# R&I PRIORITIES FOR ENHANCING **ARTIFICIAL INTELLIGENCE** APPLICATIONS IN MANUFACTURING IN LOMBARDY

AFIL Lombardia

The following publication is edited by AFIL.

AFIL
Lombardia

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# AI R&I PRIORITIES TEAM

The process of defining research and innovation priorities for enhancing artificial intelligence applications in manufacturing in Lombardy was led by **AFIL – Lombardy Intelligent Factory Association** with the support of key stakeholders of the Lombardy Region dealing with innovation in Artificial Intelligence. To complete this group, clusters and other organisations promoted this activity among their members, inviting companies, universities, and research bodies to get involved in the process in their specific field, thus contributing to the definition of R&I priorities.

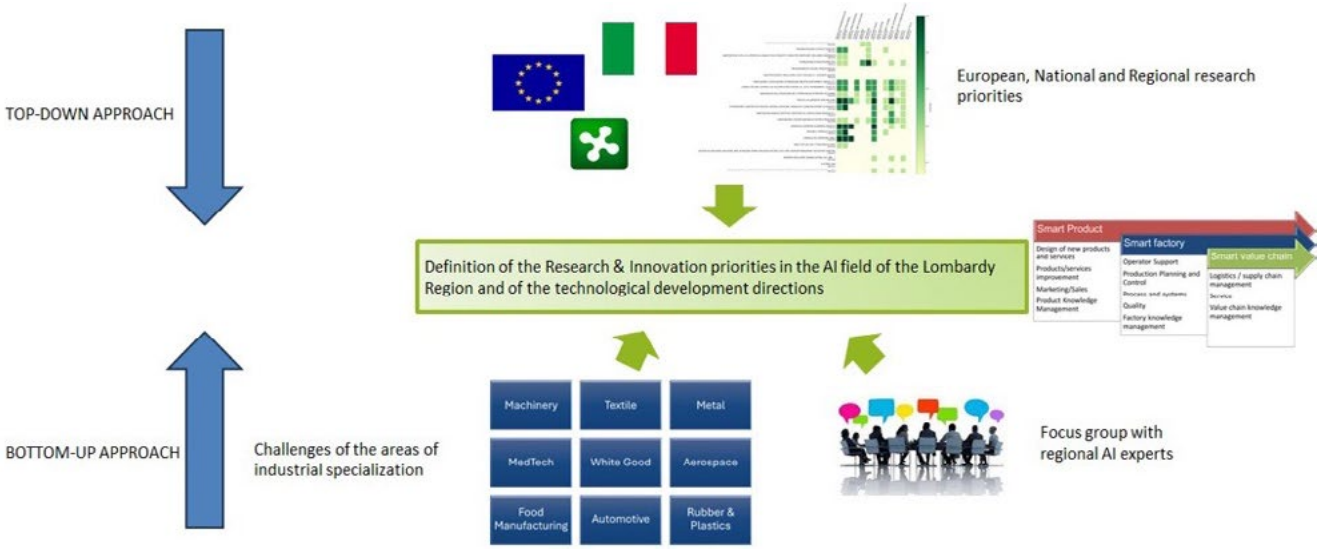

"Figure 1. The ecosystem activated by AFIL in the identification of R&I Priorities for enhancing Artificial Intelligence application in the manufacturing sector in Lombardy."

A restricted group of experts were identified to strategically and practically coordinate the activities. These experts were already involved in AFIL Strategic Communities targeting various aspects and industrial applications of AI. Moreover, additional experts from the regional ecosystem were invited to this steering group with the aim of providing a more enlarged vision of AI applications that goes beyond the advanced manufacturing area.

# THE METHODOLOGY

The methodology followed consisted in a mixed top-down/bottom-up approach.

**Top-down approach**: after analysing the socio-economic megatrends in the European Context and identifying European, National, and Regional Specific Challenges, a set of AI R&I priorities was identified.
**Bottom-up approach**: collect input representing specific needs coming from the most relevant industries of Lombardy through focus groups and interviews with targeted stakeholders. This process led to a detailed map of Artificial Intelligence opportunities and barriers in specific sectors of regional specialisation, categorised as **"Specific Sectoral R&I priorities"**. Then, focus groups with regional AI experts were organised to discuss these priorities and identify possible AI technologies that can be implemented to address these priorities.
Lastly, taking into account also the R&I priorities coming from the European, National and Regional roadmaps, these sector-specific challenges and opportunities were generalized with the aim of deriving **Research and Innovation priorities** transversal to multiple sectors.

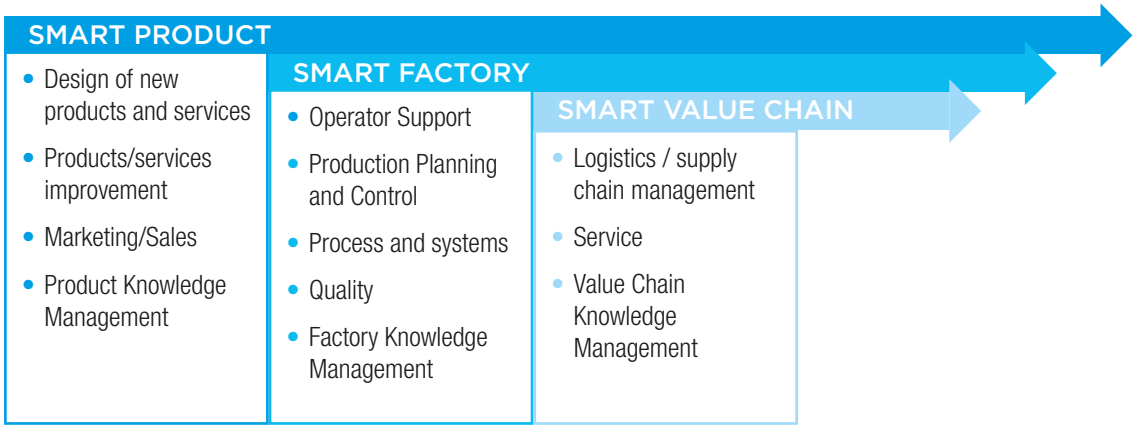


# THE REFERENCE MODEL

**AI Taxonomy:** the advancements in AI have been classified according to a taxonomy of themes related to AI derived from the one proposed by the European JRC.

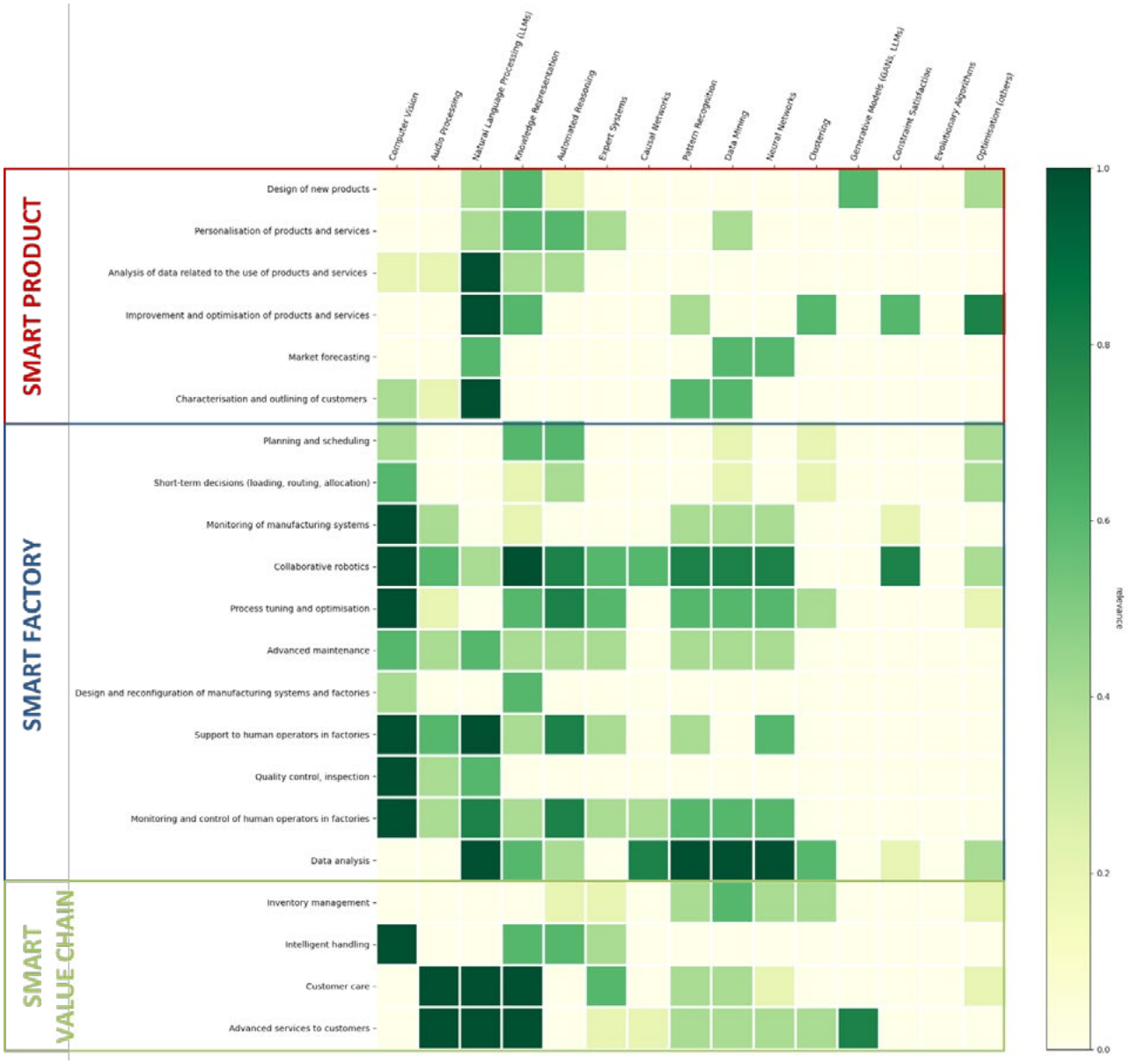
| | |
|---|---|
| **Perception and Communication** | Computer Vision |
| | Audio Processing |
| | Natural Language Processing (LLMs) |
| **Retrieval and Reasoning** | Knowledge Representation |
| | Automated Reasoning |
| | Expert Systems |
| | Causal Networks |
| **Learning and Prediciton** | Pattern Recognition |
| | Data Mining |
| | Neural Networks |
| | Clustering |
| | Generative Models (GANs, LLMs) |
| **Planning and Scheduling** | Constraint Satisfaction |
| | Evolutionary Algorithms |
| | Optimisation (others) |

**Manufacturing application area classification scheme:** to provide a mapping of AI technologies to applications in manufacturing, a classification scheme was defined based on the definition of three macro areas: smart products, smart factory, and smart value chain. Within these macro areas, sub-themes were defined, with the aim of providing a more detailed framing of challenges and applications for AI technologies in the manufacturing area.



# RESULTS: Analysis of regional, national and european roadmaps

The results of the classification and mapping analysis are here summarised in a set of graphs aimed at identifying the most promising AI-related technologies and their most relevant applications in the manufacturing industry. This identification is based on the presence of explicit or direct references in the road-mapping documents analysed to potential applications and/or impacts in the considered manufacturing areas.



The figure shows that the **manufacturing challenges and applications** potentially impacted most by AI technologies are those related to the smart factory. Specifically in manufacturing processes, systems, quality, and production planning and control. Significantly impacted areas are also those related to smart products, focusing on the design and improvement of products and services. Furthermore, knowledge management is also pointed out to be strongly impacted by AI, especially concerning the structuring and formalising workers' knowledge. Finally, in the wake of the diffuse use of AI in many services, also those related to manufacturing are likely to be significantly impacted and transformed, taking advantage of natural language processing techniques, first of all, LLMs, driving a redesign of customer services, documentation management, and the retrieval of relevant information.

Looking at the results from the perspective of **AI-related technologies**, it is clear that almost all the clusters defined in the taxonomy are relevant to many manufacturing areas. In particular, it is evident the very broad impact of AI technologies on computer vision and natural language processing. Similarly, AI technologies aimed at learning at prediction (e.g., neural networks, large language models) are also accredited with a strong potential in many manufacturing areas. At the same time, more traditional AI technologies supporting automated reasoning (e.g., expert systems), together with their evolution, are still considered an important player in the way our factories are designed and controlled. Finally, although in a less broad and evident way, AI technologies supporting planning and scheduling have found a natural outcome in the management of manufacturing systems and related operations.

# AI R&I PRIORITIES IN MANUFACTURING

Analysing and summarising the contributions gathered from the involved regional stakeholders (i.e. companies, research centres, universities and associations) in the different sectors, the following three main high-level Research & Innovation priorities can be identified:

- Human centred – operator support and valorisation
- Design and use of intelligent products/machines/systems
- Forecasting / lean and resilient planning

These high-level priorities can be further declined into the three analysis dimensions of smart product, smart factory and smart value chain.

## Human-centred – operator support and valorisation

AI has the high potential to deal with complex problems and situations that are often unpredictable and not completely formalisable. In the industrial setting, the need to interact with humans is particularly relevant, enabling them to manage increasingly complex systems and make frequent and better-informed decisions. In detail, AI can support the human operator in the design of complex products, in the execution of activities and processes in the factory, and in the provision of advanced services to customers.

### SMART PRODUCT

- Automatic generation of products' designs in line with the requirements
- Assessment of non-tangible design aspects characteristics of the products (e.g. tactile feedback of material).
- Analysis of products use data to identify specific customer requirements, needs, and / or hidden / latent functionalities
- Collection, rationalization, systematization and retrieval of design and engineering knowledge (often tacit and personally owned by experienced designers, or fragmented)

### SMART FACTORY

- Automatic generation of instructions, intelligent search engines to quick provide operators with the required information and support them in production, maintenance, setup and similar activities thus increasing efficiency and effectiveness
- Suggestion of the most adequate / customized trainings for operators, automatic assessment based on the monitoring of tasks execution, consolidation of operator experience
- Automatic detection of potential risks in the workplace, monitoring of operators safety and ergonomics during tasks execution

### SMART VALUE CHAIN

- Advanced technical assistance (e.g. automatic troubleshooting based on similar problems would be relevant)
- Automatic translation of technical documentation related to product usage or maintenance
- Support in technical assistance activities through the automatic identification of relevant information to help the end-user
- Collection, rationalization, systematization and retrieval of service-related knowledge (e.g. service reports) to improve product design as well as service provision

## Design and use of intelligent products/machines/systems

One of the main impacts of AI in the manufacturing sectors is the development of intelligent products/machines/systems. These products/machines/ systems have features that differentiate them from conventional products/machines/ systems. First of all, intelligent means that they are capable of communicating effectively with their environment, can retain or store data about themselves, and are capable of participating in or making decisions relevant to their destiny. To achieve this intelligence, they have the features of connectedness (with other products, humans, data and services through networks) and data-driven (connected over the network, they form a platform to collect data and information through their sensing capabilities that can be processed for both technical and commercial purposes). AI plays a fundamental role in the development of such products/machines/ systems since it is the technology enabling advanced intelligence features in products (e.g. ability to adapt to external environment) and factories (e.g. capacity to control, adjust and optimise complex production processes automatically), and enabling the provision of advance services (e.g. predictive maintenance or pay per use business models).

### SMART PRODUCT

- Automatic configuration and optimization of process parameters based on manufacturing requirements.
- Provision of advanced functionalities to support safety and traceability

### SMART FACTORY

- Monitoring and control of production processes in relation to the operational conditions and proactive implementation of corrective actions to improve process performance
- Optimization and self-adaptation of production processes to manufacturing changing requirements
- Automatic detection of anomalies and defects to support the improvement of the quality of the final products
- Estimation of the residual life of products/ machines/ systems preventing/ anticipating failures
- Management and optimization of machines/ systems energy requirements and consumption.

### SMART VALUE CHAIN

- Use of product-use information to support advance services and customer assistance (e.g., predictive maintenance, automatic troubleshooting, etc)
- Provision of high-value services: e.g., product / process parameters optimization, automatic re-order of spare parts, substitution / upgrade of the product based on the estimation of the residual life.
- Support to the definition and implementation of new contracts typologies (e.g. pay-per-use, pay-per-performance)

## Forecasting / lean and resilient planning

One of the distinguish feature of artificial intelligence is the ability to perceive the surrounding environment through data acquisition, interpret this structured and unstructured data and decide the best action(s) to achieve the given goal. This would allow manufacturing companies to quickly react, or even forecast and anticipate, the increasingly changing external and internal conditions to strengthen their resilience capabilities.
Thus, artificial intelligence is a relevant technology to support planning and forecasting in product development (e.g., anticipating market trends or forecasting customers' needs and demand), in the factory (e.g., dynamically adapting production scheduling based on internal and/or external situations), and along the supply chain (e.g., forecasting supplier performance or dynamically optimising stock levels based on demand prediction).

### SMART PRODUCT

- Market trends and needs forecasting based on analysis of external data and product-use information
- Customer segmentation and profiling, analysis of intangible aspects related to the product characteristics (e.g., emotional reactions)
- Demand forecasting of product with high volatility
- Dynamic Pricing in order to match demand and supply

### SMART FACTORY

- Dynamic Planning and scheduling integrating internal (e.g. production capacity) and external data (energy price, supplier capacity, etc)
- Optimization of production plans combining information from production data as well as from the experience of production planners
- Quality forecasting through the monitoring and control of the production process parameters
- Forecasting of the environmental impact of the factory on the basis of several production scenarios and operational decisions

### SMART VALUE CHAIN

- Identification and intelligent traceability of raw materials and automatic recognition of the composition of the raw materials to reduce supply chain variability
- Dynamic life cycle assessment of products/ machines/ systems
- Forecasting of supplier's performance in terms of quality, service and flexibility enhancing the visibility and collaboration along the Supply Chain
- Stock management and inventory optimization of critical parts (e.g. spare parts)
- Prediction of availability of raw materials depending on natural factors

# LEGAL ASPECTS FOR THE USE OF AI IN MANUFACTURING

Artificial intelligence (AI) has the potential to revolutionise production processes and increase efficiency, but its adoption can take time and effort. The first essential aspect companies may face when implementing AI in their processes and activities is the potential impact of using these technologies. As AI technologies continue to advance and become more integrated into various aspects of our activities, some key legal considerations need to be taken into consideration, such as:

**AI Regulations**. Depending on the industry and application, there may be specific regulations that govern the use of AI.

**Machinery Directive.** The integration of AI into machinery may have implications for machinery safety.

**Privacy and Data Protection.** The use of AI often involves the collection and processing of vast amounts of data. This raises concerns about data privacy and compliance with regulations like the General Data Protection Regulation (GDPR).

**IPR and Know How.** AI-generated content and inventions may raise questions about who owns the IP rights.

**Cybersecurity.** The use of artificial intelligence (AI) in cybersecurity has become essential. As most of the cybersecurity attacks can leverage AI technologies, also threat detection, incident response, and the protection of critical infrastructure and sensitive data can benefit from them.

**Liability.** Determining liability in AI-related accidents or errors can be complex, as questions arise about whether the AI developer, the user, or the AI itself is responsible for any harm caused by AI systems.

# BARRIERS TO THE USE OF AI IN MANUFACTURING

Further barriers to adopting AI technologies in manufacturing companies relate to adequate skills to integrate and exploit AI in the production processes. Furthermore, AI is based on data; however, there still needs to be more effective data standards and frameworks to allow an easy and safe exchange of information. Moreover, a general shortage in the EU landscape is the need for suppliers / technological providers.

| BARRIERS | |
|---|---|
| **LACK OF COMPETENCE AND SKILLS** | Due to the continuous and fast progress that AI technologies are experiencing, companies lack adequate skills to be able to integrate and properly exploit AI solutions in their production processes. Not only the introduction of new skills but also the re-skilling of the operators is strategic in this sense, especially if we think that most of the time senior employees have a wide experience and competences which do not include modern AI technologies. |
| **COLLABORATION WITH R&D INSTITUTIONS NOT FOCUSED ON INDUSTRIAL UPTAKE** | Although companies have well-established collaboration in place with R&D institutions, they are mainly focusing on research activities and usually remain far from the industrial uptake. These collaborations must be shifted towards the last stages of the innovation cycle to support companies in the integration of AI technologies. |
| **LACK OF SUPPLIERS / TECHNOLOGY PROVIDERS** | In order to turn the general shortage of AI suppliers and IT providers in the EU landscape into an opportunity for the future, it would be necessary to map the competences and infrastructures available properly and extensively on AI. |
| **SOLUTIONS COMPLEXITY / COSTS** | One limitation to the application of AI is the complexity of such systems and their high costs. For example, AI solutions require collection, management and retrieval of data to feed the systems and these still represent a barrier for its high costs. |
| **CYBERSECURITY** | Ensuring the proper production system security is becoming more and more strategic and this is still representing a barrier in some cases. In addition, for security reasons, customers are reluctant to accord access to their data and, thus, machine suppliers often have difficulties in ensuring the optimization and the improvement of the system and, consequently, of the process they implement. |
| **INTEROPERABILITY/ STANDARDIZATION** | There are no effective data standards and interconnection frameworks for easy data exchange among different systems. A priority for the development of AI in production is then related to the possibility of making faster and easier the integration of machine/system information systems with the customer information system (i.e. production management and monitoring systems), considering the multitude of machines and information protocols in the job shops. |
| **CULTURE / CHANGE MANAGEMENT / ACCEPTANCE** | General lack of industrial cultural attitude to undertake AI adoption path. This reluctancy is usually generated by mistrust in new technologies, a very rooted work mindset and a general lack of digital culture. This situation can be also negatively affected in case results coming from the implementation of new solutions are not aligned with the expectations. |
| **LEGAL FRAMEWORK AND REGULATION** | Legal framework and Regulation are usually strict and complex, and companies are struggling to provide products/systems meeting the criteria laid down. Growing attention should be put on the development of a competitive and proactive context and preserve the human resources in the company |
| **INTELLECTUAL PROPERTY** | Specific attention should be put on the protection of digital contents in order to avoid problems associated with the spread of knowledge. The reduction of time to obtain a patent should be reduced to enhance this aspect. |
| **LOSS OF PERSONALIZATION** | Even if the use of digital tools and AI can increase the efficiency in the design of new products, it may also lead to the introduction of standardized rigid solutions which are in contrast with the typical need of customization and craftsmanship which are characteristic of many Lombardy sectors, where the expertise and ability of operators is often a key-added value. Thus, it is relevant to understand where it is motivated to implement such AI systems or to realize solutions that do not kill creativity, preserving in this way the Italian/Lombardy culture and heritage characterized by high quality, creativity and flexibility. |

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