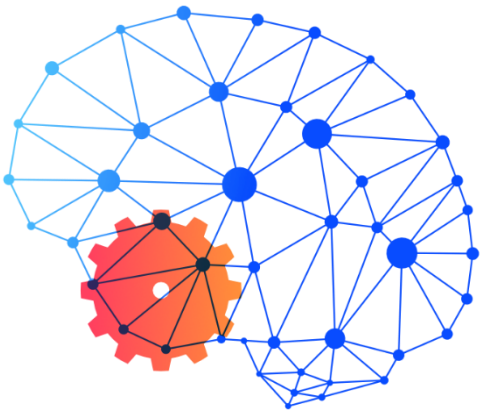

capri

Cognitive Automation Platform for European PRocess Industry digital transformation

Deliverable

D7.3 Initial Report: Training and Education program report

Deliverable Lead: Politecnico di Milano

Deliverable due date: 31/03/2022

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List of Acronyms and Abbreviation	
Acronyms	**Description**
AI	Artificial Intelligence
API	Application Programming Interface
BDVA	Big Data Value Association
CAP	Cognitive Automation Platform
CPS	Cyber Physical Systems
CS	Cognitive Solution
DIH	Digital Innovation Hub
D BEST	Data Business Skills Technology
DR BEST	Data Remote Business Skills Technology
DT	Digital Twin
ERP	Enterprise Resource Planning
GUI	Graphical User Interface
HMI	Human Machine Interface
ICT	Information and Communication Technologies
IDSA	International Data Space Association
IoS	Internet of Services
IoT	Internet of Things
IT	Information Technology
IIoT	Industrial Internet of Things
MES	Manufacturing Execution System

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ML	Machine Learning
OEE	Overall Equipment Effectiveness
OT	Operation Technology
PLC	Programmable Logic Control
PLM	Product Lifecycle Management
Q&A	Questions and Answers
RA	Reference Architecture
RAP	Reclaimed Asphalt Pavement
SME	Small Medium Enterprise
ToC	Table of Content
VR	Virtual Reality
WEF	World Economic Forum
WMF	World Manufacturing Forum
WP	Work Package

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EXECUTIVE SUMMARY / ABSTRACT SCOPE

Deliverable D7.3 – "Initial Report: Training and Education program report" defines the strategy to be followed by CAPRI to establish a training program to disseminate and exploit its cognitive assets.

D7.3 is the result of the activities run in T7.3 – "Training and Education Program", in the context of WP7 – "Training, Replicability and Exploitation": with the perspective of exploiting the assets implemented within the project, it is fundamental to identify what kind of training should be delivered to make the assets accessible to third parties and the material required to support the training.

Namely, three different types of assets have been identified, requiring a training to be exploited:

- **The Open Source Reference Architecture** has been conceived as a combination of a (variable) number of open-source components, so very likely suitable for exploitation, also because it may have a large applicability even beyond CAPRI use cases and sectors. To present it and to properly understand the layers on which the Architecture is based (scope and applicability) at least a standard general presentation will be required, together with a demonstration of how the CAPRI platform, built on top of the Architecture, works. Specifically, the Reference Architecture has been conceived as an enabler to support a number of different cognitive processes (that in CAPRI correspond to the Cognitive Solutions), so the training will be complemented with a demonstration of how they work and of the advantage of integrating them into the platform.
- **The Cognitive Solutions** have been implemented in CAPRI initially at laboratory level, with the objective of being deployed in the production environment, so very likely to become part of the tools used daily in the plants. It is important to train the final user, represented by the plant operator in case of sensors/control solutions, or by the technician/decision maker in case of planning/operational solutions, about how to use them. To this regard, the partners who developed the CSs have identified the type of training required, taking into account who is the final user and the competences needed, the material to be prepared, the effort in terms of time/budget to follow the course. Not all Cognitive Solutions require training to be adopted, as for instance they are not based on a direct interaction with the workers or since they propose very simple concepts. However, the majority requires at least an introductory presentation; some of them, one (or more) day trainings.
- **The 6Ps Methodology** aims at defining a digital transformation roadmap for enterprises and to measure its impact, based on a self-assessment and an interview, taking into account six main pillars of the industrial productive process. In CAPRI, the methodology has been already applied to the three pilots, but in the context of a training planning, the objective is to teach other partners (mainly technology providers who are often in contact with several industrial enterprises) about how to perform the assessment, so that, it will be possible to reach a larger audience.

Aiming at defining an effective training strategy, D7.3 reports also the results of the analysis run with CAPRI pilots regarding the skills and professional competences required to succeed in the digitalisation process adopting AI and other cognitive solutions based on data. T7.3 prepared a survey for the asphalt, steel and pharma demonstrator in order to prioritise the skills (selecting those considered most relevant for the specific sector, also comparing the three of them) and to identify those already possessed and those required to adopt CAPRI solutions but also to proceed in the digital transformation.

The combination of the two results (relevant skills and required skills) allows to define some actions to be performed by the pilots in terms of up-skilling/re-skilling, but also to generalise the analysis identifying some trainings useful for the process industry that could be included in our training strategy.

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1 Introduction

1.1 Scope of Deliverable

Deliverable D7.3 – "Initial Report: Training and Education program report" is the definition of the training program to be pursued by CAPRI partners in next months. It is an "initial" report: it means that in this framework, only the strategy and a preliminary plan are defined; the results of the training will be provided in next deliverable D7.7 – "Final Report: Training and Education program report".

The objective of D7.3 is twofold.

On one side it aims at identifying the CAPRI assets that require a preliminary training in order to be exploited, specifying what type of training will be provided, the audience to whom it is addressed and who will be in charge of delivering it.

On the other side, it aims at identifying some trainings to be addressed to pilots (and generally, to process industry) in order to fill their gaps and provide the expertise to fully adopt the digital solutions. To this regard, D7.3 investigates the skills and professional expertise available/required in the three pilots, with a specific focus on those identified as the most relevant.

1.2 Audience

D7.3 is an informative report, free of technical aspects, 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 the full consortium since it contains the list of trainings to be prepared and delivered and this involves all the partners. Several assets have been identified to be equipped with a training (the Reference Architecture, the Cognitive Solutions and the 6Ps methodology) and the developer(s) will actively participate to the training material's preparation.

1.3 Relationship with other deliverables

D7.3 – "Initial Report: Training and Education program report" is strongly related to D7.7 – "Final Report: Training and Education program report", that is its sequel expected at Month M42 (end of the project). If the former is the analysis of the CAPRI cognitive assets that require a training to be exploited/adopted and contains a preliminary plan about training activities to be performed in next months, the latter will provide the results.

As well as D7.7, also the entire WP7 will refer to it, since training (workshops, conference, online material, etc.) is the best way for exploiting the assets implemented in CAPRI and so it's important that the exploitation strategy in T7.1 – "Exploitation and business plan development" takes into account also achievements displayed in D7.3.

1.4 Document Structure

The document is organized in three main chapters (Section 2 – Section 4), beside the introductive 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 - Training program for CAPRI assets describes the set of trainings expected to be performed in next months, related to the main CAPRI assets (the Reference Architecture, the Cognitive Solutions and the 6Ps methodology). Each asset is equipped with a description, the people involved (both training providers and final users) and with the type of training required to make the asset accessible (a workshop, a demo, a course, etc.), including the material to be prepared and the estimated effort both to prepare and to provide the training.

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In case of a mature asset, also a draft planning of next activities is provided.

Section 3 - CAPRI Skills Catalogue and Jobs Certification program is divided into three main subsections. A background chapter presents an overview of emerging skills related to digital transformation, with a specific focus on Industry 4.0. Secondly, a theoretical chapter presents some roles and skills related to data science, AI, Industry 4.0 management, together with a set of useful soft-skills to be employed in manufacturing industry. Finally, the results of the survey conducted among the three pilots is provided, showing which are the possessed and needed skills and prioritising the most relevant ones.

Section 4 - Train the trainers – a collaboration with DIHs presents a plan to involve a number of DIHs (dealing with Process Industry) to share with them lesson learnt in CAPRI project and use cases, but also to teach the main results achieved within the project. The trainings described in Section 2 represent the starting point.

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2 Training program for CAPRI assets

The purpose of this chapter is to provide a high-level planning of the trainings expected to be performed in next months, related to the main CAPRI assets (the Reference Implementation, the Cognitive Solutions and the 6Ps methodology). Each plan will be equipped with a description of training required to make the asset usable by the final user. It includes a description of the asset, of the type of training (a course, a presentation… 1 hour, 1 day, 1 week long, …), of people involved (both as training provider and user), considering which new skills are required and how to get them (up-skilling, new hiring…), of the benefit deriving from the adoption.

2.1 Reference Implementation

The Reference Implementation relates to the implementation of the CAPRI Cognitive Automation Platform (CAP) according to the Reference Architecture defined in WP3. The CAP is the core of the project and it is designed to be a platform able to promote digital transformation and to be used as a cognitive enabler in the process industry domain.

ASSET DESCRIPTION

In order to overcome a series of barriers that limit the cognitive in current process industry, a Cognitive Automation Platform (CAP) has been implementations designed and implemented to be integrated with existing or new industrial settings, connected with big data flows from the factory to shop floor level (e.g. sensors, SCADA, PLC), and enterprise level (e.g. MES, ERP, PLM), as well as the information contained in the knowledge of workers and managers operating the plant.

Its modular architecture supports knowledge models, machine learning systems and different cognitive modules of planning, operation and control, and it has been described in detail in **D3.1 deliverable**. It enables a LEGO-like approach that facilitates the adoption in different domains, such as the three pilots (Asphalt, Steel and Pharma), and the building of complex applications combining the software components needed, enabling the exchange of IoT raw data (Smart IoT connection layer) at machine level, elaborating events and information (Smart Events processing layer) at unit (edge/fog) level, knowledge models and semantics (Smart Knowledge modelling layer) at site level, and generation of predictions, reports and graphics (Smart Decision support layer) at inter-site level. The CAPRI approach includes also Data Sovereignty principles and adopt open source components, incorporating the IDSA dataspaces technical building blocks to guarantee openness, multi-standard interoperability and data security /confidentiality in data exchanges.

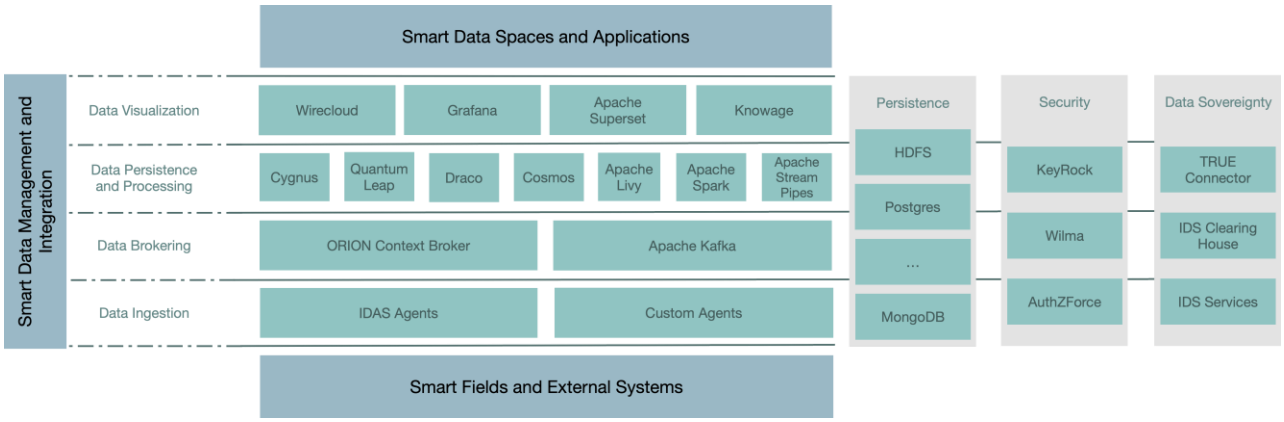

Figure 1 - CAP Reference Implementation

Final users will be process industry companies that are interested in improving their plants, taking advantage of cognitive solutions, to optimize the quality of production, reducing wastes while

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reducing energy consumption and consequently getting a positive ecological impact. At the same time IT companies, including SMEs, are interested in acquiring the knowledge and technology to build sophisticated solutions for companies that don't manage in-house the improvement of their plants. They will be advantaged by the open source nature of the asset and availability of open data to help developing and test their solutions. A third possibility is given by DIHs that could be interested in acquiring the technology and expertise to foresee and transfer the cognitive capabilities and solutions to similar domains where cognitive solutions could bring significant benefits, thus making the cognitive solutions replicable in all SPIRE sectors.

TARGET OF THE TRAINING

Recipients of the training are going to be the referrers of the entities just mentioned, so technical staff of the process industry companies, or system architects from IT companies or DIHs (potentially final users for some training modules).

TRAINING STRUCTURE AND REQUIRED MATERIAL

In order to learn most of the CAP implementation details and adapt it to the different domains and plants, the **Cognitive Platform Blueprints** will be developed, describe how to best use the CAP framework to implement cognitive solutions in specific industrial sectors, remaining agnostic to the specific pilot, and generic enough to represent the industrial sectors present in the CAPRI project. This is part of the objectives of task T4.5, integrating Data Platforms and Data Spaces to deliver concrete **blueprints specifications** to make easy the deployment in pilot domains. At the same time blueprints will pave the way to facilitate the required tailoring process before deploying the blueprints in real operational scenarios as part of the WP5 demonstrators, covering the interoperability of all 4 layers of cognitive solutions.

In the training sessions the released CAP open source software, organized in a Github repository, would be used, including **installation and configuration guides**. Specific examples in pilot domains, using also open datasets, will be the basic elements on which to tailor the training sessions for the different technical profiles. Furthermore, **a webinar for each blueprint implementation** will be performed this year, in order to showcase how to configure, run and customize the platform for addressing the domain needs. The webinar will include an interactive session in order to solve doubts and speed up the adoption of the CAP (hands-on approach).

PLANNING

As mentioned in the previous section a webinar will be organized for spreading the adoption of the platform for each domain. After the first integration of the cognitive solutions, the webinar will clarify the usage of the platform in terms of:

- Configuration of the data sources (plugging-in)
- Persisting data flow (data storage)
- Running and customization of the (pre-loaded) cognitive solutions
- Definition of basic dashboards for consuming data

Attendees will be represented by the domain leader and related pilots. All the webinars will be recorded and made available in the project website. At the same time concrete blueprints specifications will be produced, agnostic to the specific business of pilots but generic enough to represent the industrial sector of Pharma, Steel and Asphalt, and paving the way to the tailoring process needed before deploying the blueprints in the real operational scenarios of final plants.

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At the end of the project a common webinar can be organized for training and disseminating the CAP, selecting the more significant (and mature) cognitive solutions and making use of the most valuable contents (blueprints, videos, etc.) that will be freely accessible to anyone interested.

2.2 Cognitive Solutions

ASPHALT DOMAIN

2.2.1 CAS1 – Sensor for bitumen content

ASSET DESCRIPTION

CAS1's final plant prototype will be placed in the RAP line in EIFFAGE's Gerena Asphalt Plant to measure the bitumen content in the RAP delivered by the moving belt into the filling silo. This CS will be an automated sensor that will provide the bitumen content in RAP, resulting of an upscale of the CAS1 laboratory prototype described in D3.2.

Currently, this measurement is performed on a laboratory, requiring an estimated time of 5,5h to be completed, and requiring the usage of trays, balances, oven, solvents, binder extraction apparatus, desiccator, etc, as well as dedicated human resources. By installing CAS1 plant's prototype in the RAP line, it will provide the bitumen content in RAP automatically and in almost real-time to the planning platform, needing only electrical and internet connections to work properly. This CS will greatly improve the time and resources (human and economic) applied by EIFFAGE on the measurement of the bitumen content in RAP.

TRAINING STRUCTURE AND REQUIRED MATERIAL

There is **no need for specific training for the deployment** of CAS1 at EIFFAGE's plant. Nevertheless, a presentation of around 1h will be made, to made clear CAS1 functionalities, its electrical and internet needs.

Regardless, a '*CAS1 Manual'* will be delivered to EIFFAGE. This manual will include information regarding CAS1: (1) description, (2) instructions for use, (3) cleaning and maintenance, (4) troubleshooting, and (5) Safety warnings.

2.2.2 CAS2 – Sensor for particle size

ASSET DESCRIPTION

The CAS2 cognitive solution has the main objective of obtaining the amount of filler that has been extracted by the baghouse, measuring the flow of filler through the pipe that connects the dryer drum with the baghouse. This measure is very useful to estimate the real amount of filler present in the cold aggregates and waist less fuel to heat the dry aggregates. **The final user** of this cognitive solution is expected **to be the plant operator**, in the asphalt plants or in other kind of plants with similar structure of flow of particles thought a pipe, and the department of analysis of quality for the raw materials. The CAS2 solution can be used like any other common sensors: the operator will read the value and correct the parameters of the plant, and in the other hand, the quality department can use these results for their day-by-day work.

The complete description of this cognitive solution can be found in the following deliverables,

- D2.2 – Use Case Requirements → first steps of the definition of the cognitive solutions, the project.
- D2.1 – Reference architecture of Cognitive Automation Platform → How is included this Cs in to the architecture of reference of Capri project.

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- D3.2 – CAPRI Industrial IoT Platform and Data Space → Description of the Cas2 sensor, final prototypes of laboratory, data obtained.
- D3.6 – Reference Implementation of Cognitive Process Plants and Alignment with other cognitive initiatives → How is included this Cs in to the architecture of reference of Capri project and in other references of architecture.

TRAINING STRUCTURE AND REQUIRED MATERIAL

The training material to the final user will be **a user manual**, just to understand what it is displayed on the screens and possible the results shown in case problems occur. The CAS2 User Manual, will include how to install the sensors, at mechanical and electrical level, the maintenance and security recommendations, possible problems of connections, how to interpret the results.

The training can be done in the plant, with the real sensors and the user manual, to show the reality of the CAS2, taking about an hour.

2.2.3 CAC1 – Control of the asphalt drum

ASSET DESCRIPTION

CAC1 (Control of Cold Aggregates Rotary Drying Drum) cognitive control solution goal is to obtain the optimal needed setpoints to optimize and to improve the energy efficiency of the process of drying the aggregates of the asphalt mix, in Gerena Asphalt plant. Specifically, the main objectives are to obtain a dry product at an optimum temperature for the next process and to obtain combustion gases at the possible lowest temperature, in order to avoid damages to the bag filter and to minimize energy consumption.

The final plant/manager operator support application will show the following setpoints generated by this cognitive solution:

- Rotary Dryer Drum Burner Power Setpoint (%)
- Rotary Dryer Drum Rotation Speed Setpoint (%)
- Exhaust Damper Opening Setpoint (%)

All of these setpoints will be shown in a real-time basis in a local screen at the Gerena asphalt production plant so that these setpoints can be applied by the plant operators in the corresponding local control system if they consider that their implementation is adequate for the production process.

Also, several indicators and KPIs will guide the corresponding final users to assist in the decision based action of applying or not the corresponding setpoints data coming from the CAC1 asset.

The main cognitive solution goal is trying to facilitate the operator decision making through digital expert knowledge.

A more detailed description of this Cognitive Solution can be found in the following deliverables in their corresponding subsections:

- D2.2 – Use Case Requirements
- D2.1 - Reference architecture of Cognitive Automation Platform
- D3.3 - CAPRI Industrial Analytics Platform and Data Space
- D3.6 - Reference Implementation of Cognitive Process Plants and Alignment with other cognitive initiatives

TRAINING STRUCTURE AND REQUIRED MATERIAL

The training material that will make CAC1 usable for the final user will be based on **a presentation** that will last no more than 30 minutes (1 hour max), complemented with and **a short manual**. As

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stated before, final users of this cognitive solutions are the plant operator(s) and plant manager(s). No new skills will be required and no new hiring either.

The structure of the mentioned presentation will be based on how the final user(s) must interpret the data coming from CAC1 and how to apply them to the actual plant control system if necessary. No direct intervention with the actual production process is required if the final user considers it is not the case.

2.2.4 CAO1 – Predictive maintenance of baghouse

ASSET DESCRIPTION

The baghouse filter consists of a collector which removes dust, mainly filler content in dry aggregates during drying process in drum. Baghouse performance is heavily depended on inlet and outlet gas temperature and flow speed as well as opacity climatic conditions and pressure drop, in the bag house (temperature and humidity, the recipe of asphalt). More information about the baghouse can be found in D2.2: *Use Case Requirements.* The final user of this asset is the plant operator (EIFFAGE), which is interested in the predictive maintenance of the baghouse.

In the context of the developed Cognitive Solution (CS), two prediction models will be developed:

- The first model predicts if the baghouse is working properly by attempting to identify any abnormal behaviour.
- The second model predicts the remaining useful life of a component of baghouse (days or hours).

The former is utilized for generating a set of alarms based on the process measurements (Requirement R4 – Table 10, D2.2: *Use Case Requirements*) while the latter is utilized for providing an estimation of the saturation level of the filters as well as a value of the evolution of the saturation level of the filters (Requirement R1 & R2 – Table 10, D2.2: *Use Case Requirements*).

A more detailed description of this CS can be found in the following deliverables: D3.4 - *CAPRI Smart knowledge and semantic data models* and D3.6: *Reference Implementation of Cognitive Process Plants and Alignment with other cognitive initiatives.*

TRAINING STRUCTURE AND REQUIRED MATERIAL

There is **no need for specific training** for the deployment of CAO1 at EIFFAGE's plant.

2.2.5 CAP1 – Planning and control of asphalt production

ASSET DESCRIPTION

The objective of the cognitive control solution CAP1 (Cognitive Solution for Planning and Control of Asphalt Production) is to generate a tool that helps the decision making in the planning of the production process carried out in the Gerena Asphalt plant.

The final user of the tool is the plant operator, in order to know better the correct composition of the raw materials, as well as their relevant properties and to be able to optimize the production and logistic processes.

A more detailed description of this Cognitive Solution can be found in the following deliverables in their corresponding subsections:

- D2.2 - Use Case Requirements
- D3.5 – CAPRI Smart decision support

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- D3.6 - Reference Implementation of Cognitive Process Plants and Alignment with other cognitive initiatives

TRAINING STRUCTURE AND REQUIRED MATERIAL

The training material that will make CAP1 usable for the final user will be based on **a presentation** that will last no more than 30 minutes (1 hour max). Final users of this cognitive solutions are the plant operator(s) and plant manager(s). No new skills will be required and no new hiring either.

The structure of the above presentation will be based on how the end user(s) should interpret the data coming from CAP1 and how to apply it to the actual plant control system if necessary.

STEEL DOMAIN

2.2.6 CSO1 – Digital Twin architecture

ASSET DESCRIPTION

The cognitive solution CSO1 of the steel use case is a software concept, how to create a digital twin of a physical object like a product or a machinery or a spare part of a machine. For the steel use case the digital twin is used to represent the product (here: steel billets and steel bars), collecting all digital information along the production chain. The CSO1 is the basis for all CSSx, it contains all necessary information for the application of the CSSx and is also the target to store their results.

The digital twin platform is also equipped with a graphical user interface (GUI). For the implementation of the GUI well-known software techniques are used that can be found also in many web sites of the internet. No specific skills by the plant operator are needed beyond the common usage of a web browser, but it is important that the user knows how to interpret the results and where to find required information.

TRAINING STRUCTURE AND REQUIRED MATERIAL

Because the CSO1 is primarily a software concept and a software library for its implementation, the API is only of interest for system integrators and application developers. Neither the operator nor the system administrator will get in direct contact with the API. The functionality is implicitly used in the GUI of the implementation of the CSSx. Therefore, a tailored training of the plant personnel or the process experts for the CSO1 is not foreseen. For the application developer, the specification of the Digital Twin API will be provided for reference, and **a tutorial on how to create an application** that connects to the Digital Twin.

The graphical user interface of the twin provides only a visualisation tool and a decision support system with no feedback to the process and therefore no danger to influence the process due to wrong actions of the user directly via the interface. There is also no necessity to install software on the user's computer, a web browser is usually already available. Therefore, it is foreseen to prepare **an online webinar of about two hours** to introduce the system and to have a 'hands on' for the users. After that a certain time of self-studying is foreseen followed by a Q&A session to discuss questions as well as to get feedback for improvements.

2.2.7 CSS1 – Sensor for product tracking

ASSET DESCRIPTION

The final product of long steel producers are bars of different composition, size and length. As the process is discontinuous and the product varies in form, size and number during the whole production operation, the detailed tracking of the final bar and link to the detailed data collected at different moments is a challenging issue. In fact, the amount of data is also very variable, from the liquid steel as one unit, to the intermediate product (a billet) in units of tens up to the final bars in units of hundreds.

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TRAINING STRUCTURE AND REQUIRED MATERIAL

The CSS1 is a mixed hardware and software solution. The hardware connects the billet from the casting machine to the rolling mill by marking each billet with laser and later reading with visual cameras. The software connects the information with the MES systems and Level 2 systems. Therefore, only system integrators and OT administrators are involved. There is **no training for the users foreseen**.

2.2.8 CSS2 – Sensor for solidification

ASSET DESCRIPTION

The solidification sensor provides insights about the temperature and shell thickness evolution of the solidifying steel strands in the continuous casting machine. This information cannot be measured directly and, thus, is calculated by a soft sensor based on a 3-dimensional heat flow equation with reasonable simplifications that enable a real-time process simulation. Boundary conditions are calculated from available online measurements, for instance of the steel temperature in the tundish, temperatures and flow rates of mould cooling water as well as flow rates of spray water loops applied in secondary cooling zones. To follow up on the further production steps, the solidification sensor creates digital twins of the steel billets, the intermediate products which are cut from the continuous strands at the end of the casting machine. By feeding also all the upstream data from secondary metallurgy and the casting process to the twin, the sensor provides a solid basis for the risk and anomalies detection of CSS5, which will identify anomalous situations in the production early on and help the operator to make informed decisions about the further processing of the semi-products (see below).

The web-based graphical user interface enables the user both to access the current state of the strand and billets in the casting process as well as to replay historical castings.

TRAINING STRUCTURE AND REQUIRED MATERIAL

The solidification sensor is integrated via an appropriate application programming interface (API) into the general CAP framework with digital twins (CSO1). The final users of the developed solidification sensor are the engineers and operators responsible for the casting and rolling processes at the steel plant. In order to use the web-based front end of the solidification sensor and to understand its contribution to the risk and anomalies detection of CSS5, they should participate in the **training** scheduled **for introduction into the decision support system** and the GUI with its different views and functions (see above).

2.2.9 CSS3 – Sensor for product temperature

ASSET DESCRIPTION

The temperature soft sensor is a software solution that tracks the temperature development of steel billets and bars in the hot rolling mill and the following cooling bed. A couple of temperature measurements of the steel surface are made by means of pyrometers, installed at fixed locations in the rolling mill. The soft sensor interpolates the product temperatures to time intervals where no measurements are available, in our case the time spent on the cooling bed. The temperature sensor is realized as a 2D-model using partial differential equations for the heat transfer. Boundary conditions are given by the contour, and start conditions are provided by temperature measurements. The digital twins provided in the tracking system are updated with this temperature information. The CSS3 temperature sensor is required for the CSS4 scale sensor, because the resultant cooling curve of CSS3 is used as input for the scale sensor.

The web-based graphical user interface enables the user both to access the current temperature state of the billets in the rolling and cooling process as well as to replay historical billets.

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TRAINING STRUCTURE AND REQUIRED MATERIAL

The temperature sensor is integrated via an application programming interface (API) into the general CAP framework with digital twins (CSO1). The final users of the developed temperature sensor are the engineers and operators responsible for the rolling and cooling processes at the steel plant. In order to use the web-based front end of the temperature sensor, they should participate in the **training** scheduled **for introduction into the decision support system** and the GUI with its different views and functions (see above).

2.2.10 CSS4 – Scale sensor for scale build-up

ASSET DESCRIPTION

The scale soft sensor is a software solution that calculates the scale forming on steel billets and bars during the cooling process after rolling. This soft sensor calculates the scale layer thickness as well as the oxide layer thickness based on the detailed knowledge of the material composition. The CSS3 temperature soft sensor is a prerequisite for this scale sensor, because the temperature cooling curve is used as input for the scale model. The knowledge of the amount of scale is important for the following processes because scale can lead the quality issues. It is used in the CSS5 anomaly detector for the steel production.

The digital twins provided in the tracking system are updated with this scale information.

The web-based graphical user interface enables the user both to access the current scale state of the billets in the cooling process as well as to replay historical billets.

TRAINING STRUCTURE AND REQUIRED MATERIAL

The scale sensor is integrated via an application programming interface (API) into the general CAP framework with digital twins (CSO1). The final users of the developed scale sensor are the engineers and operators responsible for the cooling process at the steel plant. In order to use the web-based front end of the scale sensor, they should participate in the **training** scheduled **for introduction into the decision support system** and the GUI with its different views and functions (see above).

2.2.11 CSS5 – Sensor for risks and anomalies

ASSET DESCRIPTION

The CAPRI risk and anomalies sensor for the steel production aims to estimate of the processing risk for intermediate products at different stages of the processing chain. This risk estimation will be the basis for a decision support system, which will provide recommendations regarding the further processing of a semi-product. For instance, if an item will likely fail to meet the quality specification for its original customer order, the support system could recommend changing the target order the product will be assigned to, or it could recommend to immediately recycle the item or to do some reprocessing. The earlier we identify a problematic item, the less energy and time needs be wasted in its further processing, therefore the solution can lead to substantial savings both in cost and CO2 emissions.

TRAINING STRUCTURE AND REQUIRED MATERIAL

The recommendation generated by the decision support system will be available on the one hand through the graphical user interface explained above, but also through a dedicated alerting channel, e.g. via email or a messenger application. **Training** will be needed to ensure that the operations personnel authorized **to take a decision on the further processing of semi-products** understands the capabilities and limitations of the model generating the recommendation and how to validate them. **A manual will be provided** for this purpose and possibly **a short training course** (1-2 days) with sample scenarios and recommendations. During the introduction phase of the tool its

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performance must be monitored closely and the analysis of any issues specific to the usage scenario should be shared with the user.

PHARMA DOMAIN

2.2.12 CPS1 – Sensor for blend uniformity

ASSET DESCRIPTION

The blend uniformity sensor is based on a RAMAN system. The correct installation of the probe to the process is essential. For that purpose, a custom made mechanical interface including an automatic cleaning system has been developed and built. The end user, i.e., the operator of a manufacturing line, needs to be capable of installing the equipment to the process. Further, an electronic system was developed for actuating the probe interface and software was written to provide the RAMAN data. The user needs to be trained on running the mentioned systems.

TRAINING STRUCTURE AND REQUIRED MATERIAL

Personalised and group training programmes are available for this Cognitive Solution. The preferred training route is personal attendance at RCPE for **a one day hands on workshop**. However, it may also be possible to develop an online distance education solution in order to provide an initial understanding of each Cognitive Solution, which should subsequently be followed-up with a shorter face to face session at RCPE. The hands on part will cover the installation of the hardware sensor to the manufacturing line. The training on the configuration of the data processing can partly be done online.

2.2.13 CPS2 – Sensor for granule quality

ASSET DESCRIPTION

The inline measurement of granule size allows the use of that information as part of a feedback control concept. The installation of the probe to the process by means custom built mechanical interfaces requires specific operator skills. Further, the use of the developed software components that are performing the required computations needs training of the user.

TRAINING STRUCTURE AND REQUIRED MATERIAL

Personalised and group training programmes are available for this Cognitive Solution. The preferred training route is personal attendance at RCPE for **a one day hands on workshop**. However, it may also be possible to develop an online distance education solution in order to provide an initial understanding of each Cognitive Solution, which should subsequently be followed-up with a shorter face to face session at RCPE. The hands on part will cover the installation of the hardware sensor to the manufacturing line, including the setup of the measurement software. The training on the configuration of the data processing can partly be done online.

2.2.14 CPS3 – Sensor for product moisture

ASSET DESCRIPTION

The CPS3 concept is based on a mathematical process model that uses available process data for predicting the granule moisture in a fluidized bed dryer. This model needs to be fed by data originating from the OPC server of the manufacturing equipment. Further, model parameters need to be set correctly. The identification of these model parameters is specific to the processed material, and therefore, operator training is needed.

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TRAINING STRUCTURE AND REQUIRED MATERIAL

Personalised and group training programmes are available for this Cognitive Solution. The preferred training route is personal attendance at RCPE for **a one day hands on workshop**. However, since the CPS3 solution does not involve any hardware modifications of the manufacturing system, it may also be possible to develop an online distance education solution in order to provide an understanding of the Cognitive Solution.

2.2.15 CPS4 – Sensor for prediction of dissolution

ASSET DESCRIPTION

The CPS4 solution aims at predicting dissolution performance based on process data. For that purpose, a material specific prediction model needs to be created. The creation of this model involves the systematic change of process parameters during production, the determination of the dissolution profile of the produced tablets. From that data, a data driven model is identified. This model is then implemented in an online-fashion for predicting the dissolution profile in real-time. In order to do all the mentioned steps, a dedicated operator training is required.

TRAINING STRUCTURE AND REQUIRED MATERIAL

Personalised and group training programmes are available for this Cognitive Solution. The preferred training route is personal attendance at RCPE for **a one day hands on workshop**. However, since the CPS4 solution does not involve any hardware modifications of the manufacturing system, it may also be possible to develop an online distance education solution in order to provide an understanding of the Cognitive Solution. This course will cover the basic idea underlaying the CPS4 solution and it will train the required skill for using it.

2.2.16 CPS5 – Sensor for fault detection

ASSET DESCRIPTION

The CAPRI sensor for the fault detection monitors the quality of pills processing. Main goal is to perform the fault detection of the system and to alert the operator about the malfunction of the system for making the required corrections. It enables an efficient detection of the anomalous situations based on the analysis of the past data. The learning method is based on the cognition-driven variation detection. The process is described in D3.6. There are two main advantages: 1) previously unseen anomalies can be detected and 2) some of the anomalies can be proactively detected

TRAINING STRUCTURE AND REQUIRED MATERIAL

Alarms will be available through the graphical user interface, but also through a dedicated alerting channel, e.g. via email or a messenger application, to create awareness. **Training** will be needed to ensure that the operations personnel understands how are alarms created and authorized **to take a decision on the further processing** understands the capabilities and limitations of the model generating the recommendation and how to validate them. **A manual will be provided** for this purpose and possibly **a short training course** (1-2 days) with sample scenarios and recommendations. During the introduction phase of the tool its performance must be monitored closely and the analysis of any issues specific to the usage scenario should be shared with the user.

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2.2.17 CPC1 – Cognitive Control Concept

ASSET DESCRIPTION

The CPC1 solution contains a model based control concept of dedicated unit operations of the ConsiGma 25™ manufacturing line. The implementation of the concept requires the use of the CPS2 solution and optionally the CPS3 solution. Parametrization of the controllers and implementation of the real-time data communication requires dedicated training. The operator needs to have a profound knowledge in the field of model based control in order to attend the suggested 2-day workshop.

TRAINING STRUCTURE AND REQUIRED MATERIAL

Personalised and group training programmes are available for this Cognitive Solution. The preferred training route is personal attendance at RCPE for **a two day hands on workshop**. This workshop will cover an introduction to the control concept proposed, as well as an hands on session for installing the hardware sensors used for CPS1 and/or CPS2. However, it may also be possible to develop an online distance education solution in order to provide an initial understanding of the CPC1 solution, which should subsequently be followed-up with a shorter face to face session at RCPE.

2.2.18 CPO1 – Cognitive Operation Concept

ASSET DESCRIPTION

The CPO1 concept suggests process parameter adjustments and/or maintenance actions to the operator in form of text messages. Although the provided messages are mainly self-explanatory, some training is still needed to familiarise with the proposed solution.

TRAINING STRUCTURE AND REQUIRED MATERIAL

Personalised and group training programmes are available for this Cognitive Solution. The preferred training route is personal attendance at RCPE for **a one day hands on workshop**. However, it may also be possible to develop an online distance education solution in order to provide an initial understanding of CPO1, which should subsequently be followed-up with a shorter face to face session at RCPE.

2.2.19 CPP1 – Cognitive Planning Concept

ASSET DESCRIPTION

The CPP1 solution aims at scheduling a given set of experimental runs in order to minimize the total time and/or energy needed. For that purpose, simple models need to be parameterized which describe the transition from one experimental setting to the next one. This model parametrization and the execution of the CPP1 algorithm requires a dedicated training of the operator.

TRAINING STRUCTURE AND REQUIRED MATERIAL

Personalised and group training programmes are available for this Cognitive Solution. The preferred training route is personal attendance at RCPE for **a one day hands on workshop**. However, it since this solution does not require any hardware setup, it will also be possible to develop an online distance education solution in order to provide an initial understanding of CPP1.

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2.3 6Ps Methodology

The 6Ps methodology, as the name suggests, is not a physical asset but a set of guidelines (equipped with a survey) to be followed in order to identify a digital transformation roadmap and/or to measure a project impact in terms of digitalisation, addressed to manufacturing enterprises. Hence, it does not require a proper training to be "adopted" by the final user (since it is just a matter of performing an assessment), but in the perspective of increasing the number of final users, we are planning to train technology providers/DIHs about how to present the 6Ps assessment to the enterprises in their community.

ASSET DESCRIPTION

The 6Ps methodology is a tool conceived to support enterprises along their digital transformation journey, by providing a complete analysis of the main six pillars that characterised the production process. It is based on the assumption that, to succeed in a digital transformation process, it is important to boost not only the technical dimensions, but also the so called "socio-business" dimensions.

The six dimensions of analysis (from which, the name "6Ps") are: Product, Process, Platform, People, Partnership and Performance, grouped in three "technical" and three "socio-business" pillars.

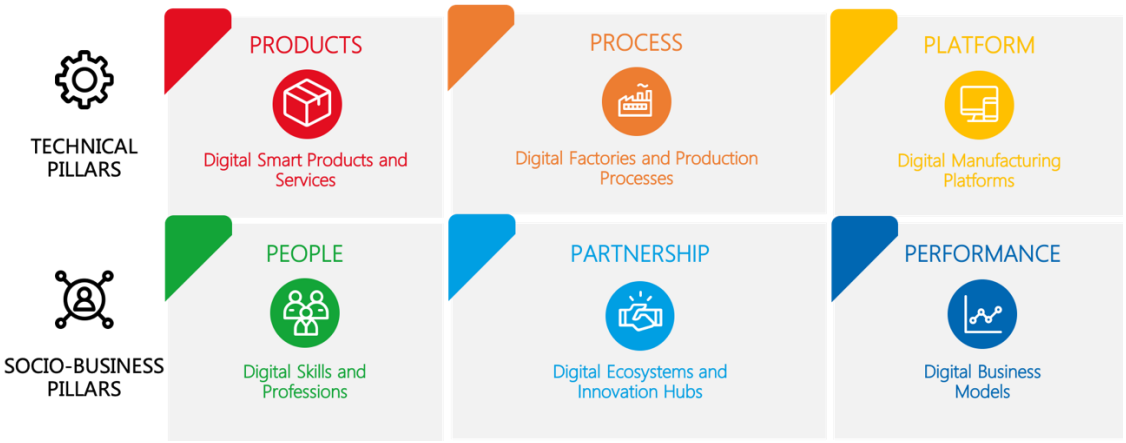

Figure 1 The six Pillars of the 6Ps methodology

The methodology includes an assessment defined from a tactical perspective, that helps the enterprises to highlight the main gaps to be filled with a digital transformation process since it is required to **evaluate both the current and the expected level**, for each pillar and sub-dimension.

The 6Ps methodology can be applied at to different levels:

1. **Enterprise level**: it is addressed to enterprises willing to start a digital transformation journey
2. **Experiment pilot level**: it is addressed to enterprises involved in research projects willing to measure the benefit deriving from the implementation of the project's solution.

The former are typically enterprises that are aware of their gap in the digital scenario but they don't have the expertise to identify the required actions to reach the desired level and need an external support to prioritise them. The second ones are partners of a research project and their digital transformation is partially driven by the project itself: in this case, the 6Ps methodology is a useful tool to measure the impact of the project on the enterprise and to highlight aspects that still need to be boosted.

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For further details about the structure of the assessment and the steps of the methodology, refer to D2.3 – "Digital Transformation methodology for process industries definition", including also the results of the assessment performed with CAPRI pilots.

For the purpose of D7.3, it is enough to understand who is the final user and the benefit that can derive following the 6Ps methodology, that may be or the **definition of a digital transformation roadmap** or the **measurement of the project's impact**.

TARGET OF THE TRAINING

Quite surprisingly, the target of the training is not expected to be the final user, that is, the enterprise willing to measure its initial and final level. Actually, even if it is true that the 6Ps methodology includes a step where the methodology itself is explained to the industrial companies, it can't be considered a proper training since it is simply a step of the standard methodology.

Instead, Politecnico di Milano, who is the owner of the 6Ps, would like to teach other organizations (as research institutes, Digital Innovation Hubs, technology providers typically in contact with several industrial enterprises) how to perform the assessment, from the perspective of the methodology's provider. The objective is to be able to contact a larger number of enterprises and to make more organizations aware of the benefit deriving from the 6Ps, both at Enterprise and Experiment Pilot level.

Since the 6Ps is a very flexible tool, applicable in a number of different scenarios and pilots, organisations that are driving the digital transformation of manufacturing enterprises can benefit from it, since they can propose it to their customers/project partners, are a complementary tool.

TRAINING STRUCTURE AND REQUIRED MATERIAL

The material required to train third parties to run the assessment has been mostly already prepared, since it partially corresponds to what is presented to the industrial enterprise to make them perform the 6Ps assessment:

- **A presentation containing an overview of the methodology**, including its five main steps. For each pillar, the list of the sub-dimensions is provided, crossing them with the five possible levels. As the picture below shows (the Product dimension has been chosen as example), each intersection is equipped with a description.

  These tables (six in total, one for each pillar) are the summarised version of the online survey and allow, during the general presentation, to get an idea of the structure of the survey.

	LEVEL-1 INITIAL	LEVEL-2 MANAGED	LEVEL-3 DEFINED	LEVEL-4 INTEGRATED	LEVEL-5 EXPLOITED
INTEGRATION OF SENSORS / ACTUATORS	no use of sensors/ actuators	External sensors/actuators are integrated	sensors readings are processed by the product	sensors and other data sources are analysed inside the product	the product is able to autonomously respond to the ambient
COMMUNICATION / CONNECTIVITY	the product has no communication interfaces	the product sends or receives I/O signals	the product has field bus interfaces	the product has industrial ethernet interfaces	the product is securely connected to the internet
STORAGE AND EXCHANGE OF INFORMATION	no functionalities	possibility of individual identification	product has passive data store	product with data storage for autonomous information exchange	data and information exchange as integral part
MONITORING	no monitoring by the product	detection of failures	recording of operating conditions for diagnostic purposes	prognosis of its own functional condition	monitoring at the basis of decisions and prescriptions
PRODUCT-RELATED IT SERVICES	no IT services correlated to the product	product-related services adjunct via online portals	service provision and execution performed directly via the product	product intended as a service platform	complete integration of the product into an ecosystem of product-service systems
BUSINESS MODELS ENABLED BY THE PRODUCT	main revenue streams from selling standardized products	sales and consulting services regarding the product	sales, consulting and adaptation services for customised products	services as decisive factor for additional sales of products	main revenue streams from selling product related services

Figure 2 Example: structure of the Product dimensions

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- **The online survey**, to be compiled by the enterprises evaluating for each dimension and sub-dimension their current and expected level.

Additionally, to that, in order to better understand how the methodology works, **D2.3 can be used as support tool**, since it contains the detailed description of each dimensions and, being a textual document, is for sure more self-explanatory.

What is missing from previous list are the **guidelines about how to generate the final report** that elaborates the information of the survey, providing a complete overview of the use case as well as the expert point of view. Of course, the guidelines is something that is not shown to the final user but only to the "assessment provider".

Hence, to make other people able to manage the 6Ps methodology, following documents are required:

- A document describing **how the online survey works** and how to extract the results from the online platform,
- A document describing how **the templates to generate the final report** works,
- A document containing the **guidelines to run the interview** after the self-assessment,
- A document containing the **guidelines to write the final report**.

The training session consists of a workshop where all the documents aforementioned are explained in details, together with the purpose of the 6Ps methodology and benefits deriving by adopting it. The objective is that, after the training session, other organisations will be able to propose the 6Ps to industrial companies, from the initial presentation to the generation of the final report, including the self-assessment on the online platform and the interview.

PLANNING

The initial planning is to train the CAPRI partners who express interest in learning it. (Probably the three pilots won't be included as the training is addressed more to technology providers than industrial companies and also because the 6Ps methodology has been already presented to them, in form of assessment).

As soon as the training material will be complete, a training session will be organised. Taking into account that, in the scope of WP6, CAPRI is going to perform the 6Ps assessment with the SPIRE-06 pilots and this can represent a good opportunity for CAPRI partners to learn how to do it.

Still in the context of WP6, CAPRI is planning to create a network of Digital Innovation Hubs for Process Industry (see D6.5 – "Initial Report: SPIRE Digital Transformation Ecosystem", §5.3): they would represent a fertile ground of possible targets for the 6Ps training, since they could benefit of a very useful tool to be offered to their constituency. Chapter 4 of the present document will explain it in details.

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3 CAPRI Skills Catalogue and Jobs Certification program

In Section 2, we identified a number of trainings to be implemented in order to make accessible and exploitable the assets developed within CAPRI project; Section 3 aims at providing a broader perspective of skills and training required in manufacturing domain, without specifically focus on CAPRI assets.

It is structured as follow.

- First of all (Section 3.1), the continuous transformation of the labour market is presented, with a specific focus on the **impact of digitalisation on workers**, stressing the fact that to properly adopt digital solutions, new skills and competences are required. This is the result of desk researches performed to be aligned on the new market requirements in terms of job profiles. The objective is to highlight which are **the new skills of the future** and how the **existing roles are expecting to adapt to this change**.
- Then (Section 3.2) creates a bridge between the activities run in T7.3 (about training and up-skilling) and the Digital Transformation assessment run in T2.3 at the beginning of the project, focussing on the **"People" dimension of the Transformation roadmap**, that is, the one impacting workers.
- Section 3.3 presents the "Osservatorio Industria 4.0 - Politecnico di Milano" as a valuable source of skills and roles for industry. Taking into account only workers dealing with "Data science and AI management", Section 3.4.1 presents a number of New Roles that will be required in next years; Section 3.4.2 presents a number of existing professional figures that will be required to acquire new skills and competences to be up-to-date; Section 3.4.3 presents a number of Soft Skills.
- Finally, desk research results are validated with the CAPRI partners and the **output of the survey** is presented, with the objective of **shaping a suitable Transformation roadmap for the People** dimension of three CAPRI pilots. In Section 3.5 the competences for both "New Roles" and "existing professional figures" are prioritised; in Section 3.6, participants have investigated the skills associated to such professional figures, identifying the possessed and required ones.
- Section 3.7 is core for Task T7.3, since the objective is to highlight which are the **training activities required for the CAPRI pilots**, with a broader perspective to process industry in general.

3.1 Background

In this section, first, significant references such as World Manufacturing Forum (WMF)[1] and World Economic Forum (WEF)[2] and the importance of paying attention to the Skills catalogue and job certification are discussed, then the methodology that is being implemented in CAPRI project will be introduced.

3.1.1 An overview of digital transformation emerging skills

The Industry 4.0 (I4.0) concept has emerged from an initiative supported by academics and the industry along with the support of the German Government. The initiative aims at strengthening the

1 https://www.worldmanufacturingforum.org/

2 https://www.weforum.org/agenda/2020/10/top-10-work-skills-of-tomorrow-how-long-it-takes-to-learn-them/

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competitiveness of the manufacturing industry through the convergence between production processes and Information and Communication Technologies (ICT)[3].

Industry 4.0 utilizes technologies such as the as the Artificial Intelligence (AI), Internet of Things (IoT) and services (IoS), Cyber Physical Systems (CPS), cybersecurity, smart robotics, augmented and virtual reality technologies, to improve the productivity of the industrial manufacturing systems. CAPRI project is exploiting the power of data **developing cognition** on top of four fundamental layers of the production processes, that is the **Sensor, Control, Operation and Planning**. As a result of the increased use of digital technologies, the boundary between the real and the digital world is increasingly obscuring, leading to what is known as cyber-physical production systems.

In addition to the technologies mentioned in the Industry 4.0, Industry 5.0 (I5.0) is already being spoken about and involves robots and smart machines allowing humans to work better and smarter[4]. Therefore, in order to realize the ideas of better communication between machine, robot and human, the main focus is on technologies that make this process easier and more accessible, such as Artificial Intelligence (AI), and machine learning (ML), because AI and ML refer to machines which utilize algorithms to process data and reach conclusions that were not programmed into them by human developers. These machines learn from data in order to generate increasingly accurate predictions[5]. Learning and training are fundamental key factors for achieving the I4.0 and I5.0 objectives as they will significantly transform the job and skills profiles of the blue and white-collar workers. New skills requirements are changing rapidly, and enterprises, especially SMEs, struggle to find the talent they need. On the other hand, due to the digitalization of many processes and the high speed of progress, new needs emerged in the society as well as in the business environment.

Before analysing in details the CAPRI scenario, where three pilots will be impacted by the adoption of the CAP and of a number of Cognitive Solutions conceived to boost their digital transformation, the following Section will provide a summary picture, generalising for many organisations.

According to the research conducted in "**Shaping Europe's digital future**[6]", about the needed digital skills in current society, as Figure 3 depicts, people are divided into 3 categories:

- **Young people**: This category includes 16-24 years old people and almost the 95% of them is an internet user so in this case education must adapt to the digital era. In addition, society needs to raise the number of students in ICT because the number of ICT graduates has decreased of the 13% between 2013 to 2016.
- **Working aged people**: This category includes people active in the job market, older than 25 years. Dealing with digitalisation and workers, it's worth to mention digital technologies create new jobs and opportunities, and it should be noted that each job in ICT creates 3 more jobs elsewhere in the economy. In addition, here also the whole workforce needs to be digitally trained.
- **Older people**: This category includes aged people no more interested to the job market. To them, society needs to raise awareness of the benefits of going digital, for instance by providing supports to older people to get online and develop digital skills.

3 H. Kagermann, J. Helbig, A. Hellinger, and W. Wahlster, Recommendations for implementing the strategic initiative INDUSTRIE 4.0: Securing the future of German manufacturing industry; final report of the Industrie 4.0 Working Group. Forschungsunion, 2013.

4 https://www.twi-global.com/what-we-do/research-and-technology/technologies/industry-4-0

5 https://www.machinemetrics.com/blog/industry-4-0-technologies#artificial-intelligence-and-machine-learning

6 https://ec.europa.eu/digital-single-market/en/news/digital-europe-needs-digital-skills

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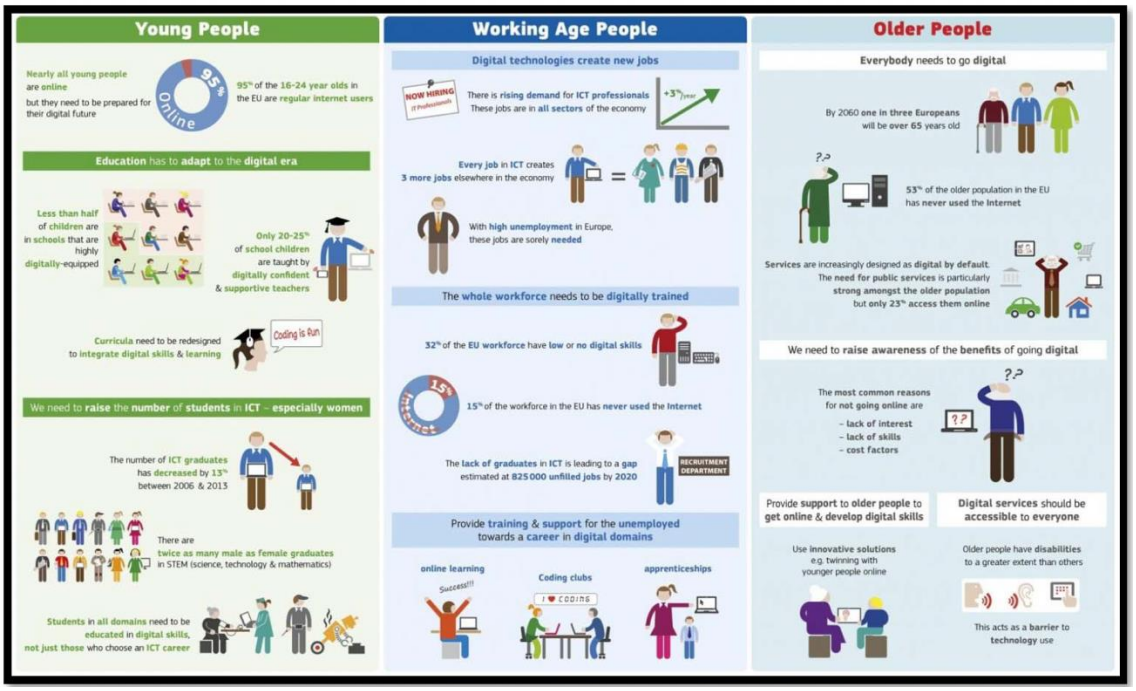

Figure 3 A digital Europe need digital skills

Furthermore, in order to investigate the impact of creating and adopting new jobs and skills according to the trend of emerging new technologies such as artificial intelligence on current organizations, a lot of researches have been done, among which we can mention the studies conducted by Mc Kinsey & company – "The Future of Work in Europe- 2020[7]". Based on questions about people's expectations regarding "skill gaps" and "technology trends alter organizations' talent needs" the following results (Figure 4) were obtained.

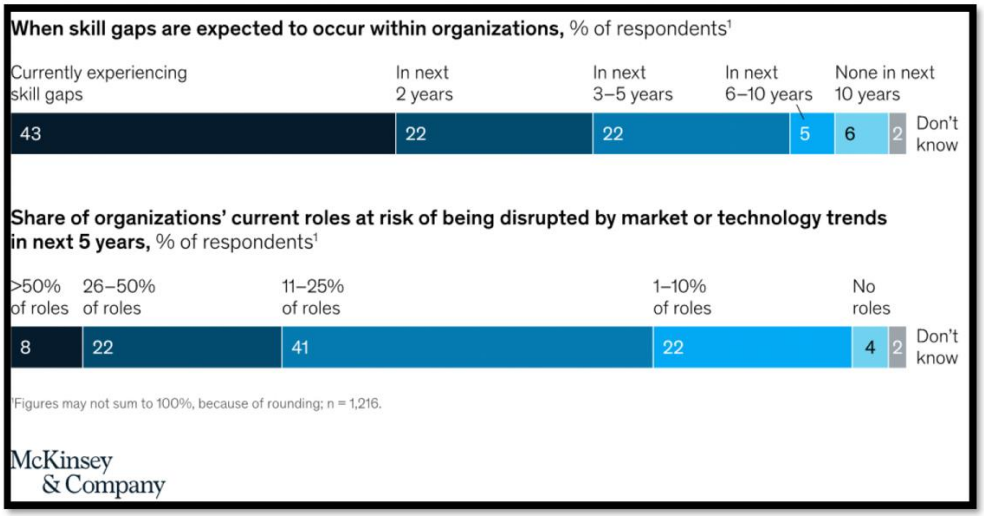

Figure 4 Market and Technology trends

Analysing these responses, it comes out that technologies and the market are changing and developing very fast: many organizations are already facing these changes and many others are expected to be touched in the very near future in their business.

In addition, according to second analysis about "share of organizations' current roles at risk of being disrupted by market or technology trends in next 5 years" and based on respondents' expectation, it

7 https://www.mckinsey.com/featured-insights/future-of-work/the-future-of-work-in-europe#

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can be concluded that the 41% believes that from 11 to 25% of roles will be disrupted in next 5 years and the 22% believe this percentage is between 1 to 10 % and same percentage of participants believes that a percentage between 26 to 50% of roles will disappeared or replace by new roles in next 5 years. The analysis of these answers shows that the common perception is that the market and technology will change and grow a lot in the next 5 years, so that many of the existing roles will be affected by the new trends and, as a result, they will be removed, modified or replaced.

3.1.2 Labour market trends and needs for skills

The development of novel technologies such as Artificial Intelligence, smart sensors, intelligent assistants, robots, and automation will continue to demand change in the types of skills as well as the labour landscape[8]. Global labour markets are undergoing major transformations, with changes to business needs and workforce profiles picking up an even more incredible pace in recent years. The human-centred paradigm shift will only be successful if work processes are reshaped and new training approaches are introduced to support the continuous development of skills taking into account personal capabilities, skills and situational preferences of individual operators[9]. The Future of Jobs Report 2020[10] from World Economic Forum (WEF) maps the jobs and skills of the future. For 2020 the report suggests that "while technology-driven job creation is still expected to outpace job destruction over the next five years, the economic contraction is reducing the rate of growth in the jobs of tomorrow". WEF reports estimate the needs in terms of reskilling to answer to the expected demand of the labour market. In Figure 5 below the infographics of the WEF report mentions that 73,2% of the employees will require a considerable amount of training (i.e., more than one month).

Figure 5 Reskilling needs in Advanced Manufacturing according to WEF 2020 report [8]

8 Ocident Bongomin , Gilbert Gilibrays Ocen, Eric Oyondi Nganyi, Alex Musinguzi,and Timothy Omara Exponential Disruptive Technologies and the Required Skills of Industry 4.0, 2020, https://doi.org/10.1155/2020/4280156

9 Ace factories, White paper on Human-centred factories from theory to industrial practice. Lessons learned and recommendations, 2019.

10 World Economic Forum, 2020, The Future of Jobs Report, October 2020.

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3.1.3 Skills for the future of I4.0 and I5.0

Boosting the paradigm of a sustainable, human-centric, and resilient European industry, Industry 4.0 and 5.0 recognize the power of industry to achieve societal goals beyond jobs and growth to become a resilient provider of prosperity by making production respect the boundaries of our planet and placing the well-being of the industry worker at the centre of the production process[11].

The skills for the future of manufacturing identified by the 2019 World Manufacturing Report are[12]:

- **Digital literacy** as a holistic skill to interact with, understand, enable, and even develop new digital manufacturing systems, technologies, applications, and tools;
- **Inter-cultural** and **inter-disciplinary**, inclusive, and diversity-oriented **mindset** to address new challenges arising from a more diverse manufacturing workforce;
- Ability to use and **design new AI and data analytics solutions** while critically interpreting results;
- **Cybersecurity, privacy, and data/information** mindfulness to reflect the rapidly increasing digital footprint of the manufacturing value chain;
- **Creative problem-solving** in times of abundant data and tasks technological opportunities in smart manufacturing systems;
- Ability to **handle the increasing complexity** of multiple requirements and simultaneous tasks;
- A strong entrepreneurial mindset including **proactiveness** and the ability to think outside the box;
- **Effective communication skills** with humans, IT, and AI systems through different platforms and technologies;
- Ability to **work** physically and psychologically **safely and effectively** with new technologies;
- **Open-mindedness towards constant change and transformation** skills that constantly question the status quo and initiate knowledge transfer from other domains.

3.1.4 Changing roles and new roles

The manufacturing transition with the implementation of AI has major effects on the positions and abilities of workers in the industry. It stressed the crucial role played by people to redefine the strategy of the organization. When the strategy is defined, the requisite steps for the transition are to be planed and assessed by other people. New functions and profiles are created for the design, execution, operation, and maintenance of new AI applications during their life cycle. In a new organization of human and artificial intelligences, people can eventually cover deeply changed positions. Such functions will be defined by the improvement of the already existing competences, which both include improving foundational and core ones in the manufacturing sector and learning new data and AI skills. Figure 6 depicts ten Emerging jobs and top ten skills based on World Economic Forum report[13].

11 Romero, D., Stahre, J., Wuest, T., Noran, O., Bernus, P., Fast-Berglund, ., Gorecky, D.: Towards an operator 4.0 typology: a human-centric perspective on the fourth industrial revolution technologies. In: Proceedings of the International Conference on Computers and Industrial Engineering, pp. 1–11 (2016).
12 World Manufacturing Forum's ten skills for the future of manufacturing World Manufacturing Forum - https://worldmanufacturing.org/
13 https://worldmanufacturing.org/wp-content/uploads/WorldManufacturingForum2020_Report.pdf

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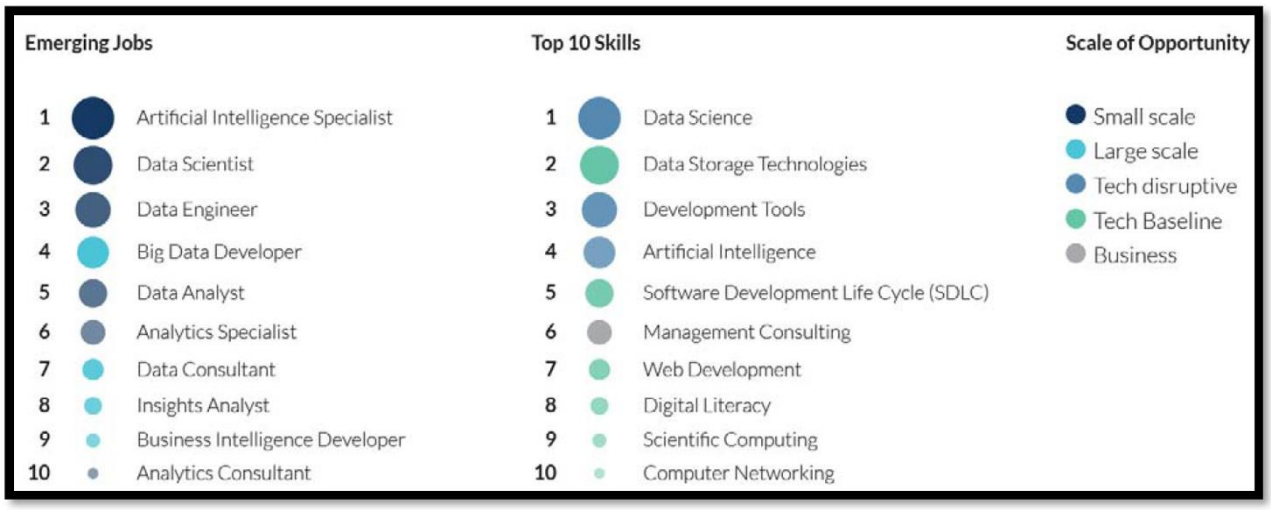

Figure 6 World Economic Forum- Emerging Jobs and Top 10 Skills

According to Figure 6, Job profiles that have emerged can create opportunities in different scales, these scales depict the extent of influence and impact of these emerging jobs and skills in different sectors of the industry, which are classified as, Business, Tech Baseline, Tech disruptive, large and small scales. For instance: Data analyst and Analytics specialist in Tech disruptive scale, Analytics consultant in business scale, Artificial intelligence specialist, data science and data engineers in small and other job profiles in large scale. There are similar conditions for the top 10 skills, the most important ones which can mentioned are Management consulting in Business scale, Data science, Development tools and artificial Intelligence in Tech disruptive scale and Data storage Technologies, Software development Life cycle in Tech baseline scale, etc.

3.2 6Ps methodology in People dimension

The 2020 WMF Report and the 2020 WEF Jobs of tomorrow suggest that the digitalization process and upgrading skills based on new technologies such as AI, does not refer to technologies and processes but must encompass also a proportionate empowering of digital skills at every level (from shop floor to top management) and eventually the creation of roles aligned to the digital advancement that industry is facing. In light of this, metrics measuring which skills are needed and how much developed must be at every level of an organization seem to be a fundamental element to transform the suggestions articulated into practice.

As CAPRI project utilizes AI technologies, the main scope in this chapter is to consider all the different dimensions affected by digitalization within the industrial environments, the Product, the Process, the Platform, the People, the Partnership, and the Performance. To this regard, the objective is to adopt a structured methodology able to assess the current level of AI and digital maturity of manufacturing companies (AS-IS), quantify the desired level that these latter aim at achieving (TO-BE), and design a specific action plan to allow the transition needed to fill the gaps identified. In CAPRI, we have introduced the so-called “6Ps methodology”, as it deals with the 6 dimensions starting with “P” mentioned above (more details about it are available in D2.3 – “Digital Transformation methodology for process industries definition”).

For the purpose of the current document, the main focus will be on the People dimension since a thorough analysis of current jobs and professions involved in this project context will be conducted in order to identify possible skills gaps derived by the adoption of digital and cognitive solutions. In addition, T7.3 organised **workshops and surveys to collect the needed feedback** from the partners: a structured approach – Survey-based (Industry 4.0) has been followed and skills needed/possessed analysed and discussed as well as identification of the most suitable training programs to bridge such gaps. The first step of this methodology is primarily concerned with

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identifying new roles, professions, and relevant skills based on the project's content. In addition, related to these new roles and skills, **two main questionnaires** were asked of project partners and the first iteration of surveys implementation among project partners have already been completed. (The Summary result of this step is reported in Section 3.5.)

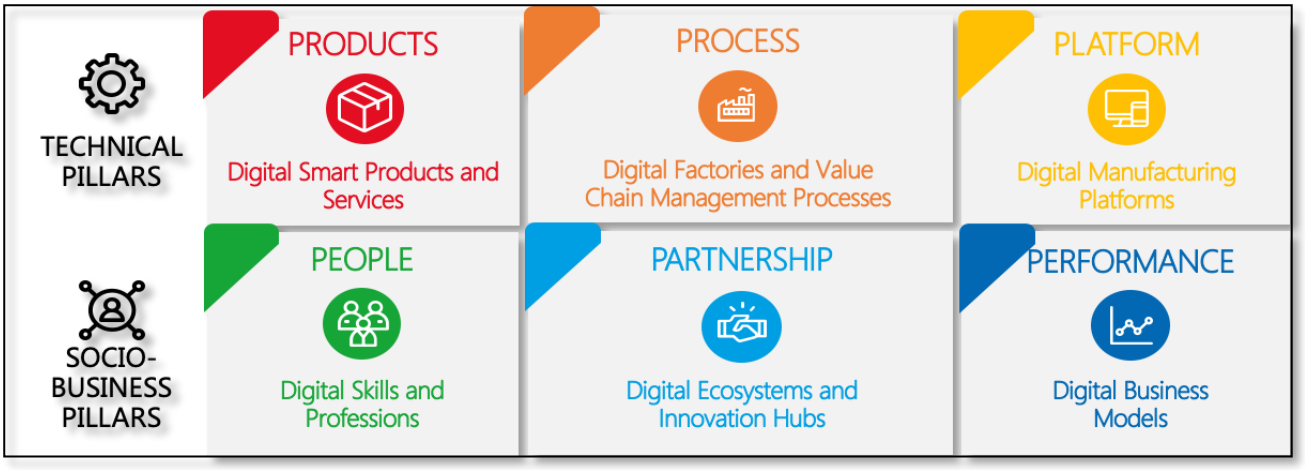

Figure 7 6Ps Digital Transformation Tool

Figure 7 depicts all six dimensions of the 6Ps methodology; the main focus of this section is on the People dimension. According to the analysis performed in the content of the project, two main groups were identified under the titles of “DATA/AI New Roles & Professions “, and “DATA/AI Skills for Enterprise Industry 4.0 Roles”.

The first group, "DATA/AI New Roles & Professions" includes jobs and skills that do not yet exist in the industrial environment but will be needed in the coming years due to technological trends. Of course, it's worth to note that some businesses may have already recognized the value of some of the skills associated with these jobs and have begun to implement them.

The second group “DATA/AI Skills for Enterprise Industry 4.0 Roles” is related to jobs that already exist in some form in companies, but due to the rapid growth of technology, especially artificial intelligence, and machine learning, they need to update their skills.

These jobs were examined at three levels “Managers, Professionals, and Workers Level” which will be introduced in section 3.4.

3.3 Skills in Industry 4.0

In addition to the references mentioned in Section 3.1 and the two main groups mentioned in Section 3.2; it should be noted that another main source “Osservatorio Industria 4.0 - Politecnico di Milano” was effective in introducing the job profiles and defining related skills. Osservatorio Industria 4.0 is a structured repository of 100+ technical and managerial skills 4.0 covering five areas[14], necessary to define Industry 4.0 strategies, and design, manage and enable Industry 4.0 processes and business models which are:

- Smart product-service design management
- Smart Hyperconnected Factories management
- Smart Autonomous Factories management
- IT-OT integration management
- Data science and AI management

14 Osservatorio Industria 4.0 - Politecnico di Milano

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For T7.3 purposes we are interested in last bullet point: originally the Pentagon was labelled only "Data Science Management", but due to the effect of Artificial Intelligence technology on many skills, job profiles were updated in accordance with the skills related to AI and machine learning, and this change also was made in its original name of this pentagon – Figure 8.

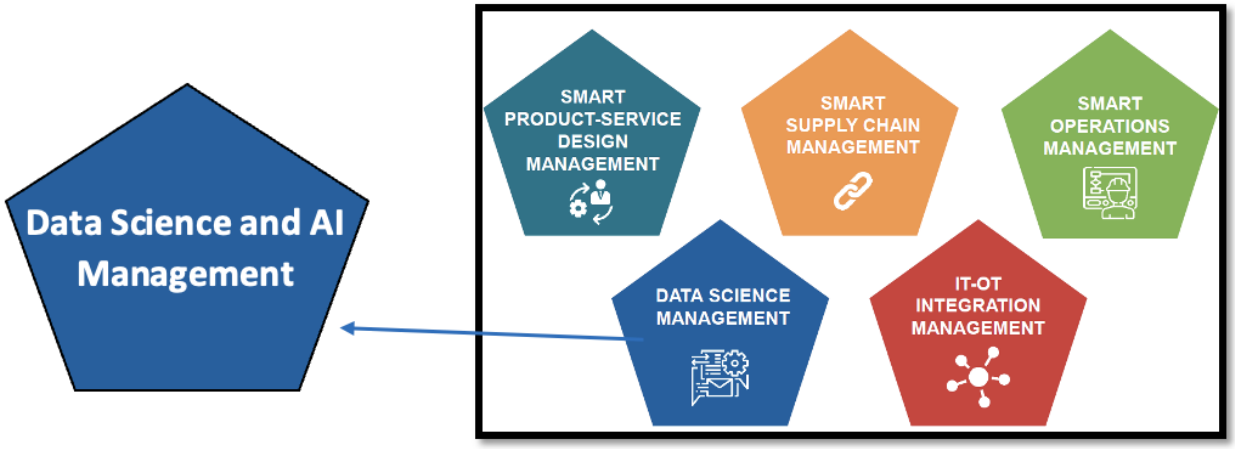

Figure 8 Skills in Industry 4.0 - Osservatorio Industria 4.0

The Data science and AI management Pentagon contains the following seven job profiles: Data Science Manager, Data/AI Architect, Data/AI Scientist, Data/AI Specialist, Visual Data Designer, AI Manager/Head of AI, Remote Worker.

3.4 New Roles and Professions for the Digital Transformation

3.4.1 Data / AI new roles and Professions

As mentioned in section 3.2, the first set of job profiles examined is about "DATA/AI New Roles & Professions." This category includes jobs and relevant skills: companies may not recognize the importance of their existence at the moment, but it will be felt in the coming years due to the growing technology in the fields of data science and artificial intelligence advances.

These are the jobs and related skills that are listed below:

Data Science Manager

Data Science Managers propose, plan and manage functional and technical evolutions of the data science and AI operations within the relevant domain.

Skills:

- Knowledge about data and AI processes
- Knowledge about business processes
- Communication with domain experts
- Develop and execute the data and AI strategies
- Manage the data science team and resources
- Knowledge about performance indicators

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Data/AI Architect

Data Science /AI Architects design and maintain the architecture of data science / AI applications and facilities.

Skills:

- Ability to integrate data universe
- Select software platforms for big data (Hadoop, Data Lake)
- Knowledge about big data architectural standards
- Select hardware platforms for big data (performances…)

Data/AI Scientist

Data/AI scientists find, interpret and merge data/AI sources, manage large amounts of data, ensure consistency of data and sets, and create visualizations to aid in understanding data/AI.

Skills:

- Identify and interpret relevant data sources
- Use a programming language (R, Python)
- Communicate with domain experts
- Mathematical and statistical models' knowledge
- Knowledge about domain-specific processes
- Use of AI technologies (ex. machine learning)
- Use of Bayes classifier, Deep Learning and optimization algorithms

Visual Data Designer

Visual Data Designers create custom visualizations from complex data sets in a compelling way.

Skills:

- Develop interface & interaction to increase user experience
- Develop vector graphics, scientific illustrations, and icons
- user experience analysis, design, and evaluation
- Understand complex information by integrating AI tools
- Visualize the huge and complex volume of data
- Develop insightful and engaging data analytics view
- create infographics (maps, charts, diagrams)

Data/AI specialist

Data /AI specialist build, manage and maintain data/AI pipelines.

Skills:

- Integrate data and AI technologies into existing systems
- Knowledge about data storage, query languages and use of machine learning
- Use and interact with collaborative robots, systems, and sensors
- Build AI models from scratch and help the different components of the organization
- Develop data models and workflows
- Maintain security, quality, integrity, safety, and availability of data

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- Develop applications from big data /AI & provide operational tools for data and AI analytics
- Knowledge of OEE & hardware platforms for big data and Analysis related to AI
- Use cloud computing and AI in industrial control software and applications to monitor and control activities.

AI Manager / Head of AI

AI Mangers manage and implement AI according to business objectives.

Skills:

- Adapt technological (new tech. such as AI, VR etc.) innovations to business and Supply Networks
- Build, implement and manage concurrent Digital/intelligence Supply Networks
- Understand and take advantage of IT-OT architectures, sensors, communication, data flow, cloud
- Develop and execute the data and AI strategies according to business objectives
- Knowledge about data and AI processes /User experience analysis, design, and evaluation
- Analyse and understand how the value chain is transformed by virtue of Industry 4.0 and new technologies related to AI
- Improving production process with the introduction of new technologies related to AI and I4.0

Remote Worker

Remote workers are employed in the company but work outside of a traditional plant environment.

Skills:

- Use applications to increase sensory, remote, and cognitive abilities
- Interpret quantitative data, graphs (KPIs) and 3D digital models
- Understand and use additive manufacturing / AI technologies and mathematical models
- Perform scenario analysis to evaluate and prepare for possible interventions

3.4.2 Data / AI skills for enterprises I4.0

This section is about "DATA/AI Skills for Enterprise Industry 4.0 Roles," which is related to the second group of jobs. Several companies currently have these profiles or relevant job titles but based on the industry 4.0 and artificial intelligence technology trends, they need to be improved and upgraded. This section also examines jobs at three levels: managers, professionals, and workers, as listed below:

Strategy Manager I4.0

Strategy managers analyse transformation of Value Chain by adopting I4.0 tech, provide leadership for creation of an I4.0 strategy, create relationship with various stakeholders.

Skills:

- Analyse and understand how the value chain is transformed by virtue of I4.0
- Define, implement, and manage a roadmap of technological evolution oriented to the generation of value (according to a lean approach)
- Lead structured problem solving (multi-objective, multi-actor) and provide real-time responses to changes in demand in the digital and intelligence supply network
- Ability to interface with complex knowledge management and reporting systems

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- Redesign the production process end-to-end, improving it with the introduction of new technologies 4.0
- Engage and dialogue with stakeholders and trade unions to better manage change related to the introduction of new technologies such as AI
- Define the business model around the product-service and implement Digital Supply Networks

I4.0 Professional

I4.0 professionals use common and enterprise systems, analyse and interpret production data, improve performance through I4.0 tech.

Skills:

- Streamline production processes by digitalizing them and use computer-aided process planning (CAPP)
- Ability to perform scenario analysis to evaluate and prepare for possible interventions (simulations, classifiers, etc.)
- Ability to program & interact with collaborative robots and conduct testing simulations in a virtual environment
- Ability to design product data storage (big data database system) and Integrate sensors/actuators/ ports/ antennas/HMI into the product
- Independently analyse data related to demand and supply networks (e.g., R, Python, MATLAB)
- Knowledge of IoT platforms and sensors and use applications to monitor and control activities
- Use platforms for application development and execution

Digital Transformation Professional 4.0

DT Professionals evaluate pros and cons of different Software, protocols, select and implement new techs (AI).

Skills:

- Analyse the impact of emerging technologies on business (e.g., AI, big data)
- Evaluate pros and cons of platforms based on company's needs and select components (e.g., data and event processing, Tech. related to AI)
- Perform user/human centred analysis for the development of human-machine interfaces, mobile interfaces, augmented reality
- Knowledge and use of machine learning, Deep Learning techniques and develop applications from big data
- Realize communication networks (wireless, wired etc.) to connect robots, machines, products, systems, and people in real-time
- Ability to monitor, understand, contribute to the creation of new standards (e.g., IIoT, Cloud, AI and Data Technologies)

Plant Worker 4.0

Plant workers supervise the operation of an industrial plant.

Skills:

- Use of basic standard of HMI
- Use virtual and augmented reality goggles

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- Use exoskeletons and other wearable devices
- Interact with collaborative robots.
- Interpret quantitative data and graphs and 3D digital models

Technician 4.0

Technicians work in a field of technology who is proficient in the relevant skill and technique, with a relatively practical understanding of the theoretical principles.

Skills:

- Use sensors/actuators/ ports/ antennas/HMI standards
- interact with smart warehouses equipped with automated picking systems and autonomous vehicles
- Analytical skills to Interpret data from operations
- Ability to use discrete event simulation
- Ability to use 3D printers

3.4.3 Soft Skills

This section looks at soft skills in addition to the technical skills mentioned in previous sections. Soft skills are characteristics and personality traits that assist employees in interacting with others and succeeding in the workplace. The following is a list of all the soft skills associated with the various levels: "managers, professionals, and workers." Section 3.7 depicts an analysis of the responses received from project partners regarding soft skills.

List of Soft Skills:

- Emotional Judgment
- Teamwork
- Communication
- Professional ethics
- Problem solving
- Critical thinking
- Innovation
- Ethical / Legal mindset
- speak second language
- Time management Judgment
- Interpersonal skills
- Critical problem solving
- Digital literacy problem solving
- Self-management
- Global perspective
- Digital skills

3.5 CAPRI catalogue of skills - Voting and prioritizing skills - Survey

In order to examine the perspectives of project partners on the jobs and skills mentioned in the previous sections, surveys were set up to ask the experimenters' opinions on the skills assigned to each job in the first place, and the skills were prioritized based on the answers received. This survey,

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which is named "Voting and Prioritizing skills", was published online[15], which in section 3.5.1, the results of its first iteration is depicted.

3.5.1 Skills prioritisation - Result of first iteration

The target group of the survey are all individuals and project partners. The results of this survey – First Iteration are presented below: for each professional figures of the Pentagon "Data Science and AI Management", related skills are prioritised.

Data Science Manager

Based on the responses received for "Data Science Manager", the most important skills are "Manage the data science team and resources - 25%", and "Knowledge about data and AI processes- 25%". And skills related to, "Knowledge about business processes – 8.33%" and "Knowledge about performance indicators – 4.17%" are less important than others.

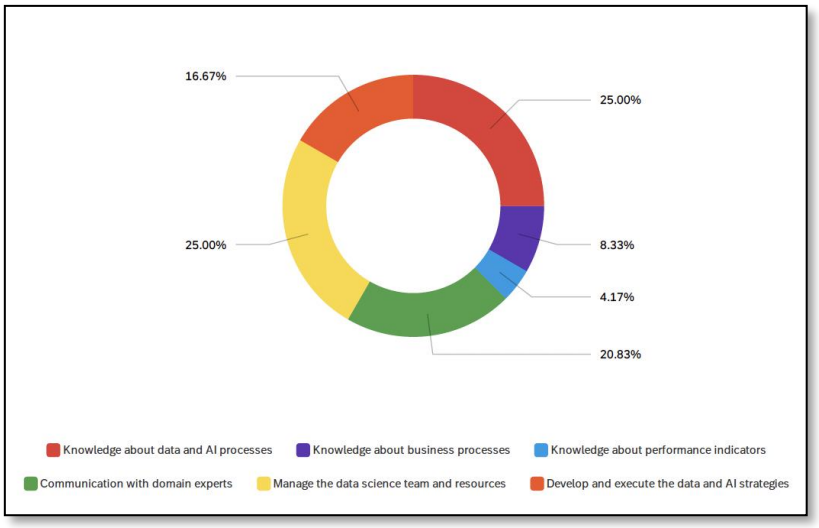

Figure 9 Data Science Manager - result of Voting survey - 1st Iteration

Data/AI Architect

In this job profile, according to the project partners' point of view "Knowledge about big data architectural standards – 35.71%" and "ability to select hardware platforms for big data (Performance, cost…) – 35.71%" are more significant than the other two skills.

15 https://polimi.eu.qualtrics.com/jfe/form/SV_eFIlA3qG7jWUw5w

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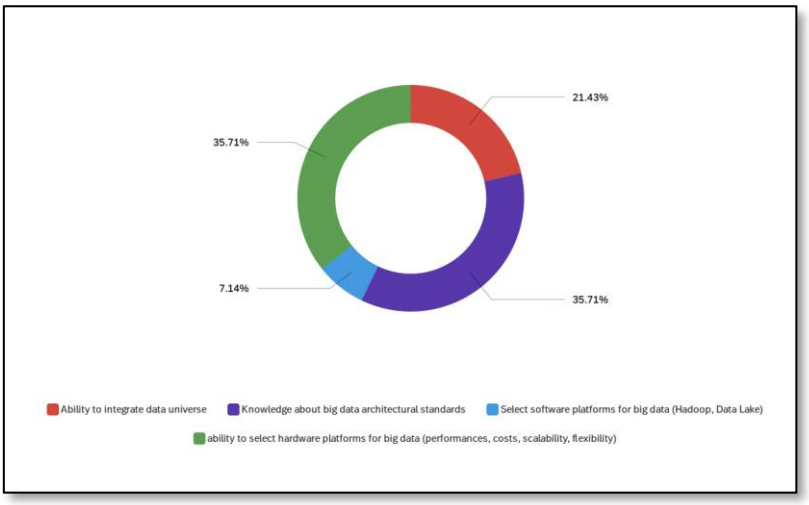

Figure 10 Data / AI Architect - result of Voting survey - 1st Iteration

Data/AI Scientist

Skills related to this job title, in terms of importance can be divided into high priority "Mathematical and statistical models' knowledge – 25%", "Use of Bayes classifier, Deep Learning and optimization algorithms – 20.83%", medium priority "identify and interpret relevant data sources – 16.67%", and "Use of AI technologies (ex. machine learning) – 16.67%", as well as low priority that other skills which were not mentioned, are in low priority level.

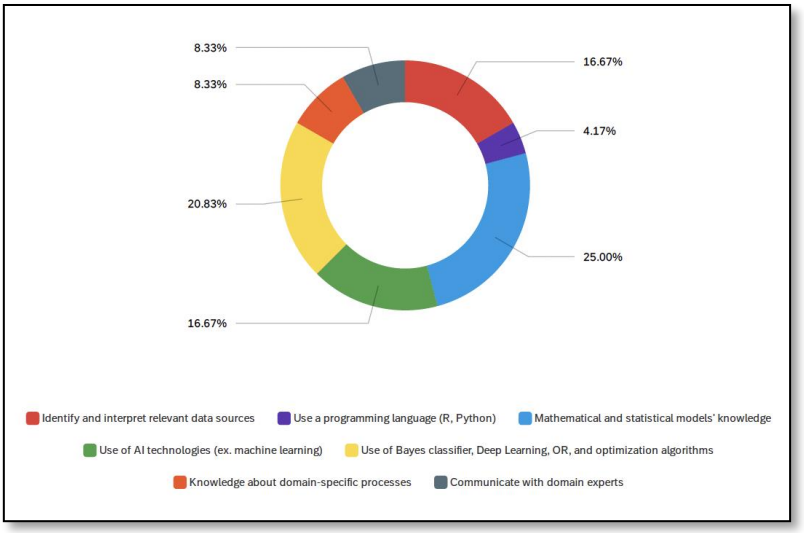

Figure 11 Data / AI Scientist - result of Voting survey - 1st Iteration

Visual Data Designer

The most important skills of this job are "Develop interface & interaction to increase user experience – 25%", "create infographics (maps, charts, diagrams) create infographics (maps, charts, diagrams) – 20%", and "Visualize the huge and complex volume of data – 20%" which are related to better display data and create better communication with users, and the "Develop vector graphics, scientific illustrations, and icons– 5%" has low importance in this role.

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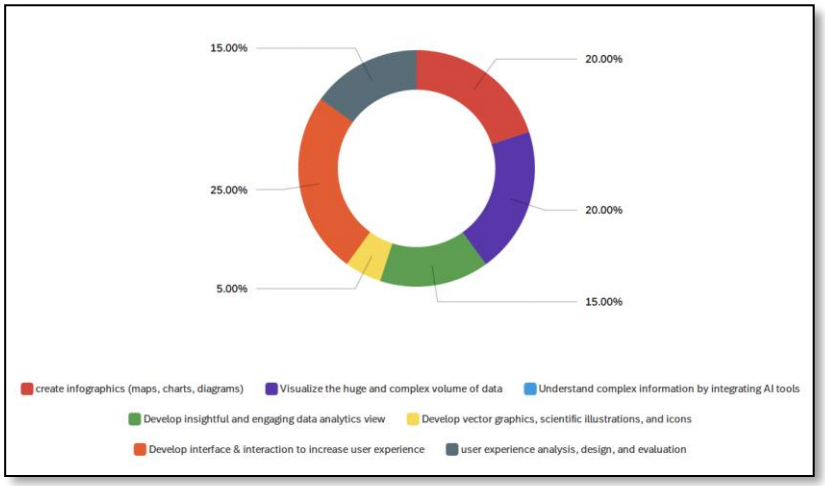

Figure 12 Visual Data Designer- result of Voting survey - 1st Iteration

Data/AI specialist

In this role, four main skills are "Knowledge about data storage, query languages and use of machine learning – 24%", "Integrate data and AI technologies into existing systems – 16%", "Develop data models and workflows – 16% ", and "Maintain security, quality, integrity, safety, and availability of data -16% ", which are related to information about new technologies such as artificial intelligence and machine learning and how to use them in existing systems and organizations. On the opposite side, skills related to monitoring and controlling activities as well as working with robots and sensors have a lower priority in this job profile.

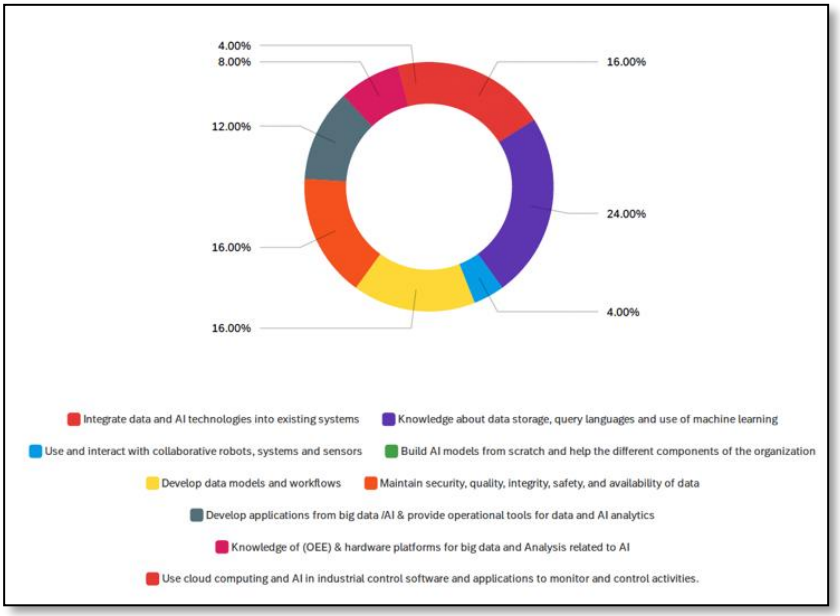

Figure 13 Data / AI Specialist - result of Voting survey - 1st Iteration

AI Manager / Head of AI

Skills related to "Analyse and understand how the value chain is transformed by virtue of Industry 4.0,and AI - 25%", is in the first priority of this role, while skills about "Build, implement and manage

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concurrent Digital/intelligence Supply Networks – 15 %", "Adapt technological (new tech. such as AI, VR etc.) innovations to business and Supply Networks – 15%" and "Improving production process with the introduction of new technologies related to AI and I4.0 – 15%" can also be recognized as the main skills of this job.

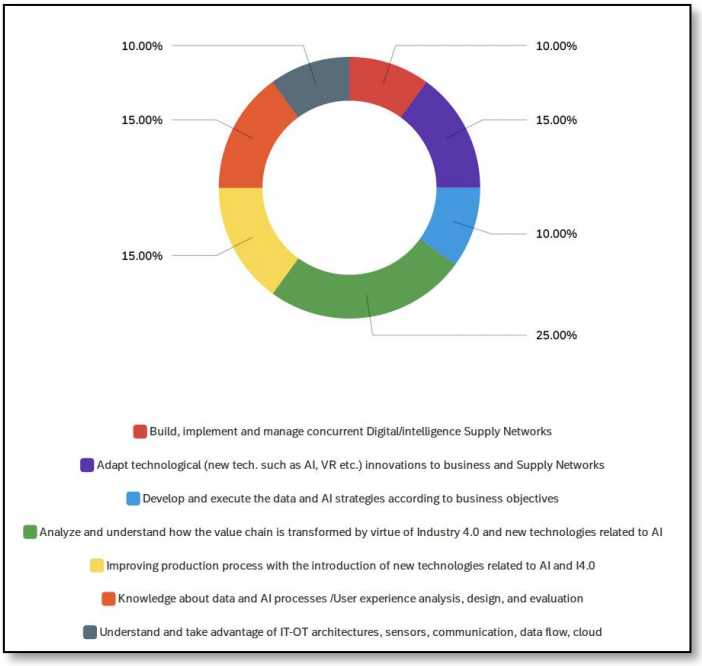

Figure 14 AI Manager / Head of AI - result of Voting survey - 1st Iteration

Remote Worker

Since people in this role work from outside the company environment, skills such as "Use applications to increase sensory, physical, and cognitive abilities", and "Perform scenario analysis to evaluate and prepare for possible interventions" are crucial and according to the responses received from project partners "Interpret quantitative data, graphs (KPIs), and 3D digital models" is a skill with less importance compared to others (Zero Vote).

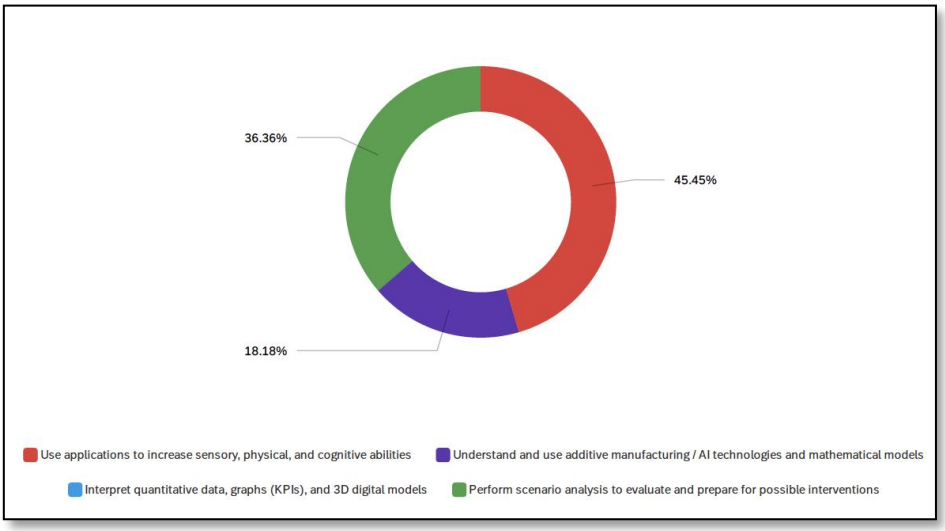

Figure 15 Remote Worker - result of Voting survey - 1st Iteration

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Strategy Manager I4.0

This job, which has been analysed at the management level, needs to improve some skills due to the growing trend of technology such as AI. The most important of which are related to "Analyse and understand how the value chain is transformed by virtue of I4.0 – 33.33%" and "Define, implement and manage a roadmap of technological evolution oriented to the generation of value – 33.33%."

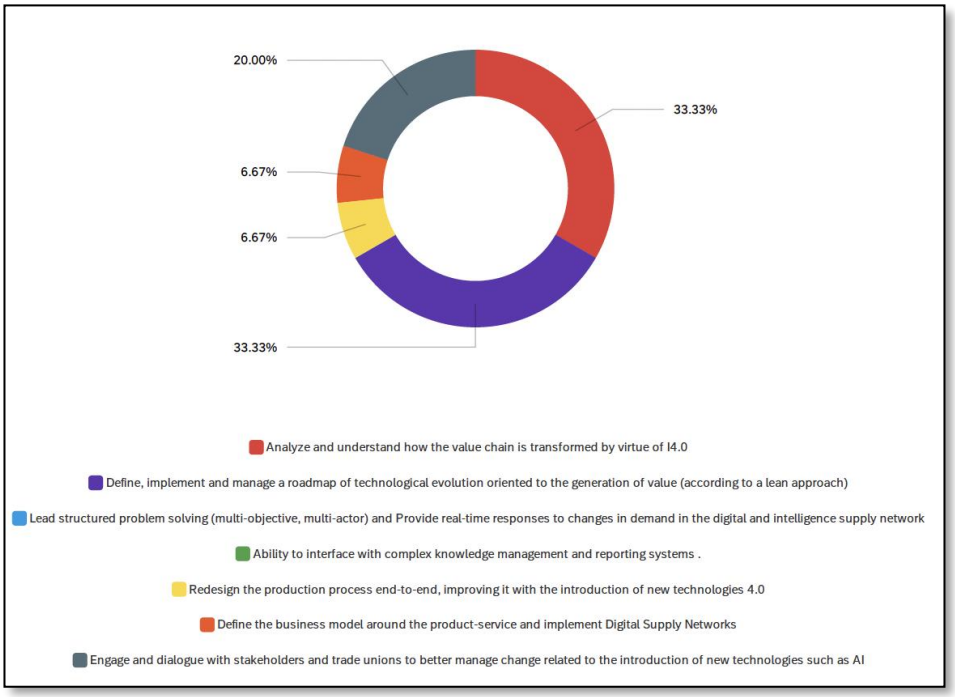

Figure 16 Strategy Manager I4.0 - result of Voting survey - 1st Iteration

I4.0 Professional

This job profile has been analysed in professional level. Its skills need to be improved in line with industry4.0 - related technologies, especially artificial intelligence, IoT. Therefore, the most important skill that has been considered by project partners is "Ability to perform scenario analysis to evaluate and prepare for possible interventions (simulations, classifiers, etc.) – 22.22%." This skill is mostly related to analyse and use new technologies such as AI, and simulation in different activities.

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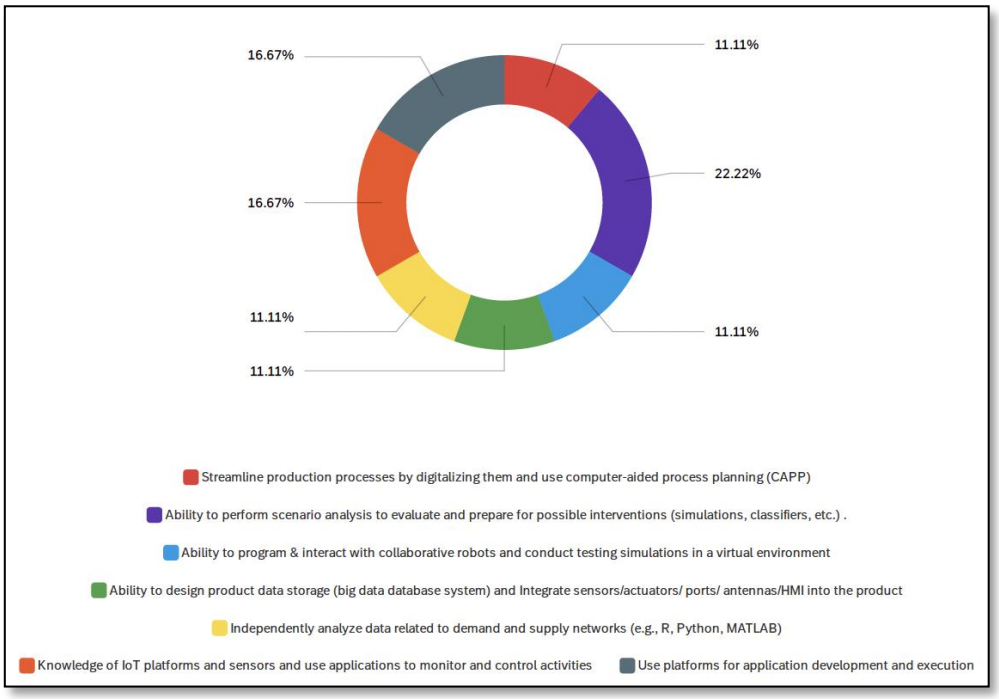

Figure 17 I4.0 Professional - result of Voting survey - 1st Iteration

Digital Transformation Professional 4.0

This job profile is another role that is analysed at the professional level and what emerged from the survey is that "Analyze the impact of emerging technologies on business (e.g., AI, big data) – 40%" is in the main priority of this job. Also, "evaluate pros and cons of platforms based on company's needs and select components" is another important skill of this job, which is related to evaluating platforms according to the conditions of companies.

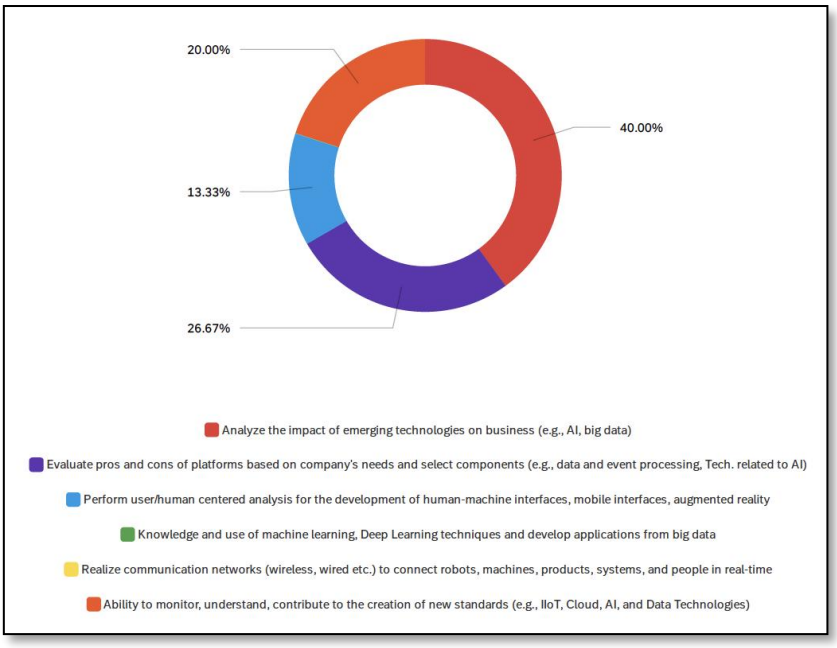

Figure 18 Digital Transformation Professional 4.0 - result of Voting survey - 1st Iteration

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Plant Worker 4.0

In this job profile, which has been analysed at the worker level, the skills of "Use of basic standard of HMI", "Interpret quantitative data and graphs and 3D digital models" and "Interact with collaborative robots" that are mainly related to analyse data and workers' collaboration with new technologies such collaborative robots, have a higher priority than other skills. In addition, "Use exoskeletons and other wearable devices" from the point of view of project partners, has no place among the skills of this job.

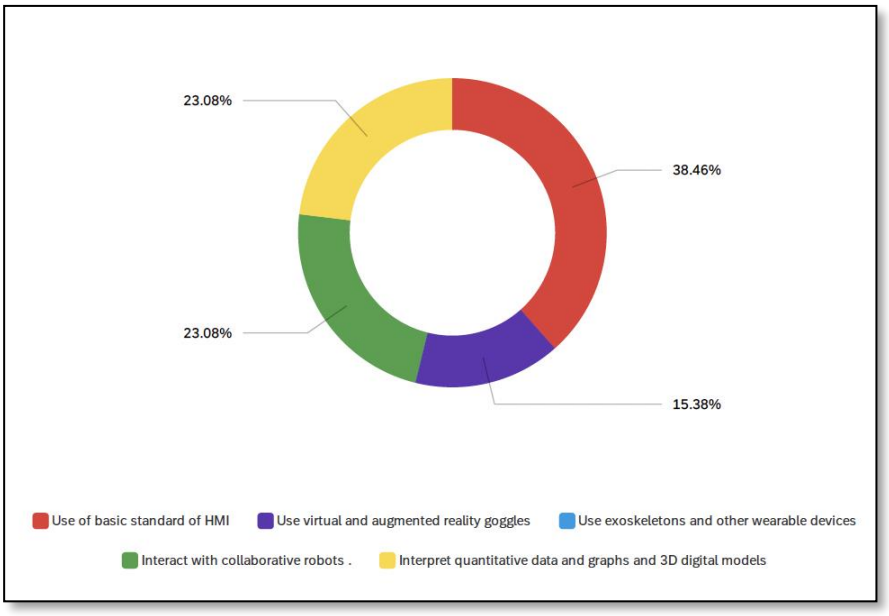

Figure 19 Plant Worker 4.0 - result of Voting survey - 1st Iteration

Technician 4.0

This job title is another role that is analysed at the worker level, and same as previous role, data analysis related skills are prioritized "Analytical skills to Interpret data from operations". Also, skills related to the use of sensors, actuators and HMI standards is another important skill of this job.

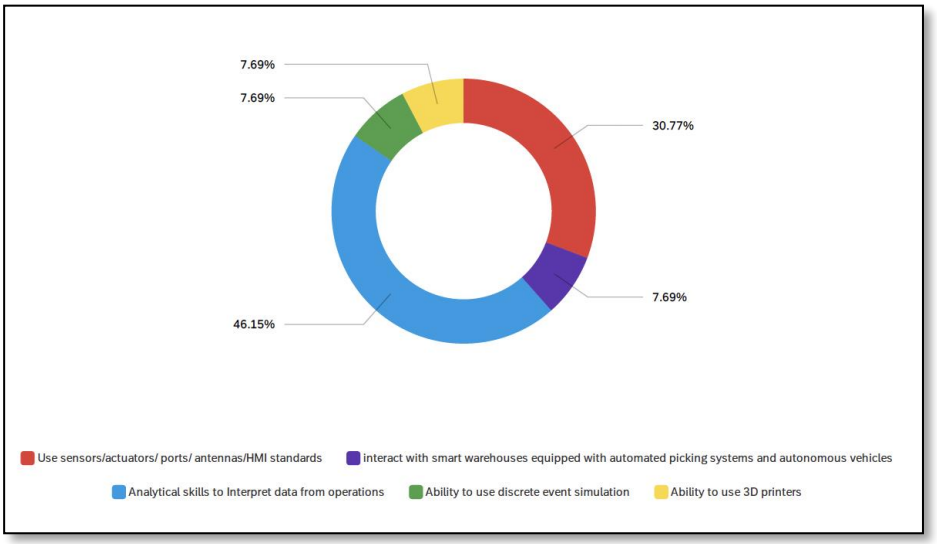

Figure 20 Technician 4.0 - result of Voting survey - 1st Iteration

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3.6 CAPRI catalogue of skills - Possessed and Needed - Survey

In order to assess the current situation of the project pilots and also their future expectations in relation to the jobs introduced in Section 3.4.1 and 3.4.2, the second survey entitled “Possessed and Needed” was asked of them, in this survey pilots specify whether they need these skills in their company or were currently using them. To display this information, a numerical range between 1 and 5 has been used, in which 1 depicts "basic level required" and 5 shows "expert level required". The most important purpose of this survey is to compare the AS-IS Situation and their target conditions, finding the gap between them and the possible activities of the partners to bridge these gaps. This survey was published in online[16] and in section 3.6.1, the results of its first iteration and is depicted.

3.6.1 Possessed and Needed Skills - Result of first iteration

This survey was compiled by the three pilots of the project representing the Asphalt, Pharma, and Steel domains. For better clarifying their answers and opinions in the questionnaire, interviews were conducted with pilots of Asphalt and Steel industries. Since the number of participants in this survey is limited (CAPRI project, as mentioned, counts only three pilots), showing the percentage of importance of possessed and needed roles in these industries will not make sense: in this regard only, the analysis performed on the answer will be fully described.

According to the answers received and interviews conducted with partners in the **Asphalt industry**, it is possible to understand the **necessity of some aforementioned roles** and their level of importance, such as **Data/AI Architect** (at intermediate level), **Data/AI Scientist** (at upper intermediate level), **Visual Data Designer** (intermediate level), and **Plant Worker 4.0** (Basic level). Other jobs, according to industry experts, are not needed at the moment, although in the future it is possible to create a platform for their growth. In addition, it is possible to access up-to-date technologies such as artificial intelligence and machine learning in this industry, but there are also **obstacles** in their way, including: the **quality of information** that is provided to different parts of the organization, as well as the **difficulty of measuring a lot of data** in the industry, difficulties in creating **coordination and synchronization** between new technologies and existing departments, high cost and **uncertainty in return on investment**. Product type and **company size** may represent an additional obstacle: according to industry experts, large companies can buy these technologies, use them in their products and define these jobs for their own organization much faster than small and medium size companies.

Furthermore, based on the answers received from the survey as well as interviews with **Steel industry** experts, it is possible to understand the necessity of some aforementioned roles and their level of importance, such as **Data/AI specialist** (at expert level), **Remote Worker** (at upper intermediate or expert level), **I4.0 Professional** (intermediate to upper intermediate level), **Digital Transformation Professional 4.0** (at intermediate level) and **Technician 4.0** (at expert level). In this industry, as well as the Asphalt industry, it is possible to create a platform for the growth of the introduced jobs. They already have some of the skills mentioned above in the role of IT director, but it needs more practice and improvement to up and re skill. There are also barriers in: **establishing connections between different parts** of the organization that are far apart in terms of distance; in **software management and communication** between departments; in the **overcoming high cost and market maturity** of different countries; in **employing specialized employees** in relation to data and artificial intelligence.

3.6.2 Soft Skills

As mentioned in the Section 3.4.3, in addition to technical skills, we also analysed soft skills at three different levels: Management, Professional, and Worker levels, which in the Table 1 you can see the results of the survey of project partners.

[16] https://polimi.eu.qualtrics.com/jfe/form/SV_0CfCgK9GIt5vkFw

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Table 1 Soft Skills in three different Levels

	Manager	Professional	Worker
Teamwork	7.25%	8.33%	19.23%
Communication	7.25%	8.33%	7.69%
Professional ethics	7.25%	6.67%	15.38%
Problem solving	4.35%	8.33%	7.69%
Critical thinking	7.25%	5.00%	0.00%
Innovation	5.80%	6.67%	3.85%
Emotional Judgment	7.25%	5.00%	3.85%
speak second language	5.80%	5.00%	0.00%
Time management	7.25%	6.67%	11.54%
Interpersonal skills	7.25%	5.00%	3.85%
Critical problem solving	4.35%	6.67%	3.85%
Digital literacy problem solving	4.35%	6.67%	0.00%
Self-management	7.25%	8.33%	11.54%
Digital skills	2.90%	6.67%	7.69%
Ethical / Legal mindset	7.25%	5.00%	3.85%
Global perspective	7.25%	1.67%	0.00%
Total	69	60	26

The participants to the survey were asked to express their opinions on soft skills at each organizational level (management, Professional, and worker levels) to identify essential ones. The percentages represent the importance of each skill listed in Table 1. For example, at the professional level, out of a total of 60 votes received, the most crucial soft skills are specific to Teamwork, Communication, Problem solving, and Self-management. It should be noted that the most important skills are highlighted in red in this table. As a result, we can conclude that Teamwork and Self-management are common skills for all three levels, indicating the significance of these skills in the workplace

3.7 Training activities and Next Actions

In this section, we go to the second step of the method describe in Section 3.2. After introducing the related jobs and skills in the first step and implementing and analysing the surveys that were explained in the sections 3.5.1 and 3.6.1 and finding the gaps among the project experiments, we will now introduce training activities that can help partners to strengthen their required skills in the introduced job profiles.

In this step, first of all, three levels “Awareness”, “Foundations”, and “Extended Know-How” were considered which “Awareness” refers to general knowledge and information to get familiar to the subject, “Foundation” refers to basic useful information, and “Extended Know-How” refers to a range of information that can help audience to increase their level of knowledge and understand of how to use the technology. Then, each of the training courses that were introduced in “I4MS Catalogue of Trainings[17]” and “Polimi open knowledge[18]” in relation to the topics of data science and artificial intelligence were analysed and the correlation between jobs and related skills and these courses at three levels were defined.

[17] https://i4ms.eu/trainings/
[18] https://www.pok.polimi.it/

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Matrix: relation between courses and Roles 1 - Awareness 2 - Foundations 3 - Extended Know-How	Provider	I4MS	Poli- Politecnico di Milano	Poli- Politecnico di Milano	I4MS	I4MS	Poli- Politecnico di Milano	Poli- Politecnico di Milano	I4MS
	Course name	AI Opportunities for SMEs	Artificial Intelligence - An Overview	Artificial Intelligence and legal issues	Assessing HPC readiness for SMEs	Blockchain Technology in Manufacturing Industry	Data science, visualization and interactive narratives for CCIs	Ethics of Artificial Intelligence	I4.0 Workshop
Data Science Manager									
Knowledge about data and AI processes		1	1				2	1	1
Knowledge about business processes		2		1	2				1
Communication with domain experts						1			
Manage the data science team and resources			1				2		1
Knowledge about performance indicators				1	1	1			
Develop and execute the data and AI strategies		1	1	1			1		
Data/AI Architect									
Ability to integrate data universe			1				1		
Select software platforms for big data (Hadoop, Data Lake)			1			1	2		1
Knowledge about big data architectural standards				1		2	2		
Select hardware platforms for big data (performances…)			3						
Data/AI Scientist									
Identify and interpret relevant data sources			1				1	1	1
Use a programming language (R, Python)									
Communicate with domain experts						1			
Mathematical and statistical models' knowledge			3						
Knowledge about domain-specific processes			1						
Use of AI technologies (ex. machine learning)		3				2	2		2
Use of Bayes classifier, Deep Learning, OR and optimization algorithms		1	1			1			1
Visual Data Designer									
Develop interface & interaction to increase user experience				2		2	2		
Develop vector graphics, scientific illustrations, and icons							2		
Visualize the huge and complex volume of data									
Develop insightful and engaging data analytics view						2	1		
create infographics (maps, charts, diagrams)									
user experience analysis, design, and evaluation						2	2		1
Understand complex information by integrating AI tools		1	1			1	1		1
Data/AI specialist									
Integrate data and AI technologies into existing systems		2	1	1		2	1	1	1
Knowledge about data storage, query languages and and use of machine learning		3	2				2		
Use and interact with collaborative robots, systems and sensors		1							
Build AI models from scratch and help the different components of the organization		2	2	1	1		1	1	1
Develop data models and workflows									
Develop applications from big data /AI & provide operational tools for data and AI analytics			1			2	1		
Knowledge of (OEE) & hardware platforms for big data and Analysis related to AI			3	1	1				2
Use cloud computing and AI in industrial control software and applications to monitor and control activities.		2	2		3	3			
Maintain security, quality, integrity, safety, and availability of data				3	1	1	1	3	

Figure 21 Database of Training Activities

In this database, all the 12 jobs that were introduced in the previous sections and their related skills are covered and the Figure 21 is just a part of this database to show how it works. For example, in the first column of the courses, we have the “AI Opportunities for SMEs” which is presented by “I4MS Catalogue of Trainings”. This course is held in the context of Artificial intelligence and in connection with the “Data / AI new roles and Professions” provides explanations in awareness level for “Knowledge about data and AI processes” and “Develop and execute the data and AI strategies” skills, Knowledge in Foundation level for “Knowledge about business processes”, and “Build AI models from scratch and help the different components of the organization” skills. Also, its main focus is on “Knowledge about data storage, query languages and use of machine learning” skill which provides in information Extended Know-How Level. It should be noted that this database is open source, which means that if the partners were able to improve their required skills using other training activities, they can add to this file so that other partners can get acquainted with it.

Among the activities that can be mentioned for the future there is the implementation of the second iteration of surveys in order to analyse the TO-BE condition of partners that can be also evaluated the effectiveness of this method in the project. As well as increasing the number of training courses and improving the database of training activities.

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4 Train the trainers – a collaboration with DIHs

This chapter aims at depicting a set of actions to involve DIHs dealing with Process Industry, to share with them lessons learnt in CAPRI project and use cases, but also to teach them how to exploit the main assets implemented within the project.

As described in D6.5 – "Initial Report: SPIRE Digital Transformation Ecosystem" (§5.3) about the CAPRI dissemination plan, it is foreseen to start a collaboration with Digital Innovation Hubs with a specialisation in Process Industry, that represent a fertile ground to spread CAPRI's results and achievements to a wider community. In the aforementioned deliverable, it is expressed the willing of creating an online community to foster interaction among hubs, information exchange and peer-learning.

In this perspective, the Process Industry DIHs are identified as trainers for SMEs, Midcaps and large enterprises that could be interested to CAPRI assets; hence, **the role of WP7.3 is to train the trainers**, sharing our methodology and assets, as well as the training material. The solutions described in Section 2 – "Training Program for CAPRI assets", are expected to be presented to the Hubs and then, by the hubs to their community of enterprises, as success stories or as exploitable assets.

On one side CAPRI may take advantage from the point of view of the dissemination, guaranteeing that its results are spread to a wider community (also after the end of the project); on the other, the Digital Innovation Hubs will benefit of CAPRI training program by increasing the number of Skills services.

To this regard, next paragraph is a digression dedicated to shortly present the concept of "service classification" for DIHs' Portfolios.

The DBEST framework for Digital Innovation Hubs – the SKILLS class

Politecnico di Milano, in the frame of MIDIH project[19] first and AI REGIO project[20] then, has developed a 3-levels taxonomy catalogue, in order to classify the list of services that a DIH may provide to its customers. The objective is twofold: on one side, DIHs are equipped with a standard Service Portfolio that allows to interact with other European organizations, "speaking the same language"; on the other, it represents a stimulus to define new services in order to get a complete range of services to be offered to the constituency.

The macro categories of the portfolio's taxonomy (that are those from which the name DR BEST comes from) are:

- **Data:** services that a DIH may provide to support data management, including the creation of data spaces, from Data Acquisition to Data Sharing, from simple Data Analysis to complex Artificial Intelligence models.
- **Remote:** services that a DIH may provide from remote to enable experimentation and that don't require the physical interaction with the customer. It covers different degrees of DIH-customer interaction, including four type of assets that can be put at disposal: data, software, simulations (Digital Twin), physical assets.
- **Business:** services that a DIH may provide to support the customer from the business perspective, including the research of funding opportunities, the support in project proposals development, the provision of training about business topics, the provision of working spaces.
- **Ecosystem:** services that a DIH may provide for the creation and management of a stakeholder ecosystem, including other DIHs, Didactic Factories, enterprises, technology providers…

[19] https://www.midih.eu/
[20] https://www.airegio-project.eu/

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- **Skills:** services that a DIH may provide in terms of training and competences assessments, addressed to both single workers and organisations. It includes the provision of training and educational programmes, of training material and repository, but also running maturity assessment (possibly followed by a detailed analysis to define the transformation roadmap).
- **Technology:** services that a DIH may provide to its customers to support the development of a new technological solution and it is related to the "test-before-invest" paradigm, that helps enterprises to test and validate an idea before doing large investments to produce it**,** covering the entire lifecycle of the implementation process.

The label "3-levels taxonomy" means that services are organized according to a three levels categorization: for each class of services (Data, Remote, Business, Ecosystem, Skills, Technology) considered as level 1, a level 2 and a level 3 are defined in order to better detail and classify the type of activity.

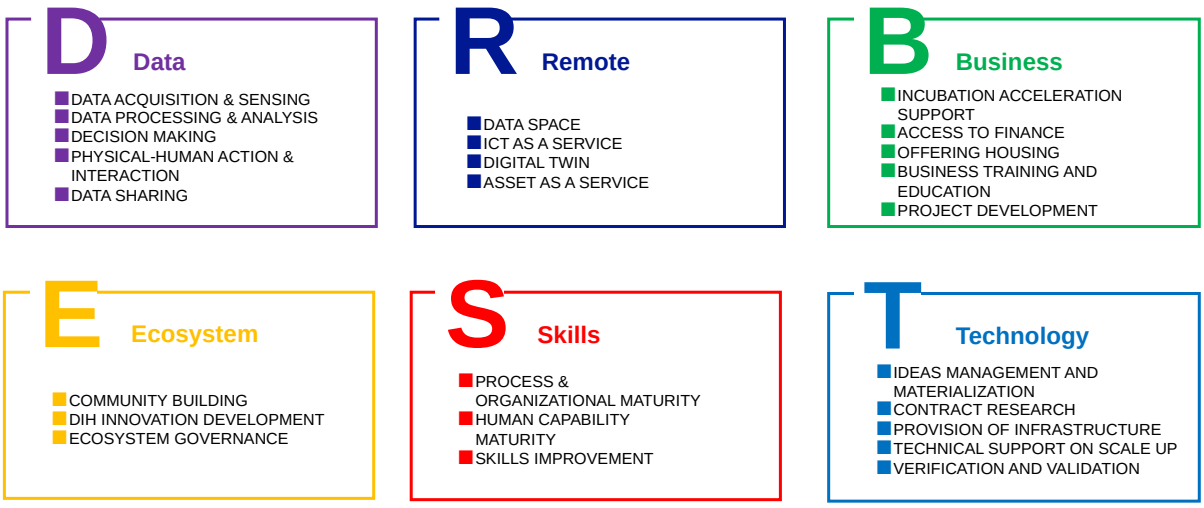

Figure 22 The DR BEST taxonomy, level 1 and 2

Not surprisingly, for the purpose of the CAPRI training planning described in the current document, we **focus on the Skills class**. Starting from the assumption that the Service Portfolio of each Digital Innovation Hub can be described according to the DR BEST taxonomy, the objective is to share with the Process Industry DIHs the set of training developed in CAPRI, in order to extend their set of Skills services.

Actually, analysing in details the Skills class, it is possible to better identify what types of services the CAPRI trainings represent. The Table below shows the related level 2 (type) and level 3 (service) of the Skills class.

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Table 2 DR BEST Skills class

DR BEST Taxonomy		
LEVEL 1 CLASS	**LEVEL 2 TYPE**	**LEVEL 3 SERVICE**
SKILLS	Process & Organizational Maturity	Maturity Assessment
		Maturity Strategy Development
	Human Capabilities Maturity	Human Skill Repository
		Human skills maturity
		Skills strategy development
	Skills Improvement	Human up-skilling, re-skilling training
		Educational Programs
		Scouting and Brokerage
		Standardisation and certification

The training material prepared in CAPRI can be put at disposal to DIHs in “Skills Improvement”, dimension, specifically as “Human up/re-skilling training” and “Educational Programs” service. The former refers to a set of activities related to training on technical and soft skills at corporate level, addressed both to the plant operators (to be able to deal efficiently with the digital innovation) and to the management (in order to overcome the cultural barriers). The latter includes a more complex set of courses and classes, with the objective of attracting next generation talents, but also forming Industry 4.0 employees and workers.

The platforms identified to get in touch with Process Industry DIHs are both the JRC catalogue21 (where it is possible to filter by sector and service provided, in order to select the suitable subset of DIHs) and the DIH4INDUSTRY platform22. The latter aims to become a digital platform targeted to European Digital Innovation Hubs that operate in the context of manufacturing to support European enterprises in their digital transformation, by providing a support tool to facilitate the exchange of skills, assets, knowledge, technologies and data. It means that it can represent an effective service marketplace also for CAPRI trainings, if properly included in the Skills set of services of some DIHs.

[21] https://s3platform.jrc.ec.europa.eu/digital-innovation-hubs-tool
[22] https://dih4industry.eu/welcome/

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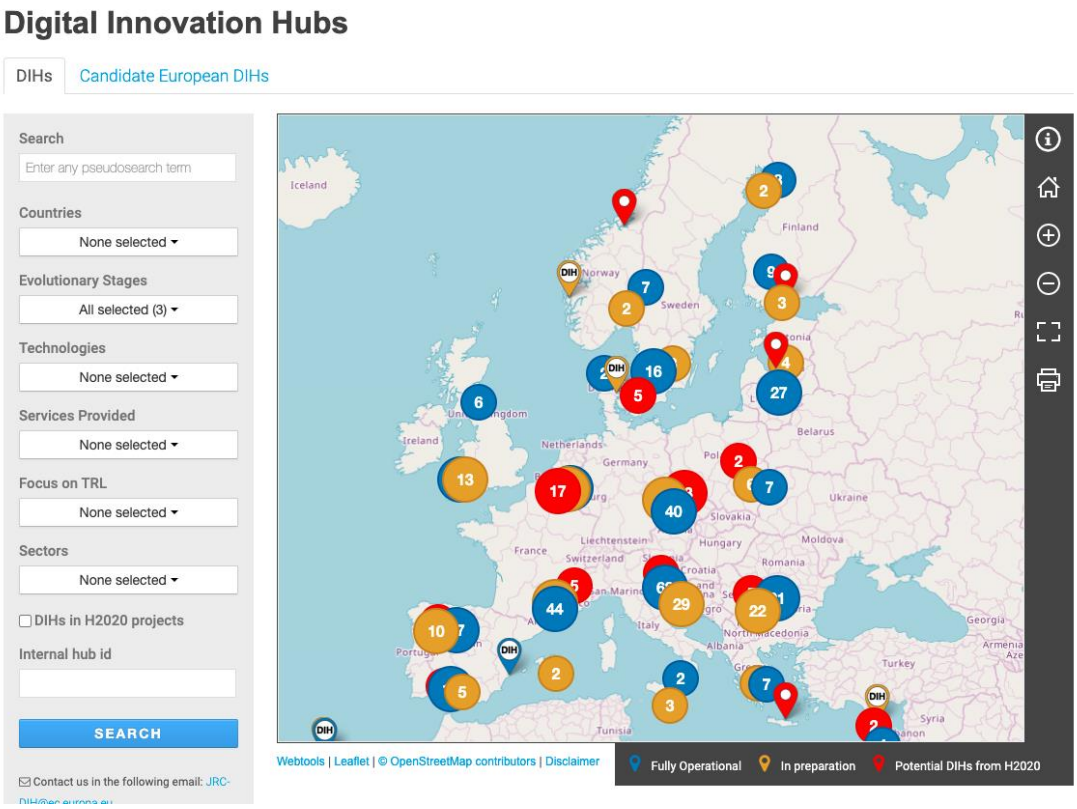

Figure 23 The JRC catalogue landing page

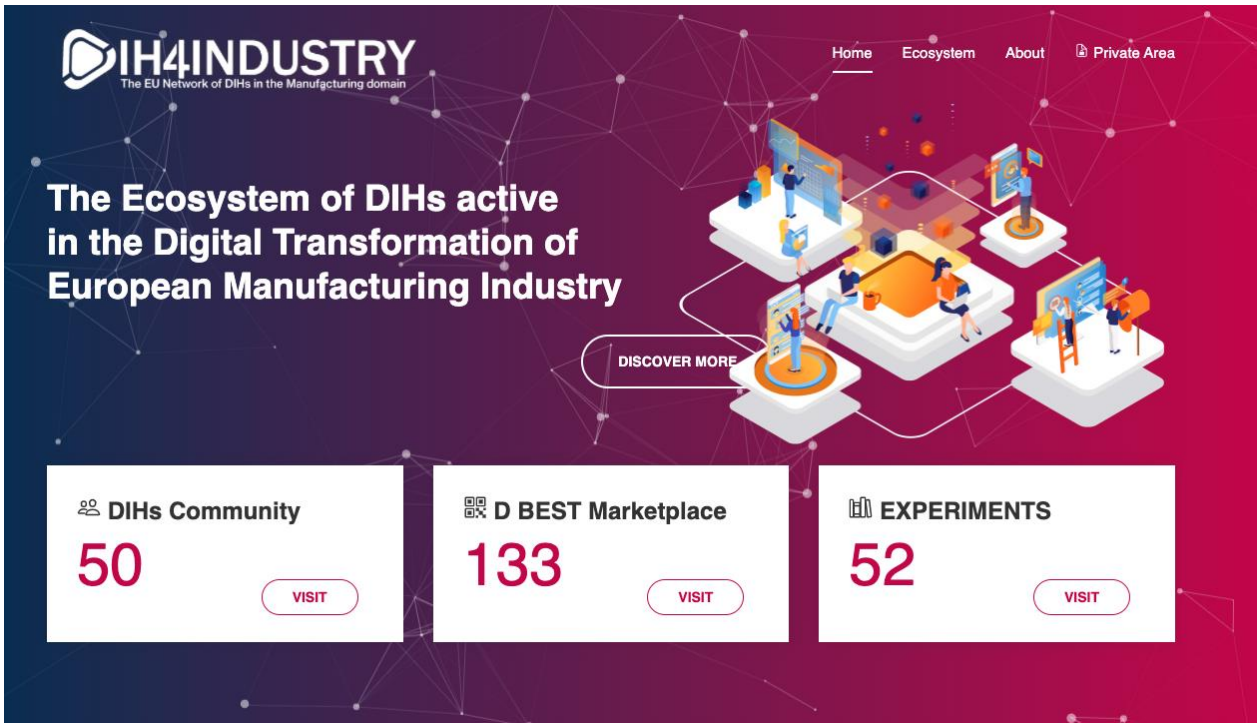

Figure 24 DIH4INDUSTRY landing page

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The DIH4INDUSTRY community represents a fertile ground of manufacturing Digital Innovation Hubs to whom CAPRI aims to present its set of trainings, enhancing the DIHs' portfolio of services. In particular, the DIH4INDUSTRY platform has been already conceived to display services according to the DR BEST taxonomy, as shown in the cards below, so including also the Skills class.

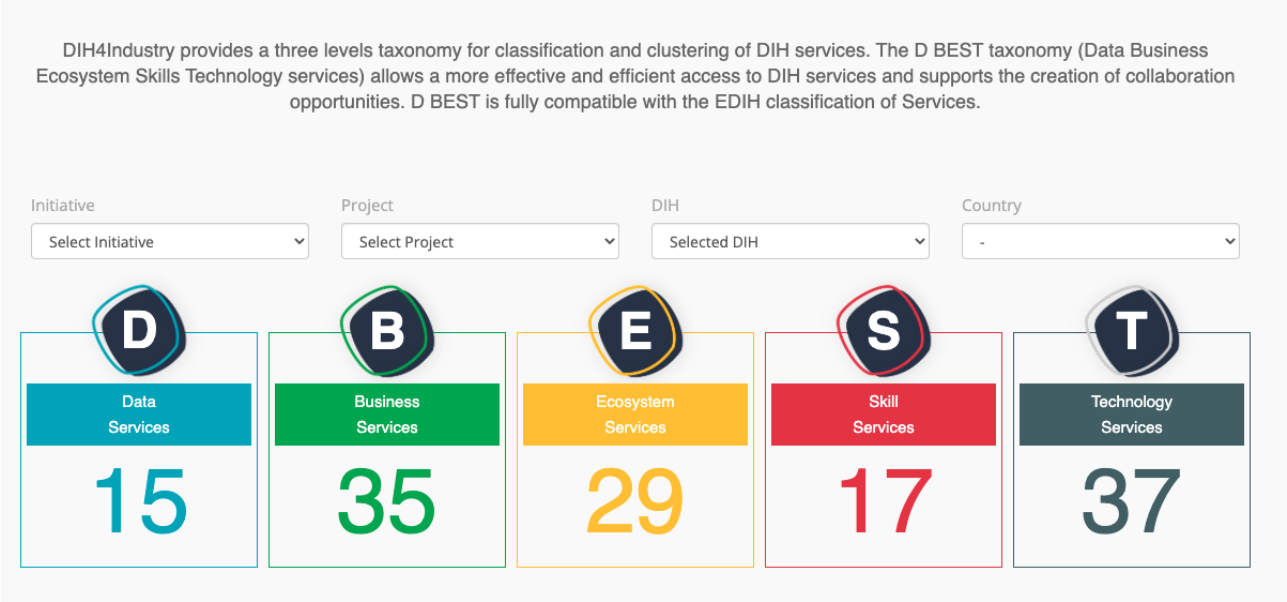

Figure 25 The DIH4INDUSTRY DBEST Service Marketplace

So far, different initiatives operating in different domains of the Manufacturing sector have been contacted to be involved in the DIHINDUSTRY project such as I4MS, SAE, SCoDIHNet, RODIN, BDVA and DIH4AI. It allows to have at disposal a wide catalogue of Digital Innovation Hubs to whom present the CAPRI training program and share the training material.

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5 CONCLUSION

The objective of D7.3 – "Initial Report: Training and Education program report" was to identify a number of trainings to be developed within CAPRI project taking into account two possible directions:

i) trainings related to the assets implemented during to project, to make them accessible and exploitable;
ii) trainings addressed to the pilots workers, to fill the existing gaps in terms of Industry 4.0 competences, beside the CAPRI solutions.

Considering point i), a preliminary analysis about CAPRI assets (the Reference Architecture, the Cognitive Solutions and the 6Ps methodology) has been conducted, to identify those that require related trainings to be exploited. So far, most of them are still not mature enough to already provide some trainings, but it is important to start reasoning on them in order to outline an effective training plan to be developed in parallel.

In Section 2, following assets have been identified as subject of training activities:

- the Reference Architecture and the CAP, whose related trainings will be initially addressed to the three CAPRI industrial companies that will deploy it as pilot, and in a second step, to other enterprises interested in the platform
- 16 Cognitive Solutions requires that at least an introductory presentation to be properly adopted in the plant; some of them need a more structured approach, including, for instance, one (or more) day trainings and specific competences to understand how the solutions works.
- the 6Ps methodology, to be presented to DIHs and other competence centres to make them perform it in their ecosystem of enterprises.

About point ii), the final objective is not to up-skill/re-skill workers and/or to introduce new professional figures within the duration of the project, since it is out of the CAPRI's scope and it is a non-trivial task that requires a huge amount of effort. Instead, the goal is to track together with the partners an effective medium/long-term roadmap to boost the People P (that is, company's workers).

T7.3 performed a detailed desk research regarding the current trends in the labour market, to be applied to CAPRI pilots, in order to identifying which skills and competences are missing, prioritising the most relevant ones.

Not surprisingly, in line to what was derived investigating the job market, some gaps in terms of competences have been identified, to be filled with training and skilling activities where it is possible, but also to be replaced by external consultancy when it is not possible to acquire new competences. Actually, making reference to the 6Ps methodology, it's important to take in mind that together with the P of People, there is also the P of Partnership, meaning that, to achieve a successful digital transformation, it's required to boost also to external resources able to provide tools, solutions and competences, wherever the enterprise is not able to get.

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