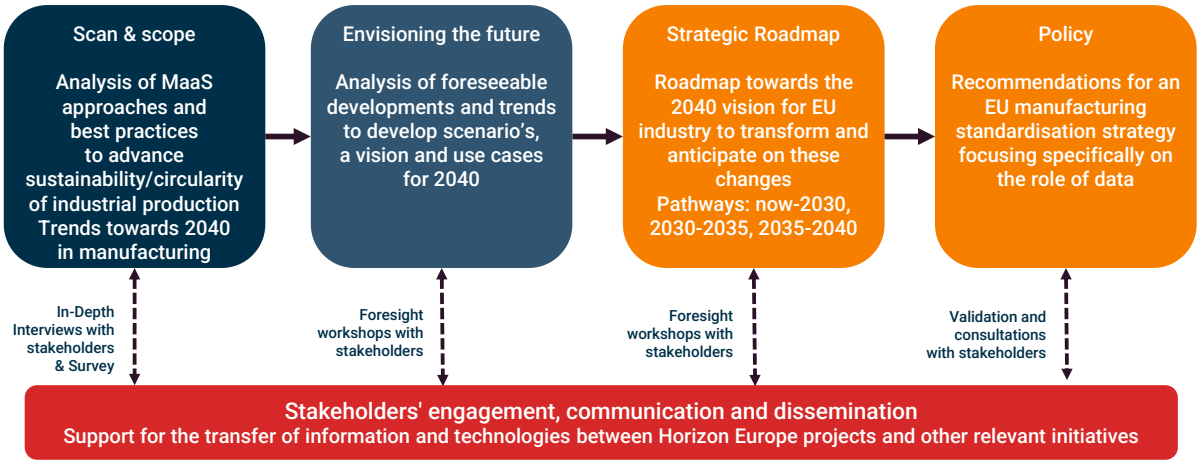


**Figure 1: Overview of MASTT2040 Phases**

Overall, the MASTT2040 project is analysing key aspects of MaaS in 4 phases as shown in Figure 1 with the following objectives:

- **Scan & Scope:** Phase 1 analyses the "Manufacturing as a Service" approaches, business models and best practices and their current contribution to advance circularity, decarbonisation, and sustainability of industrial production.
- **Envisioning the Future:** Based on foreseeable developments and trends, phase 2 develops a shared MaaS transformative vision for Europe until 2040 including the potential advantages and disadvantages, with respect to distributed Manufacturing as a Service vs. centralized manufacturing.
- **Strategic Roadmap:** Phase 3 elaborates a strategic roadmap and action plan addressing the short-term (5 years), medium-term (10 years) and long-term (15 years) timescales to identify and track desired developments in order to anticipate these changes and advance digitalization, circularity, decarbonization and sustainability of industrial production towards the 2040 vision.
- **Recommendations:** Phase 4 develops recommendations to enable Europe to target strategic investments and identify the needs for industrial data standardisation to promote uptake.

The aim is to adopt an inclusive and participatory approach with a wide range of expert stakeholders to help in building a shared understanding of which changes, opportunities or disruptions are present and emerging both inside and outside of the "Manufacturing as a Service" (MaaS) domain to guide decision making, strategies and actions for the EU manufacturing sector in the context of twin transition up to 2040.

## Manufacturing Vision for Roadmapping

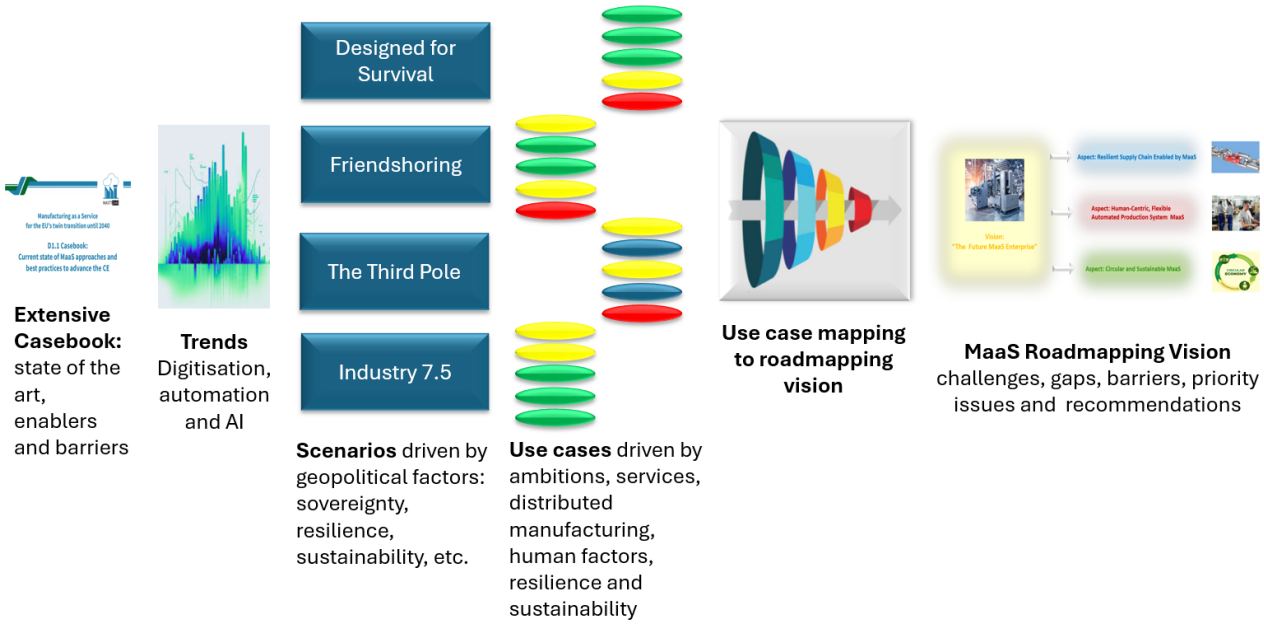


**Figure 2: State of the Art and Foresight Outcomes Mapping to MaaS Vision**

Based on previous analysis of the state of the art and foresight work identifying key trends, scenarios and use cases the MASTT2040 project has identified a vision for the future of MaaS which will be explored for roadmapping as shown in Figure 2. The vision is both challenging but feasible within a 2040 timescale. The vision is specifically designed to explore key challenges that face Europe in terms of digitization and automation, manufacturing of mass produced parts and low volume bespoke parts, and provision of products and services. Within the roadmapping key aspects of importance to Europe will be further explored including the provision of resilient manufacturing supply chains for MaaS, human-centric MaaS and approaches to sustainable and circular manufacturing for MaaS.

***Manufacturing as a Service***
***is a distributed system of production in which resources (including data and software) are offered as services, allowing manufacturers to access distributed providers to implement their manufacturing processes.***



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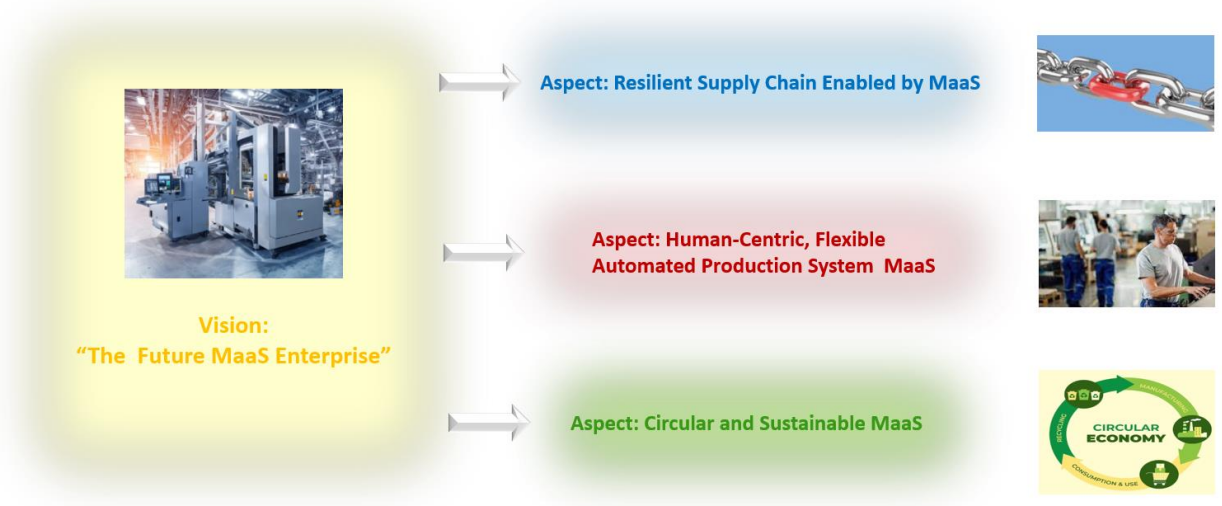


**Figure 3: MASTT2040 Manufacturing Vision and Aspects to be Explored**

The MaaS vision and specific aspects to be further explored are shown in Figure 3. The aspects to be investigated represent trends in manufacturing that companies are likely to increasingly follow. In fact companies can follow more than one of the trends, for instance, combining circular approaches to provide more resilient supply chains. Ultimately the roadmap generated will present an overall MaaS vision from which recommendations will be elaborated. In the following sections a brief description of the key characteristics of the MaaS vision and aspects to be explored are presented.

## The Manufacturing-as-a-Service Enterprise

**2040 Vision statement of MaaS**

"The 2040 vision of Manufacturing as a Service (MaaS) is to provide on-demand, flexible production via a flexible, efficient, and accessible manufacturing ecosystem that exploits digital technologies at all levels, real-time data, and decentralized production capabilities. A future MaaS in 2040 could provide a fully digitalized and autonomous ecosystem where artificial intelligence and machine learning algorithms will control the pre-production, production and post-production processes as well as predict market needs, optimize raw material procurement, and automatically adjust production schedules, driving cost reductions, accelerating innovation cycles, and making manufacturing more agile and customer-centric."

**Characteristics of MaaS in 2040**

The MaaS enterprise offers on-demand manufacturing services *enabling flexible, on-demand production of custom parts and components with short lead time*. The manufactured goods can be complex and fully customized. A key characteristic is that the MaaS enterprise can face short-notice requests for both low volume and high volume orders. This requires the enterprise to have extreme flexibility and a high degree of automation to quickly reconfigure and scale up its office processes and production system depending upon requirements and to quickly configure for bespoke product production. This requires a high degree of digitization and interoperable platforms to allow the rapid sharing of information with customers, the ability to integrate with other suppliers if required, and to be able to rapidly enter into business agreements to fulfil new orders appropriately. Core company values are to provide a 'what you see is what you get' (WYSWYG) capability with fast turnaround and with competitive pricing.

**Other Services That May Be Offered**

The range of services offered may go beyond the pure manufacturing process, extending across the value chain, for example providing product design services, with opportunities for after sales support and product maintenance if the company has appropriate capabilities. Another form of service provision is in the provision of equipment as a service to manufacturers. This is so that they do not incur the high capital costs of purchasing equipment but rather pay for equipment on a usage basis moving this financial risk to the equipment manufacturers.

**Dependencies**

A MaaS company is strongly dependent on an efficient mechanism for providing its services and an efficient interface with customers to provide fast quotations based upon integration with design and manufacturing software (computer-aided design (CAD)/computer-aided manufacturing (CAM)) that the company and its clients use. Interoperability is a key factor as to maximize the client base it is necessary to support a myriad of different software packages that clients use. Fundamental to a service company's strategic plan is to be able to anticipate changes in demand from customers and to constantly innovate with respect to manufacturing technologies to improve efficiency and services provided to meet ad hoc orders. Companies may also exploit data mining from a variety of data sources, including social networks, to predict market trends in order to provide on-demand services.

**Core Requirements**

Digitization is core to the success of broad-based application of MaaS by 2040 in order to cover the complete design and manufacture life cycle exploiting highly digitized and automated office processes and tools for design, costing, engineering, prototyping, production, qualification and logistics. Key to success is a high level of plant automation, and the customization of production requires short reconfiguration and tool change



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cycles, as well as short ramp-up and scale-up cycles. Such cycles need to include tests/experimental production, fast re-programming of machines and frequent updates of information to the workers. Providing inline and automated quality control is also a core requirement requiring installation of sensor systems to record production parameters of interest which can also be used to improve the production process, products and services. To support mass customization the MaaS supply network needs to provide a mix of long-term and ad-hoc co-operation relying on extensive digitalization and exploitation of technologies like AI for optimization and orchestration in product development, production planning and engineering, production execution and manufacturing. A key challenge is to provide a competitive price while meeting the required degree of customization and product quality in a short development cycle.

## Aspect: Resilient Supply Chain Enabled by MaaS

**2040 Vision statement for Resilient Supply Chains Enabled by MaaS**

"The vision for a resilient supply chain enabled by MaaS in 2040 is to provide a supply chain network that can quickly adapt to disruptions, minimize risk, and recover effectively when faced with challenges. This vision depends on agility and flexibility, end-to-end visibility, predictive analytics, risk management, communication, collaboration, redundancy and sustainable practices."

**Characteristics**

Resilience in the supply chain will be vital by 2040 and an association of companies can act as a production and/or innovation network to form a resilient MaaS enterprise. The supply chain for the MaaS may be totally based in Europe or it may cross world-wide borders. Companies flexibly co-operate as and when required reacting to market opportunities, developing new or improved products. To be efficient the resilient supply chain must minimize the costs and risks involved in targeting new markets with new products. The supply chain must also have sufficient redundancy in capabilities such that different partners can interchange seamlessly within the chain. Beyond pure manufacturing the supply chain may also perform research together in order to improve products and processes.

**Key Driver - Flexibility at level of supply chain and its participating companies**

Companies must ensure flexibility within their complex supply chain and have the ability to quickly re-configure their production lines utilizing agile modular machine tools and robots to meet changing consumer requirements and be able to integrate new partners when needed. This drives requirements for flexibility at company level and flexibility in the supply chain with the goal of collaborative productivity. The resilient supply chain enterprise may be established ad hoc to meet a short-term need and dissolved after the desired outputs have been achieved or it may be based on a long standing commercial relationship. The companies

involved must join forces effectively in order to form what is in essence one business out of several separate ones in a distributed manufacturing network. As multiple partners may well have overlapping capabilities, it is important that companies are able to bid internally for selection. This automatically introduces a self-healing capability into the supply chain.

**Commercial Advantages**

A resilient supply chain made up of SMEs, for instance, may enable them to complement each other's strengths to produce products or be able to rival the capacities of large enterprises to bid for orders. This may also link with providing dynamic labour support between companies to meet demand and provide specific skills. When both large and small companies are combined, large companies can bring in their manufacturing capacity, while the small companies can provide flexibility and power to innovate proving modular manufacturing capacity. An example of this is through the provision of local additive manufacturing capabilities. A resilient supply chain enterprise enables a much broader product and service portfolio than any individual company could provide by working alone.

**Core Requirements**

Key to success is the exploitation of digitization for communication and sharing of information to allow efficient networking, collaboration and integration. This requires a high degree of data collection and knowledge management covering the entire production cycle from design to sales and service supply. Key to this is providing full virtualization of resources through an interoperable platform that connects and synchronizes critical business processes along the value chain aligning priorities, managing resource demand and supply, and exchanging critical product and production data information in order to enable fast ad-hoc decision making. This heavy reliance on gathering and processing critical data, which may include commercial information, makes cyber resilience in the manufacturing network a core requirement.

## Aspect: Human-Centric, Flexible Automated Production System MaaS

**2040 Vision statement for Human-Centric, flexible automated production system MaaS**

"The 2040 vision for human-centric flexible automated production system MaaS focuses on creating an environment that prioritizes the well-being, skills, and experiences of the workers directly involved in the production process as well as end consumers. In the vision technological innovation is reinforced by worker empowerment and safety, creativity, upskilling, inclusion, job creation and seamless integration of people with manufacturing systems to promote both well-being and increased efficiency."

**Characteristics**

Within a human-centric and automated MaaS enterprise in 2040, there is an extremely high integration between workers and automated/supported office processes and production systems with the aim of producing products with increasingly shorter product life cycles. This drives the need for seamless integration between the manufacturing systems and workers placing emphasis on human centric approaches. This starts with consumer directed approaches to manufacturing to provide increasing degrees of customization in order to remain competitive and extensive co-operation between humans, machines and data to manage the production of the final products. This will change the role of humans creating a new type of knowledge worker integrated with a human friendly production environment reducing stress and automating many repetitive jobs like quotation, ordering, planning, programming and logistics.

**Key Driver - Seamless Human Integration**

The factory will be highly digitized gathering data at a much higher granularity level and exploiting optimization of processes via data aggregation and through the use of greater automation. The exploitation of data analytics for trend monitoring, fault identification and predictive modelling will provide smart and automated ways to support production personnel in decision-making. Workers will also work alongside cobots allowing much greater efficiency. A key challenge is that workers will swiftly need to acquire new knowledge and the rate of human knowledge acquisition becomes a limiting factor for companies attempting to keep pace with technological progress. Humans need to be embedded in the digital factory, provided constantly with context-relevant information from knowledge-based decision support systems or self-learning systems based on AI and Machine Learning. There is also an opportunity for companies to provide these features as services to support the production system.

**Commercial Advantages**

Close integration of the human within the factory allows for more efficient operation, increased productivity and better worker welfare. The need for highly skilled workers within MaaS leads to more rewarding jobs and a more motivated workforce. The operation of workers alongside cobots allows for much greater efficiency in production allowing the integration of human decision making and adaptability into the manufacturing process.

**Core Requirements**

A human centric approach is needed and the workers themselves need to be suitably skilled and frequently re-trained. Here there are opportunities for the AI-augmented workforce and the exploitation of smart augmented reality tools placing a greater emphasis on Industry 5.0, human factors and cobots. These will need to be seamlessly linked with manufacturing execution systems (MES) and enterprise ICT systems to create a de-centralised, flexible automation architecture. A key need is context-awareness of production

facilities to allow better decision making based on data gathered from sensors and monitoring systems. This allows real-time adaptation of production to meet product specifications and customer demands as well as to quickly react and schedule order execution.

## Aspect: Circular and Sustainable MaaS

**2040 Vision statement for Circular and Sustainable MaaS**

"The 2040 vision for circular and sustainable MaaS focuses on creating a system where products, materials, and resources are continuously reused, repurposed, or recycled, with minimal waste and environmental impact. The vision closes the loop on the production process and ensures that every product and material within the MaaS ecosystem is continuously cycled back into the system, reducing the need for new resources, minimizing environmental impact, and creating a sustainable, regenerative economy. This will be achieved by comprehensive exploitation of interoperability, data usage and transfer to support all aspects of the R-cycle."

**Characteristics**

In a circular and sustainable enterprise by 2040 environmental awareness is an essential part of corporate identity. The company's goal is to go beyond mere 'green washing' of its image and products to the introduction of environmental sustainability as a key parameter in all steps of the product life cycle, including sourcing of raw materials, reducing usage of materials, energy and waste in production and recycling products via a circular economy. Many companies are now concentrating on minimizing resource consumption and energy efficiency is a critical performance indicator. In particular, adapting energy demand and supply could result in major economies. Already regulation is in place for Corporate Sustainability reporting and many companies have installed renewable energy sources and reduced energy and materials consumption, however, the future circular and sustainable enterprise vision is for a step change in sustainable approaches through the adoption of R-cycles requiring much greater networking withing the supply chain

**Key Driver - Increased Environmental Awareness**

Minimization of waste will be a key driver and already this is being pioneered in areas such as 3D printing, however, the drive towards zero waste within factory environments could in future be driven by factories striving to achieve zero waste certification. New policies for "buyback" of products for recycling or product rental and return-to-recycle will increase sustainability on sourcing and create stronger bonds with customers. This will lead to dynamic ecosystems for circular manufacturing and already coming regulation such as Digital Product Passports is driving this change. This will lead to digital circular trade hubs and urban mining networks to recover raw materials. Regional repair hubs will also allow the repair of products to keep

them in use longer, extending their lifetime in the marketplace and reducing waste. These new green manufacturing production networks may exploit the use of materials banks, local production services and parts remanufacturing. This will require the creation of software tools and platforms to support integrated R-cycles. At the design level modular design approaches are required to create products that are designed from the outset for greater reuse considering sustainability in the design itself.

**Commercial Advantages**

With a much greater customer awareness of climate change the environmental footprint of ordered, customized products will need to be made available to customers, so the footprint generated along the value-chain will become transparent to the customer. This will allow environmentally aware buying decisions to be made. The environmental footprint will be a key driver and decision parameter for both manufacturers and customers making the environmental implications of design, process, and buying decisions completely transparent. Customer demand for such transparency and company "greenness" will be a key factor in the competitiveness of the company as it will need to able to demonstrate its level of environmental sustainability.

**Core Requirements**

Key to success will be the analysis of data from a large number of sources based on advanced AI to optimize the environmental footprint of manufacturing processes in real time to steer production towards minimal environmental impact. This requires extensive digitization and exploitation of sensors to gather relevant environmental impact and process data. Raw materials are a key consideration and keeping record of the origin and history of raw materials as an additional aspect of environmental awareness can be used as a marketing advantage.