capri

Cognitive Automation Platform
for European PRocess Industry
digital transformation

Deliverable

# D6.5 Initial Report: SPIRE Digital Transformation Ecosystem

Deliverable Lead: Politecnico di Milano

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| Lead beneficiary | Politecnico di Milano |
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| **List of Acronyms and Abbreviation** | |
|---|---|
| Acronyms | Description |
| AI | Artificial Intelligence |
| AIOTI | Alliance for Internet of Things Innovation |
| AR | Augmented Reality |
| BD | Big Data |
| BDVA | Big Data Value Association |
| CAP | Cognitive Automation Platform |
| CDT | Cognitive Digital Twin |
| CF | Connected Factories |
| CPS | Cyber Physical System |
| CSA | Coordination and Support Action |
| DIH | Digital Innovation Hub |
| DMP | Data Management Platform/ Data Manufacturing Platform |
| EDIH | European Digital Innovation Hub |
| ERP | Enterprise Resource Planning |
| GHG | GreenHouse Gas |
| ICT | Information and Communication Technology |
| IA | Innovation Action |
| IP | Intellectual Property |
| IT | Information Technology |
| IoT | Internet of Things |
| IIoT | Industrial Internet of Things |
| MES | Manufacturing Execution System |
| MVP | Minimum Valuable Product |
| OT | Operational Technology |

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| | |
|---|---|
| PI | Process Industry |
| PICO | Process Industry COgnitive |
| PIHUB | Process Industry Hub |
| PIWARE | Process Industry DIHIWARE |
| PLC | Programmable Logic Control |
| PPP | Public-Private Partnership |
| RTO | Research and Technology Organisation |
| SG | Sub Group |
| SME | Small Medium Enterprise |
| SMI | Smart Manufacturing Industry |
| SPIRE | Sustainable Process Industry through Resource and Energy Efficiency |
| SRIDA | Strategic Research and Innovation Development Agenda |
| SW | Software |
| TF | Task Force |
| UX | User Experience |
| VR | Virtual Reality |
| WG | Work Group |
| WP | Work Package |

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# EXECUTIVE SUMMARY / ABSTRACT SCOPE

Deliverable D6.5 – "Initial Report: SPIRE Digital Transformation Ecosystem" provides an initial description of how the CAPRI project and the Cognitive Automation Platform (CAP) can impact the SPIRE network and process industry in general, by dissemination activities. Coherently with T6.5's objectives and to avoid overlapping with other deliverables, the present document will focus more on additional assets to be disseminated beside the CAP.

Actually, D6.5 is the first document associated to task T6.5 – "Community Building, Innovation Hubs and Clustering with other projects" that has a threefold objective:

1. to create a community of experts in Cognitive Process Plants who can share competencies and technology thanks to a common SPIRE marketplace;
2. to create bridges with similar initiatives active in discrete manufacturing;
3. to identify a set of Digital Innovation Hubs (DIHs) that can support SPIRE process industry.

The current document is a presentation of the activities that T6.5 together with all CAPRI partners is running to achieve the Task's objectives.

The first important step is to better known SPIRE-06 ecosystem, by analysing commonalities and peculiarity of the other five projects funded in the same call and their pilots, with respect to CAPRI. This is a preparatory phase that allows to tailor a possible collaboration and dissemination plan to other pilots' specificities.

In Section 3, a number of tools customized for process industry requirements are presented, with the objective of detailing the added value that they can bring if applied in an industrial context (including, of course, SPIRE ecosystem) and of outlining an initial collaboration plan (Section 4).

PICO (Process Industry COgnitive) Architecture is an innovative way to conceive the architectural space where data are ingested and elaborated. The innovative aspect is that its structure reflects the need of explaining the intelligent behaviour through cognitive processes, according to how human being do. It is addressed to a general audience of people interested in modelling cognitive processes, with a specific focus of course in SPIRE ecosystem.

PIHUB (Process Industry Hub) is expected to be a collection of Industrial Plants and Experimental Facilities, success stories and best achievements, to be disseminated mainly through SMEs, in order to support them in their cognitive digital transformation. This activity goes in the direction of identifying a set of Digital Innovation Hubs that can support SPIRE process industry (T6.5, objective 3).

PI 6Ps (6Ps methodology for Process Industry) is the customization of the 6Ps methods (originally conceived for discrete manufacturing) fitting with requirement of process industry. It is mainly addressed to SMEs and the objective is to provide a methodology and a set of tools to define an overall digital transformation journey, including six dimensions of analysis (Product, Process, Platform, People, Performance, Partnership). It represents the first tool to be shared in the community of experts (T6.5, objective 1).

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PIWARE (the DIHIWARE[1] for Process Industry) is expected to be an instantiation of the DIHIWARE platform, to create a collaboration tool and a marketplace that allows SPIRE community and process industry in general to build and manage knowledge in an innovative way. This activity goes in the direction of implementing a SPIRE marketplace to facilitate the sharing of expertise, competences, technology and assets (T6.5, objective 1).

Still in the direction of achieving T6.5 objective 1, CAPRI is interested to get in touch with communities of expert in discrete manufacturing (DMP cluster and Connected Factories project) and in digital technologies (AIOTI and BDVA) and to leverage on national and regional initiatives related to digital innovation for manufacturing.

1 https://dihiware.eng.it/dihwelcome/

# 1 Introduction

## 1.1 Scope of Deliverable

Deliverable D6.5 – "Initial Report: SPIRE Digital Transformation Ecosystem" is the initial description of the foreseen impact that the CAPRI Cognitive Automation Platform (CAP) could have in process industry.

The objective is to present a number of assets and tools, developed and/or enhanced in CAPRI project, beside the CAP, to be proposed to SPIRE-06 ecosystem at first stage and to a process industry community in general at second stage, useful to disseminate the cognitive level achieved in CAPRI.

SPIRE-06 network represents the first channel through which the cognitive platform and solutions implemented in CAPRI will be promoted and this is why is it is important to well know it. Second goal for D6.5 is to provide a detailed description of SPIRE-06 projects and pilots, identifying commonalities and specificities with CAPRI.

## 1.2 Audience

D6.5 is a dissemination report that can be easily understandable by anyone familiar with European projects and that does not require any specific background and/or expertise.

Inside CAPRI project, it is addressed to all partners since WP6 and dissemination activities involved all the twelve companies. It represents a basic document to better know the SPIRE-06 ecosystem, its objectives, its achievements and to be aware of activities running in different projects. On the other side, Section 5 is helpful to broaden the horizon beside process industry domain and to get familiar with different regional initiatives related to the domain of digital technologies for manufacturing.

In addition, D6.5 presents the collaboration plans to promote PICO, PIHUB, PI 6Ps and PIWARE assets outside CAPRI's borders and this may be of interest for anyone interested in disseminating them.

## 1.3 Relationship with other deliverables

D6.5 – "Initial Report: SPIRE Digital Transformation Ecosystem" is strongly related with D6.10 – "Final Report: SPIRE Digital Transformation Ecosystem", that is its sequel expected at Month 42 (end of the project). If the former is a preliminary analysis of the cognitive assets to be disseminated in SPIRE ecosystem, equipped with a collaboration plan, the latter will start from D6.5 to describe the main results achieved by following the guideline defined in the current document. Hence, the relationship is quite evident.

Since WP6 is the "Communication, Dissemination and Community Building" work-package, not strong dependencies are foreseen with the other work-packages involved in the implementation of the final solution. WP6 and T6.5 takes advantage of other WPs work, but it ends in itself, or better, activities are addressed outside CAPRI borders and there are no other work-packages depending on it.

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## 1.4 Document Structure

The document is organized in four main chapters (Section 2 – Section 5), beside the introductive introduction chapter (the current **Section 1**, where the purpose of document, the target audience and the structure are described) and the conclusive one (**Section 6**, summarizing main achievements and addressing future activities).

**Section 2 – The SPIRE-06 Ecosystem** presents the A.SPIRE community, positioning CAPRI and its pilots inside the digital transformation roadmap supported by SPIRE organization.

It also provides a description of the five funded projects that together with CAPRI are part of SPIRE-06 ecosystem. The goal is to collect the relevant information to identify commonalities and specificities of the projects, in order to create a link with CAPRI. In addition, for each one, also basic information are included such as start/end date, the aim and the concept behind, the list of pilots and the domains of activity.

**Section 3 – CAPRI unique selling points for SPIRE-06 Ecosystem** describes the four CAPRI assets conceived for process industry: PICO (Process Industry COgnitive) Architecture, PIHUB (Process Industry Hub), PI 6Ps (6Ps methodology for Process Industry) and PIWARE (the DIHIWARE for Process Industry). The objective is to identify the added value that they can bring to SPIRE-06 ecosystem and process industry in general, highlighting their innovative aspects and advantages deriving in the adoption.

**Section 4 – SPIRE-06 Ecosystem Collaboration Plan**, for each one of the four assets described in previous section, presents the collaboration plan, that is, the list of activities foreseen to be performed in next month (especially in next six months, between Month 19 and Month 24).

**Section 5 – CAPRI extended Ecosystem Collaboration Plan** presents some organizations of experts, outside the border of process industry with the objective of extending the CAPRI dissemination ecosystem. For instance, to get in touch with discrete manufacturing domain, the DMP cluster and Connected Factories project are taken into account; a collaboration plan is proposed also for digital technologies organization (AIOTI and BDVA, for instance) and national and regional initiatives are presented.

# 2 The SPIRE-06 Ecosystem

## 2.1 A. SPIRE roadmap and the role of Digital Transformation.

According to the *SPIRE Roadmap 2030*[2], *SPIRE Vision 2050* [3]and the *new PROCESSES4PLANET Strategic Research and Innovation Agenda 2050 Roadmap*[4], **process industries produce the materials that are used by the manufacturing industry to make products**. Materials like cement, steel, plastics, paper, industrial minerals, chemicals, fuels and ceramics are created from raw material resources in **energy-intensive processes**. Some materials are the first step of a long value chain and other materials are directly used as a product. Manufacturing industry is increasing the pressure on process industry to provide $CO_2$-neutral materials and with increasing content of secondary resources. This aligns with the process industries involved in the development of the **CAPRI project**, i.e.: asphalt industry through the EIFFAGE demo site, steel industry through the SIDENOR demo site and the pharmaceutical industry through the RCPE/AMS demo site.

**The transformation of the process industries is key as they are energy intensive.** The energy sector will undergo a massive disruption in the coming decades to decrease its GHG emissions, and **this will affect all value chain stakeholders**. Process industries account for a **significant part of energy consumption** and therefore will be an important part of this ecosystem. Process industries will need to cooperate and align with the energy sector to make optimal use of alternative energy resources/feedstocks and contribute to the transition. Process industries are essential to accelerate the energy transition, as they can offtake large volumes of GHG emission-free energy and thereby rapidly decrease production costs to a competitive level. Additionally, due to their high energy consumption, process industries can contribute significantly to system flexibility by shifting energy demand, thereby enabling a GHG emission-free, **highly digitalized**, and dynamic energy system.

**At the same time, process industries can close material loops while minimizing/removing substances of concern for human health and the environment in recycled materials and products.** A **circular economy** is only possible with involvement of process industries, given their pivotal importance in the most critical value chains. In the transition towards more recycled, $CO_2$-based and bio-based materials, process industries play an important role as they can use these materials to replace primary resources.

**The digitalization of the process industries** will happen holistically and cover **the entire product life cycle and value chain**, including R&D, plant operations, supply chain management, customer relations and integrating material flows in a circular economy and across industry sectors. It will make processing plants and operations more agile and resource and energy efficient, contribute to significant reductions of GHG emissions, orchestrate the pathway to a climate neutral economy, improve safety and working conditions and contribute to securing competitiveness and jobs in the European process industries over the next decades. The potential impact of digitalization exceeds that of historic disruptive technological breakthroughs like the steam engine or automation.

[2] https://www.spire2030.eu/what/walking-the-spire-roadmap/spire-Roadmap
[3] https://www.spire2030.eu/what/walking-the-spire-roadmap/spire-2050-vision
[4] https://www.spire2030.eu/content/p4planet-sria-2050

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**Digital technologies act as key enablers** for various other innovations in SPIRE roadmap, such as industrial and urban symbiosis, integration of renewable energy carriers, enhancing flexibility and diversity of energy and resource inputs, innovative materials and new business models.
**Given the speed of innovation of digital technologies**, the roadmap focuses on a 2030 timeline.

### 2.1.1 Digitalization of process/product R&D

**Digital technologies** will increasingly be applied in the different stages of product and process research and development. They will enable the integration of life cycle thinking and advanced sustainability assessments throughout the development process. Innovation will be accelerated, leading to more efficient and much faster idea-to-market processes. One challenge is to embed customers into the R&D process. With increasing complexity of connected industries in a circular economy, this becomes even more important.
**Digital technologies** will improve all development phases of innovative materials. On the one hand, this consists of new forms of data sharing with customers and other stakeholders in the supply chain. On the other hand, new models and simulation tools will be developed to characterize the performance of new materials already in the design phase. The design of production plants will be significantly improved with respect to reliability, speed and cost by moving further in the direction of model-based design processes. Ultimately, the design of materials and plants and the operation of the plants will be supported by digital twins that embody all available information in a condensed form that can be used for predictive simulations, troubleshooting, optimization, and continuous improvement.
Different technologies will be developed to enable **digital materials design**. This includes (1) the further development and integration of modelling and simulation tools, (2) connecting the use and end-of-life phases to the materials design phase, (3) more efficient materials design processes by combining data and models in different forms and from different sources, and (4) the development of digital tools for effective and intelligent data and knowledge management.
Materials and formulation design will be integrated with process design to achieve **digital process development and engineering**. Information about production process and feedstock will be included into materials design phase and detailed characterization methods of (secondary) feedstocks will be developed as input for more flexible processes.
**Digital technologies can also support the design of processes using digital twins**. Process design is increasingly done using faithful predictive simulation models of processes, pieces of equipment, and plants. However, several aspects still prevent the use of the full potential of the model-based approach:

- Fundamental data
- Building fundamental models is a demanding process that absorbs the capacity of high-level experts over long periods of time, so that many process elements are not described by rigorous models
- Dynamic models that can describe the reaction to changeovers of materials and feedstock or load changes, e.g. in response to the availability of green electric power are usually not available
- Models for the design phase (usually as stationary models) are rarely used in the production phase of the life cycle of the process (transient models are needed in this phase), and

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information on the behaviour of the real plant and on its modifications is rarely fed back to the design model

The objective is to disruptively transform how process engineering is done today by moving to fully model-based process design within the process industry, including the objective to develop a digital twin ecosystem.

This is precisely done at **CAPRI project level** in the steel demo use case because one first mayor problem tackled in steel processing by CAPRI is product tracking. Therefore, a **digital twin** approach is realized at the plant for products and machinery, where **the twin does not only represent a simulation, but actively accompanies the product through the whole chain**. It is the overall cognitive component for the whole automation system, fostering the digital transformation envisioned by CAPRI. For gaining new insights via cognitive technology developed at CAPRI project, multiple cognitive steel sensors (CSSx) (see section below) are being developed in the steel use case to supply information to the digital twin.

Also, similar approaches can be found at Pharma Use Case Pilot and at Asphalt Use Case Demo (more details can be found in the subsequent subsections).

### 2.1.2 Digitalization of plants

Industrial processes and related process chains are increasingly complex. This is triggered by several trends, like market demand of new and more customized products with new features and higher demands on production plants, the need of more flexibility towards alternative feedstocks (e.g. waste, biomass, $H_2$, $CO_2$) and process electrification to make use of renewable energy sources.

**New digital-enabled solutions are necessary to improve process control and operations** as well as plant reliability. Significant gains in efficiency (e.g. reductions of downtime, reduced usage of raw materials and energy) can be achieved because of less rework and less waste in each production facility.

The movement towards a circular economy and the utilization of electric power from renewables will put much higher demand on the flexibility of the plants and processes, in terms of load variations, variations of feedstock, and variations of product specifications.

**The switch to more sustainable and flexible production** increases the need to develop integrated physical and soft-sensor measurements combined with advanced modelling of all critical product quality attributes. **Automated feedback and closed-loop control of the relevant parameters** of **materials** and **processes** ensures efficient operation and reduced material variability, thereby preventing materials being rejected further down the supply chain; and flexibility with respect to types and amounts of materials as well as varying availability of feedstock and utilities.

**In fact, specific control approaches** are tackled at **CAPRI project** through the development of cognitive control solutions, where different control techniques are being developed:

Asphalt use case:

Cognitive control of Asphalt Drum (CAC1) in charge of drying aggregates before final mixing with bitumen.

Steel use case:

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The cognitive control approach is achieved through the digital twin explained in previous section

Pharma use case:

The cognitive control of particle size after granulation and the granule moisture in the dryer (CPC1).

On a higher level, **model-based** plant and site wide visualisation and optimisation of energy, resource efficiency and other relevant indicators such as the $CO_2$-footprint will lead to significant reductions of the ecological footprint of the process industries.

The **digital solutions** consist of **digital models of processes**, **decision support systems** and **predictive control techniques**. Novel powerful and intelligent sensors and sensor networks that provide reliable information, especially about the properties of materials or streams of material at reduced cost, are necessary, and solutions to handle the huge amounts of online data coming from these sensors must be available.

The aim is to develop highly flexible, easy to handle, and generally applicable solutions for the optimisation of processes and complete process chain of a company, even among different companies and industries. Digital twins for plants, processes and materials which can communicate with each other in a highly flexible way and be employed to solve complex site wide optimisation problems are an important element of these solutions. In 2050, a company will have access to large amounts of accurate, curated, and readily accessible operational data to support process monitoring and process optimisation.

Tools are needed for **digital plant operation** and optimisation so that the plants can be operated in a fully energy and resource and environmentally friendly way. These tools provide the basis for the realisation of lights-off plants that are monitored remotely by a small crew and where maintenance and improvement measures are performed in a planned and coordinating fashion with the least possible disruption and resources. Developing these digital solutions will result in:

- Demonstration of fully dynamic and model-based control of single processes
- Coordination and optimisation of control of interconnected processes in a process chain
- Decision support systems for all processes and process chains where model-based online control is not yet possible
- Early detection of possible cyber-attacks to process control systems and triggering of suitable counteractions as soon as possible
- Development of an ecosystem of suitable digital twins of plants, processes and materials

In the case of these roadmap objectives, **CAPRI project** is developing different plant operation, digital models and predictive control techniques to achieve these goals. Specifically:

Asphalt use case:

Predictive maintenance of baghouse based on cognitive sensors and expert knowledge (CAO1).

Cognitive solution of Planning and Control of Asphalt Production (CAP1)

Steel use case:

Through the previously explained development of the digital twin for the steel use case, the decision support system implemented on top of the digital twin shall lead to a direct reduction of rejected

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products. When a process risk has been identified for a product, then the models available in the digital twin enable an informed decision about its further treatment.

Pharma use case:

Operating Cognitive solution (CPO1) as a decision support system.

Planning Cognitive solution (CPP1) as a digital plant operation to achieve proper scheduling.

**Intelligent material and equipment monitoring**, sensors and sensor networks, data processing, and predictive maintenance tools need to be developed. For the operation and management of complex plants in the process industries, the availability of online information about the plant, the process, the environment of the process and product quality attributes are essential. Without such information, process control, production scheduling, material allocation, energy and pollution reduction and efficient maintenance actions are not possible. Powerful and intelligent online sensors or sensor networks are necessary, and solutions are needed to handle the huge amounts of online data coming from these sensors and to extract useful knowledge out of them.
These digital tools will eventually result in:

- Powerful and intelligent online process sensors or sensor-networks with focus on the properties of resources and materials, environmental aspects of the plants and processes, e.g. energy usage and emissions, and on predictive maintenance
- Solutions for automatic pre-processing of the large amounts of data coming from plants, processes and materials
- Automatic real-time extraction of knowledge from large amounts of process data
- Solutions to detect possible equipment failures early automatically by intelligent condition monitoring system
- Expanding process monitoring systems by methods to reveal the full environmental footprint of the running process in real time
- Integration of life cycle assessment aspects into the plant and site wide monitoring strategies

These roadmap objectives are dealt with within the **CAPRI project** through the development of Cognitive Sensors based on different advanced sensor systems (specific description can be found in the corresponding deliverables, like D2.2), such as:

Asphalt use case:

Cognitive sensor of bitumen content in recycled asphalt to add in the asphalt mix. (CAS1)

Cognitive sensor for measurement of dust (filler) quantity in aspiration of drying drum (CAS2)

Steel use case:

Product tracking sensor (CSS1) - to allow the digital twins of products to identify their (approximate) position

Cognitive solidification sensor (CSS2) - new information about the solidification process and the initial temperature profile of the produced billets

Cognitive temperature sensor (CSS3) - temperature cognitive sensor along the whole process chain

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Cognitive scale sensor (CSS4) - predicts scale-build-up and thickness after the rolling processes

Risk and anomalies sensor (CSS5) – based on machine learning techniques, to identify process anomalies in the plant

Pharma use case:

Blend uniformity cognitive sensor (CPS1) - wet granulation step an in-line monitoring procedure for granule composition and moisture

Granule Quality cognitive sensor (CPS2) – after granulation process, in-line measurement of granule size distribution

Product moisture cognitive sensor (CPS3) – to predict residual moisture in different sections of the drier

Prediction of dissolution cognitive sensor (CPS4) - for predicting dissolution profile of a tablet from available process data

Cognitive sensor for fault detection sensor (CPS5) - allow the early identification of possible faults in the manufacturing line

### 2.1.3 Digitalisation of connected processes and supply chains

Supply chain digitalisation can occur on different levels:

1. Supply chains within a company or single production processes: planning and scheduling can be improved to optimise efficiency and reliability of supply in the presence of uncertainties on raw materials, prices, or resources.
2. Integration of the upstream supply chain: procurement and predicted deliveries are integrated into the planning to optimise not only on the company level but on the full upstream supply chain level to achieve efficiency improvements that reduce the carbon footprint.
3. Full supply chain: integrated optimisation of logistics, energy and industrial symbiosis but now also with downstream actors. Additionally, it includes integrated waste management (wastewater treatment, thermal treatment, other by-products, etc.) optimisation.

The first two levels can be supported by a set of digital solutions for **autonomous integrated supply chain management**. Developing digital solutions that can assist managing complex processing and supply chains dynamically is a key challenge. This allows for energy and resource efficiency, a quick response to changing customer demands for prices for raw materials and energy and the availability of green power to be realised simultaneously. More specific targets that are addressed are:

- Development of solutions for integrated planning, scheduling and control within plants to optimise efficiency and reliability of supply while addressing the trade-off between the maximisation of throughput and resource and energy efficiency.
- Integration of production planning and scheduling with the provision of utilities (e.g. steam, electric power, waste treatment) and electric-power procurement, adaptation to the supply of electric-power from renewables and demand side management. Integrated management of production with waste and wastewater treatment.

- ☐ Applications of these previous concepts can also be found, again, in the already mentioned cognitive solutions applied to planning and scheduling:

Asphalt use case:

Cognitive solution of Planning and Control of Asphalt Production (CAP1)

Steel use case:

Through the decision support system implemented on top of the digital twin shall lead to a direct reduction of rejected products.

Pharma use case:

Operating Cognitive solution (CPO1) as a decision support system.

Planning Cognitive solution (CPP1) as a digital plant operation to achieve proper scheduling.

- Integration of planning and scheduling along the supply chain, including real-time integrated logistics, procurement and production optimisation and real-time cradle-to-gate resource efficiency and life cycle assessment monitoring and optimisation.
- Data integration and along the supply chain and across sectors, considering protection of IP and commercial interests and development of platforms that implement these concepts.
- Facilitation of reuse and recycling by digital fingerprints of products and materials along the supply chain, based on standardised product descriptions (see also Circularity of resources).
- Real-time characterisation of waste streams (see also Circularity of resources), enabling an increase of the use of secondary materials.

The success of digital solutions will depend on several factors:

- **Training of the existing and future workforce is required** to make optimal use of the emerging capabilities of digital technologies.
- **Cybersecurity must be ensured**. The deployment of digital technologies will increase the vulnerability to cyberattacks, which pose significant risks for plant safety and efficient plant operations. The process industry is an important stakeholder and should play an active role in developing solutions to increase cybersecurity.
- **Organizations must get ready**. A digital strategy is needed to integrate digital systems and platforms in the organizational structure, set the responsibilities clear and secure time of staff.
- **Co-create with digital firms and industry partners** to design the best solutions in limited time.

## 2.2 The SPIRE 06 Community

SPIRE (Sustainable Process Industry through Resource and Energy Efficiency) is the European Association which is committed to manage and implement the SPIRE Public-Private Partnership. Apart from CAPRI, the projects which participate in the SPIRE 06 community (Digital Technologies for improved performance in Cognitive Production Plans – DT-SPIRE-06-2019) are:

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## COGNIPLANT

**Full Title:** Cognitive Platform to enhance 360º Performance and Sustainability of the European Process Industry

**Aim:** COGNIPLANT project will develop and demonstrate an innovative approach for the advanced digitization and intelligent management of the process industries. This approach will be based on a novel vision to data monitoring and analysis, that will make the most of the latest developments on advanced analytics and cognitive reasoning, coupled with a disruptive use of the Digital Twin concept to improve.

**Concept:** The COGNIPLANT solution will provide a hierarchical monitoring and supervisory control that will give a comprehensive vision of the plants' production performance as well as the energy and resource consumption. Advanced data analytics will be applied to extract valuable information from the data collected about the processes and their effect on the production plant's overall performance enabling to design and simulate operation plans in digital twin models based on the conclusions.

**Start date:** 01/10/2019

**End date:** 31/03/2023

**Website**: https://www.cogniplant-h2020.eu/

**CAPRI presence in COGNIPLANT**: CORE Innovation is the common partner. Moreover, STAM was organising the Dec 16th 2020 event and close interactions with POLIMI are ongoing especially thanks to the EUR3KA project[5] about Manufacturing Repurposing and Resilience.

## COGNITWIN

**Full Title**: Cognitive Plants through proactive self-learning hybrid digital twins

**Aim**: COGNITWIN aims add the cognitive elements to the existing process control systems and thus enabling their capability to self-organise and offer solutions to unpredicted behaviours. COGNITWIN's strategic, high-level objective is to establish the fully digitalized concept of self-learning and proactive next generation of Digital Twins, which operates in the hybrid world and can i) recognize, forecast and communicate less optimal process behaviour well before these occur and ii) adjust itself in order to keep the process continuously close to or at optimum.

**Concept:** COGNITWIN will set a new standard for the design, development and operation of the European process industry by introducing a platform for virtual component-based architecture that integrates IoT, Big data, AI, smart sensors, machine learning and communication technologies, all connected to a novel paradigm of self-learning hybrid models with proactive cognitive capabilities.

**Start date:** 01/09/2019

**End date:** 31/08/2022

**Website**: https://www.sintef.no/projectweb/cognitwin/

**CAPRI presence in COGNITWIN.** SIDENOR and NISSATECH are common partners.

## FACTLOG

**Full Title:** Energy-aware Factory Analytics for Process Industries

[5] https://www.eur3ka.eu/

This project receives funding in the European Commission's Horizon 2020 Research Programme under Grant Agreement Number 870062

**Aim:** Cognition can improve the behaviour of a complex process system and FACTLOG offers a real-time processing layer where observations, knowledge and experience interoperate to understand and control the behaviour of a complex system (i.e., cognition).
**Concept:** FACTLOG is driven by several specific business cases in the process industry and focuses in innovation about Analytics, AI and Optimisation on the Deployment and Assessment of coherent Enhanced Cognitive Twins for the specific sectors represented in the project.
**Start date:** 01/11/2019
**End date:** 30/04/2023
**Website:** https://www.factlog.eu/
**CAPRI presence in FACTLOG**: NISSATECH is a common partner. Moreover, many beneficiaries of FACTLOG are very active members of KYKLOS4.0 Innovation Action in sustainable manufacturing and circular value chains. This can create interesting links with the Digital Manufacturing Platform cluster, Connected Factories CSA, EFFRA and Made in Europe Partnership

### *HyperCOG*

**Full Title:** Hyper connected architecture for high cognitive production plants
**Aim:** The main objective of HyperCOG is to demonstrate the potential of cyber-physical systems and data analytics to transform the process industry and associated business models. The cyber-physical system architecture being developed by HyperCOG will attempt to realise the concept of cognitive manufacturing, combining cognitive computing techniques (such as artificial intelligence), the Industrial Internet of Things, and advanced data analytics to optimise manufacturing processes in ways that were not previously possible.
**Concept:** The HyperCOG project is developing an innovative cyber-physical system that supports industrial production, based in computer-based algorithms to provide useful information to operators. The final solution will be a flexible platform able to adapt to changing conditions, leveraging on advances data analytics (for decision support system) and cybersecurity.
**Start date:** 01/09/2019
**End date:** 28/02/2021
**Website:** https://www.hypercog.eu/
**CAPRI presence in HYPERCOG**: SIDENOR and MSI are common partners.

### *INEVITABLE*

**Full Title:** Optimization and performance improving in the metal industry by digital technologies
**Aim:** The general objective of the INEVITABLE project is to improve the performance indicators in the steel and nonferrous metals sectors by retrofitting existing production sites by digitalization and innovative control technologies, to elevate the overall digitalization level.
**Concept:** The main ambition is to exceed the level and functionality of traditional process automation and control systems by applying the functionalities of Digital Factories and Industry 4.0 concepts.
**Start date:** 01/10/2019
**End date:** 30/09/2022
**Website**: https://inevitable-project.eu/
**CAPRI presence in INEVITABLE:** SIDENOR and BFI are common partners.

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## 2.3 The Cluster collaboration event on December 16th 2020

On the 16th of December 2020, (9.00-11.30 AM CEST), SPIRE-06 projects organised a collaboration event to discuss general aims of the SPIRE call and common strategies among the projects.
The aim of this meeting was to align R&I innovation activities among four older SPIRE 06 projects (started in 2019) i.e. HyperCOG, COGNITWIN, COGNIPLANT and INEVITABLE.


**Figure 1 Cover page of 16th December Cluster collaboration event**

Different topics were discussed: the need of developing new technologies to implement cognitive production plants, with improved efficiency and sustainability, exploiting smart and networked sensor technologies, intelligent handling and online evaluation of various forms of data streams as well as new methods for self-organizing processes and process chains.
The webinar provided the audience with a unique view of the latest developments in this field as well as introduce them to the people developing this vital technology.

**HyperCOG** was mostly focussing on its Reference Architecture (see §4.1 PICO Collaboration Plan) and the impact KPIs of Industrial Pilots (see §4.3 6P for Process Industry).

**STEEL**

| Item | AS-IS (today) | TO BE |
|---|---|---|
| Reduction of waste | 5% (20% in ingot casting) | 4% (16% in ingot casting) |
| Costs of the product | 210 €/ton | 204 €/ton |
| Reduction of $CO_2$ (due to raw materials) | 14,640 tonnes of CO2 | 14,146 tonnes of CO2 |
| Reduction of raw materials | 8000 tonnes | 7730 tones |

**CEMENT**

| Item | AS-IS (today) | TO BE |
|---|---|---|
| Reduction of water | 38 tons/h | 36.1 tons/h |
| Reduction of energy | 141 kWh/tons | 134kWh/tons |
| Reduction of $CO_2$ | 50,000 tons of CO2 | 47,500 tons of CO2 |
| Cost of clinker | 29€/ton | 27.6€/ton |

**CHEMICAL**

| Item | AS-IS (today) | TO BE |
|---|---|---|
| Accuracy | Net OEE = 75% | Net OEE = 85% |
| Reduction of waste | 100 T (400 k€) | 95 T (380 k€) |
| Reduction of energy | 8,5 t steam /t rare earth separated | 8 t steam /t rare earth separated |
| Costs | 7100 €/ton | 6650 €/ton |

Figure 2 HyperCOG expected impact – KPIs to measure project success

**COGNITWIN** presentation was mostly focussing on their Reference Architectural model and the concept of Hybrid Twin which characterises the project and stimulated the preparation of a common scientific paper

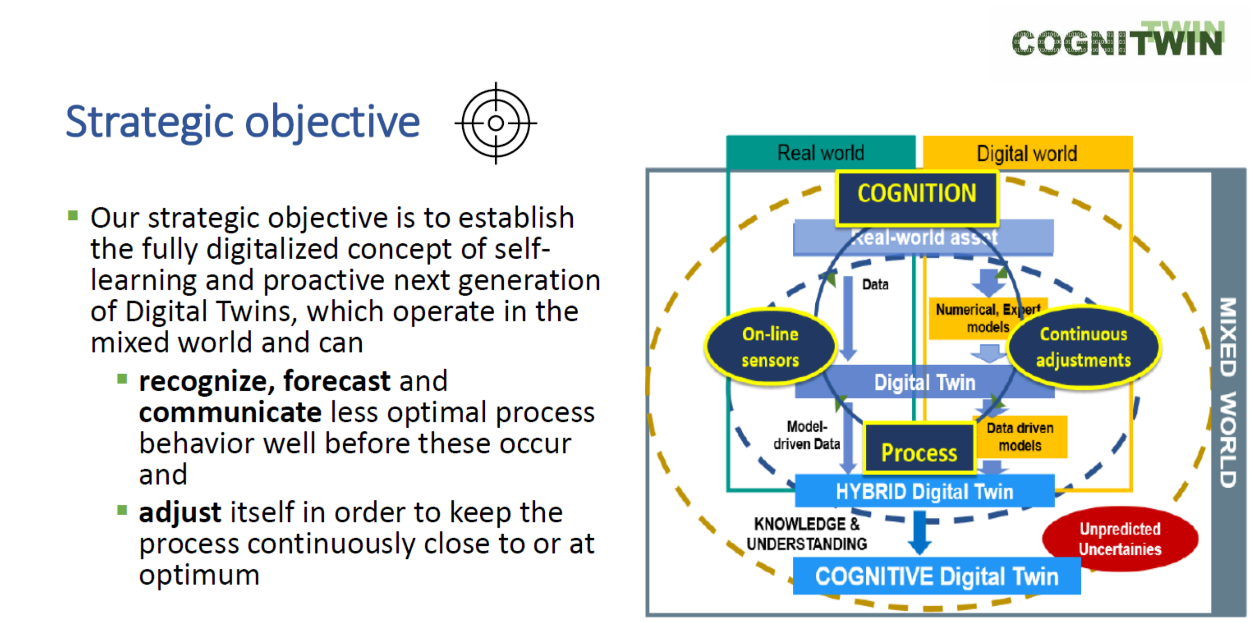


Figure 3 COGNITWIN strategic objective

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**COGNIPLANT** presented its holistic cognitive view in digitising processes, analyse data and take decisions. This is very relevant for §4.1 PICO collaboration plan

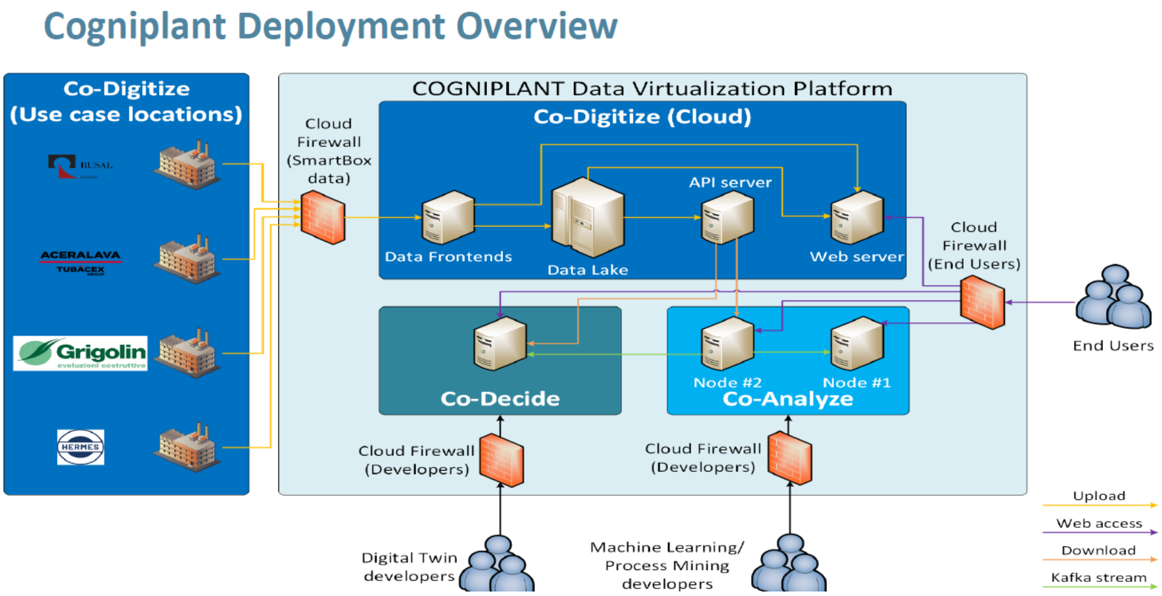


Figure 4 COGNIPLANT deployment overview

**INEVITABLE** is focussing on steel and nonferrous metals sector and circular loops to be implemented in three industrial applications of Electric Arc Furnace in Steelmaking, secondary Steelmaking and non-ferrous alloys.

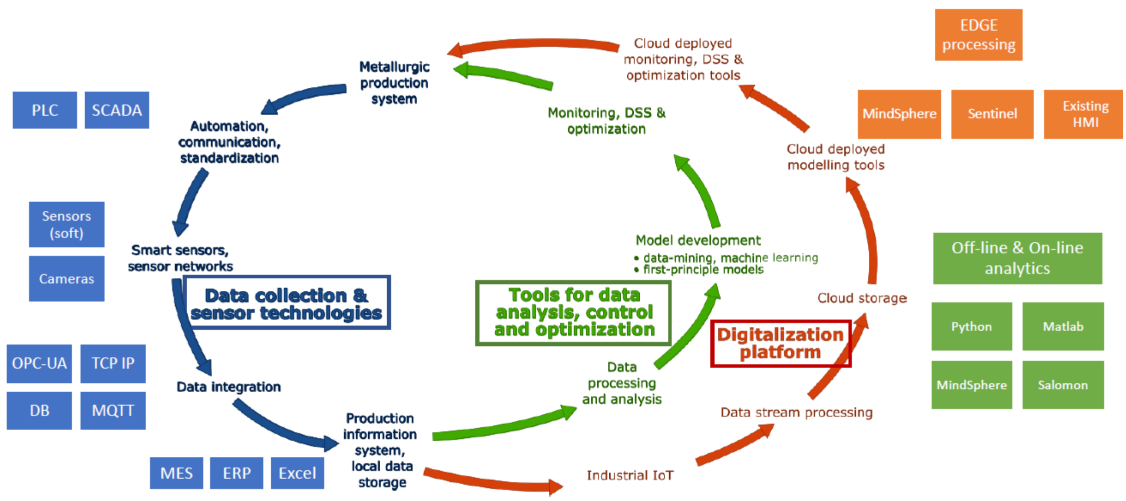


Figure 5 INEVITABLE main concepts

The four project expressed a generic manifestation of interest to build a SPIRE 06 portal (PIHUB) which could be the vehicle to reach SMEs also via Digital Innovation Hubs in Process Industry (PIWARE) (DIH4Industry[6] marketplace).

6 https://dih4industry.eu/welcome/

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## 2.4 The Cluster collaboration event CAPRI-COGNITWIN March 3rd 2021

On March 5th, 2021 CAPRI participated to the first collaborative meeting with COGNITWIN, with the purpose of strengthening the collaboration within the SPIRE-06 partners. It was a 3-hours meeting organised by CAPRI, with over 25 participants from both projects. The agenda was organised in three main slots:

- First of all CAPRI presented the project, the concept behind and its objectives. Each domain provided a short presentation of the Cognitive Solutions to be implemented and, finally, a preliminary overview of the Cognitive Automation Platform followed.
- The second slot was entirely dedicated to COGNITWIN, who went through a general introduction to the project (partners and countries; key topics; objectives; industrial pilots), an overview of the developed toolbox with a practical demonstration and detailed presentations of two of the six pilots (the steel case and the aluminium case).
- Last slot represents the starting point of possible collaboration together with COGNITWIN and SPIRE-06 ecosystem.

| ITEM | | time | PRESENTER |
|---|---|---|---|
| **0.** | **WELCOME, INSTRUCTIONS FOR THE MEETING** | 5’ | CARTIF |
| **1.** | **CAPRI: GENERAL PRESENTATION** | 5’ | CARTIF |
| i. | ASPHALT, CS´S TO BE DEVELOPED, DEVELOPMENT METHODS TO BE USED (e.g., predictive maintenance, MPC) | 10’ | CARTIF, AIMEN, EIFFAGE |
| ii. | STEEL, CS´S TO BE DEVELOPED, DEVELOPMENT METHODS TO BE USED (e.g., digital twins) | 10’ | SID, BFI, MSI |
| iii. | PHARMA, CS´S TO BE DEVELOPED, DEVELOPMENT METHODS TO BE USED (e.g., MPC) | 10’ | RCPE, AMS |
| iv. | CAP (Cognitive Automation Platform) | 10’ | ENG, POLIMI, NISS |
| **2.** | **COGNITWIN: GENERAL PRESENTATION** | 10’ | SINTEF |
| i. | COGNITWIN Toolbox | 5’ | SINTEF |
| ii. | Digital twins in COGNITWIN | 5’ | FRAUNHOFER IOS |
| iii. | COGNITWIN Digital twins Demonstration | 10’ | FRAUNHOFER IOS |
| iv. | Sidenor Pilot Use case | 10’ | SIDENOR |
| v. | Hydro Aluminium Case | 10’ | HYDRO |
| **3.** | **POINT OF VIEW OF POSSIBLE SYNERGIES** | 45’ | CORE |
| | **QUESTIONS** | | ALL |

Figure 6 5th March, 2021 Cluster collaborative meeting agenda

The synergies creation was further explored with participants trying to find both projects' touchpoints. CORE, common partner, presented a number of topics for future possible communication and dissemination activities.

In this regard, the third part of the meeting was about the contact points between CAPRI and COGNITWIN, and the potential collaboration and synergies of the two projects.
The exchange of information touched:

- technical issues, mainly in reference to the common technical hurdles to overcome, to joint developments of architectures of cognitive platforms for the process industry and to the concepts of open data and open architectures;
- deepening of the technical aspects of the pilots, with a particular focus on their concrete application to real industrial cases and processes, and on the adoption of similar guidelines for the experiments;
- legal issues such as safeguard of the operators involved in the human-in-the-loop processes, property and protection of the data, security;
- collaboration in communication and dissemination activities, including joint scientific publications like the collaborative paper that was further published in the Applied Sciences Journal (see next).

As a concrete outcome of the workshop, CAPRI was invited to co-write an academic article in Applied Sciences Journal.

### *The SPIRE-06 collaborative paper*

At the beginning of September, it was delivered to the Journal the paper "Cognitive plants for process industries: analysis of different approaches ". The paper encompassed contributions of a wide panel of authors: CARTIF, SINTEF, POLIMI, Fraunhofer IOSB, JSI, LORTEK, Athens University of Economics and Business, Nissatech, Gruppo Maggioli, IDEKO, Engineering Ingegneria Informatica, Ibermatica, from six European countries and part of SPIRE-06 ecosystem.

Its main objective was to demonstrate, also by use cases of several sectors (Textile, Steel, Oil Refineries, Automotive, Waste-to-fuel, Cement, Chemical), the applicability to the process industry of advanced cognitive solutions based on Digital Twins, with the aim to increase their efficiency and to lead to more sustainable and greener processes, same as in the discrete manufacturing industries.

The article highlighted that, first of all, the adoption of Digital Twins requires to prepare a proper digital background, by improving the digitization of field devices (sensors, actuators, controllers…) and of infrastructures (improving information and communication technologies to achieve horizontal and vertical integration of data and processes), and the ability to exploit Big Data.

Then, the article described the SPIRE-06 projects (CAPRI, COGNIPLANT, COGNITWIN, FACTLOG, HYPERCOG, INEVITABLE) and analysed similarities and differences in their approaches to Digital Twins (technical and functional features) and to the Cognitive computing and its four areas according to the European AI SRIDA model (sensing and perception; knowledge and learning; reasoning and decision making; action and interaction).

The six described projects have not been finalized yet since all of them are just in the second year of activity (out of 3 years and a half): hence, only at final stage it will be possible to collect the results and measure the impact brought by novel cognitive functionalities on product quality and plant efficiency.

# 3 CAPRI Value Proposition for SPIRE-06 Ecosystem creation

## 3.1 CAPRI PICO (Process Industry COgnitive) Architecture

### *Challenge for Cognitive Architecture*

One of the most important challenges for developing innovative solutions in the process industry is the complexity, instability and unpredictability of the processes, since they are usually running in harsh condition, dynamically changing the values of process parameters, missing a consistent or at all monitoring/measurement of some parameters important for analysing process behaviour.
For cognition-based (cognitive) solutions these are even more critical constraints, since cognition requires (usually) a huge amount of high quality data for ensuring the quality of the learning process (precision, efficiency). Moreover, getting high quality data usually requires an intensive involvement of human experts in curating (or even creating) the data in a time consuming process. In addition, a supervised learning process requires labelling/classifying the training examples by domain experts, which makes a cognitive solution quite expensive.

It is important to emphasize that the role of human is critical, which can be illustrated using the following comparison:

The difference between a **highly experienced expert** and a **highly-talented novice**: the experts have the **sixth sense** for detecting (early enough) variations/unusualities in the process and to **decide** on spot if the unusuality is something that should be followed closer or is just a temporary disruption. And they are usually very reliable in their decisions. In a very competitive industry environment, this skill can be of critical value for optimizing quality control process, e.g. by having a very efficient anomaly detection mechanism.

**Process Industry COgnitive PICO architecture**

PICO architecture is based on the recent work in cognitive science[7] and reflects the need for explaining the intelligent behaviour through cognitive processes, which are well structured processes in human beings. Following figure illustrates the original cognitive architecture.

[7] Laird, J. E., Lebiere, C., & Rosenbloom, P. S. (2017). A Standard Model of the Mind: Toward a Common Computational Framework across Artificial Intelligence, Cognitive Science, Neuroscience, and Robotics. AI Magazine, 38(4), 13-26. https://doi.org/10.1609/aimag.v38i4.2744

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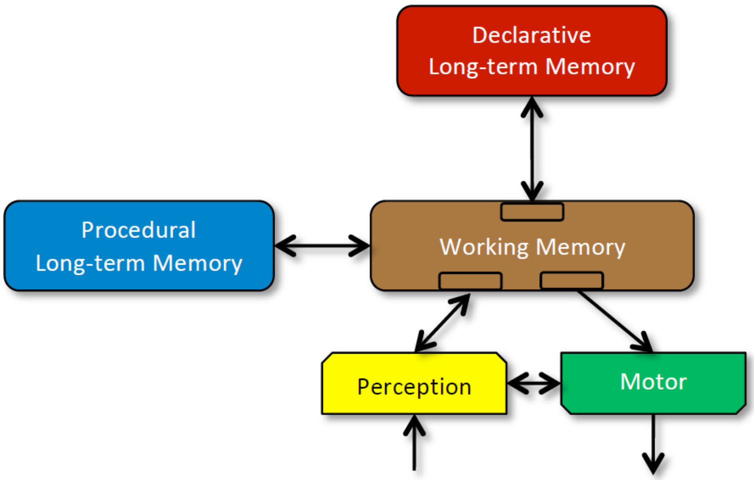


**Figure 7 (Cognitive Architecture) across Artificial Intelligence, Cognitive Science, Neuroscience, and Robotics**

A cognitive architecture is analogous to a **building architecture**, which describes its fixed structure (e.g., floors, rooms, and doors), but not its replaceable elements (e.g., tables, chairs, and people).

PICO postulates that these human-oriented processes can be mapped into industry processes, like:

- **Cognitive Perception** using dynamic data-driven scanning of the complex industry assets, realizing an efficient, cognition-based collection of heterogeneous data (all senses).
- **Fast Thinking**, enabling an efficient edge-based variations detection and fast understanding of new situations, creating attention for complex, so called unknown unknown situations.
- **Slow Thinking**, enabling complex and efficient processing of complex situations, by creating digital models of their behaviour from sensed data, supporting timely and precise decision making.

It is important to mention that these layers correspond to the modern, well accepted, theory from cognitive psychology[8] about human cognition, optimized for dealing with complex structures, enabling deep understanding of the real-time situation (monitoring)
In the following figure the high-level technical architecture of the envisioned system is presented.

[8] https://www.scientificamerican.com/article/kahneman-excerpt-thinking-fast-and-slow/

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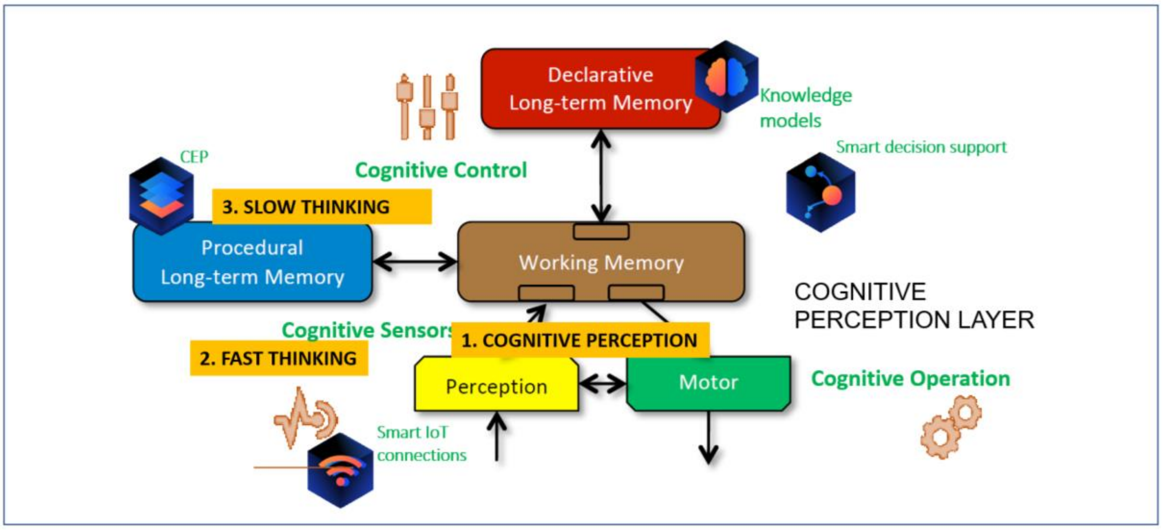


Figure 8 PICO architecture

### *Cognitive perception - hardware architecture*

One of the main challenges is to enable an easy plugging of the needed monitoring system in an industrial (shop floor) environment. In the architecture, COGNITIVE PERCEPTION LAYER describes this abstraction between the physical world and the conventional, non-intrusive sensors. The architecture will allow a “standardized” and easy plugging of the Cognitive Perception Layer in a shop floor environment. The main elements of the architecture are:

- Edge computer for gathering and processing.
- Several sensors with standard settings: camera for visual and acoustic sensing, environmental sensors: temperature, humidity, air quality, etc. Edge computer should be flexible.
- Sensors for energy consumption.
- Software components for interacting with IT systems (ERP, GMAO, etc) of the manufacturing company that provides access to relevant **machine operational data**: products manufactured, materials used, production forecast volume, maintenance history, personnel involved, etc.
- Open data models for an easy connection of machine operational data.

Below it’s presented a conceptual hardware architecture and how everything is connected. The idea behind that is to allow an easy installation in different production environments.

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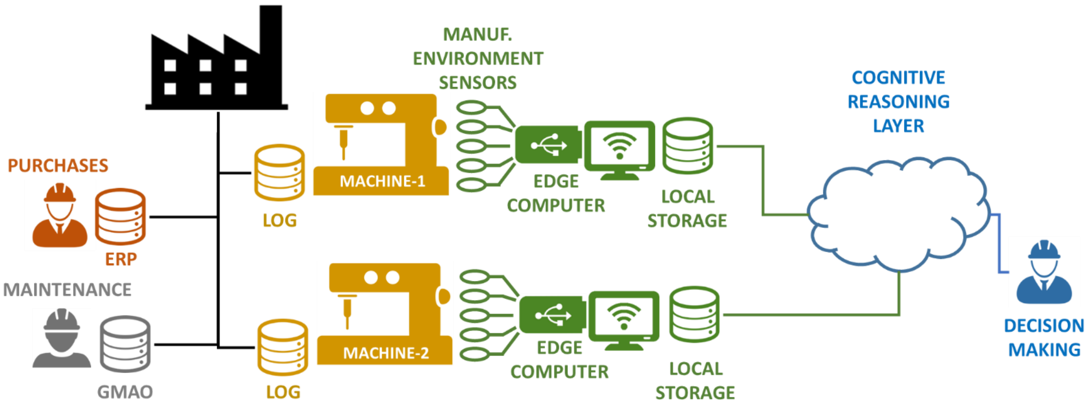


**Figure 9 Conceptual picture of cognitive architecture for an easy integration in the shop floor**

This module is responsible for processing variations which can be resolved on the edge, by using models learned in the cloud as well. From the human cognition point of view, it corresponds to System 1[9] operates automatically and quickly, with little or no effort and no sense of voluntary control.

Due to a high dynamicity in a manufacturing environment, a proper set of training examples is not always available. We will focus on three common cases: a) understanding/detecting **rare situations of interest** (e.g. some anomalies), which implies the need for creating new, significantly modified training examples for critical, unseen situations, b) adaption to **novel domains**, which requires fast learning from a few training examples, where the goal is to ensure that visual processing always provides the best possible perception of anomalous situations or their indicators and c) understanding **uncertain situations** (e.g. not certain about being anomaly or not).

### *Slow Thinking*

This module is responsible for processing variations that require additional processing/attention - **Unknown unknowns**. From the human cognition point of view, it corresponds to System 2 (see footnote for System 1), which allocates attention to the effortful mental activities that demand it, including complex computations. PICO approach is based on the initial innovation that focuses on Unsupervised ML methods for multivariate anomaly prediction, based on a deep situational understanding (cognition) of the anomalous behaviour in high-dimensional time-series data. It is related to Complex quality issues, related to a mismatch between the models and data: either process data or domain/specification models do not indicate anomalies, but they appear in real world and vice versa. Two characteristic situations are: a) **anomalies that appear although all parameters are within specification** (no indication of anomalies in parameters, but there is the need for detecting unusualities/anomalies in the correlations between parameters) and b) although **some of the parameters are outside the specification, the process as a whole is valid** from the quality control point of view. It indicates the need for learning specification values from data.

### *Advantages*

These functionalities will lead to new process and business innovations, esp. through **empowering human operators** for resolving challenging situations when neither models of the problems nor the

[9] https://scottbarrykaufman.com/wp-content/uploads/2014/04/dual-process-theory-Evans_Stanovich_PoPS13.pdf

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data related to problems are available, so called **unknown unknowns** (or unforeseen events), which are one of emerging scenarios in the industry domain. Briefly, while traditional Deep learning approaches for scene processing are related to PERCEPTION, i.e. recognizing the scene and deciding if the situation might be a problem, our approach will provide support for COGNITION, **deep understanding of the situations, supporting the decision if, how and when to react**.
Altogether, this will pave the way for new generation of process and quality control approaches which adopt cognitive sensing for "seeing invisible" and opens new possibilities for process and business innovations. The proposed **PICO approach tackles the major challenges that the process industry faces today** when it comes to applying cognition in their daily operations and therefore opens the possibility of expanded capabilities and flexibility, leading to more cost-efficiency and higher production yield.

## 3.2 CAPRI PIHUB Industrial Plants and Experimental Facilities

**PIHUB** (Process Industries HUB) under the SPIRE-06 umbrella search for "Digital technologies for improved performance in cognitive production plants" using AI cognitive solutions. Projects under this paradigm need to develop new technologies to realise cognitive production plants, with improved efficiency and sustainability, by use of smart and networked sensor technologies, intelligent handling and online evaluation of various forms of data streams as well as new methods for self-organizing processes and process chains. They also cover the full digital transformation of a complete plant or site(s) including e.g. data acquisition, communication, automation, analytics, modelling, prediction and standardisation of relevant data interfaces. Interfaces and technologies that many process industries take long time to implement.

The implementation of a full set of digital transformation techniques and the "knowledge and cognition" that can be extracted from that transformation (thanks to big data and AI applied technologies) are very innovative in the sector of the process industries.

CAPRI, as part of the SPIRE-06 community, proposes to use a general Cognitive Automation Platform (CAP in short) that can be implemented in many cases in the different pilots and experimental facilities available in any of the sister projects of this community.

There are five other projects under PIHUB apart from CAPRI. Hereafter, the different use cases and industrial plants of the different projects are listed alongside with the different partners, pilot plants and general goals of all of them:

### 3.2.1 Cognitive platform to enhance 360° performance and sustainability of the European process industry (COGNIPLANT)

**Pilots**:

The COGNIPLANT concept will be implemented by four end-users from four different SPIRE industries:

- A chemical industry in Austria (Hermes Abrasives dedicated to the manufacturing of abrasives)
- An alumina refinery in Ireland (Aughinish Alumina, Europe's largest alumina refinery and one of the world's most energy efficient alumina refineries)

- A lime manufacturing industry in Italy (The production plant of Grigolin produces lime for the de-carbonation of calcium carbonate)
- A metal industry in Spain (ACERALAVA, a Tubacex Group company, is a leading global manufacturer of long stainless steel products, specialized in rolled and forged round and square bars)

From the full digital transformation of those demo cases, advanced data analytics will be applied to extract valuable information from the data collected using 3 different "*layers*", enabling to design and simulate operation plans in digital twins to improve overall performance through their conclusions:

**Layers**

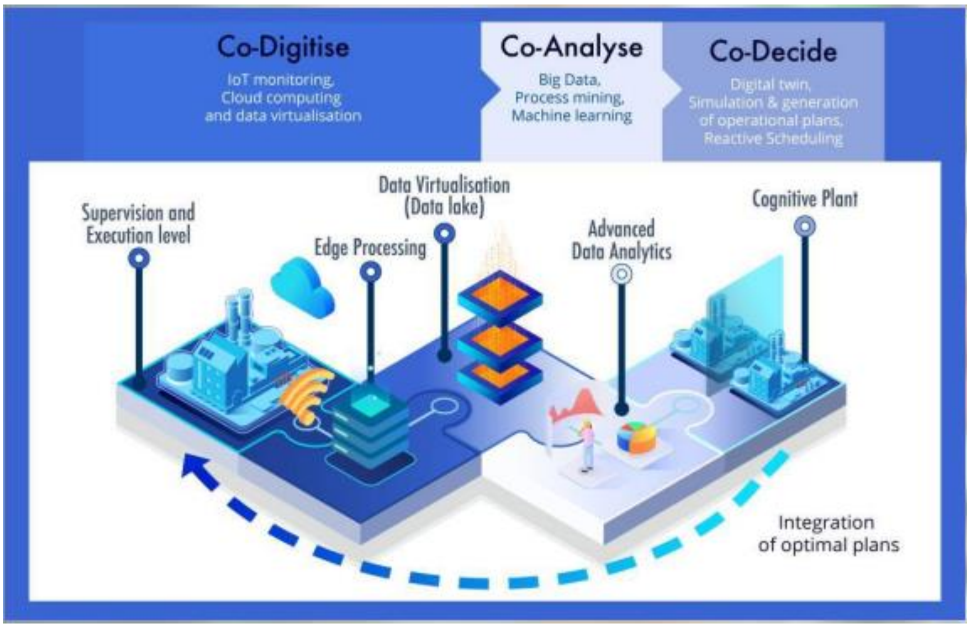


**Figure 10 The 3 big data analytics "layers" in the COGNIPLANT project**

"*Co-Digitise*": collect and structure the data from the different sensors and equipment for its further analysis.

"*Co-Analyse*": data processing, application of advanced methods of process mining, big data, data mining, etc.

"*Co-Decide*": digital twin, decision-making, generation of operational plans, prescriptive general and edge processing.

### 3.2.2 Cognitive plants through proactive self-learning hybrid digital twins (COGNITWIN)

**Pilots**:

The COGNITWIN concept will be implemented by five end-users from four different SPIRE industries:

- Hydro - It is a fully integrated aluminium company. In addition to production of primary aluminium, rolled and extruded products and recycling, Hydro also extracts bauxite, refines alumina and generates energy. Hydro pilot is based on Germany in a gas treatment centre (GTC)

- Sidenor – Based in Spain, it is a special steel producer with main customers in automotive, machinery, railway and energy sectors. SIDENOR pilot case deals with operations in steel ladles. In the steel plant, scrap steel is melted in an EAF (Electric Arc Furnace). The steel is then tapped into one or several ladles. The ladle serves first as an intermediate container for the tapped steel and is then transported to stations where melt refining and alloying is taking place.
- Elkem – Based in Norway, it produces a variety of ferroalloys for chemical, automotive and electronic industry. Elkem pilot focus is on the liquid metal refining/alloying/casting process (aka post top-hole process).
- Sumitomo - Based in Finland, Sumitomo SHI FW (SFW) pilot case deals with developing novel digital services for energy boilers. The pilot will concentrate on an energy conversion process called Circulating Fluidized Bed (CFB) of a combustion based power plant.
- Saarstahl – Based in Germany, it is a German steel manufacturing company with a global presence on the steel production market. SAG use case consists of tracking the individual billets in the rolling mill train and thus to be able to associate sensor and other data collected throughout the rolling process to the corresponding billet.

***Cognitive Twins***

An important aspect of the COGNITWIN project, as the rest of the projects under the SPIRE-06 umbrella is the cognition concept applied to process industries. *Cognitive digital twins* are an extension of digital twins with cognitive capabilities in the context of the process industry. They are an extension *of hybrid digital twins* (an extension of digital twin in which the isolated digital twin models are intertwined to recognize, forecast and communicate less optimal (but predictable) behaviour of the physical counterpart well before such behaviour occurs) incorporating cognitive features that will enable sensing complex and unpredicted behaviour and reason about dynamic strategies for process optimization, leading to a system that continuously evolve its own digital structure as well as its behaviour. A cognitive digital twin is thus a hybrid, self-learning and proactive system that will optimize its own cognitive capabilities over time based on the data it will collect and experience it will gain.

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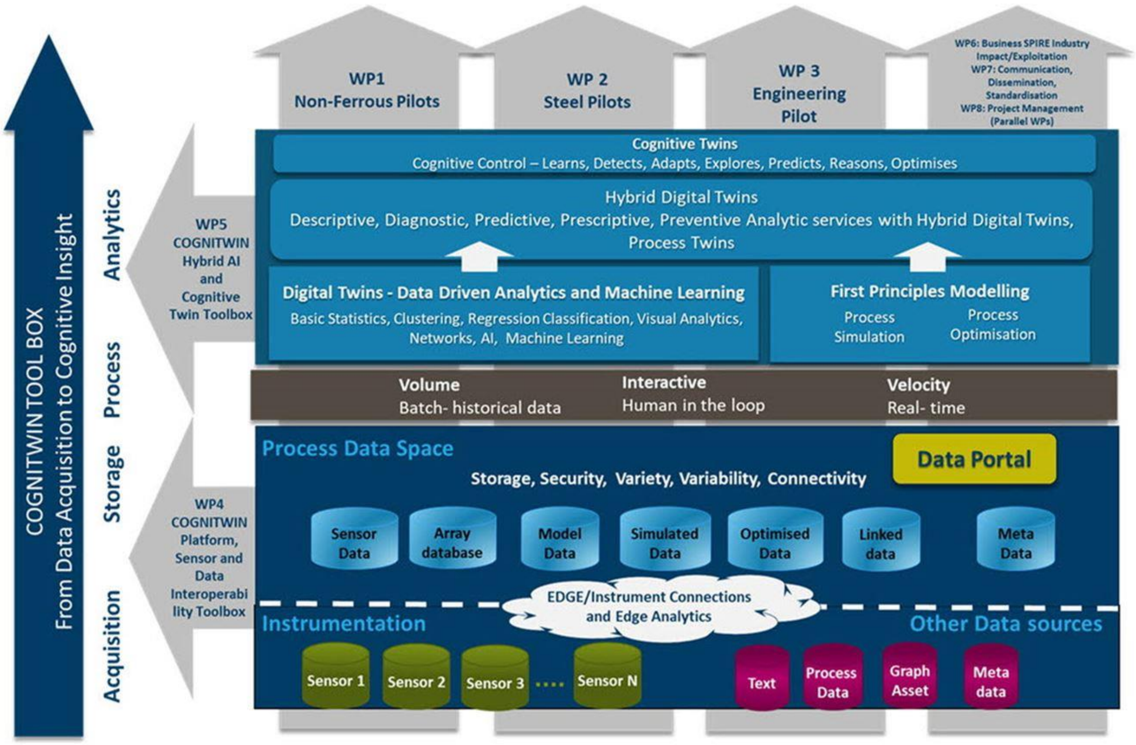


Figure 11 COGNITWIN project cognitive platform blocks

### 3.2.3 Energy-aware Factory Analytics for Process Industries (FACTLOG)

**Pilots**:

The FACTLOG concept will be implemented by five end-users from five different SPIRE industries:

- JEMS pilot based in Slovenia (Waste-To-Fuel transformation industry). It is a waste-to-fuel transformer plant. This type of plants is transforming any hydrocarbon-based waste into a high-quality synthetic diesel. Within FACTLOG, JEMS wishes to upgrade the existing plant with management, predictive and proactive features that will be deployed at the test machine. For this purpose, JEMS will be using existing and proven intelligent big data processing platforms.
- TÜPRAŞ pilot based in Turkey (oil refinery industry). It is based in four refineries of crude oil. This pilot produces many petroleum products with high level of energy consumption. Emerging technologies leading to the cognitive refinery approach are very crucial for producing in a more sustainable and efficient way due to each refinery has many different process units which are also interconnected to each other.
- Fratelli Piacenza pilot, based in Italy (textile industry). This manufacturer of fine woollen fabrics and supplier of fabrics to different fashion brand manufacturers has a pilot that consists of a machine fleet, especially in those parts of the process which have a direct impact on quality, like finishing or weaving. From those machines, relevant data to extract “cognition and knowledge” will be gathered and, in specific process steps where older equipment is used, the introduction of additional low-cost sensors will be required for process and product data.

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From all those data extractions, the use of cognition to resolve 'unknown unknowns' will be highly relevant to the production needs, especially with regard to processes like finishing.

- Continental Automotive Romania SRL pilot, based in Romania (auxiliary automotive industry), consists of a plant of different automotive electronics manufacturing process. It is comprised of different intertwined processes where the most relevant are SMT (Surface Mount Technology), PCBA (Printed Circuit Board Area), Press Fit, Handling, Flashing of Microcontrollers and Temperature functional tests, FA (Final Assembly) and Test Area and final packaging and delivery operations.
- BRC pilot, based in the United Kingdom (steel and concrete industry), is one of their steel reinforcement and associated products for concrete plant. The basic "cognition and knowledge" to be extracted under the FACTLOG paradigm is BRC wishes to optimize its machinery operational capacity and maintenance processes via predictive machine analytics (interrelating oil levels, greasing requirements, drive wear, temperatures, vibration etc.), also incorporating cognitive characteristics to further capture unresolvable situations, thus leading to predictive fault prevention.

**FACTLOG layer:**

The use of digital twins is to give the capability to observe and monitor the behaviour of their respective physical twins applied to process industries. Digital twins, which are driven by domain models (i.e. knowledge), will be combined with the models derived from data (i.e. experience). In order to realize it, a real-time processing layer where observations (i.e. events) will be implemented and, knowledge and experience interoperate to understand and control the behaviour of a complex system (i.e. cognition). FACTLOG offers such a layer and aims at deploying and adjusting it to the mentioned process industries. That will be done by incorporating different pipelines of machine learning and analytical tools at different levels (from machines to process steps and from processes to the whole production plant).

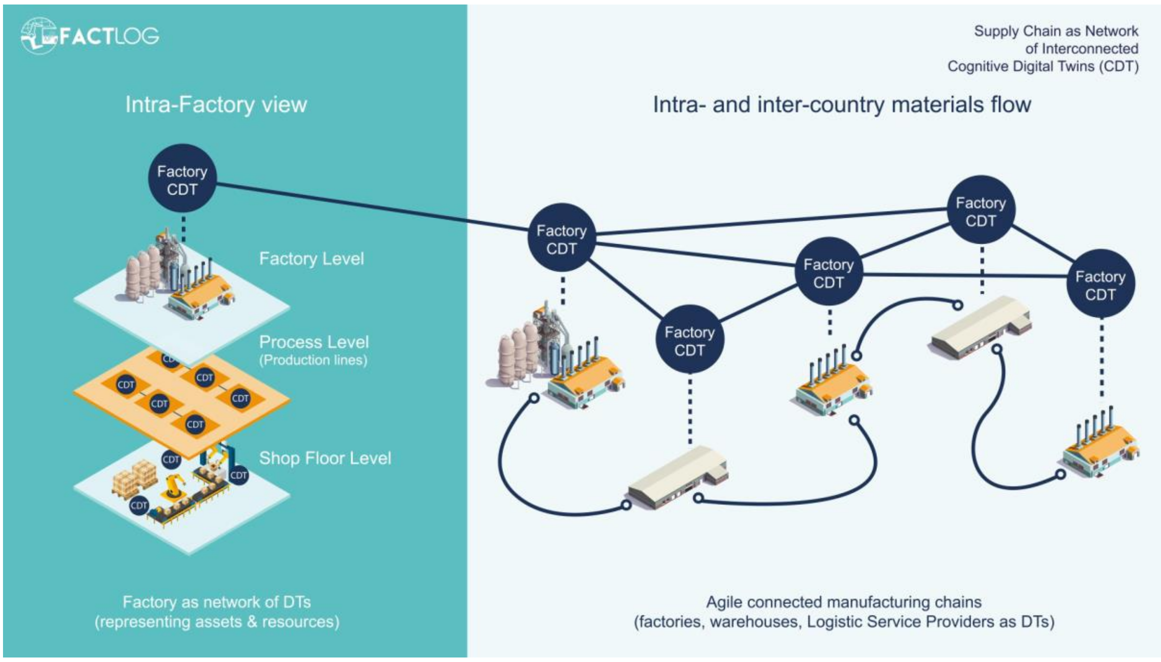


Figure 12 FACTLOG Cognitive Digital Twins layers applied to Cognitive Supply Chains

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Figure 13 FACTLOG Cognitive Digital Twins enablers

### 3.2.4 Hyperconnected Architecture for High Cognitive Production Plants (HyperCOG)

**Pilots**:

The HyperCOG concept will be implemented by three end-users from three different SPIRE industries:

- Sidenor pilot plant based in Spain (steel industry).This pilot will focus on the steelmaking process, which includes melting raw materials, getting the right composition and casting it in the chosen semi-product form. The prototype to be installed in the SIDENOR plant in Basauri, Spain, will help plant operators to solve online production planning problems arising from failures that can occur during steelmaking operations and cause delays or other problems to the scheduled production.
- Çimsa pilot plant, based in Turkey (cement industry). The pilot at ÇIMSA will focus on the white Portland cement manufacturing process, which is usually not energy efficient and requires regular manual interventions to maintain continuous operation. The project's solution will optimise the process parameters based on monitored and recorded data in order to achieve a more energetically efficient cement manufacturing process.
- Solvay pilot plant, based in France (chemicals industry). The pilot for chemicals will focus on the liquid-liquid extraction process of rare-earth elements. This process consists of a number of continuous operations of series equipment that require manual analysis to be controlled. This results in frequent process problems and interruptions. A distributed control system and sensors for pH, mass meters, levels and in-line spectro-photometers are in place to control the process. However, there is no overall structure to optimise the entire process. The project will optimise the productivity, quality and energy efficiency of the steam boilers.

**Cognition platform objectives**

The HyperCOG project aims to show that cyber-physical systems and data analytics can be used to drive transformation within the European process industry, improving efficiency and competitiveness by harnessing the power of data. Cyber-physical systems control and monitor physical processes using computer-based algorithms to provide useful information to operators. HyperCOG is developing a cyber-physical system architecture that will attempt to realise the concept of cognitive manufacturing, combining cognitive computing techniques (such as AI), the Industrial Internet of Things, and advanced data analytics to optimise manufacturing processes in ways that were not previously possible.

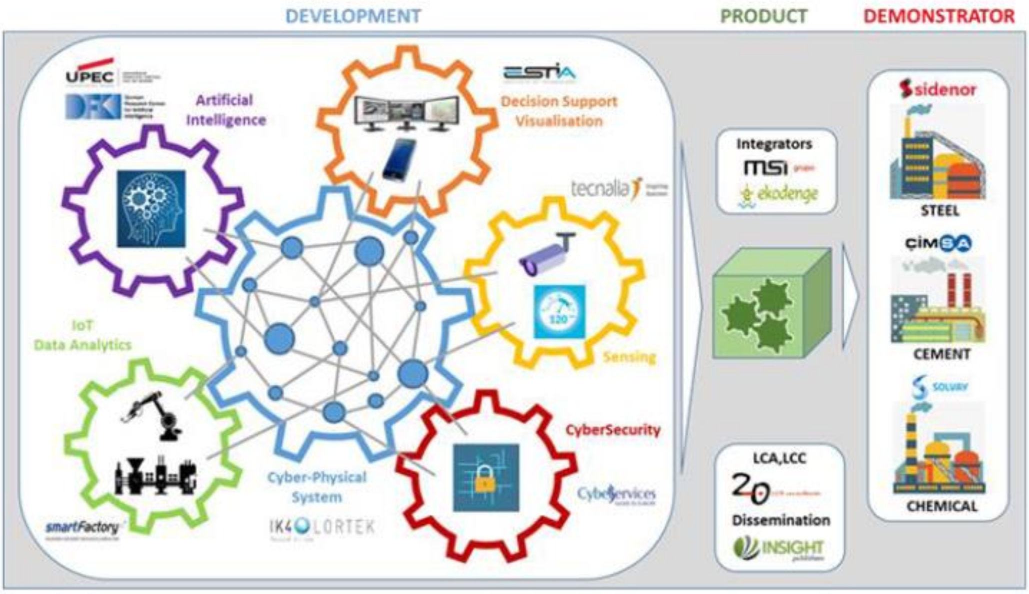


Figure 14 HyperCOG concept.

### 3.2.5 Optimization and performance improving in metal industry by digital technologies (INEVITABLE)

**Pilots**:

The INEVITABLE concept will be implemented by three use cases from a specific SPIRE industry (metal industry):

- Use case #1 - ACRONI pilot based in Slovenia (steel industry). This use case consists of two different industrial processes, installed at the ACRONI steel plant. The first process is the Electric Arc Furnace (EAF) process, which is considered as a process of primary metallurgy, while the second process, i.e., the cold-rolling mill (ZRM) is located further downstream of the steelmaking process. Both processes have in common the development of the process optimization and plant data acquisition, improved process monitoring, development of decision support system and provision of the advisory system. The proposed goal for the first process is to design a complete software solution for continuous monitoring and offline optimization, using EAF measurements and historical data and for the second one is to increase the reliability and reduce process down-time due to failure is the diagnostics and condition monitoring of the process equipment.

- Use case #2 – SIDENOR (Spain) and Voestalpine Stahl (Austria) (steel industry). This use cases consists of two different steelmaking plants. SIDENOR plant consists, first, of an Electric Arc Furnace (EAF), and steel refining is carried out in the secondary metallurgy (SecMet) station as a combination of a Ladle Furnace (LF) and a Vacuum Degasser (VD), and finishes with casting in the Continuous Caster (CC). The manufacturing route at VAS steel plant starts in a Basic Oxygen Furnace converter process (BOF), and steel refining is carried out in a Ladle Furnace (LF) and a Ruhrstahl-Heraeus (RH) vacuum degasser. For Ca-wire feeding the steel is again brought to a LF or a conditioning stand. The manufacturing route finishes with casting in the Continuous Caster (CC). The objectives for this use case are an online advisory system as a tool for process optimization and control in clean steel intelligent manufacturing. On the one hand, it should be ensured that supplied steel products meet defined composition and cleanliness specifications, and on the other hand, plant efficiency should be increased in terms of high quality product yield.
- Use case #3 – EIPC (Spain) (non-ferrous casting industry). This use case consists of a manufacturing plant of advanced aeronautic components plant. The use case plant consists of different process stages to manufacture a component mould: wax injection, assembly, shell making, drying, dewaxing, firing, insulation, preheating, melting and pouring. After pouring of the melt the component itself is already visible and goes through different post processing stages such as: cutting, cleaning, heat treatment, and the final inspection stage where the component is analysed. This manufacturing process has its main challenge in not knowing the component or material condition until the final inspection. In nonferrous casting process at EIPC the goal is to control the processes by existing and integration of new sensors of critical process parameters. Sensor network will be introduced/upgraded to increase the number of measured process variables and widen the area of analysis and monitoring.

**INEVITABLE paradigm**

The general objective of the INEVITABLE project is to improve the performance indicators in the steel and nonferrous metals sectors by retrofitting existing production sites by digitalization and innovative control technologies, to elevate the overall digitalization level, and hence, contributing to the full digital transformation of the European process industries. The main ambition is to exceed the level and functionality of traditional process automation and control systems by applying the functionalities of Digital Factories and Industry 4.0 concepts.

This project receives funding in the European Commission's Horizon 2020 Research Programme under Grant Agreement Number 870062

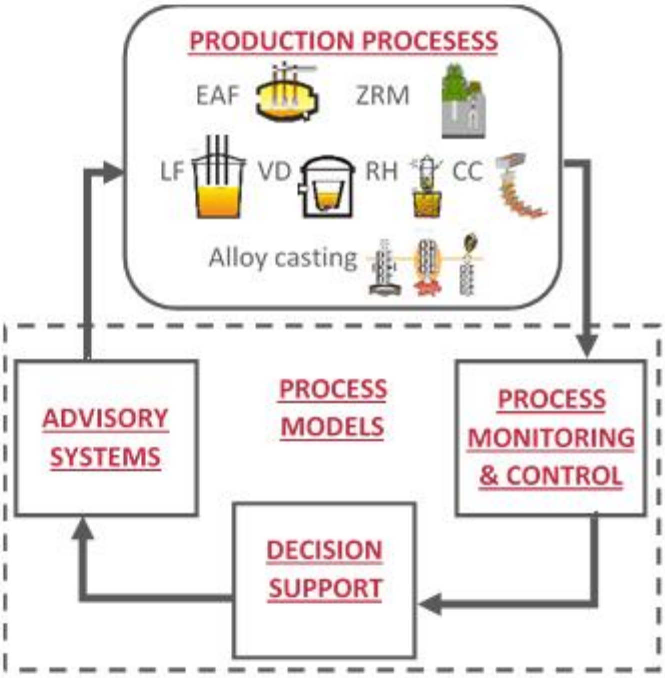


**Figure 15 INEVITABLE common proposed structure for metal industries in the cognitive ecosystem.**

### 3.2.6 Towards a SPIRE-06 community Hub

As it can be seen in the previous sections, key partners from the entire SPIRE 06 community share several technical and business aspects that can be applied throughout the whole SPIRE-06 chain.

A community can be created by leveraging on common partners:

- **SIDENOR** – key industrial partner of the steel industry in several of the SPIRE-06 community projects. Every aspect and result of the "cognitive" technologies applied in their premises and facilities will be perfectly extrapolated to any other process industry under the same community.
- **MSI group** – another key partner in several projects of the SPIRE-06 community, SW integrator of several of the use cases (usually in the steel industry use cases). Their experience and results throughout the different projects will help to spread CAPRI platform among the sisters projects of the mentioned community.
- **Nissatech** – key partner in the definition, development and implementation of the "cognitive" side of the different implementations and solutions that exist in the different projects where they are involved. Their experience in several projects in the SPIRE-06 community is key to help spread and implement the CAPRI platform to the other projects' partners.
- **CORE -** Core Innovation And Technology OE – CORE, are part of the consortium of the COGNIPLANT SPIRE-06 project. In COGNIPLANT, CORE leads the exploitation and innovation management activities. Their work focusses on developing suitable business models for the cognitive technologies that meet the requirements of the process industries and on developing the roadmap to take the COGNIPLANT solutions to the market. Their work in the development of sustainable business models tailored to the needs of the process industries can be used by the SPIRE community (i.e. technology providers and End Users) to ensure that

the developed technologies in all SPIRE-06 projects (including CAPRI) reach the market, generating positive impact throughout the different process industries.

- **BFI - Vdeh-Betriebsforschungsinstitut Gmbh** – another key partner of the SPIRE-06 community, where as an institution specialized in metallurgy and related control technologies, performs applied research and development in the field of steel technology and connected branches. Their experience in the development of the different projects under this community, where they will implement process monitoring systems, predictive process models and integrate them in process control and decision support systems, will help to integrate the different platforms of the "cognitive" community among the different involved process industries.

These commonalities give an idea of the common ground all sister projects of the SPIRE-06 community share experience and implementation of different AI and cognitive experimentations. They could implement some replications of the CAPRI platform as, many times, a common standard reference architecture like, for example, FIWARE, will be deployed and make it easy to extrapolate the different developments among the different process industries which are part of the SPIRE-06 community and even the rest of sectors that belong to the general SPIRE community in the current Process4Planet association.

**Table 1 Sectors addressed in the different SPIRE-06 pilots**

| | Steel | Minerals | Chemical | Cement | Non-ferrous metals | Refining |
|---|---|---|---|---|---|---|
| **CAPRI** | • | • | • | | | |
| **COGNIPLANT** | • | • | • | | • | |
| **COGNITWIN** | • | • | | | • | |
| **FACTLOG** | • | • | • | | | • |
| **HyperCOG** | • | | • | • | | |
| **INEVITABLE** | • | | | | • | |

**Table 2 Main features comparison of the SPIRE-06 projects**

| COGNIPLANT | COGNITWIN | FACTLOG |
|---|---|---|
| Advanced data analytics (multilayer)<br>Outside automation levels | Cognitive digital twins<br>Toolbox<br>Outside automation levels | Cognitive digital twins + Ad-hoc digital twins<br>CDT at each automation level |
| **HYPERCOG** | **INEVITABLE** | **CAPRI** |
| Cyber Physical Systems<br>Data Analytics + AI<br>CPS architecture | Retrofitting<br>Digitization + control | Cognitive automation platform<br>Cognition at automation levels |

This project receives funding in the European Commission's Horizon 2020 Research Programme under Grant Agreement Number 870062

## 3.3 CAPRI PI 6Ps Digital Transformation pathway for Process Industry: strategic, tactical and operational viewpoint

An additional asset to be exploited in SPIRE-06 community is the 6Ps methodology, in order to provide to the other partners an efficient tool to generate strategies toward Industry4.0.

As mentioned in D2.3, the 6Ps transformation model is part of a wider methodology consisting in three main steps: the assessment of the digital maturity of a company, the setting of the digital transformation journey (the 6Ps), the implementation of the roadmap.

In CAPRI project the second and partially the first step (see D2.3) are applied, by collecting feedback to adapt both tools to process industry.

For dissemination purposes, the 6Ps model of great interest. Differently from a maturity model (that was proposed in CAPRI but it is not part of current analysis), the 6Ps methodology is more dynamic since it pushes the company to reflect about the expected digital level, not only about the current situation; moreover the analysis is conducted over both technical and socio-business pillars and it helps the definition of an overall strategy.

Even if the core concept of the 6Ps transformation model is part of a wider methodology defined by POLIMI some years ago to be applied to discrete manufacturing, PI 6Ps (that is "6Ps for Process Industry") is the result of CAPRI validation and activities (in T2.3) that moved the focus on process industry. Consequently, it could be of great interest to test the methodology on a wider community of enterprises (SPIRE-06 for instance). On the other side, pilots of the other projects can benefit from the analysis deriving from the assessment, that will help them to define a proper strategy toward Industry4.0 and digital transformation.

### 3.3.1 Toward a 6Ps model for process industry (PI 6Ps)

The 6Ps digital transformation roadmap is a methodology to be followed in order to identify the digital transformation journey that a company should explore toward the application of Industry4.0 concepts.

It is not a tool to measure the digital maturity of an enterprise, that is, to evaluate the level of readiness to embrace the paradigm of digitalization, but it provides a concrete idea of actions that it needs to follow along its digital transformation journey. The main objective is to put in light the **level of progress** that a company has towards digital solutions implementation, identifying the aspects that can be boosted the most against those for which a valuable level has been already reached.

In fact, the 6Ps assessments deals with 6 different dimensions of analysis, covering both technical and socio-business aspects of the productive activity.

The logic that stands behind the choice of using six dimensions of analysis is that introducing just an innovative solution is not enough to complete the transformation, since it is required to have an infrastructure behind to support it, people with right skills and competences to handle it, the capacity to monitor progresses and results, etc, and all these aspects must be taken into account.

The six dimensions, starting all with letter P, give the name to the methodology and are: Product, People, Process, Platform, Partnership and Performance.

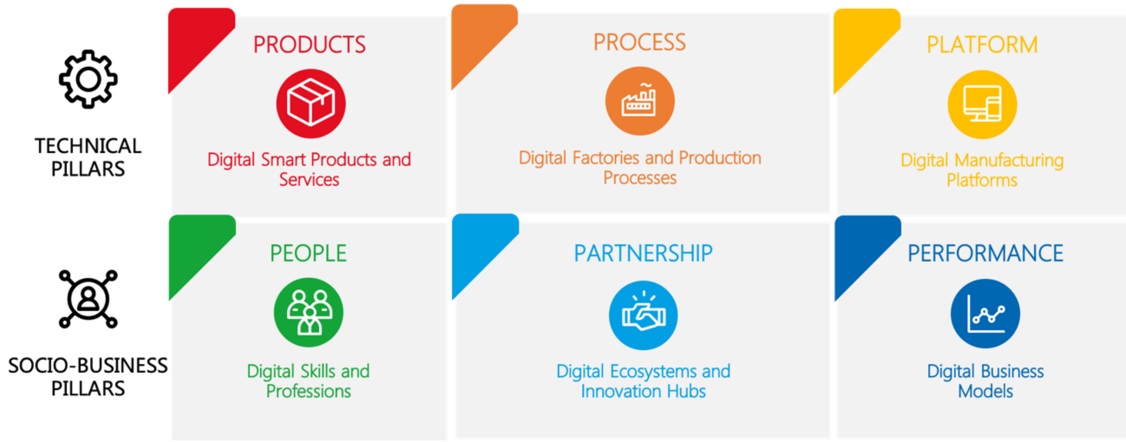


**Figure 16 6Ps digital Transformation Tool**

As already mentioned, the original version of 6Ps tool was created to be addressed to the discrete manufacturing domain, that under some aspects is very close to the process industry, but regarding others, it presents clear differences. This is why activities run in "T2.3 - 6Ps methodology for Cognitive Digital Transformation of process industry" required a certain effort since it was not just a matter of presenting the model and to evaluate the results applied to the three different pilots' context. Actually, it was a collaborative process together with all the partners in order to validate the existing model (originally conceived for discrete manufacturing) with the purpose of applying it to the process industry.

Trying to avoid repetition (see deliverable D2.3 for more details), we go now quickly through each dimension, underlining the main aspects that was pointed out by CAPRI partners during the validation of the tool.

- **Product**: This dimension has the objective of evaluating in a quantified way to which extent the manufacturing SME is digitally mature (and expect to be) in terms of Product or Product-Service System that offers to the market. It takes into account a number of aspects related to the product, for instance the presence of sensors or related services.
  The Product dimension has been subject of delicate discussions among partners since it has not a large applicability in the context of process industry, where the product can be hardly adapted to make it "more digital". However, it has been agreed to keep this dimension since it can be related also to the Product System Service in general and it has been decided to not evaluate it in case it is meaningless.

- **Process** → This dimension has the objective of assessing the current and expected level of digital maturity in each of the most relevant processes that characterize the manufacturing sector, for instance Design and Engineering, Production, Quality management, Maintenance, Logistics, Supply Chain.

- **Platform** → This dimension has the objective of evaluating the current and expected level of digital maturity of platform components that supports both vertical and horizontal integration. It means to take into account the infrastructure that support the production that, according to

the Industry4.0 paradigm, can't be isolated: the introduction of new sensors (steps one to digitalized the platform) produces a large amount of real time data that must be managed (Industrial IoT), they can be integrated with information from other sectors of the plant (horizontal interoperability), simulation tools can be developed on-top.
Together with the Process dimension, it seems to be the one most directly impacted by SPIRE-06 projects.

- **People →** This is one of the most complicated dimensions to be analysed and in fact it counts a bigger number of sub-dimensions with respect to all the other ones. Even if it is a "socio-business pillar" and may be regarded as a side dimension with respect to the previous three (more technical), it is fundamental to evaluate the "digital attitude" of workers.
  First of all, "managers" are analysed since they represent the mindset of the company that must be well-orientated toward digital transformation in order to reach it and that must be aware of possible benefits deriving from it.
  Then there are "professionals and engineers" who play the role of technical driver toward the transformation and must have the right expertise and competences; finally, there are the "operators" who have to deal with it in their everyday job activities and must be put in the condition of accepting it.

- **Partnership →** This dimension describes the type of relationship that a company has established with different stakeholders, from academia and university to Digital Innovation Hubs, from tech and training providers to suppliers and customers.
  In preparation to a digital journey that is a complex challenge requiring lot of different expertise and skills, it is fundamental to be part of a strong network of competencies. This dimension stands at the basis of a transformation process and it is probably one of first to be evaluated while drafting the roadmap.

- **Performance →** This dimension takes into account the analytical level adopted to measure performance: starting from a basic level where indicators are not defined at all, you arrive to the highest level ("perspective analytics") passing through intermediate ones, such as diagnostic and predictive analytics. Six sub-dimensions are identified to classify KPIs, as operational, economic, environmental.
  Improving the way a company measures its performance is strictly related also to its ability of collecting data and it can represent a great advantage if it allows to discover insights and hidden partners.

The six dimensions listed above are presented to the company via an online survey, a self-assessment where the enterprise is required to evaluate its current digital level but also its expectation for the future.

To complement the assessment itself, the 6Ps methodology consists of five different steps:

1. **Set-up of a team, bringing together different organizational areas:** Since the assessment deals with six different areas (that typically employ several workers with different skills and

backgrounds), it is fundamental to involve the right people (more than one, possibly) to compile it in the most correct way as possible.

2. **Identification of the AS-IS profile of the manufacturing SME**: Team defined at point 1 is required to define the current profile of company, according to the six dimensions (part 1 of the self-assessment).
3. **Identification of the TO-BE profile of the manufacturing SME**: Team defined at point 1 is required to define the profile of company expected to be reach after the digital transformation process, according to the six dimensions (part 2 of the self-assessment).
4. **Identification of actions, feasibility and prioritization:** By analysing the results got at point 1 and 2, the objective is to define a roadmap to reach the TO-BE level starting from the AS-IS, taking into account benefits and costs, risks and dependencies and prioritizing actions. Typically this kind of analysis is performed by external experts (POLIMI team for instance) after conducting a face-to-face interview with the company in order to better understand the result of the self-assessment.
5. **Development of the Migration Plan towards Industry 4.0:** Finally, the migration plan is developed.

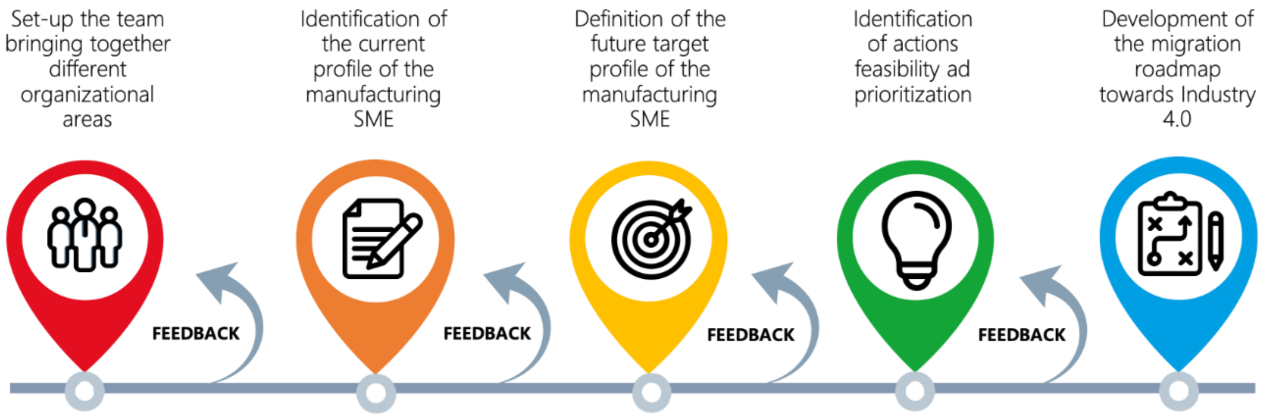


Figure 17 The five steps of the 6Ps methodology

The main target of 6Ps methodology are SMEs or enterprises in general, who want to start their digital transformation journey with a clear goal in mind (to reach the TO-BE profile). In the context of European projects (CAPRI but also a number of other projects where it was/is applied), typically point 5 and partially point 3 are a priori defined by the project itself. It means the pilot industry has already in mind the path to follow and the development actions to be addressed, since it is part of the project that guides it. Probably, also some of the six dimensions of analysis are already covered by the project itself and the expected (TO-BE) profile concerning them is the purpose of the entire project.

However, since typically research activities stop at an MVP level, not all the six dimensions are touched by the project. This is exactly the added value that the 6Ps methodology may bring inside a project: compiling the assessment is a good incentive to explore further areas of the company that can be improved and that usually are not taken into account.

Having a disposal a full picture of the gaps to be filled to reach the expected digital level allows the company to generate a strategy that takes into account also socio-business pillars.

The methodology described in previous paragraph has been validated and applied in the early stage of the project (M1-M6) with the objective of having a clear picture of the situation before the project and of the expectation after it. In this way, it is possible to define KPIs to measure the progress step-by-step and to define lessons learnt and general recommendations.

The assessment is planned to be re-proposed to CAPRI pilots at the end of it, to check if the expected TO-BE level has been eventually reached, in order to identify the weakest area where the company could spend more effort to improve it in the future. At the end of the project, having a picture of the actual achieved result is very useful to evaluate the contribution that CAPRI has given to the single pilots and the 6Ps may turn out to be a tool for describing success stories in a measurable manner.

Discussing with the pilots about their self-assessments' results, it came out that, of course, there is a great expectation in the digital improvement that the CAP can bring at Platform level. However, the development of the CAP impact also the Process pillar since it represents the basis to implement innovative solutions supporting the lifecycle of the product.

On the other side, all the three pilots foreseen a growth of the People dimension level. It means that there is a strong awareness that the transformation can't happen if you don't consider also the human factor and that to manage new technology also new skills, competences and expertise are required.

### 3.3.2 PI 6Ps for SPIRE-06

Each of the solutions that will result from SPIRE-06 projects is expected to have a strong impact in the digital transformation of an enterprise. However, a complete digital transformation must be centred not only on the re-definition of Process and Platform pillars, but must have an impact in Product, Process, Platform, People, Partnership and Performance dimensions and the 6Ps method helps to identify it.

Additionally, in CAPRI, the 6Ps has been applied only in the context of asphalt, steel and pharma domain. Presenting it to SPIRE-06 community, a wider range of industrial processes will be taken into account (chemical, steel, textile, cement, etc) and this allows us to collect a number of success stories and recommendations to be disseminate to process industries that are approaching a digital transformation.

## 3.4 CAPRI PIWARE Innovation and Collaboration Platform for Process Industry: Digital Transformation

The DIHIWARE Platform is a solution developed by ENG within the MIDIH[10] H2020 EU project, I4MS Phase 3 - 2017, and currently in use in many digital ecosystems in Europe. The DIHIWARE Platform offers a complete collaboration environment inspired by Enterprise Social Software, realizing a bridge among stakeholders with different experiences backgrounds, providing access to the latest knowledge and expertise and pulling teams together and supplying a fertile ground for experimentation. These knowledge-driven services are fully integrated with collaborative services in

[10] http://midih.eu/

order to create a digital space where all the platform stakeholders can collaborate to boost innovation together, enabling and digital supporting the co-creation methodology envisaged.

The Platform is based on different Open Source components, using a flexible and modular integration and deployment approach to guarantee the possibility to have custom-tailored solutions suitable for the variegated environments. Each component provides a specific function and complements the functionality of the other. The Platform is also adopting state of the art identity management and authorization components in order to ease interoperability with other platforms using well known standards.

The core of the Platform is grounded on Liferay that has been selected since it is a widely used Open Source and state-of-the-art Content Management System, suitable for many integration scenario as well. It is the main entry point for users: it enables open collaboration, online community building and management as well as information exchange and peer-learning, empowering an efficient collaboration network, based on a powerful knowledge hub able to link Users, Processes and Resources.

The second subsystem is the Catalogues Management that handles the resources organization and cataloguing, being configured according to the platform instance requirements. The Catalogue Management System is the main pillar of the one-stop-shop business model enabled by the platform that focuses on the value of the honest brokering. Therefore, the platform allows the construction and the management of a showcase of structured data coming from various sources.

The high-level architecture of the DIHIWARE Platform is shown in the following figure.

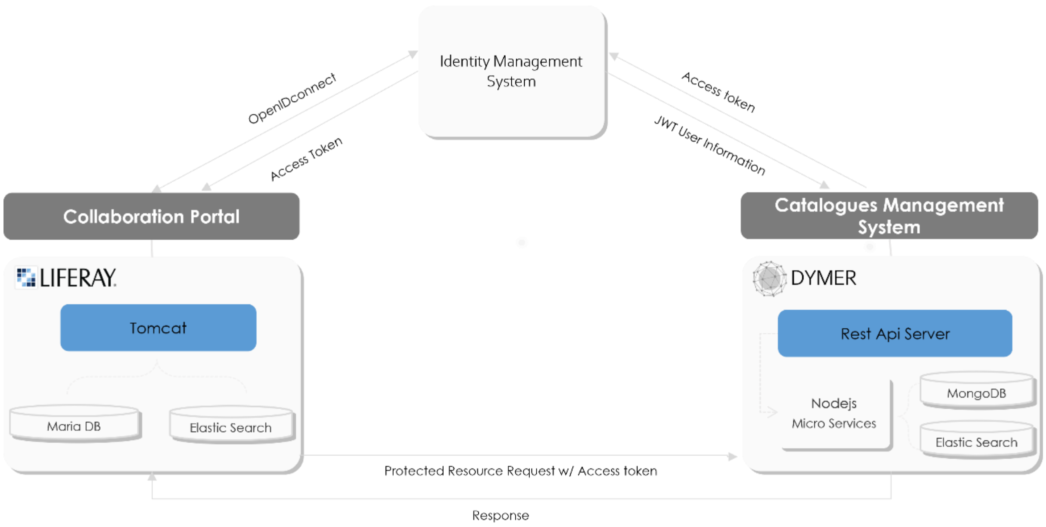


**Figure 18 DIHIWARE Architecture**

The DIHIWARE Platform can be considered a very flexible base environment, on top of which specific customizations (environment customization, catalogue designing and dedicated user journeys), as well as new developments, needed for the new community will be realized. The DIHIWARE customization capabilities, next to a concrete adoption plan of the Platform, enables the delivery of specific tailored environments, based on selected DIHIWARE modules and in line with the stakeholders needs and requirements.

To this end, a specific powered by DIHIWARE instance named PIWARE will be developed in CAPRI to create the virtual arena where all the SPIRE stakeholders could be engaged with a dedicated digital space designed to support the following main goals:

- Understand gaps: the platform users will have the possibilities to navigate a structured library of the most relevant and updated resources and lessons learnt, coming from the previous relevant projects in the sectors tackled by SPIRE. Lessons learnt, best practices and the main scientific and technological challenges already solved, will be conveyed in order to "inspire" the newcomers on how to overcome the business scenarios they are willing to master.
- Boost networking: several collaboration tools will provide easy access to user generated contents, dynamic discussions, matchmaking services and networking opportunities that will deliver a growing effect to move from the needs (idea seeds) to the solutions (growing and nurturing ideas using collaboration and co-design methodologies), especially supporting cross-organization and even cross-sector collaboration networks.
- Foster excellence: the catalogue management services will provide ease and intuitive access to the main technologies, research results, innovative experiments, services and business applications, fostering an easy uptake of the innovation achievements of the whole community to be built around SPIRE.

The adoption plan of the platform, that will be detailed in the following section (4.4), aims to map out a strategy to optimize and improve the platform adoption process in order to address the key challenges of the SPIRE Community.

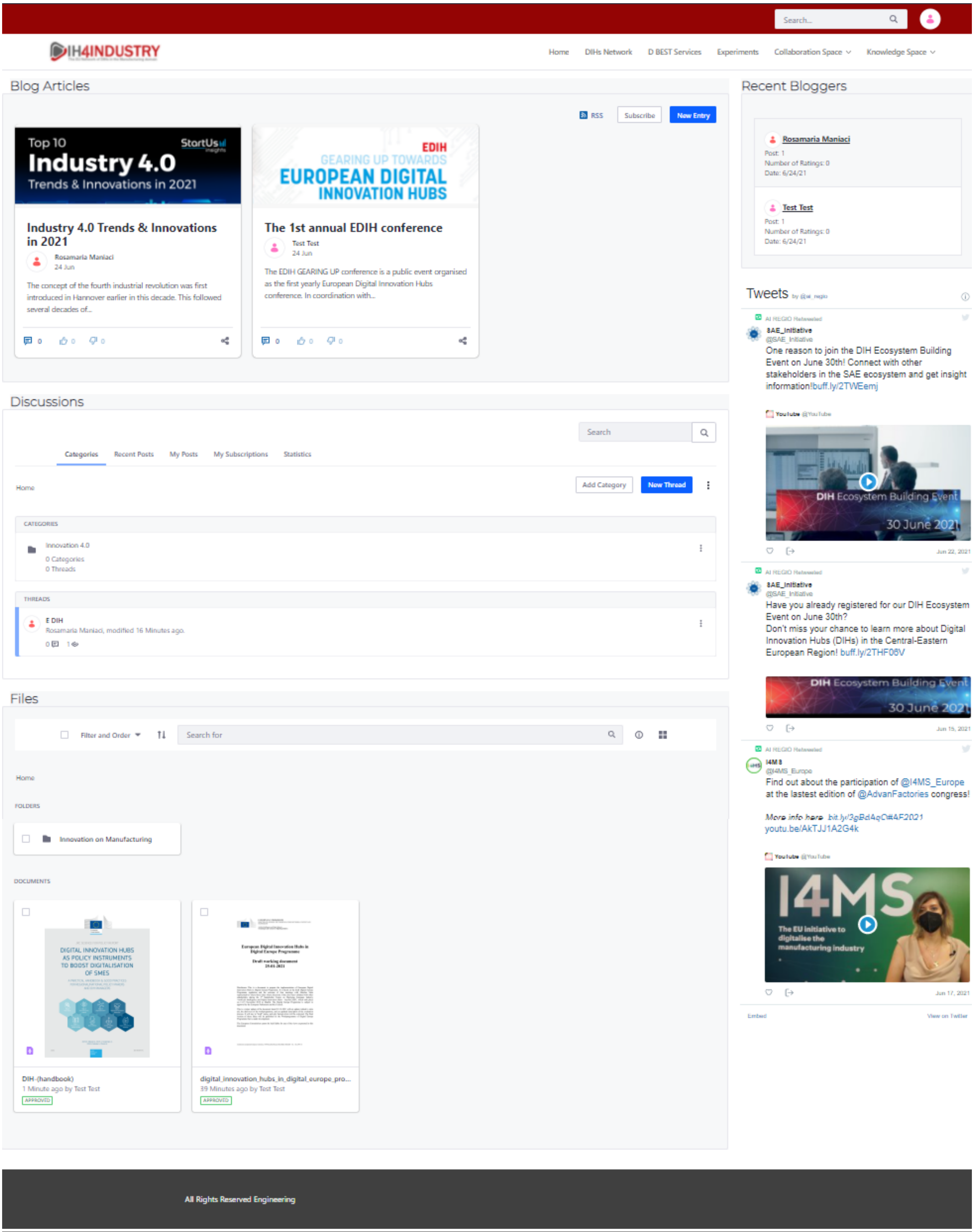


Figure 19 DIHIWARE Collaboration Capabilities

This project receives funding in the European Commission's Horizon 2020 Research Programme under Grant Agreement Number 870062

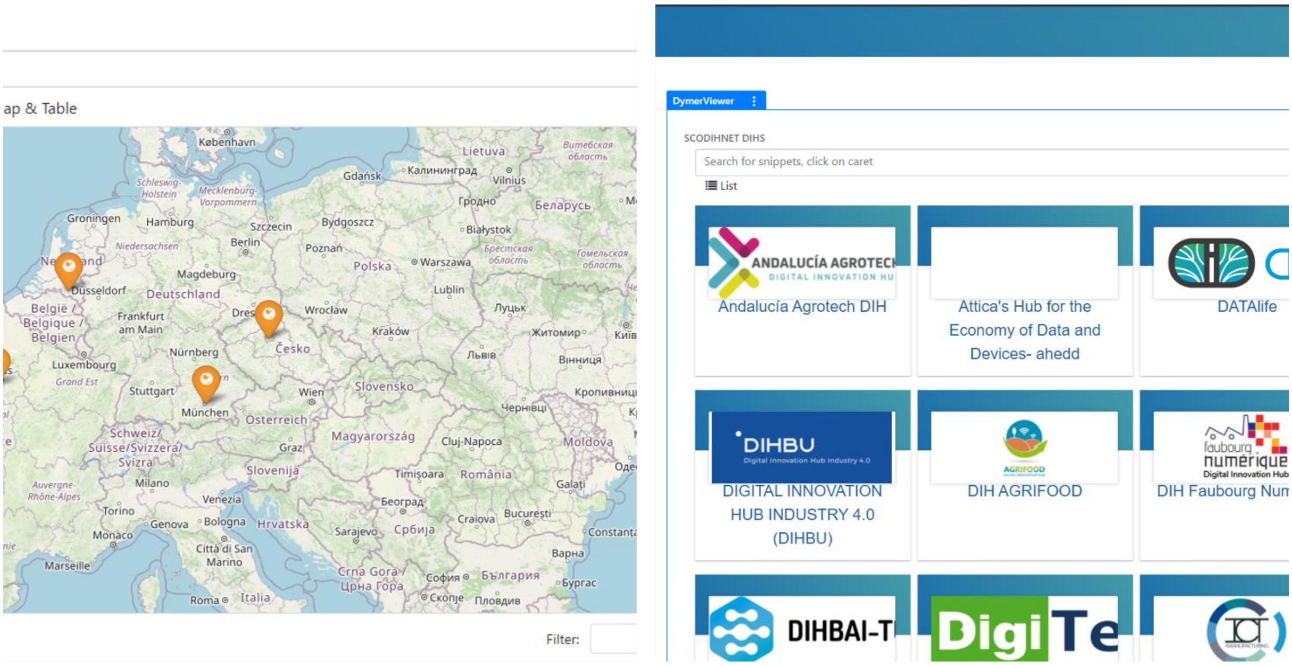


Figure 20 DIHIWARE resources catalogues

# 4 SPIRE-06 Ecosystem Collaboration Plan

## 4.1 CAPRI PICO Collaboration Plan.

Collaboration approach should be based on already established communication with other projects.

The plan is to start with **COGNITWIN** since there is a huge overlap between two cognition approaches. However, the communication should remain open to a broad audience in order to collect the opinion and comments from various actors. For example, a webinar related to PICO and cognitive architecture (general one) can be organized. The results of the collaboration can be published in a joint paper.

## 4.2 CAPRI PIHUB Collaboration Plan

Among the dissemination activities that were officially launched at M8, focused on fostering the transfer of knowledge created within the project, there are the following, related with the PIHUB SPIRE-06 Community:

CAPRI project has already established connections with other projects and clusters and is part of initiatives, both in the Process Manufacturing and in the ICT Cognitive domains and within the PIHUB SPIRE-06 community. In this line of collaborations, as with COGNITWIN sister project as described in a previous section.

As previously stated, CAPRI project will participate and collaborate in the future meetings of the CLUSTER SPIRE-06 community (PIHUB), to disseminate results, share progress or challenges with the rest of the other sister projects. At least, there will be a meeting once in a year (starting 2022 from the date of this deliverable) to establish commonalities, possible common experiments and sharing test results and conclusions.

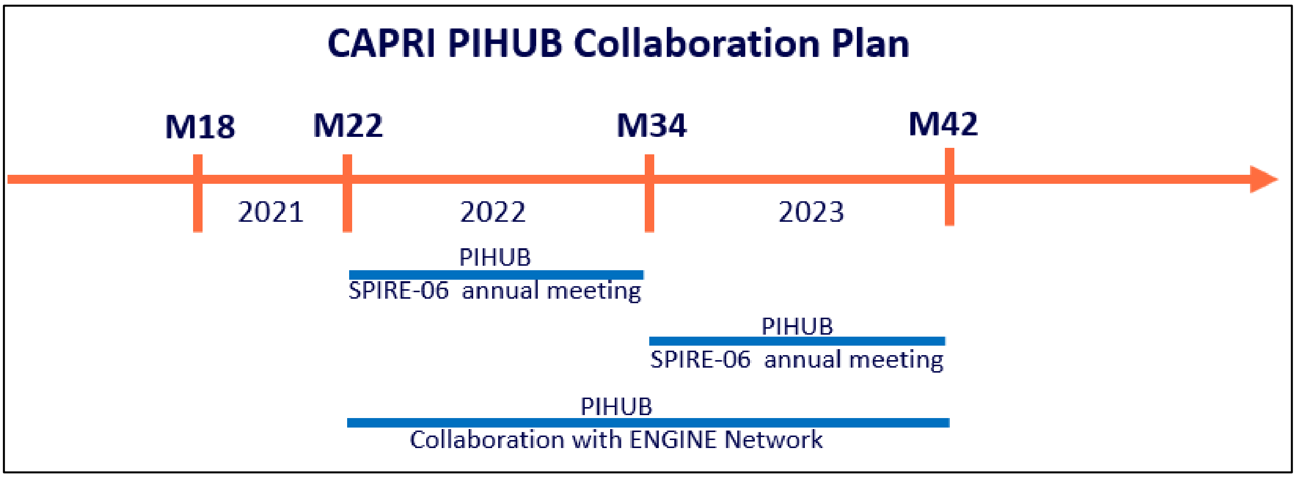


Figure 21 CAPRI PIHUB collaboration plan

Also, PIHUB cluster (SPIRE-06 community), being part of the ENGINE Network (EuropeaN diGital Innovation NEtwork), CAPRI project will also take advantage of this HUB to participate in the different conferences to be hold by this network in the following years from M18, but there are no still definitive established dates.

## 4.3 CAPRI PI 6Ps Collaboration Plan

To disseminate the PI 6Ps methodology outside CAPRI's border and to make it known to the SPIRE-06 network, the first step is to present it to the other projects.

We are planning to organize the first meeting in next months (October or November 2021, depending of the availability of different projects) at least with the coordinators in order to present the methodology, the job done in CAPRI to improve it and to describe the added value that can bring to the single pilots. This may represent also an interesting occasion to gather together the entire network and to collect any feedback and suggestion about the 6Ps tool.

As it was presented in Section 3.3, the methodology is based on five steps that require some time to be applied and the same structure will be re-proposed to SPIRE-06 community.

1. **Set-up of a team, bringing together different organizational areas:** The "PI 6Ps Digital transformation model" will be presented to the partners of the 5 projects (to be discussed if it is feasible to arrange a single big event involving the pilots of the entire SPIRE-06 network or to meet them separately). They will be invited to find the right people inside the company to compile the assessment in the most correct way as possible.
   Planned activity period: M21, December 2021
2. **Identification of the AS-IS profile of the manufacturing SME**: An online survey will be prepared, containing the self-assessment to be filled by each partner. Evaluating the AS-IS profile means to describe the situation before the adoption of the project solution (that in same case could coincide with the current situation since the solution is not ready yet).
   Planned activity period: M22, January 2022
3. **Identification of the TO-BE profile of the manufacturing SME**: The same online survey can be used also to evaluate the TO-BE profile. It means to describe the expected situation after the adoption of the project solution and the changes that will derive in each of the 6 pillars.
   Actually, the survey is just one where participants will be required to evaluate both the AS-IS and TO-BE profile.
   Planned activity period: M22, January 2022
4. **Identification of actions, feasibility and prioritization:** in the specific case of a European project, part of the actions is already defined by the project itself, who outlined guidelines and expected output. However, as previously mentioned, there is a number of fundamental aspects that remain untouched by the project, but must be taken into account. A detailed analysis, run by POLIMI on survey results, will allow to identify if all the "side dimensions" have been considered and to define a roadmap for their implementation (probably outside the scope of the project).
   The analysis in general takes lot of time (that depends of course on the number of participant pilots) since it is paired with the face-to-face interview.
   Planned activity period: it is not possible to estimate in advance the time required since the number of participants is not known yet. The objective is to start interviewing projects' pilots as soon as they have compiled the self-assessment, so starting from M22 on.
5. **Development of the Migration Plan towards Industry 4.0:** the migration plan is already started, as in part it coincides with the project itself. Even if this step is in charge on the single

pilots, it could be of great interest to define a list of KPIs that helps to monitor progresses and to measure results.

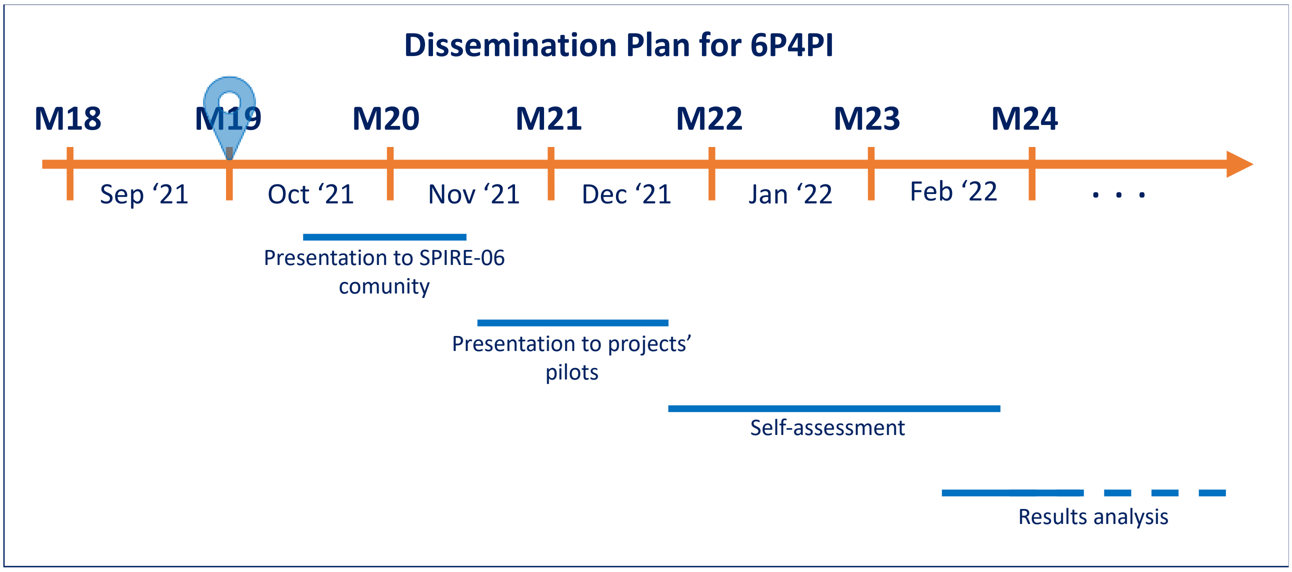


**Figure 22 Dissemination Plan for 6Ps for Process Industry**

In the second step, when the methodology will be presented to pilots, in order to speed up activities but also to put in contact companies acting in a similar domain, the possibility to cluster together pilots presenting commonalities will be evaluated. The same groups will be kept also in the analysis phase with the objective of identifying common actions to be addressed and to identify success stories organized by domain.

### 4.3.1 Collaboration with AI CUBE

AI CUBE[11] is CSA project funded under H2020 (start: 1st September 2020, end: 31st August 2022) dealing with artificial intelligence (AI) and big data (BD), whose main purpose is to define a roadmap in AI and the use of BD for the process industries, with a specific focus on SPIRE sectors.

The project has recently contacted CAPRI coordinator asking its contribution in the evaluation of the impact that AI and BD technologies can have in relevant sectors of process industry. Four areas where Artificial Intelligence and Big Data can be applied are taken into account: human, research & innovation, plant and value chain.

The proposed exercise is quite simple: for each of the four areas, possible impacts are listed and for each a number of reasons why it happens are provided. For instance, a possible impact at "human" level is that with AI/BD it is possible to build a more creative and efficient workforce (impact) because it provides tools to speed up data-understanding (reason why). The goal is to identify sentences considered true.

[11] https://www.ai-cube.eu/

This project receives funding in the European Commission's Horizon 2020 Research Programme under Grant Agreement Number 870062

The second activity proposed is a survey to evaluate (from CAPRI's perspective) the level of the maturity of current AI or Big Data implementations in the processes of process industry and to identify future exploitations opportunities offered by digital technologies.

So far, CAPRI project has simply participated to the two exercises proposed by AI CUBE. However, it is quite clear that there are some commonalities between the CSA activity and PI 6Ps, since both aim at defining a roadmap for process industry: the former regarding Artificial Intelligence and Big Data implementation, the latter regarding digital transformation toward Industry4.0.

CAPRI is getting in contact with AI CUBE coordinator in order to discuss about a possible collaboration. The objective is to explore the main aspects of both methodologies to find points of contact between the two and to identify if there is space for future synergy exploitation.

## 4.4 CAPRI PIWARE Collaboration Plan

The DIHIWARE Platform have been identified as the starting point for the new PIWARE environment.

The DIHIWARE Knowledge-driven services, harmonised with a collaborative and innovation side of the platform, will be the core on top of which specific customizations (e.g. look&feel, page layouts, site map, catalogue designing and dedicated user journeys) and new developments will be drawn up, with the help of the Consortium, carrying out an in-depth study of the objectives that can be achieved through the use of this Platform, also exploiting the connections and potential interoperability with other systems and communities.

To do that it is necessary bringing the platform stakeholders together around user needs and not around the platform designing a high-level user journey that will allow us to understand and determine how users experience the platform based on their unique motivations and goals.

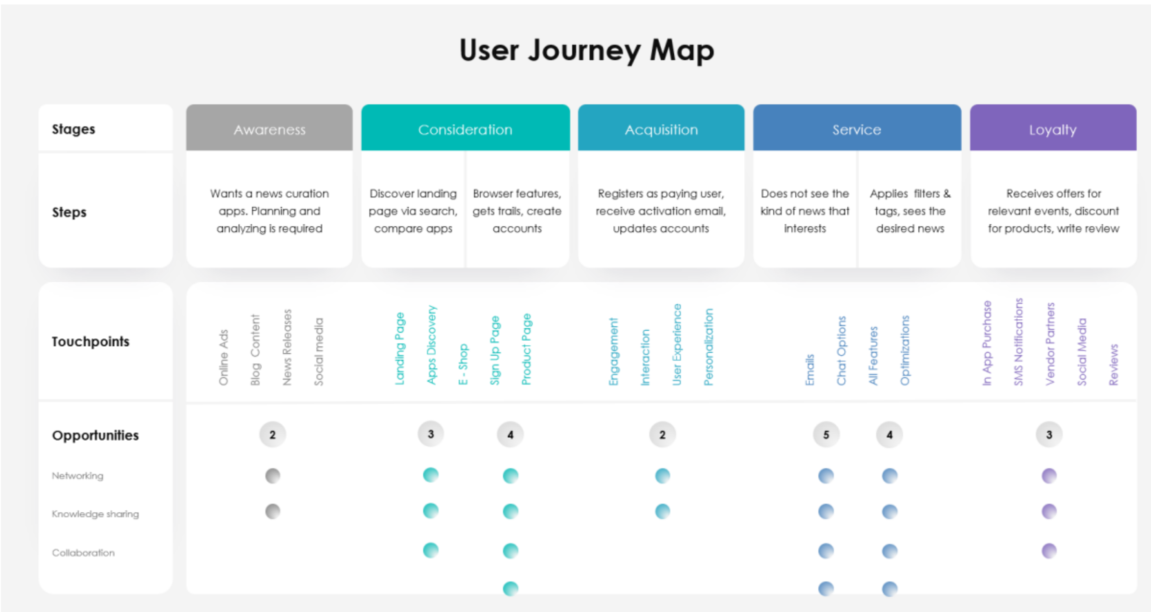


Figure 23 User Journey map template

This project receives funding in the European Commission's Horizon 2020 Research Programme under Grant Agreement Number 870062

The User Journey mapping (Figure 23) helps keep user motivation top of mind and create UX flows that get users where they want to go.

With User Journey mapping, it is possible to make simple tweaks that help users accomplish their goals easier and faster, come back to do it again, and build habits around the platform.

All the platform stakeholders will be involved in putting together all the information they have and sketch a first high level journey using a predefined template.

After that, the adoption strategy targeting our users will go ahead, positioning the product value, determining when the platform is ready to be launched and starting using viral loops.

To achieve this objective, the SPIRE community's needs should be analysed and begin designing and implementing and adoption strategy of the platform aimed at bringing the virtual environment suitable to be filled with the SPIRE community knowledge and expertise.

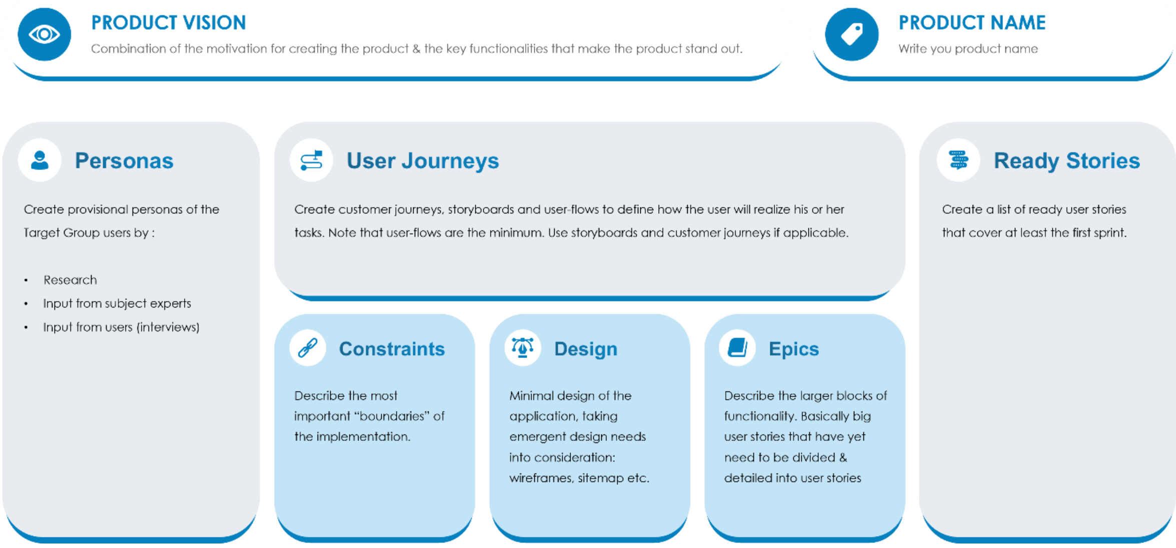


Figure 24 Adoption Plan template

We are planning to organize the first meeting in next months (in Q4-2021, depending of the availability of different projects) at least with the coordinators in order to present the platform and start with the design of the SPIRE Workspace Story map.

# 5 CAPRI extended Ecosystem Collaboration Plan

## 5.1 CAPRI and Discrete Manufacturing communities.

The current section deals with the DMP cluster and Connected Factories activities, with the objective of highlighting points of contact for a possible collaboration with CAPRI.

### 5.1.1 The DMP cluster

The Digital Manufacturing Platform (DMP) cluster is a group of six projects answering to the DT-07-2018/2019 topic, part of H2020 program, with the common objective of enhancing the digital manufacturing platform potentiality inside mid-caps enterprises and SMEs. It is well known that the DMP is playing more and more a relevant role to manage the manufacturing production, increasing the competitiveness of companies.

Projects included in the cluster are oriented to the discrete manufacturing domain. In details, they are :

- **DigiPrime**, Innovation Action (IA) with the objective of developing the concept of a circular economy digital platform, to be validated in 20 use cases covering different European industrial sectors (automotive, renewable energy, electronics, textile, construction);
- **eFACTORY**, IA that is developing a connected factories platform to enable an agile manufacturing industry, supporting the "lot size one" production concept;
- **KYKLOS 4.0**, IA that aims at showing how cyber-physical systems, product life-cycle management, life-cycle assessment, augmented reality and artificial intelligence technologies and methods are able to transform Circular Manufacturing.
- **QU4LITY**, IA that plans to introduce and demonstrate a shared data-driven zero-defect manufacturing product/service model and technologies;
- **SHOP4CF**, IA that is developing a platform on an open architecture that can support humans in production activities and provide basic implementation as a free, open-source solution, for exploiting data potential;
- **ZDMP** (Zero Defect Manufacturing Platform), IA that is building a platform solution to support high-interoperability companies toward the Zero Defect goal. It will allow end users to connect their systems (such as the ERP) to benefit of the features of the platform, including product and production quality assurance.

The DMP cluster is pursuing joint activities in a number of areas (platform interoperability, dissemination, business models, standardisation etc) to synchronise the related activities taking place in different projects.

*Collaboration opportunities and next steps*

The SPIRE work-programme, and CAPRI in particular, includes several topics and challenges in common with the DMP cluster view on Discrete Manufacturing: both aims at developing new technologies to realise cognitive production plants, with improved efficiency and sustainability, by the use of smart and networked sensor technologies. Furthermore, projects are expected to cover the full digital transformation of a complete plant or site(s) including e.g. data acquisition, communication, automation, analytics, modelling, prediction and standardisation of relevant data interfaces. The DMP cluster acts to develop platforms for the connected smart production facilities of the future, by integrating different technologies, make data from the shop floor and the supply network easily accessible, and allow for complementary applications.

These commonalities pave the way to a future close collaboration between CAPRI and the DMP cluster, with the objective of sharing best practices and success stories. As first foreseen activity for next six months (M19 - M24), WP6.5 will contact the DMP cluster coordinators in next weeks with the objective of arranging a presentation meeting where both parts can describe their mission and identify point of contact.

### 5.1.2 Connected Factories project

The Connected Factories[12] (CF) project is a Coordination and Support Action (CSA) started in December 2019 that is working to define a structured overview of technological approaches and best practices in the field of digital manufacturing. Toward this objective, 3 + 2 "pathways" have been defined (respectively in CF and CF2 projects) and others are still under development. Pathways are a useful visual tool that reflects how digitalisation and eventually the deployment of digital platforms can bring value within different kinds of manufacturing areas, such as factory automation, value networks or product-service development.

A pathway is composed of different levels of digitalization that are associated to a number of milestones and that become more advanced while evolving to the right-hand side of the pathway. It helps to position a company at a specific level, depending on the added value that the adopted solution brings to the achievement of the next milestone.

For instance, the "Autonomous Smart Factories" pathway is addressed to enterprises that are pursuing a digitalization process to climb the so called automation pyramid. The milestones are "Spreadsheet, text editors and paperwork", "Software and data silos", "Connectivity", "Off-line optimisation" and "Real-time optimisation", directly linked with Field Level, PLC, SCADA, MES and ERP respectively. The enterprises are request to evaluate how a specific digital solution can increase the digital level, reaching next milestone(s).

[12] https://www.connectedfactories.eu/

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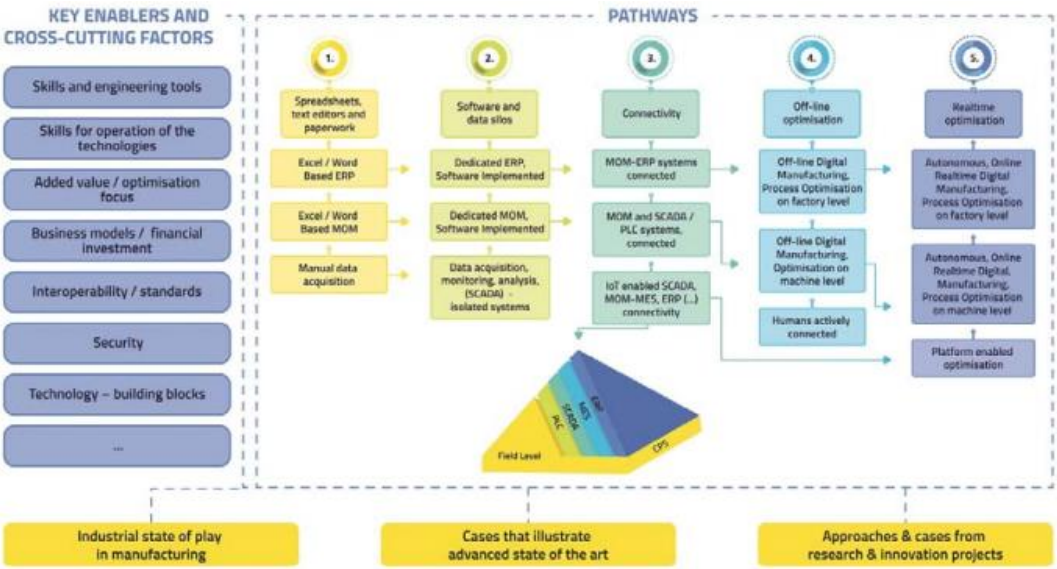


**Figure 25 The CF Autonomous Smart Factories pathway**

A second pathway, "Hyperconnected Factories pathway", has been designed for networked enterprises in complex, dynamic supply chains and value networks dynamic that need to establish IT connections to communicate with other companies; the "Collaborative Product-Service Factories pathway" defines the milestones to be achieved to develop a product whose business is based on related services; the "Circular economy for manufacturing pathway" describes the development of circularity inside the company and "Data spaces for manufacturing pathway" for enterprises that are overcoming the siloed data phase by establishing an ecosystem for data sharing.

Each pathway is equipped with a set of cross-cutting aspects that enable the implementation of the milestones, such as skills, tools, business models, interoperability and standards, that must be taken into consideration. Additionally, pathways are accompanied by a number of use cases and success stories of companies that managed to move from a level to a following one, but also by an analysis of the state of the art in manufacturing industries and research and innovation projects regarding that specific pathway.

### *Collaboration opportunities and next steps*

WP6.5, leveraging also on the bridge role played by POLIMI who is common partner, foresees a bi-directional collaboration with Connected Factories project. First of all, CAPRI may represent a pilot project to validate the pathways in process industry domain, by providing use cases, success stories but also feedbacks about the applicability of pathways.

Secondly, CAPRI wishes to present the PI 6Ps methodology that, despite it is shaped in a different way with respect to CF's pathways, can be of interest for pathways developers.

WP6.5 will contact the Connected Factories coordinators in next weeks with the objective of arranging a presentation meeting, that will be followed by a workshop about CF's pathways for CAPRI pilots and a workshop about PI 6Ps for Connected Factories partners.

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## 5.2 CAPRI and Digital Technologies communities

In current section two technologies communities (AIOTI WG11, expert Internet of Things domain, and BDVA, expert in Big Data), with whom CAPRI could establish an interesting collaboration, are presented.

### 5.2.1 AIOTI WG11

**AIOTI**, Alliance for Internet of Things Innovation, is a community of experts founded in 2016 to contribute to the creation of a dynamic European IoT ecosystem and speed up the take up of IoT. Among their members you can find key European IoT players – large companies, successful SMEs and dynamic start-ups – as well as research centres, universities, associations and end-user representatives.

AIOTI activities are carried out through groups, which focus on well-defined areas of development.

Horizontal Working Groups are covering areas that can be applied to any sector. It includes research, innovation eco-systems, policy, standards, green deal and distributed ledger technologies. On the other side, Vertical Working Groups are covering domain-specific areas, focusing on key IoT issues.

WG11 is the Vertical Working Groups dealing with manufacturing. In particular, it focuses on Industrial Internet of Things (IIoT), with the objective of outlining how IIoT should evolve to support the challenges for Sustainable Manufacturing. Research & Innovation (R&I) directions on realising and validation the following evolutions are expected to be further discussed within AIOTI and with other relevant stakeholders:

- **Massive Decentralisation of the IIoT Paradigm over Large Numbers of Smart Objects**, to overcome centralised cloud coordination toward the implementation of new massively decentralised architectures.
- **Blending of IIoT into emerging 5G/6G networks**, to support remote manufacturing support applications, guaranteeing bandwidth to IoT applications and selecting the objects that shall collaborate as part of the decentralised control applications at scale.
- **Blending AI into the IIoT – Towards Safe, Trusted and Effective Artificial Intelligence of Industrial Things**, to achieve flexibility, intelligence and autonomy at scale by integrating leading-edge AI technologies with IIoT. The main aspects of this integration will include: Data4AI Distributed Spaces, Embedding intelligence in the Things, Trusted and Acceptable Intelligence, Distributed AI for Industrial Things.
- **Symbiotic Human-Machine Collaboration Supporting Tactile Internet Paradigms based on IIoT Systems and Applications**, to enhance remote real-time physical interactions between objects/machines and humans, i.e., eliminating time and space barriers in Human-Machine Interactions.
- **Business Models for Next Generation IoT Systems,** to explore and validate business models for the next generation of decentralised industrial systems, embedding not just IoT/AI automation and control technologies, but also advanced capabilities for interoperability and human interaction.

•

***Collaboration opportunities and next steps***

Challenges identified by the Manufacturing WG are of great relevance for CAPRI project, both considering the technical (such as AI technologies with IIoT) and the non-technical ones (the Business Model for IoT Systems).

It would be of interest to analyse them in details to highlight the point of contact with CAP solution, identifying which challenges are already faced (in any) and which ones should be faced in the future. The same topics can be addressed also the other projects of SPIRE-06 community, since Industrial IoT is a common subject for the entire network.

In next months, W6.5, leveraging on the collaboration of all CAPRI partners, will start a detailed analysis to select the most relevant challenges to be discussed in a collaborative perspective.

### 5.2.2 DBVA SMI

The **Big Data Value Association** (BDVA) is an industry-driven not-for-profit organization, with more than 220 members from all over Europe, whose main objective is to boost Data and AI, to create value for business, citizens and the environment. The main instrument on which BDVA is leveraging to develop its activities is are Task Forces (TFs), that take care of specific matters and focus on sector-specific or cross-disciplinary issues related to Big Data Value.

So far, ten Task Forces have been created and, for each one, a number of SubGroups (SG) have been established.

**TF7 – "Application"** aims at identifying applications in which Big Data technologies can create the biggest impact in Europe: different industrial sectors were identified and their requirements in terms of technology and skills are analysed by dedicated SubGroups with the objective of defining next steps and actions. The industrial sectors include healthcare, telecom, content/media, energy, manufacturing, finance, supply chain, etc.

**TF7.SG6 Smart Manufacturing Industry (SMI)**, led by Davide Dalle Carbonare from Engineering and co-led by Sergio Gusmeroli from POLIMI, also beneficiaries of CAPRI project, is the SubGroup of Task Force 7 dedicated to manufacturing.

In 2020, TF7.SG6 released the **second version of the "Big Data challenges in smart manufacturing industry"**, a whitepaper signed both by Sergio Gusmeroli (POLIMI) and Anibal Reñones (CARTIF), respectively partner and coordinator of CAPRI project. In the 2020 edition, the paper's approach is twofold: on one side, to update the 2018 version including not only technological challenges but also legal and socio-business ones; on the other, to identify disruptive topics to be implemented in Horizon and Digital Europe program.

Regarding **non-technical challenges**, it is fundamental to have in mind that they could severely affect the digital transformation process, so they must be evaluated before starting any evolutionary journey. Four main classes of non-technical challenges for Smart Manufacturing Industry are presented: regulatory and legal domain, innovation and business model, Industry 4.0 and Data-oriented digital skills.

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In continuity with the 2018 edition, three grand scenarios are analysed: i) Smart Factory (adoption of Data Technology in the production plants); ii) Smart Product (adoption of Data Technology along the lifecycle of products) and iii) Smart Supply Chain (adoption of Data Technology integrating the various stakeholders in the value chain). In the paper, technical challenges are presented and prioritised for each of the three scenarios.

CAPRI solution, as an example of a platform for process industry, seems to go in the direction of Smart Factory's requirements.

***Collaboration opportunities and next steps***

WP6.5, leveraging also on the bridge role played by common partners, foresees a bi-directional collaboration with TF7.SG6. On one side, in next months, CAPRI will start a detailed analysis of the challenges highlighted in the paper in order to evaluate in which way they are tackled by the pilots, in order to identify if something is missing and what it may be improved, according to own use cases. On the other side, CAPRI will contact the SubGroup members to propose a validation activity where the three CAPRI pilots could provide examples of success stories from the perspective of process industry manufacturing.

These activities are planned to be finalized in next six months (M19 – M24), depending of course on the availability of people involved.

## 5.3 CAPRI and DIH for Industry communities

Enhancing the collaboration between the different stakeholders from the European DIH Community with a wide range of services, information and tools that will help DIHs, operating in the manufacturing sector, to communicate, align, collaborate and synchronize activities.

- Developing a clear overview of the DIHs related services provided in Europe exploring how these relate to networks and their service.
- Upgrading the DIH Catalogue, among others, identifying/triggering activities in the DIH Community in coherence with regional, national and EU policies.
- Creating an online community to foster interaction among hubs, information exchange and peer-learning.

DIH4INDUSTRY aims to be a matchmaking platform for European DIHs that allows solutions and services to be shared in the context of manufacturing to support European SMEs in their digital transformation.

The mail goal with DIH4INDUSTRY is to create an extensive and connected network of industrial DIHs enabling interaction through the platform, sharing solutions and services that respond to local needs for industrial digitalization. DIH4INDUSTRY's mission is clear: to facilitate the exchange of skills, assets, knowledge, technologies and data between European DIHs to provide an effective and efficient response to the technological and digital needs of European SMEs.

The DIH4INDUSTRY aims to become a digital platform targeted to European Digital Innovation Hubs that operate in the context of Industry 4.0. For this reason, it is important to attend to Industry 4.0 market data as they have direct influence on DIHs and EDIHs environments. It is difficult to find relevant offering when it comes to the digitalization of the manufacturing sector.

It is also important to mention that the big firms only target multinationals and big deals, so their services and solutions are not accessible for small and medium enterprises.

DIH4INDUSTRY intends to cover this gap by supporting the European Digital Innovation Hubs strategy, providing innovative solutions and services to the DIHs manufacturing network to support small and medium-sized companies in the digitization of their processes, products and services.

It aims to become the essential service provider for Digital Innovation Hubs, where services, solutions and knowledge about Industry 4.0 are provided to support the digital transformation of European industrial SMEs. With this objective and in line with the European strategy on DIHs, DIH4INDUSTRY must promote the engagement with DIHs as potential customers of the platform.

Thus, the value of DIH4INDUSTRY for the DIHs to support them in complying with their mission (the digitalization of the manufacturing SMEs) is a sum up of three aspects below:

- Access to a dedicated collaboration space to foster innovation in the DIH. DIH4INDUSTRY offers the DIHs a dedicated digital collaboration space to host the innovation projects developed at the DIH, to share documents and information among DIH members, to open calls for experiments or pilots, in summary a common repository and communication tools for supporting the internal collaboration at the DIH.
- Provisioning a marketplace of assets and services for supporting the digitalization of all SMEs approaching the DIH. DIH4INDUSTRY offers the DIHs a catalogue of assets and services provided by different IT providers to support them in the digitalization of the SMEs engaged to their DIH.
- Engagement with other DIHs of the network and sharing common information. As part of DIH4INDUSTRY, a DIH is member of a network of DIH focused on Industry 4.0, so it can share information and practices with other DIHs with the same focus.

The new brand has been officially launched at EBDVF2020 on November 2020 as part of the exploitation plan of the MIDIH project and now, under the umbrella of the AI REGIO project, the DIH4IINDUSTRY platform will be supported and promoted.

DIH4INDUSTRY constitutes a European network of Digital Innovation Hubs that are active in the Industry 4.0 context, providing information about their main activities and direct link to the relevant spaces. The focal point of the platform is the Services Map (Fig. 18) that, in line with the catagorization specified by the MethoDIH standard, allow our DIHs to showcase their services. In addition, a map with DIH experiments is also available.

A first version of the DIHINDUSTRY instances is public available at https://dih4industry.eu even if if the user registration is not publicly open yet.

Together with SPIRE, different initiatiaves, operating in different domains of the Manufactury sector have been contacted and involved in the DIHINDUSTRY project such as I4MS, SAE, SCoDIHNet, RODIN, BDVA and DIH4AI.

The potential is therefore to put together hundreds od DIHs and give life to a new ecosystem also taking the burden of making it grow providen not only a showcases of services but also an environment to share knowledge and where collaborate.

The first members of the DIH4INDUSTRY have been already gathered and to do that we are leveraging on the interoperability mechanisms among the DIHIWARE instances and versus external systems. This is why we have today a limited number of DIHs and services into the platform and that's why it is not yet publicly available but the opening is planned by the end of the 2021, covering at least a subset of the engaged initiaves.

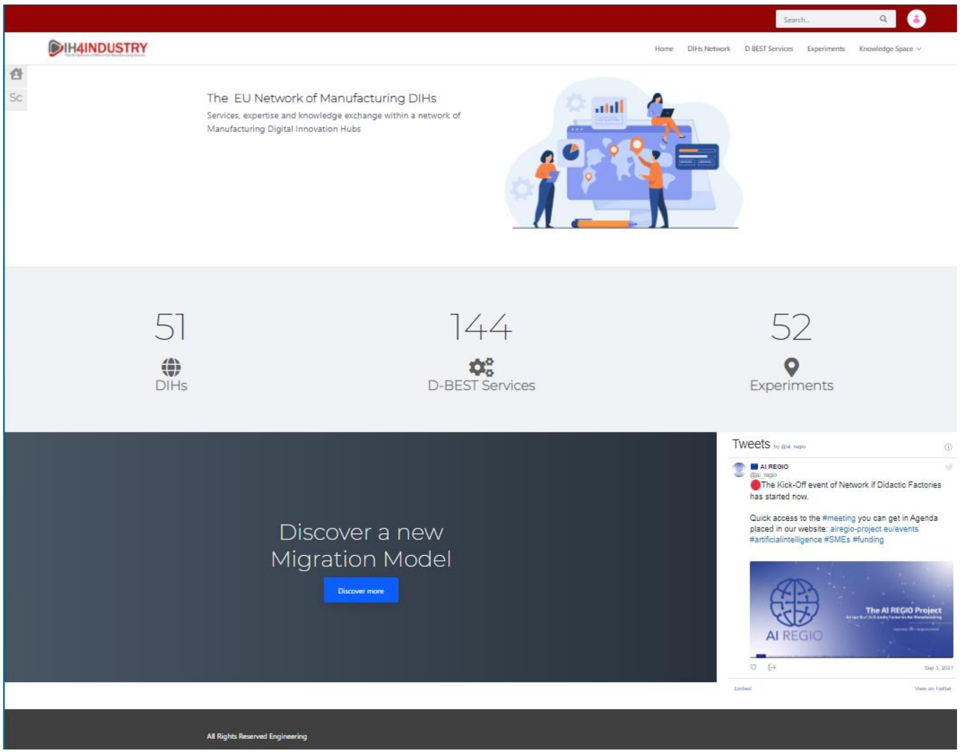


Figure 26 DIHI4INDUSTRY private landing page

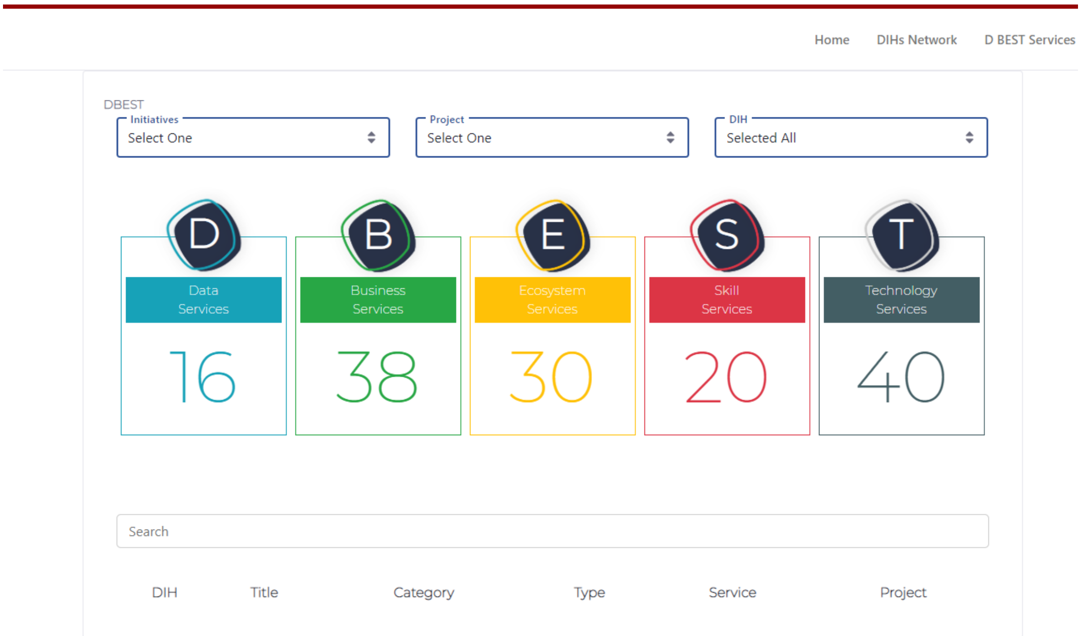


Figure 27 DIH4INDUSTRY Services Map

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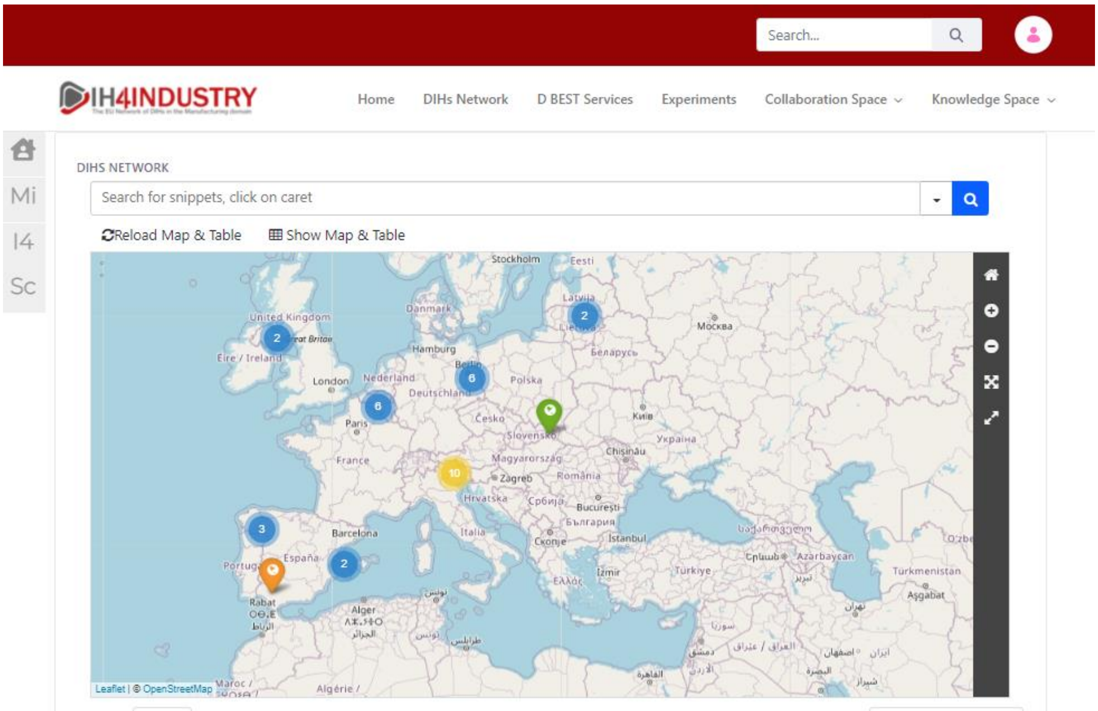


Figure 28 DIH4INDUSTRY DIHs Map

## 5.4 CAPRI and National Regional Initiatives

In the current section, the main initiatives related to the domain of digital technologies for manufacturing are presented, focusing on regional area where CAPRI partners act.

### 5.4.1 Spain

This section presents a selection of programs and initiatives that focus on the development of key innovative digital technologies (AI, Big Data, IoT and IT security & trust) in Spain, including some of the regions represented in the project.

#### *Digital Spain 2025*

**On July 2021, the Spanish government presented the 'Digital Spain 2025' agenda, which will mobilize a public-private investment of 70,000 million euros in the period 2020-2022.**

The 'Digital Spain 2025' plan aims to promote the country's digital transition as an essential lever to relaunch economic growth, reduce inequality, increase productivity and take advantage of the opportunities offered by new technologies. This new digital agenda includes 47 measures articulated in ten strategic axes, which in the next five years will be implemented in line with the digital strategy of the European Union, with public-private collaboration and the participation of all economic and social agents.

One of the objectives is to overcome the digital divide currently happening in Spain between rural and urban areas. The goal is for 100% of the population to have coverage with more than 100 Mbps compared to 89% today. Another is for the 5G rollout aiming for 100% of the radio spectrum to be ready for 5G within 5 years (nowadays only 30% are). Another focus is to strengthen the digital skills of workers and the general public. In 2020, people with basic digital skills constituted 57% of the population. The goal is to raise this percentage to 80% until 2025. Also on the objectives is the improvement of the Spanish capacity in cybersecurity, both for the benefit of citizens and companies. The goal for 2025 is to have 20,000 new specialists in cybersecurity and, by extension, in data and Artificial Intelligence. With this approach, the aim is to stimulate the creation of a business ecosystem in this sector. To promote the digitization of Public Administrations is a complex and long-term objective that is also included in the agenda. By 2025, half of public services are expected to be available in a mobile app. Today the percentage stands at 10%. Another great line of action foreseen in this digital agenda is the acceleration of the digitization of companies, with special attention to microenterprises, SMEs and start-ups. Today the contribution to electronic commerce by SMEs is less than 10%. By the 2025, it is expected to reach 25%. Additionally, digitization is a determining factor to change the production model and it is also contemplated in the digital agenda. Specifically, the aim is to promote projects that are leading to sectoral transformation that generate structural effects. For example, a 10% reduction in $CO_2$ emissions due to digitization. The sectors who were identified to have the greatest potential for transformation are: agri-food, health, mobility, tourism, and commerce. Another key aspect of the agenda is to improve the attractiveness of Spain as a European platform for business, work, and investment in the audio-visual field. The goal is to achieve a 30% increase in audio-visual production in Spain by 2025 compared to the current level. Another important issue on the agenda is related with data economy. Currently, the Spanish companies that use Artificial Intelligence and Big Data are less than 15%. The Spain Digital 2025 Agenda sets the objective of doubling this percentage in five years. Furthermore, it is also proposed to draw up a Charter of Digital Rights, which formulates the rights of citizens and companies in the new environment in a current and accessible language, eliminating uncertainties about the interpretation of certain principles. A parallel initiative is Digital Future Society, a project promoted by the Ministry of Economic Affairs and Digital Transformation of the Government of Spain and Mobile World Capital Barcelona, to build a fairer and more inclusive future in the digital age, improving the impact of technology on the society.

At national level too, the **Ministry Of Industry, Commerce and Tourism** has the initiative called ***Connected Industry 4.0*** where they have different support programs:

Their objectives are:

The digitization of society and industry poses challenges and creates opportunities for the industrial sector that must adapt its processes, products and business models. Thanks to hyperconnectivity, customers are now more informed and have immediate access to the offerings of industrial companies around the world. It is a very competitive environment, but with many opportunities for Spanish companies. Facing these challenges successfully will allow the generation of a new industrial model in which innovation is collaborative, production means are connected and completely flexible, supply chains are integrated, and distribution and customer service channels are digital. Therefore, ***the Connected Industry 4.0*** strategy responds to a triple objective:

- Increase industrial added value and qualified employment in the industrial sector.

- Promote the industrial model of the future for Spanish industry, in order to strengthen the industrial sectors of the future of the Spanish economy and increase their growth potential, while developing the local offer of digital solutions.
- Develop differential competitive levers to favour Spanish industry and boost its exports.

To achieve these objectives, the General Secretariat for Industry and SMEs has been designing a series of support programs for industrial companies in order ***to face their digital transformation*** with more guarantees. Among these support programs you can find the following:

- *ACTIVA Industry 4.0*. A specialized and personalized advisory program, carried out by accredited consultants with experience in the implementation of Industry 4.0 projects.
- *ACTIVA Industrial Challenges*. The program seeks to select as many start-ups that respond to solutions based on the digital enablers of Industry 4.0. To facilitate obtaining these solutions, the program offers selected start-ups a virtual acceleration space with common areas for meetings, networking and places that facilitate shared learning. In addition, they will have individualized mentoring and support, as well as specific training on those aspects that are crucial to address the key issues related to the chosen challenge. The ultimate aim of the project is to promote open innovation models and have 12 successful cases of start-up company collaboration that help the growth and consolidation of the entrepreneurs participating in the program.
- *ACTIVA Cybersecurity*. The main objective of this program is focused on SMEs, which currently the have to face with the incessant increase in cyber-attacks. This program helps them to determine their current security level and establish the level they must achieve to protect their corporate systems and information. It is a free program that consists, among others, of four complementary actions aimed at SMEs with registered offices in any province of the national territory.

### CASTILLA y LEÓN region

**At regional level**, where CARTIF facilities are located, the ***General Directorate of Industry of the Junta de Castilla y León***, has recently launched a funded program called *Industrial Cybersecurity and Industry 4.0* whose objective is to promote the implementation of projects related to Industrial Cybersecurity and Digital Transformation in the Community of Castilla y León. The funded initiative are those related to the following topics:

Projects related to Industrial Cybersecurity and Industry 4.0, linked to the industrial product-process, in the following areas:

- Convergence and integration of protection systems against cyber-attacks for IT / OT environments (Information Technology / Operational Technology). Design and execution of secure architectures and, where appropriate, materialization of industrial network segmentation.
- Securisation of remote accesses to the industrial equipment of the OT network required for the equipment maintenance, control and operation

- Securisation of industrial information / data. Audits and simulations of attacks by external people and audits on internal profiles with different levels of access to data from the company.
- Cybersecurity evaluation of industrial software in production plants and improvement of the same.
- Initiatives to raise awareness of the company's staff in the field of Cybersecurity.
- Diagnosis of the current situation of the industry in terms of industrial Cybersecurity and preparation of the action plan for its improvement. Risk analysis and industrial vulnerability.
- Pentesting of any technology belonging to the OT network.
- Adoption of good practices included in Industrial Cybersecurity standards (IEC 62443 or equivalents) or others widely recognized.
- Adaptation to compliance with the National Security Scheme (R.D. 3/2010, of January 8), PIC Regulation (R.D. 704/2011, of May 20).
- Continuous improvement of the Cybersecurity management process through the deployment of measures specific or evolution of the same to maturity levels higher than the pre-existing
- Protection measures for strategic or sensitive information such as industrial property, intellectual property, R & D & i strategies, building plans or product design, information affected by the General Data Protection Regulation (RGPD) or any other directly related to the competitiveness and sustainability of the business.
- Implementation of perimeter security devices and other industrial devices (switches, sensors, actuators, industrial firewalls, PLCs, etc.).
- Evaluation of the security levels implemented in the design phase, as well as the management of the security life cycle of systems, devices or solutions.
- Adoption of a contingency plan that improves Cybersecurity and resilience of production security systems (Backup & Recovery)
- Other projects that significantly increase the level of Cybersecurity of the industrial companies and reduce the risk and vulnerability to different types of existing attacks.

In addition, in Castilla y León there is also the ***Digital Innovation Hub Industry 4.0***, whose objectives are to **promote industrial digitization** in Castilla y León, helping SMEs to incorporate enabling technologies from Industry 4.0. Within their purposes, they also guide administrations in the implementation of digitization solutions. Their ecosystem is made up of industries, centres of competence and R&D, and developer companies. They incorporate a specific program to support start-ups, and they have a network of alliances with other entities, at a regional, national and international level. They are **part of the European IHL Network** as a fully operational Hub, focused on smart manufacturing, and with a high degree of maturity.

Moreover, **CARTIF**, CAPRI coordinator, is part of the ***"Centr@tec***" Training, Technology Transfer and Support to Business R & D + i Program. Focused for SMEs in Castilla y León, it is carried out by the ***Institute of Business Competitiveness (ICE)*** in collaboration with the Technological Centres of Castilla y León that are part of the Network of Entrepreneurship and Innovation of Castilla y León.

***Centr@tec*** focuses on different thematic areas:

- *Industry 4.0*. Its objective is to incorporate SMEs into the digital transformation that is taking place in the global economy, supporting them in incorporating the 4.0 skills and technologies available in each sector.
- *Digitalization*. Its objective is to promote the incorporation and generalization of the use of ICT Technologies by SMEs in the different areas of the company, with special attention to applications related to e-commerce and digital marketing.
- *Innovation in Processes*. Its objective is to incorporate innovations in production processes and the design of products and services for SMEs, especially in rural areas, in order to improve their competitiveness and adaptation to new markets.
- *Internationalization*. Its objective is to increase the transfer of international technology and the participation in European R&D programs in the business sector.
- *Support for Technology-Based Entrepreneurs*. Its objective is to support the generation of new projects by studying their technical feasibility, studying the state of the art and defining the strategy for the protection and exploitation of the future results obtained.

### *Basque Country Inputs*

**On March 2021, the Basque Government presents to Parliament the bet of 1,400 million euros for the digital transformation of the Basque Country**

The Basque Government has presented to Parliament the "Strategy for the Digital Transformation of the Basque Country 2025"[13]. This plan, led by the Department of Economic Development, Sustainability and the Environment, will accompany with a synergetic, proactive and coordinated support from all the agents involved, the challenge imposed by a new model of digital transformation.

The Government of Euskadi will allocate, for the period 2021 -2025, a minimum joint budget of 1,400 million euros. This amount includes both the digitization of its own processes, services and the acquisition and maintenance of its computer equipment, as well as the promotion of the digital transformation of external agents that are within the scope of their respective competencies.

**Strategy for the Digital Transformation of the Basque Country 2025**

Through the Strategy for the Digital Transformation of Euskadi 2025, in its Spanish abbreviated name ETDE2025, a new model of digital transformation is defined that supposes a different way of understanding and exercising the relationship between the Basque Public Administration and the economic and social agents, so that global challenges can be tackled together.

ETDE2025 is structured in three dimensions that make it possible to define the elements on which the Basque Government will focus and its priorities during the period of validity of the strategy. These

[13] https://bideoak2.euskadi.eus/2021/03/30/news_67948/ETDE2025_Estrategia_ES.pdf

dimensions are the technological levers, the support enablers and the fields of application. These three dimensions do not act in isolation, but rather as a system, and must be viewed from the perspective of generating value for the Basque Country.

The lines of action include the consolidation of initiatives that have already been working in recent years, such as the Basque Cybersecurity Center (BCSC), the Ultra-fast Broadband Observatory or the Metaposta service. It also includes the launch of a new initiative such as the Basque Artificial Intelligence Center (BAIC), the launch of an interoperability platform for companies, support for the creation of Data Centers or facilitate the use of 5G in the Business field. All of this always seeking to reduce digital inequality.

Notable among the unique initiatives is the goal of introducing 5G coverage in 50% of industrial estates by 2025.

To this end, within the framework of ETDE2025, it will collaborate with the rest of the Government departments, exchanging knowledge to create synergies whenever necessary. This collaboration will contribute to a new scenario of digitization of the Basque Public Administration, having a positive impact on the improvement of services and the quality of life of citizens.

The Strategy for the Digital Transformation of the Basque Country 2025 has a time horizon of five years to ensure the fulfilment of its objectives, develop the driving initiatives identified and incorporate, where appropriate, new ones that are considered appropriate to address based on progress in the execution or in response to legislative, economic, social or technological changes.

The Basque Government is very aware of the guidelines emanating from the European Commission and endorses them, adjusting them to the particular objectives and priorities of our country. Thus, on March 9, the European Commission presented a Communication entitled "Digital Compass for 2030: the European Way of the Digital Decade." This Communication is based on the strategy for shaping the digital future of Europe , which constitutes the overall framework. However, it also takes into account the enormous changes brought about by the coronavirus pandemic, which has greatly accelerated the use of digital tools and demonstrated their opportunities, but which has also revealed the vulnerability of our society to new digital inequalities.

**The Basque Country is in a good position to take on the greatest challenge posed by this transition by tackling a new model of digital transformation.**

### 5.4.2 Italy

This section presents a selection of programs and initiatives that focus on the development of key innovative digital technologies (AI, Big Data, IoT and IT security & trust) supported by Italian government.

In February 2017, the Italian Ministry of Economic Development has launched the Industria 4.0 National Plan (I4.0). The new strategy puts in place horizontal measures accessible for all enterprises with an objective to boost the investment in new technologies, research and development, and revitalise the competitiveness of Italian companies. The Plan includes fiscal incentives for Digital

Transformation of Manufacturing enterprises as well as the development of **Competence Centers** and **Digital Innovation Hubs**.

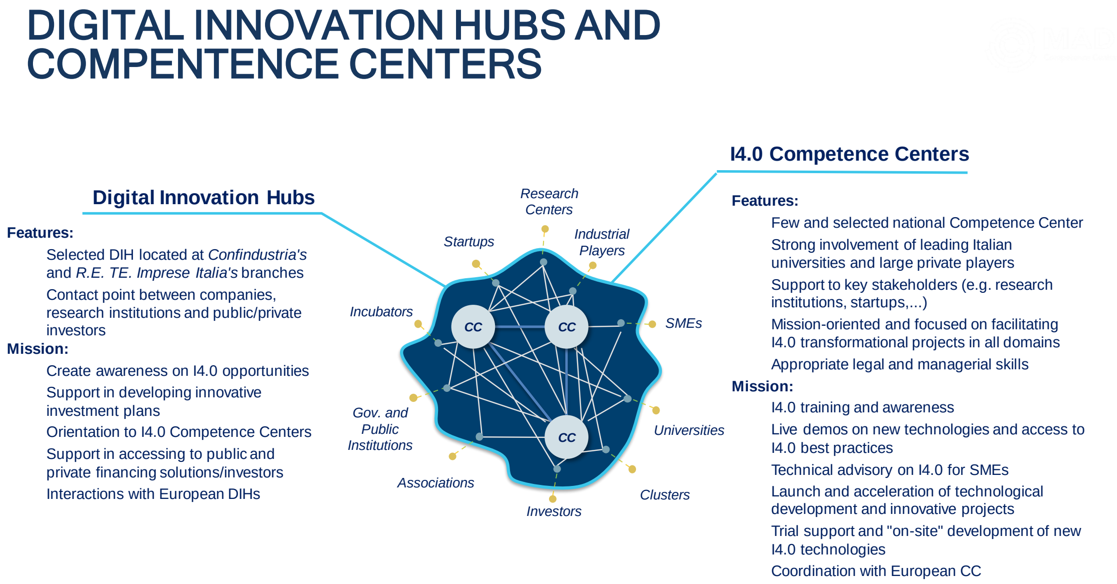


**Figure 29 DIHs and CCs main feature**

A Competence Center is a hub with a strong academic background and often link to universities, whose mission is to facilitate I4.0 transformation projects, by providing trainings, “test and experimentation facilities”, demos of new technologies and high quality of technical support.
In Italy, the Industria 4.0 plan financed 8 highly specialized competence centers (one of them, the MADE[14] Competence Center, is associated to Politecnico of Milano) and it means that they are highly sparse on the territory and it is not so easy for SMEs to reach them.
On the other side, Digital Innovation Hubs are organizations with a similar mission to CCs but, being typically smaller and well distributed in the national territory, they have been conceived to directly reach the enterprises (SMEs mainly). DIHs are usually more Business and Ecosystem oriented, providing services related to dissemination and awareness raising, trend analysis and market ratings, community management and brockerage activities (for example putting in contact SME with technology facilities, as CCs for instance).

### *The DIH Lombardia*

DIH Lombardia[15] is the regional DIH of Confindustria Lombardi, where Politecnico di Milano is located. All the Territorial Association in the region are Founding members of DIH Lombardia. Thanks to the «Antenne territoriali» (local organizations) and the regional «digital ecosystem» coordinated by DIH Lombardia, DIH aims to support companies’ needs, towards Digital Transformation Journey regardless of their business sector or size, with a specific focus on SMEs. DIH Lombardia main tasks are:

- Promoting the training of qualified human resources (training & education)
- Raising the companies’ awareness on opportunities of I4.0

[14] https://www.made-cc.eu/
[15] https://www.afil.it/

This project receives funding in the European Commission’s Horizon 2020 Research Programme under Grant Agreement Number 870062

- Support in the choice and planning of investments for innovation
- Orientation to the Competence Center I4.0
- Support in accessing to finance (public and private)
- Mentoring to companies
- Interaction and networking with European DIHs
- Trans-sectoral DIHs which suit the characteristics of the Italian industrial system and business culture according to Confindustria system structure

In particular, DIH Lombardia is conducting the "TestIndustria 4.0" as a digital maturity assessment especially tailored for SMEs.

### 5.4.3 Austria

This section presents the major initiative that focuses on the development of key innovative digital technologies (AI, Big Data, IoT and IT security & trust) in Austria.

***AIM AT 2030 - Strategy of the Austrian Federal Government for Artificial Intelligence*** focuses on pursuing the following three objectives:

I. A broad deployment of AI oriented towards the common good is targeted, carried out in a responsible manner on the basis of fundamental and human rights, European fundamental values, and the upcoming European legal framework.

II. Austria should position itself as a research and innovation location for AI in key areas and fields of strength, and

III. by means of the development and use of AI, the competitiveness of the Austrian technology and business location should be secured.

The AIM AT 2030 comprises clear objectives and measures pursuing these, which are divided into general fields of action of the two basic pillars "Trustworthy AI" and "Creating ecosystems". The Austrian Federal Government is planning extensive studies and support measures to achieve these objectives. Numerous initiatives (Hubs and Clusters including Start-ups, SMEs, Industry, RTOs, Universities as members) operate within the defined Fields of Action.

This project receives funding in the European Commission's Horizon 2020 Research Programme under Grant Agreement Number 870062

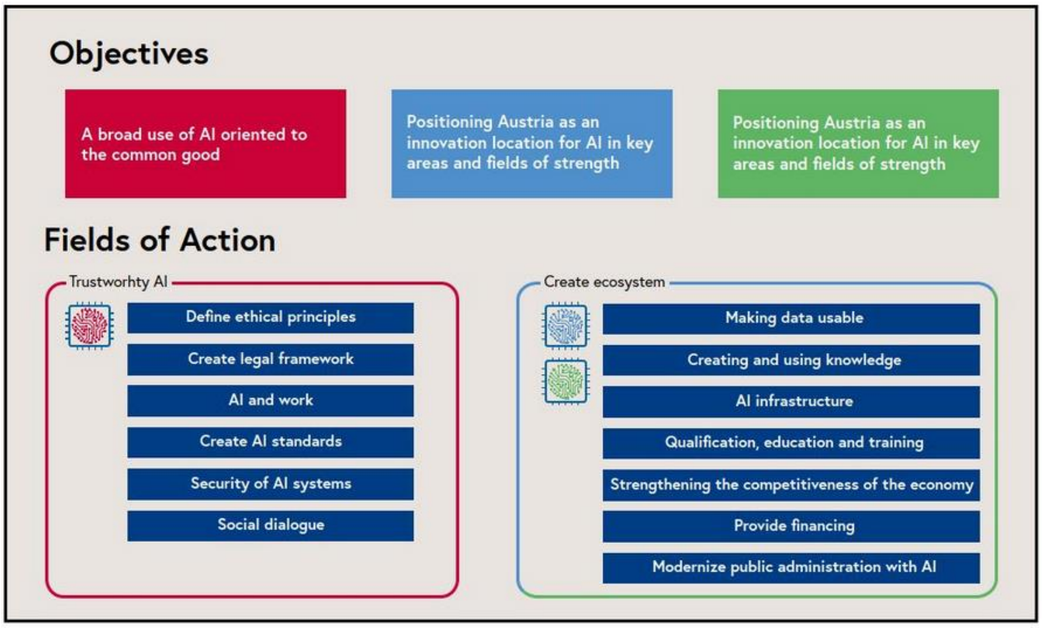


**Figure 30 Objectives and Fields of Action photo: BMK/BMDW**

The AI application fields listed cover numerous sectors, including industry, climate protection, agriculture, energy, health, education, law, and culture. They are regularly updated and supplemented depending on the topic area.

Fields of Application:

- AI as a tool for addressing climate change
- Digitalized energy systems
- AI for sustainable mobility
- AI in agriculture
- AI and space applications
- City and energy space planning
- AI in the material goods industry
- AI in the building sector
- AI in healthcare
- AI in the arts, media and creative industries
- AI in education

### 5.4.4 Germany

This section presents a selection of programs and initiatives that focus on the development of key innovative digital technologies (AI, Big Data, IoT and IT security & trust) in Germany.

***Central Innovation Program for SMEs (ZIM)***

ZIM[16] is a large-scale funding programme for R&D activities of SMEs. Eligible projects can be conducted either individually, as cooperation projects between different SMEs or between an SME and a research and technology organisation (RTO), or as an innovation network. In 2018, ZIM projects of 2720 different entities were concluded, 64% of which were SMEs, and the remaining ones were RTOs. ZIM is funded by the Federal Ministry for Economic Affairs and Energy.

### *The Digital Hub Initiative*

The Digital Hub Initiative[17] is a network of twelve digital hubs whose aim is to connect companies of all sizes with researchers, entrepreneurs, and investors to foster digitization. The hubs are distributed throughout Germany and every hub focuses on a particular sector, such as FinTech, Logistics, CyberSecurity, Artificial Intelligence, Health, or Industry. Among other activities, they provide matchmaking tools, organise events and developed an innovation guide. The initiative is funded by the Federal Ministry for Economic Affairs and Energy.

### *The National Research Data Infrastructure (NFDI)*

The aim of the National Research Data Infrastructure[18] consortium is to curate and make accessible a set of datasets for different selected areas of interest for research use. In addition, they provide recommendations on software tools and services for efficient usage and preparation of datasets. The organisation consists of several consortia, focusing on topics such as human genome data, plants, biodiversity, catalysis, chemistry, engineering, culture, health, and the social sciences. NFDI is funded by the Federal Ministry of Education and Research.

### *Plattform Industrie 4.0*

Plattform Industrie 4.0[19] is a joint undertaking of the ministries for economic affairs and energy, and of education and research, who initiated a network of more than 150 companies, associations, trade unions, researchers and politics dedicated to the digital transformation in the industry. The aim of the platform is to promote the transfer of Industry 4.0 concepts into business practice, in particular to SMEs. It defines three strategic fields of action: autonomy, interoperability and sustainability. A roadmap "2030 vision for Industrie 4.0" has been published,[20] as well as a geographic mapping of use cases.[21]

### *GAIA-X*

GAIA-X is a European project for the development of a secure and trustworthy infrastructure for data exchange, fostering the European digital sovereignty. It aims to define standards for a cloud infrastructure that enables data federation, i.e., controlled sharing of data between different entities and hence create new and innovative cooperation potentials. The GAIA-X association has been set up along with several country level GAIA-X hubs. Members of the German GAIA-X hub are

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16 https://www.zim.de/ZIM/Navigation/DE/Meta/Englisch/englisch.html
17 https://www.de-hub.de/
18 https://www.nfdi.de/
19 https://www.plattform-i40.de/IP/Navigation/EN/Home/home.html
20 https://www.plattform-i40.de/IP/Navigation/EN/Industrie40/Vision/vision.html
21https://www.plattform-i40.de/IP/Navigation/Karte/SiteGlobals/Forms/Formulare/EN/map-use-cases-formular.html

organised in several domain working groups, including agriculture, energy, finance, health, industry 4.0, etc.

### 5.4.5 Greece

The Greek innovation landscape is becoming more and more promising. First, new technologies in AI, IoT, 5G, etc preoccupy younger generations more willing to risk, to try and fail. The never-ending economic crisis (12 years) and the high unemployment rates have led to many start-ups formation, more clusters and associations. Therefore, the initiatives and innovation business landscape are more on the funding and diffusion of knowledge to increase awareness rather than purely technological. Technology is the medium and not the object of funding, so does the industry. To this end, all the Indudstry4.0 technologies have a place in this landscape, are attractive for funding, and become a trend.

This section presents a selection of programs and initiatives that focus on the development of key innovative digital technologies (AI, Big Data, IoT and IT security & trust) in Greece.

#### *Technopolis AI Cluster*

Cluster of Companies that share the same vision: their interest and knowhow for AI solutions and technologies.

#### *DigiYouth*

An initiative powered by Microsoft and Regeneration, giving the capacity to young graduates to return into digital classrooms and learn new digital and IT technologies.

#### *Greece 2.0*

Research and Investment funds to support new technologies to allow both Green and Digital Transition with new technologies like (AI, Big Data, IoT, 5G, etc). It is also investing on Skills and Employment through education, Health, and social security, facilitating private and public investments.

#### *AI Minds*

It is about digital transformation of enterprises and augmentation of people skills. A joint initiative between SEV and SAS for data science and Artificial Intelligence.

#### *Innovative Greeks*

A joint initiative between SEV and Endeavor Greece to create a community of Innovative Greeks to exploit Greece’s financial potentials by creating growth and jobs with the use of new technologies (AI, Big Data, IoT, 5G, etc.)

#### *Innovation Ready*

An initiative to support the innovation activities and the digital transformation of Greek Enterprises, by having Start-ups, SMEs, and research communities to work with the industry to provide added value solutions.

***AI in Greece***

An innovative initiative from **SciFY** bringing together all the Greek forces wanted to learn about Artificial intelligence, and how it affects the future, and how to collaborate, co-design, and co-create a better future for all.

### 5.4.6 Poland

This section presents a selection of programs and initiatives that focus on the development of key innovative digital technologies (AI, Big Data, IoT and IT security & trust) in Poland.

***Industry 4.0 in Wielkopolska***

AMS Pharma is located in Złotniki in a region of Wielkopolska(Great Poland)

Digitalization of the economy and society is one of the dynamic directions of change, as shown by the creation by the EU of a new Digital Europe programme for 2021-2027 (Digital Europe Programme - DEP), whose main objective will be shaping Europe's digital transformation. New and evolving technologies form the foundation of change in technological terms, enabling, through Industry 4.0, the implementation of new processing methods and production and information management. The priority of modern development economic are KETs, which work in many ways in many different value chains and sectors in global industry. They create value all along the chain - from materials, to equipment and facilities to products and services.

Key to the development of the idea of Industry 4.0 in Wielkopolska is primarily:

- investing in new production technologies,
- raising staff qualifications
- searching for new development paths by enterprise in cooperation with universities and research and development centres.

Natural pace of civilizational change in free-market economies and consumer lifestyle of the society somehow force the natural course of development towards modernisation and automation of production in enterprises.

***Academy for Innovative Applications of Digital Technologies "AI Tech"***

AI Tech is an government project for specialist studies in artificial intelligence and new technologies.

The main objective of the programme is to support the development of advanced digital competencies and to prepare staff for the digital economy. It will develop a model for the systemic education of top-class specialists in artificial intelligence, machine learning and cybersecurity at the level of undergraduate studies. In the future they will support institutions of key importance to the Polish economy and state.

The first edition of the project is carried out by a consortium of ten best Polish universities, which already conduct research and teaching in the areas of artificial intelligence, machine learning and cyber security. The value of the project for 2020-2023 is PLN 81 million. During this period at least 500 students from universities associated in the consortium will be covered by the activities. Co-financing for universities will include: providing second cycle studies, foreign scholarships for students, international cooperation with leading universities, cooperation with enterprises and scientific-implementation projects carried out by students in cooperation with enterprises and state administration.

### GAIA-X

Within Cloud Community Europe Poland - Gaia-X intend to support Polish data processing companies in finding European partner, creating and participating in projects at European level in various sectors such as finance, health, agriculture, logistics, transport, space, industry 4.0, e-commerce, energy.

### Digital Europe - Digital Innovation Hubs in Poland

**hub4industry** is a group of organisations with complementary expertise and a not-for-profit objective of offering companies a set of services to support their digital transformation. The hub was established in 2019 and consists of the key orchestrator (the Kraków Technology Park) and consortium partners: T-Mobile and ASTOR technology companies; the AGH University of Science and Technology and the Kraków University of Technology; and specialists from the Construction Information Technology Cluster (BIM Klaster) and the Kosciuszko Institute. Together, we create a one-stop-shop – a point of integration and standardisation of multiple competencies in the industry of the future.

The technological competences of hub4industry cover 5G Connectivity, Robotics and automatization, Artificial Intelligence, Industrial IoT, Cybersecurity, BIM, Cloud Computing, Data Analytics, 3D Printing, VR/AR

hub4industry provides:

- Demonstrations of new technologies using i.e. showrooms and study visits to leading domestic and foreign manufacturers.
- Proof of concept for new technologies in manufacturing companies in the KPT ScaleUp acceleration programme with more than 30 pilots, including VR, AR, IIoT, big data analysis, AI, and cybersecurity.
- Digitalisation readiness scanning and benchmarking using ADMA methods.
- Skills and training: Academy of Industry 4.0 an e-learning platform for entrepreneurs, engineers, and manufacturing managers; education, workshops, meetups, webinars, etc.
- Networking session for industry.

This project receives funding in the European Commission's Horizon 2020 Research Programme under Grant Agreement Number 870062

# 6 FUTURE OUTLOOK and CONCLUSIONS

D6.5 – “Initial Report: SPIRE Digital Transformation Ecosystem”, as a first report presenting the CAPRI dissemination activity channelled through SPIRE PPP, paves the way to a number of future activities that will be performed in next months. From this perspective, the entire deliverable is a detailed description of CAPRI future outlook.

Actually, in D6.5 four main assets conceived and/or validated within CAPRI project are identified and tailored for the process industry, dealing with four different aspects to be all taken into account in the process of digital transformation. **PICO** (Process Industry COgnitive) Architecture, that describes an innovative concept to manage data from the **architectural point of view**; **PIHUB** (Process Industry Hub), to collect **innovative solutions, success stories** and lesson learnt from the network of SPIRE-06 industry; **PI 6Ps** (6Ps methodology for Process Industry), that presents a **methodology** to drive a full digital transformation including also **socio-business pillars**; **PIWARE** (the DIHIWARE for Process Industry), to create a **marketplace** of cognitive solutions involving **Digital Innovation Hubs** supporting the process industry SMEs.

These tools exist and have been validated in CAPRI project. However, the next step is to present them to a wider network, mainly SPIRE-06. For each, a detailed planning has been drafted: we mainly focused on the next six months (M19 – M24) activities, in order to provide a more concrete planning, but we are expecting to disseminate the assets presented in D6.5 also later, possibly to a larger audience.

In next weeks, D6.5 will represent a useful guide since it tracks the upcoming actions in CAPRI project from the dissemination and exploitation point of view.

Moreover, last section presents a number of additionally initiatives, groups and communities to extend CAPRI ecosystem toward other domains (discrete manufacturing, technologies and industry communities) that represents a further way to disseminate CAPRI results but also a good opportunity to share knowledge and expertise.

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