D2.3 AI REGIO AI DIH experiments AI Scenarios

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EXECUTIVE SUMMARY

D2.3 "*AI REGIO AI DIH experiments AI Scenarios"* intends to provide a comprehensive description of the business and innovation scenarios for the main pillars of AI REGIO project, namely i) the 13 Digital Innovation Hubs, ii) the 17 SME- and DIH-driven experiments and iii) the AI technological tools.

Following the *"AI REGIO Requirements Engineering Methodology"*, developed within Task 2.1 and completely reported in D2.1, which mainly consists of 5 phases (see D2.1 for details), this deliverable addresses the first phase "Scenario Analysis" of the methodology. In particular, phase 1 of the methodology consists of drawing the as-is and to-be scenarios of the addressed 'system' (AI DIHs, SMEs experiments and AI platforms) including bottlenecks, objectives and KPIs elicited from the 'system' users.

Furthermore, as foreseen by the AI REGIO Requirements Engineering Methodology, the information included in this deliverable are complemented by those collected through the AI REGIO Handbooks: DIH Handbooks, TRIAL Handbooks and TECHNO Handbooks. A specific different path has been followed for the 3 pillars in order to collect the main information hereby reported and the Handbooks gather all the additional details that refers to each DIH, Experiment and technological tool.

The analysis of the scenarios of the 13 DIHs led to the identification of 6 Customer Journeys, and their related Blocking Points, that depict the typical journey of the DIH customers, namely: Technology users, Technology providers, Students, Policy Makers, Start-ups and Experimenters.

The 17 Experiments scenarios, challenges and expected results have been summarized and grouped according to the identified clusters, namely: Product Engineering and Lifecycle Management, Factory efficient and sustainable manufacturing, Quality control and predictive maintenance, Robotics and Human Interaction.

An overview about the technology access usage and the grand scenario for the main identified stakeholders is reported for each of the 5 technological assets that are going to be developed within AI REGIO, in particular: Data4AI Platform, AI4Manufacturing toolkit, DIHIWARE Platform, Collaborative Intelligence Platform and AI Data Spaces for Manufacturing.

1. Introduction

1.1. Scope of deliverable

This deliverable aims at collecting and harmonizing scenarios of the main pillars of the AI REGIO Project, in particular:

- Digital Innovation Hubs: 1 workshop was organized in February 2021 for collecting the inputs of the involved DIHs on the identified Customer Journeys. A specific collaborative tool (Mural) has been used for the workshop in order to enhance a collaborative and active interaction among the DIHs. In addition, after the workshop, participants had the opportunity to come back to the tool and they were asked to enrich their inputs in Chapter 2 of the respective DIH Handbook.
- Experiments: a structured path was followed for collecting scenarios information from the involved Experiments leveraging on the developed TRIAL Handbook Chapter 1 "Experiment Overview". Experiment Clusters leaders have been involved to review the contents provided by experiments, that were then summarized in this document.
- Technological Assets: direct inputs for the identification of technology user journey and grand scenarios were requested to the technological asset leaders.

The deliverable includes the following chapters:

Chapter 1, "*Introduction*": this chapter introduces the deliverable and explains its links with other deliverables, tasks and work packages of AI REGIO project.

Chapter 2, "*Regional DIHs Customer Journeys*": this chapter provides a comprehensive overview of the 13 AI REGIO DIH Customer Journeys. This chapter will mainly contribute to WP3.

Chapter 3, "*Experiments business and innovation scenarios*": this chapter provides a comprehensive overview of the 17 SME- and DIH- drive experiments scenarios and expectations according to the 4 identifies cluster groups. This chapter will mainly contribute to WP6.

Chapter 4, "*Technology user journey and grand scenarios*": this chapter provides an overview of the Grand scenarios and expectations from the 5 AI REGIO addressed technological toolkits. This chapter will mainly contribute to WP4 and WP5.

Chapter 5, "*Conclusions and next steps*": this chapter wrap-up the main activities foreseen within this deliverable and highlight the next steps to be followed.

1.2. Contributions to other WPs

This document will provide key inputs for several tasks and deliverables mainly belonging to:

- WP2 - *Beyond REQUIREMENTS: AI DIH Digital Transformation from scenarios to business cases;*
- WP3 - *Beyond BORDERS: AI DIH Ecosystem from Regional to pan-EU services;*
- WP4 - *Beyond PLATFORMS: AI DIH Open Platforms and DIH Platform;*
- WP5 - *Beyond INDUSTRY 4.0: AI DIH Industry 5.0 and Data Sharing Spaces;*
- WP6 - *Beyond EXPERIMENTS: AI DIH regional facilities from demos to regional champions.*

Considering that this report mainly reflects Phase 1 *"Scenario Analysis"* of the methodology developed in D2.1, it will act as input for the Phase 2 *"Business/Technological Requirements, elicitation and analysis"* and therefore for Task 2.3 and 2.4 of WP2.

In addition, considering that it addresses all the 3 AI REGIO Pillars, it will flow into WP3 for DIHs, WP4 and WP5 for the information connected to the technological assets, and into WP6 for Experiments.

1.3. Contributions to other deliverables

The collected AS-IS and TO-BE scenarios will serve as inputs for Task 2.3, mainly D2.5 *"AI REGIO User Requirements Specification*", and for Task 2.4*,* mainly D2.7 "*Legal and ethical requirements and guideline",* in order to specify and elicit both technical as well as legal and ethical requirements.

In addition, information collected on DIHs will provide inputs for WP3: Task 3.2*, D3.1 "Service Portfolio and Customer Journeys"* and Task 3.3*, D3.3 "Collaboration Scenarios for AI REGIO DIHs".*

Information linked to the technological assets will provide inputs for the development of the assets themselves, and therefore to Task 4.2, D4.3 *"Data4AI Platform"*, Task 4.3, D4.5 "*AI4Manufacturing Toolkit",* Task 4.4, D4.7 "*AI REGIO DIH Platform"* as well as to Task 5.1, D5.1 *"Collaborative Intelligence and Industry5.0"* and Task 5.2, D5.3 *"Data Sovereignty models and solutions".*

To conclude, information connected to Experiments will act as inputs for Task 6.1, D6.1 *"AI REGIO Experiments Plan".*

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2. Regional DIHs Customer Journeys

Chapter 2 gives an overview of the main DIHs Business and Innovation scenarios emerged according to the identified DIHs Customer Journeys (CJs). Overall, 13 DIHs are involved in AI REGIO: 4 DIHs belong to the 4 Motors for Europe[1] regions (Auvergne Rhone-Alpes, Baden-Württemberg, Catalonia and Lombardia), and 9 belong to other European regions that are also part of the Vanguard Initiative[2] (South Netherlands, East Netherlands, Tampere, Norte, Emilia Romagna, Navarra, Slovenia, Friuli Venezia Giulia and Basque Countries).

As described in D2.1, customer analysis is proposed in order to understand typical needs, expectations and interaction workflows by the various ecosystem stakeholders. In particular, 6 customizable templates for Technology Providers, Technology Users, Students, Start-ups, Policy Makers and Experimenters are provided, in order to ease the identification of customers and the definition of typical interaction workflows. The method as well as the Technology users and Technology Providers CJs rely on the knowledge acquired by the MIDIH Project. AI REGIO enlarge the DIHs customer base including 3 addition CJ: Start-ups, Policy Makers and Experimenters.

Customer Journeys are then defined as level-by-level Digital Transformation (DT) evolutionary pathways that typically model the customer interaction with a DIH. A third step in this analysis is the identification of Blocking Points, being factors preventing customers to evolve their Digital Transformation from one level to the subsequent one.

The implementation of such activities is indeed driven by the DIH Handbook (DIH HDB) document. A specific process was followed to identify the DIHs Customer Journeys as well as Blocking Points. In particular, one plenary workshop was organized in February to collect information from the 13 DIHs about their CJs and the related BPs. This workshop was held virtually leveraging on Mural, a collaborative tool to facilitate interactions.

Then, DIHs were requested to detail information identifying the AS-IS and TO-BE services in their service portfolio, classified according to the different CJs phases as well as to the different service categories. More information about the DIH service portfolio analysis are available in D3.1, while details about the specific DIHs CJs and Blocking Points (BPs) are collected and available upon request in Chapter 2 of the DIH HDB.

Overall, 6 CJs have been identified and described in the following sections.

2.1. Technology User (TU)

Technology Users (TU) constitute an important share of DIHs customer base. They are mainly manufacturing companies in diverse industries (machinery, metal, textile, food, aerospace, automotive…) sharing the final goal of undertaking the Digital Transformation journey to increase their competitiveness leveraging also on Artificial Intelligence technologies. TUs are therefore considered as the end-users/demand-side of the technology.

[1] https://www.4motors.eu/en/
[2] https://www.s3vanguardinitiative.eu/

All the 13 DIHs confirm to address, among their customers, Technology Users companies and mainly Small and Medium Enterprises.

2.1.1. TU Customer Journey

The Technology User CJ is depicted in Figure 1.

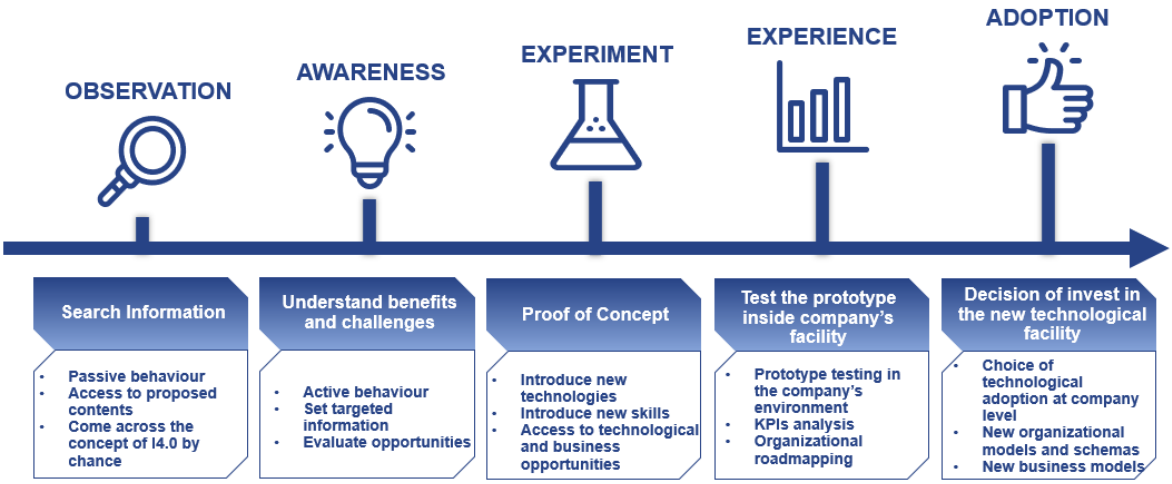

Figure 1 - Technology User CJ

In the **"Observation"** phase, the company is mainly at the discovery of Artificial Intelligence technologies and therefore it approaches the DIH with a passive behaviour, mainly for curiosity and serendipity, listening and trying to understand if the offered activities are of its interest to firstly come across the Industry 4.0 concept. They heard about AI but they are not able to determine what AI is, real benefits, and if AI fits their needs. Therefore, they are willing to understand more about technological trends and the technology itself.

In this phase the main offered services by the DIH are events and conferences, best practice promotion to increase awareness and to have a general and broad understanding of AI, as well as Infodays to inform about available funding opportunities.

In the **"Awareness"** phase, the company is now willing to access the DIH network and to understand more about the potential benefits and challenges from AI. It therefore gets more involved in the DIH community, actively attends workshops and/or more focused meetings with other stakeholders sharing common manufacturing challenges. In this phase strategic partnerships are initiated, being potentially interested in cooperation opportunities to increase R&I. Accordingly, TUs get in touch and meet strategic partners, namely industrial representatives as well as academia or other experts to build potential partnerships and evaluate collaborations opportunities.

The DIH animates this ecosystem, supporting the identification of cooperation and/or funding opportunities at regional, national as well as interregional level. In this phase, webinars, workshops, matchmaking services as well as basic trainings are also provided.

In the **"Experiment"** phase, the company aims at introducing AI within its manufacturing activities. Therefore, the DIH support it in feasibilities studies as well as maturity assessments activities to understand the specific need for AI, how to overcome the current challenge and which specific technology should be introduced and how. In this phase the understanding of the TU needed skills is fundamental as well. Accordingly, the TU is supported in the concrete elaboration of possible collaborative projects or private business experiments.

In this phase the DIH mainly offer feasibility studies and maturity assessments services, AI trainings, support in creating consortia and in developing collaboration opportunities. Open innovation Challenges and focused matchmaking activities are provided as well to let the company start cooperating with Start-ups and other technology providers.

In the **"Experience"** phase, the company is supported in the definition of a roadmap for implementing changes and innovative technologies that have been previously experimented. In particular, the TU is willing to prototype and test the technology to understand potential advantages as well as be aware of the needed investments measuring specific KPIs. Accordingly, personnel training for updating and upgrading skills is necessary as well as support for organizational change and testing in real environments.

Therefore, the DIH offers the possibility to foster the technological experience of the company giving access to specific technological infrastructures in order to concretely experience the technology, as well as proper trainings focused on the needed skills and change management for successfully implementing AI.

In the **"Adoption"** phase, the company has clear idea about the technology advantages, and it is ready to invest for its adoption. The DIH offers all the needed competences, technical expertise, management skills, new business models as well as change management competences that enhance a successful technology adoption.

2.1.2. TU Blocking Points

The main identified Blocking Points (BP) in the early phases of the TU CJ are:

- **Mindset**: Technology users do not have a proactive approach towards Artificial Intelligence and must be pushed towards innovation to understand that innovation has to be a key strategic point for the company.
- **Focus on core business**: Digital Transformation requires to startup an innovation team in parallel with the production team. In small companies this is impractical. Usually managers and employees, especially in very small businesses, focus on short-term (or tactical) activities instead of long-term strategic ones. This situation has been dramatically exploited nowadays because of the pandemic.
- **Peculiar market features**: The company innovation attitude is sometimes driven by the market, especially by the customers and the supplier requests.
- **Lack of awareness**: Companies are sceptical about the concrete advantages that can be achieved introducing AI technologies. In addition, they are not aware and lack visibility on the main regional, national and European opportunities.
- **Ecosystem building**: It is very difficult to access the right trusted ecosystem, even considering the multitude of intermediary actors, technology users do not know who can support them in their journey.

- **Employee's mistrust towards the technology**: Many employees feel in danger when hear of new potential technologies that might "replace" their work and they take position against it, being afraid that their work might be hampered or even replaced. A proper awareness campaign should be put in place to make them aware about technology advantages and their potential work upgrading.

When it comes to the latter phases of the TU CJ, the main BP are:

- **Capital Assets**: The investment needed for the introduction of AI technologies is quite huge, both in terms of time and funding. In addition, the return on investment is highly uncertain and concrete examples of the potential advantages from the introduction of AI technologies into specific business activities are few. They are afraid not to achieve concrete results that justify the initial investments. For this reason, they need to test and experience the technology before investing. Proper testing facilities may support companies in de-risking.
- **Pressure on results**: The pressure on a successful AI technology adoption, the pressure on capital expenditure and the associated potential cost of the inability to make the change work once brought into the SME environment block the company progress.
- **Lack of technological support**: Despite the high initial investment, companies do not have proper technological resources and do not even know which resources are needed in order to successfully introduce and better exploit AI technologies. Sometime external resources help in starting up, then internal resources are not able to sustain the innovation. In addition, testing facilities are needed since companies prefer testing the solution before investing in it.
- **Lack of competencies**: One of the main identified barriers concern the lack of employees' competencies and expertise. Employees have to be properly trained to use the technology in order to benefit from it.
- **Organizational issues**: A Digital transformation Journey and the adoption of AI in the manufacturing business requires changes within several activities in the company. In addition, proper managerial skills are needed for managing the technology adoption and usage.
- **KPIs evidence**: Companies must keep monitoring their evolution since the technology introduction in order to evaluate whether they are achieving the desired results or if some corrective actions are needed. Accordingly, specific suitable KPIs are needed to make evidence of the technology adoption.

2.2. Technology Provider (TP)

Technology Providers (TP), or developers, are companies that develop technologies offered to manufacturing industries (machinery, metal, textile, food, aerospace, automotive…). They are more on the "offer-side" and their final aim within the addresses CJ is to be ready to launch the technology on the market.

Most of the 13 DIHs confirm to address, among their customers, Technology Providers organizations.

2.2.1. TP Customer Journey

The Technology Provider CJ is depicted in Figure 2.

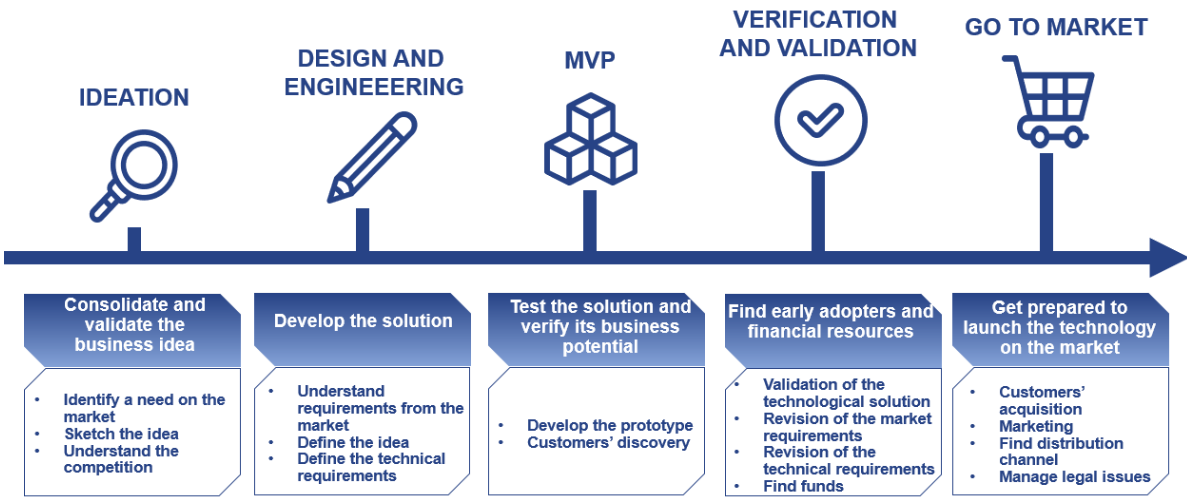

Figure 2 - Technology Provider CJ

In the **"Ideation"** phase, the TP aims at consolidating and validating the business idea. It approaches the DIH for assessing the needs for AI from manufacturing companies, as well as for understanding the main technological trends and be aware about market competition. Accordingly, the DIH let the TP enters in the proper ecosystem where it can access the market and meet strategic stakeholders, both from the industry and from the research.

The DIH supports TP with design thinking activities, fostering the development of new innovative ideas and empowering the idea creation team. In this phase TP mainly attends workshops, events and/or conferences to have a general and broad understanding of technological market needs and expectations.

In the **"Design and Engineering"** phase, TP is focused on the solution development. It gets more actively involved in the DIH community for understanding and collecting the specific business and technical requirements and for being inspired by best practices. Cross-fertilization is also considered as a strategic view for this scope.

In this phase, DIH offers workshops and more focused meetings for discussing with other stakeholders. In addition, the DIH manages the ecosystem, offering proper tools for technology maturity assessments and feasibility studies, identifying already available best practice and involving potential manufacturing users as well as key strategic experts able to support the TP in the finalization of the technology solution. The DIH also fosters the development of collaborative R&I projects.

In the **"Minimum Viable Product (MVP)"** phase, TP is willing to come up with a possible solution to be shared with the adopters in real production environments, in order to demonstrate its business potential. In this phase, proper market analysis are crucial to properly define how to develop the MVP, all the needed features according to the customers' requests.

The DIH supports the TP in the experiment development providing links with key expert players or high-level initiatives able to technically support in the realization, scouting possible funding opportunities as well as identifying manufacturing users willing to test the MVP in real environments and assess its market fit. Market analysis support is also provided.

In the **"Verification and validation"** phase, the TP is willing to complete the solution development and find early adopters in order to validate whether the proposed solution meets the market needs.

In this phase, the DIH supports the identification of potential adopters and provides useful tools for assessing market and technical requirements in order to accomplish the validation phase. Moreover, the DIH offers support in getting funds and other kind of financial resources to support the project undertaken by the SMEs.

In the **"Go to Market"** phase, the TPs focuses on the commercialization of the product to be launched.

The DIH mainly supports in setting the right ecosystem for the technology acquisition, identifying potential marketplaces and possibly supporting the TPs in the definition of proper communication and marketing strategies or further analysis to be done (e.g. neutral performance analysis).

2.2.2. TP Blocking Points

The main identified Blocking Points (BP) in the early phases of the TP CJ are:

- **Access to the ecosystem**: Access to new networks and potential end-users is crucial and often very limited especially for SMEs, that do not have a broad and well-established contacts with potential key players. In addition, they lack business sense and knowledge, which can be overcome by being in contact with the right ecosystem stakeholders.
- **Open Mindset**: A propension to innovation and an open mindset is fundamental for the development of an innovative and competitive solution to the market. The developer must be long-term oriented and able to catch the future market needs in order to be ahead of the competition.
- **Hardware**: Technical needed staff to test and validate the idea might be expensive or not easy to be found. This prevents the idea development into a concrete solution.
- **Skills and competences**: Technical analyst, data skills and a deep knowledge about technologies is needed to develop a solution. In addition, providers need to adopt new technologies as requested by their customers, and therefore they need to be aware about the maturity of the technologies.
- **Open innovation orientation**: Being able to work in a team is not enough nowadays. The ability to work in an Open Innovation environment and with a partner (even at an interregional level) is fundamental, considering also that Open Source platforms are becoming the de-facto standard.
- **Customer awareness**: The identification of business and technical customer requirements as well as the anticipation of their needs is a fundamental activity both for the solution development as well as for the service offering.

When it comes to the latter phases of the TP CJ, the main BP are:

- **Cost and effort**: Having proprietary hardware and infrastructures might be very expensive and time consuming. In addition, considering that the solution features and its complexity highly depend on customers' needs, the MVP price as well as the solution development might vary greatly.

- **Testing method**: Providers do not necessarily have equipment and datasets themselves, but need to do a feasibility study in neutral well-equipped environments (e.g. pilot line). This is necessary to determine the right target audience and test the solution on site in real environments.
- **Feedback**: In time and useful customers' feedbacks are fundamental. It is then crucial to determine how to collect feedbacks.
- **Final product**: When it comes to go from the prototype to the development of the solution, it is necessary to properly settle the right ecosystems able to let the provider access the market. Even new target segments must be considered.
- **Business method**: The mass development of the solution as well as its sustainability entails a broad knowledge all the whole business. Proper business model analysis are necessary.

2.3. Students

Students Customer Journeys have been also considered by DIHs. High-school or University students in particular might benefit from the services offered by DIHs considering that some of them collaborates with Didactic Factories or are considered a Didactic Factory themselves. Accordingly, some of the involved DIHs affirms to have an educational strategy within their mission and students as customers in their constituency.

2.3.1. Students Customer Journey

Students Customer Journey is depicted in Figure 3.

Figure 3 - Students CJ

In the **"Engage"** phase, students start being interested in the DIH ecosystem and approach the Digital Transformation and AI fields showing interest and attending events. Usually, students aim to understand more about the fields addressed during their university and post-doc carrier to better understand future opportunities and they are willing to approach soon the industrial world.

Accordingly, DIH offers services which include mainly public events, scientific conferences and Open Days inviting students into demo-labs, Didactic Factories or into companies' laboratories and/or departments.

In the **"Learn"** phase, students are willing to get more involved within the ecosystem in order to increase their theoretical knowledge.

DIH offers to organize focused workshops and events as well as proper lectures. Within the DIH community, students can also be in contact with key strategic stakeholders from the industry field, to better understand companies needs and future trends.

In the **"Practice"** phase, students aim to put the theory into practice, demonstrating what they have been studying so far. Students also approach working within cooperation projects and start working in multicultural environments.

DIH therefore offers access to proper testing and experimenting infrastructures as well as demo-labs where students can test their research into concrete real environments. In addition, DIH enhances students access to the interregional ecosystem, fostering the development of collaboration R&I projects.

In the **"Share"** phase, students have to move to an international network, joining ERASMUS projects and participating to exchange programs.

Again, the DIH interregional ecosystem gives students the possibility to fostering strong relationships with interregional stakeholders and universities according to their area of interest.

In the **"Exploit"** phase, students are willing to access the market by implementing the innovative solutions ideas they have been working on during the whole journey.

DIH supports them in accessing the digital market fostering the connection with industrial stakeholders. In this phase, the connection between the academia and the industrial fields fostered by the DIH is crucial to facilitate the students' success to the working environment.

2.3.2. Students Blocking Points

The main identified BPs of the Students CJ are:

- **Lack of Open/demonstration days**: Students' awareness of available open and demonstration days is limited. They need support from DIHs having broader awareness of the available events within their network. In addition, students need to meet companies, so that SMEs are able to find their future workers and students will get information about the companies in their own interest field.
- **Indifference to what is not curricular**: Students are usually focused on the fields and activities strictly connected to their academic career.
- **Time out of regular lesson**: Investing additional time out of regular lesson is needed in order to get involved within companies. Moreover, companies being involved in lectures might be useful to make the theory meets the practice.
- **Money to pay courses**: Deepen theoretical knowledge and becoming experts in technology might be very expensive for students.

- **Poor availability of material to study**: Lack of available open source and free material might limit students' willingness to deepen their knowledge. In addition, few studies are available on practical demonstration and concrete adoption of innovative technologies.
- **Technology facilities**: Technology facilities as well as real testing environment are not easily accessible only on a specific "project" basis for students alone.
- **Need of a team or working group**: Working adopting an Open Innovation approach is fundamental nowadays. Not only working in team capacities are needed, but also working with interregional partners as well as side by side with companies. In this way, companies and students might better understand students' knowledge on the one hand, and companies' expectations on the other hand.
- **Projects availability**: Projects availability is limited and hardly accessible for students alone. An intermediary support is necessary.
- **Missing a strong relationship network**: Students hardly have strong interregional and even regional ecosystem knowledge. They need support in creating trust and synergies with strategic innovation networks.
- **Limited access to job market**: When it comes the time to access the working environments, students should have already been accessed the industry or they must be supported in finding the right relationships. For this reason, academic and industrial collaborations are fundamental since the beginning of the students' academic career.

2.4. Policy Maker (PM)

Policy Makers are defined as regional, national or European politicians, or stakeholders in charge of developing policies and funding programs, willing to be supported in the definition and implementation of R&I policies.

Some of the involved DIHs affirm to have PMs within their customer base.

2.4.1. PM Customer Journey

The Policy Maker CJ is described in Figure 4.

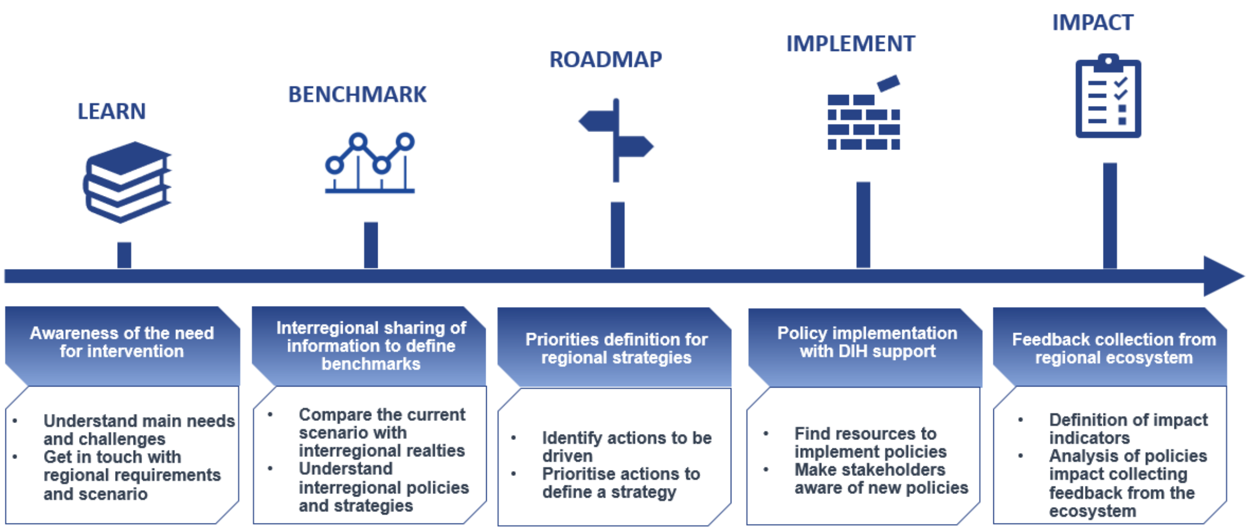

Figure 4 - Policy Makers Customer Journey

In the **"Learn"** phase, the PM is willing to raise awareness on its regional/national/European ecosystem, understanding the main needs and challenges to evaluate the need for updating or introducing a new strategy/instrument.

The DIH supports the PM in learning what is happening within the regional/national ecosystem, organizing events, round-tables and workshops aimed at highlighting the main needs and challenges and, thus, acquiring a broad comprehensive learning of the scenario. DIHs in this phase are fundamental to get closer to the industry and the other stakeholders in the ecosystem and for mapping the new value chains.

In the **"Benchmark"** phase, the PM aims at sharing the acquired information at an interregional level defining benchmarks and highlighting common R&I priorities among regions/countries. The main goal of this phase is to understand interregional policies and strategies.

The DIH, leveraging on its well-established collaborations in key strategic European initiatives (e.g. Vanguard Initiative, 4 Motors for Europe) and on the broad knowledge of the main R&I European networks (S3 Partnerships), organizes events, round-tables and workshops aimed at evaluating R&I strategies that are in place in the other EU regions and highlighting common priorities according to their S3 strategies. These activities are fundamental for the PM to better structure its policies/instruments/strategies and align them at an EU level.

The **"Roadmap"** phase is the moment for the PM to focus on the priorities definition and the collection of inputs for the definition of the R&I strategies.

The DIH supports the PM in the identification of priorities and technological trends providing inputs and contributing in the definition of roadmaps or other strategic documents for the development or upgrade of S3 strategies/work programs /national policies/instruments. To do so, the DIH leverages on the orchestration of the local ecosystem, enhancing the identification of needs, current barriers and medium-long term R&I priorities.

In the **"Implement"** phase, the PM has to execute the R&I policy/strategies implementing it within the local ecosystem.

The DIH supports the PM sharing resources for implementing the S3 strategies/policies/instruments. The DIH might be even appointed and provided with proper instruments to transfer funds to companies. Moreover, DIH fosters the dissemination of the implemented strategy/policy/instrument towards its stakeholders, through proper events or webinars to better explain the topic.

In the **"Impact"** phase, the PM is willing to receive key important Policy Impact feedbacks from the regional ecosystem.

Accordingly, the DIH supports the PM in defining proper KPIs for measuring the Policy impact and enhancing the Policy impact Assessment collecting feedbacks from the regional ecosystem and eventually creating and managing monitoring dashboards used to provide valuable feedback to the PM.

2.4.2. PM Blocking Points

The main BPs identified within a PM CJ are:

- **Lack of Ecosystem Knowledge**: Policy Makers are mainly politicians having poor direct links and knowledge about the local ecosystem. Therefore, they mainly rely on the strict relations with intermediaries and industrial association.
- **Lack of Technological competences**: PM lacks technological competencies and knowledge, which are fundamental to define a proper R&I strategy addressing future technological trends.
- **Lack of human resources**: PM usually has limited resources to be allocated for activities like understanding the regional ecosystems, attending workshops and events, since they need to focus on political and bureaucratic activities.
- **Lack of funding**: Funding resources in PM organizations are properly allocated into specific activities and low flexibility is allowed for running "extra" activities like road mapping.
- **Misalignment of regulation/legislation with roadmap**: Unpredictive variable or requirements might cause misalignments between the developed regulation/legislation and the roadmap. Constant communications with intermediaries might overcome or limit this issue.
- **Difficulties in KPIs measurement**: Finding proper KPIs to measure and monitor the impact of an implemented policy/instrument is challenging and must be properly addressed by skilled resources, that are usually not part of PM organizations.

2.5. Start-up

Start-up is an organization in the first stage of its operations willing to achieve a maturity level for the proposed idea/solution and aimed at becoming a structured enterprise. Start-ups are often quite similar to Technology Providers.

2.5.1. Start-up Customer Journey

A Start-up CJ is depicted in Figure 5.

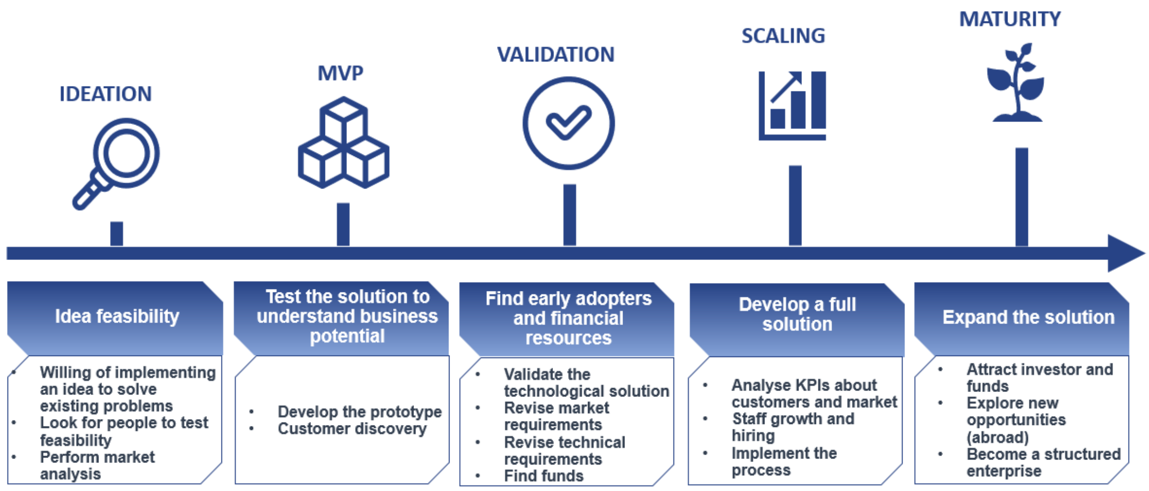

Figure 5 - Start-up Customer Journey

In the **"Ideation"** phase of a Start-up is mainly boosted by the entrepreneurial ambition. The entrepreneur, or founder, has an initial idea on how to create value, has identified a potential target market and is willing to validate the idea and assess its feasibility.

Accordingly, the Start-up approaches the DIH that offers support in feasibility studies, gives advice, and teaches the founder on how to use business models support tools. In addition, the DIH allows him to access a suitable ecosystem for testing the idea feasibility and value as well as to grasp the interest of future potential adopters.

In the **"Minimum Viable Product" (MVP)** phase, the Start-up is willing to test the solution hypothesis with the smallest possible investment of time and capital and confirm its business potential. Clarifying the target market and knowing the potential customers demand is crucial. At the same time, it is important to set up a strong team able to develop the prototype.

The DIH gives support and advices to the entrepreneur on how to run a proper and reliable market analysis. Proper networking and matchmaking events are also organized to create synergies. At the same time, the DIH supports the Start-up in finding useful funding opportunities and testing infrastructure to build the MVP, as well as providing training and experts to support the MVP development.

In the **"Validation"** phase, the goal is indeed to find early adopters and resources to validate the technological solution. Some user growth might already be available as well as some initial revenue stream. This information is critical to revise market and technical requirements, as well as to assess whether the solution fits the market, and it is sustainable over time. The feedback provided at this phase could also lead the entrepreneur to pivot its idea, maybe going back to the MVP phase.

The DIH now offers technical support to technologically validate the solution and provides best practice in the addressed field. Business model validation support techniques are also provided as well as the research for additional funding sources.

In the **"Scaling"** phase, the goal is to boost the validated solution through a considerable expansion in the number of clients. The Start-up needs to finalize the team, the processes and the channels that will be used for promoting the solution. KPIs monitoring customers demand and market analysis are important.

Accordingly, the DIH offers services, like events, suggests fairs and exhibitions, to increase the visibility of the solution. In addition, the DIH teaches the Start-up on business model expansion, pricing, risk analysis to be conducted while selling the solution. Moreover, support to find and select proper funding sources is provided and it facilitates the links with potential investors.

The **"Maturity"** phase is the moment when the Start-up has achieved a profitable market share, becoming a structured sustainable enterprise or, in same case, is willing to be acquired by/merge with another business. New opportunities are needed to access new markets and assure the sustainability of the organization.

The DIH supports the Start-up to geographically growth, assessing interregional markets as well and teaches how to become a structured enterprise leveraging on Sustainable Business Models strategies. If the Start-up is willing to join another company, the DIH might support it in finding the right acquirer.

2.5.2. Start-up Blocking Points

The main identified BPs of Start-up CJ are:

- **Lack of time and skills for Market Analysis**: Start-up founders are not always capable of conducting alone proper market analysis. Knowing proper techniques and be able to identify and access the right ecosystem is a critical milestone while generating an innovative idea.
- **Poor Ecosystem Knowledge**: Knowing potential market adopters is crucial and often very limited for Start-ups that have a poor and limited contacts with potential key players and stakeholders that might assess the market fit of the solution.
- **Lack of human resources for the business development**: Human resources are limited in Start-ups business, that are often initiated by a founder with a limited team. Teams, moreover, are not always comprehensive of all the needed skills to properly run the business expansion.
- **Lack of technological/technical resources for the solution development**: Technological/technical resources are limited in Start-ups business, that lack of the needed Artificial Intelligence and ICT competences to actually develop innovative solutions. Testing infrastructure access is also difficult.
- **Lack of funding**: Funding resources are very limited in Start-ups business, that are sometimes given with a certain limited amount of financial resources that must cover all the needed activities and is difficult to be properly managed without accurate financial plan.
- **Access the local and interregional Market**: Being able to access the target market require proper channels and contacts. Accessing the interregional market is even more difficult for Start-ups alone.
- **Business method**: The mass development of the solution as well as its sustainability entails a broad knowledge all the whole business. Proper business model analysis is necessary.

2.6. Experimenters

Experimenters are considered organizations joining Open Calls (OC) of R&I projects and willing to successfully adopt/develop the proposed solution within their business. They can belong both to the demand- as well as the offer-side.

2.6.1. Experimenters Customer Journey

An Experimenter CJ is depicted in Figure 6.

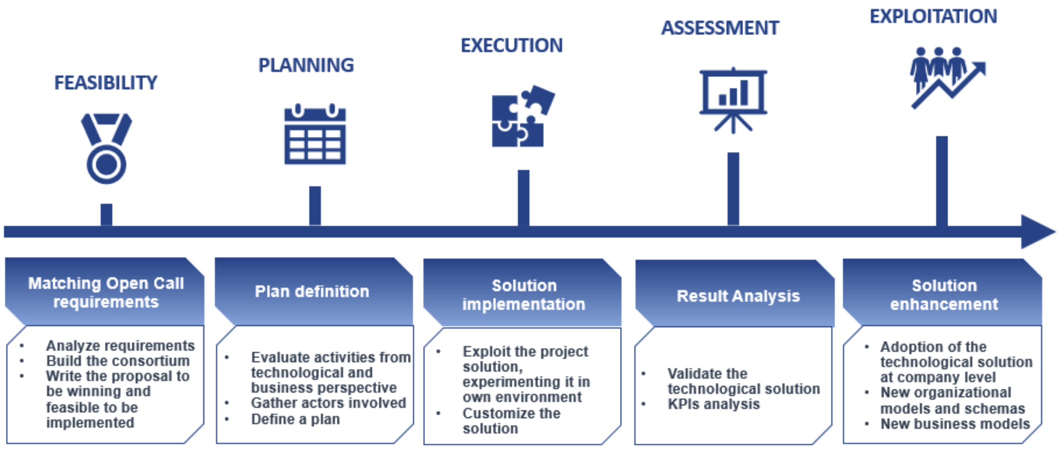

Figure 6 - Experimenters Customer Journey

In the **"Feasibility"** phase, an Experimenter has just come through the Open Call willing to apply for according to the focused topic of its interest. It has now to follow a set of activities and steps in order to match the OC requests, like analysing the requirements, evaluating whether all company characteristics are eligible for the call, building the consortium when requested and write a successful application.

The DIH offers therefore support in the preliminary activities, like analysing the companies' requirements and needs according to the DIH expertise and enhancing the consortium definition, if needed, with matchmaking activities leveraging on its interregional ecosystem. In addition, the DIH provides useful tips and suggestions in the proposal building, considering the specific company's needs and expectation.

In the **"Planning"** phase, once the proposal has been admitted, the Experimenter has to define a proper plan evaluating both business and technological activities to be developed in order to test the technological concept and assess the potential value of the solution.

The DIH supports the Experimenters with feasibility studies, providing best practices examples, and technical expertise leveraging on the project network competencies and capabilities. In addition, it can support Experimenters in realizing a successful plan for the next phases.

The **"Execution"** phase is the moment for the Experimenter to exploit the projects solution and implement it in its real environment.

Accordingly, the DIH offers technical skills and competences for concretely introducing the solution, as well as feasibility plan and business strategies for managing the transformation inside the organization.

In the **"Assessment"** phase, the Experimenter needs to analyse the results achieved so far to validate the technological solution.

The DIH supports the identification of proper KPIs to be monitored and provides useful tools and strategies to collect feedbacks and lessons learnt, internally and/or outside the company (e.g. interviews to employees whose working activities might be impacted from the solution introduction or other addressed stakeholders).

In the **"Exploitation"** phase, the Experiment is willing to uptake the technological solution at a company level. Proper management and organizational skills as well as funding sources are therefore needed.

Accordingly, the DIH offers all the needed competences, technical expertise, management skills, new business models as well as change management competences that enhance a successful technology adoption.

2.6.2. Experimenters Blocking Points

The main identified BPs of Experimenters CJ are:

- **Ecosystem access and knowledge**: Knowing and having access to proper interregional ecosystems environments is often limited to local companies, that need to find suitable partners (both industrial and academic) to build R&I consortia.
- **Applications requirements**: Local companies have usually limited capabilities in developing successful interregional proposals. They do not clearly understand the Open Calls application requirements and objectives.
- **Lack of know-how**: The lack of employees' competencies and know-how often hamper the organizations willingness to join interregional application. Employees are not used to manage solutions to be developed with third-parties.
- **Lack of Human Resources**: Organizations usually have limited resources to be allocated for managing innovation project solutions as well as for managing the bureaucracy that is implied.
- **Poor interregional attitude**: Local companies are not confident in working with interregional partners for developing technological solutions that will be then adopted inside their business. Employees in particular face several challenges in interacting and exchanging confidential information with foreign stakeholders, that hardly know their local operations and behaviour.
- **Lack of technical skills**: Technical skills and a comprehensive knowledge about technologies are needed to develop innovative solution even if it is developed within innovation consortia having technical partners.
- **Organizational issues**: In order to successfully implement and uptake a solution, proper organizational changes have to be faced. They often lead to organizational issues to be managed with several companies' functions involved.
- **KPIs and Evidence**: KPIs are needed to monitor and assess the solution feasibility and sustainability. However, it is not always clear which KPIs to be considered and how to interpret them.
- **Lack of funds**: Funding and investments resources offered by the OC are not enough to fully adopt the solution developed within the company. Additional resources are needed.

3. Experiments business and innovation scenarios

Chapter 3 provides an overview of the SME- and DIH- driven experiments scenarios and expectations. Overall, 17 Industrial Experiments are running in AI REGIO: 7 Experiments in Four Motors regions are SME-driven, while further 10 Experiments in the other nine Vanguard regions are DIH- driven. Experiments all focus on innovative AI in several Manufacturing domains: metal sheets, machine tools, industrial encoders, automation systems, plastic products, modular production.

Experiments have been divided into 4 main clusters according to the main addressed technological domain, and for each of the cluster an Experiment Cluster Leader has been nominated, namely:

- Cluster 1 "Product Engineering and Lifecycle Management", led by CEA;
- Cluster 2 "Factory efficient and sustainable manufacturing", led by Eurecat;
- Cluster 3 "Quality control and predictive maintenance", led by Nissatech;
- Cluster 4 "Robotics and Human Interaction", led by STIIMA.

The following sections depict the AS-IS and TO-BE scenarios foreseen by experiments. Moreover, the main challenges identified in the current status that could be overcome by introducing Artificial Intelligence have been reported, as well as the main expectations.

Experiments' information has been collected following a structured path that leveraged on the use of TRIAL Handbook (TRIAL HDB). Every experiment was indeed requested to provide detailed information filling the Chapter 1 "Experiment overview" of the TRIAL HDB. Then, experiment Clusters leaders have been involved in a quality assurance process reviewing the contents provided by experiments and asking for possible integrations.

Final inputs have been summarized in the following sections of the present deliverable and aggregated according to the 4 identified experiments Clusters, while detailed information of the 17 Experiments business and innovation scenarios are available upon request in Chapter 1 of the TRIAL HDB.

3.1. Cluster 1: Product Engineering and Lifecycle Management

Cluster 1 addresses experiments willing to adopt Artificial Intelligence in product engineering and lifecycle management domain, mainly leveraging on expert systems able to support operators in maintenance operations within the product lifecycle as well as during design and planning phases.

In particular, 3 experiments belong to Cluster 1, as depicted in Table 1:

	Four Motors regions	*Vanguard regions*
Product Engineering and Lifecycle Management	• Exp 02 - NLP for Maintenance Report Analysis in Machine Tools (INTELLIMECH) • Exp 03 - Anti-Tampering Devices for Connected Objects (S2P) • Exp 04 - AI for better life cycle and project management for plastronics product (SWARM)	

Table 1 - Cluster 1 Experiments

3.1.1.1. Cluster 1 AS-IS Scenarios

Exp 02 - NLP for Maintenance Report Analysis in Machine Tools (INTELLIMECH)

“Natural Language Processing for Troubleshooting” is an SME-driven experiment in Lombardy, led by Consorzio Intellimech, a consortium in the field of Mechatronics. The first experiment end-user is Fassi S.p.A, a crane manufacturer in Lombardy (Italy).

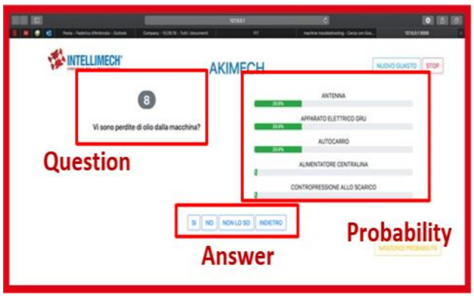

Figure 7 - Exp 02 AS-IS

The company currently uses a basic troubleshooting tool to help operators in the identification of faulty components and their failure mode. To this purpose, the system requires the operator to specify the machine faults category (overall 56 subcategories) and to answer a certain number of closed questions. Then, the tool suggests a set of broken components and, if possible, its related failure mode. Intellimech enhances the capability of this tool switching from the rigid system, based on a classical decision tree logic, to a more flexible algorithm, but there is still room for improvement exploiting AI potentialities towards a self-learning approach.

Exp 03 - Anti-Tampering Devices for Connected Objects (S2P)

“Anti-tampering devices for connected objects” is a SME-driven experiment in France, led by S2P, a company having strong activity in the so-called anti-tampering devices.

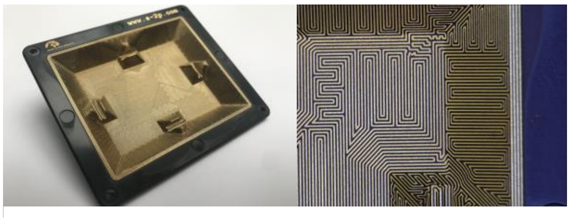

Figure 8 - Exp 03 AS-IS

Currently, there is no software able to route conductive tracks in 3D and thus engineers need to do it by themselves, directly on specific CAD software tools. The goal is to draw line per line all tracks on the 3D faces in order to cover all area. During the routing, all constraints and design rules from the technology need to be respected as geometry, size of the tracks, number of tracks intermeshed, multilayer, contact points with the electronic board. This activity is heavily time consuming since it needs several tries and so a lot of time.

Exp 04 - AI for better life cycle and project management for plastronics product (SWARM)

“AI for better life cycle and project management for plastronics products” is a SME-driven experiment in Auvergne-Rhône-Alpes (France), led by SWARM, an SME that promotes innovative technologies and creates end-to-end industrial experiment to drive digitalization.

Given the state-of-the art of the current platform, and in some case, the data in any of these systems must be re-created in one or more of the upstream systems to improve data consistency, particularly if we are not dealing with the same data structure. This situation quickly leads to information silos.

3.1.1.2. Cluster 1 Main Challenges

The main challenges highlighted by the cluster 1 experiments are summarized as follow:

- **Rigid and unreliable production systems**: Current systems used in Product Lifecycle Management are quite obsolete, based on rigid logics and not objective, since they are heavily dependent on the operators' behaviors and on the way they interact with the system. In addition, such systems usually rely on historical data that are often quite limited. These aspects bring to unreliable answers or not to the best solutions for operators in manufacturing operations (#Exp 02 – 04).
- **Time spending activities**: Operators currently spend a lot of time for understand how to use the available systems, since they are usually rigid, quite difficult to understand and not user-friendly. This is translated in budget consuming activities and low productivity (#Exp 02 – 03 – 04).

3.1.1.3. Cluster 1 TO-BE Scenarios

Exp 02 - NLP for Maintenance Report Analysis in Machine Tools (INTELLIMECH)

The new troubleshooting system is expected to be equipped with an advanced interaction tool, namely a voice dialogue between the operator and the system, based on a self-learning mechanism and enhanced overall processing logic. The system would be able to understand operators' observation, reply and continue the investigation based on its available knowledge and Natural Language. Firstly, the interactions will be textual-based. Then, the voice-based user interface will be introduced, where inputs will be generated using speech-to-text technologies and the same textual answer will be vocally proposed by the system.

Exp 03 - Anti-Tampering Devices for Connected Objects (S2P)

The experiment aims at finding a design tool able to act as an engineer in an autonomous way, having a random and unique mesh for each part produced, at the same price offering a good solution. The foreseen solution will be focused on automatic filling and different solutions might be adopted.

AI could definitely help S2P to design like an "Engineer" the tracks automatically and randomly for defence, aerospace, payment and medical industries. The solution could lead to a huge decrease of development time and cost, while increasing the use of such security devices in many markets. It could improve the overall security of massive distributed IoT systems.

Exp 04 - AI for better life cycle and project management for plastronics product (SWARM)

The mail goal of the experiment is to shorten the engineering cycle and investigate a large panel of product option and to bring services to SMEs for new products and processes design.

AI will be used for continuous improvement of some issues on the basis of historical project execution and rule basis system, especially for plastic products.

3.1.1.4. Cluster 1 Expected results

- **Increase flexibility in production**: Systems able to self-learn and provide rapid answers to operator would increase flexibility in production engineering and lifecycle management phases. In addition, these systems will be able to self-feed over time, without a huge amount of needed data (#Exp 02 – 03).
- **Improve systems reliability**: Intelligent system not based on personal or subjective interpretations would improve the reliability of the product/machine (#Exp 02 – 04).

- **Increase customer loyalty**: As a consequence, to the increased flexibility and reliability, AI based-solution would allow to support customers in a more efficient and effective way, being more flexible and rapid in answering to customer requests, even reducing time spent in finding the right person able to solve the specific customer issue (#Exp 02).
- **Increase personnel productivity**: The introduction of intelligent autonomous systems that take over strategic manual tasks or support operator in increasing their performances might lead to a higher productivity (#Exp 03 – 04).

3.2. Cluster 2: Factory Efficient and Sustainable Manufacturing

Cluster 2 includes experiments willing to adopt Artificial Intelligence in the factory efficient and sustainable manufacturing domain, mainly focused on introducing intelligent tools and solutions willing to support the planning and scheduling phases, in order to optimize demand forecasting and manufacturing processes.

In particular, 5 Experiments belong to Cluster 2, as depicted in Table 2:

	Four Motors regions	*Vanguard regions*
Factory Efficient and Sustainable Manufacturing	• Exp 05 - AI-based Predictive Dynamic Production Planner (HOHNER)	• Exp 09 - AI-based Process Control (Royal Eijkelkamp, RADBOUD UNIVERSITY) • Exp 10 - AI-based Process Control (ARMAC, RADBOUD UNIVERSITY) • EXP-12: Intelligent Computer Vision for Digital Twin and Reinforcement Learning for Assembly Line Balancing (INESC TEC) • Exp 17 - Industrial processes AI-based Optimization (TECNALIA)

Table 2 - Cluster 2 Experiments

3.2.1.1. Cluster 2 AS-IS Scenarios

Exp 05 - AI-based Predictive Dynamic Production Planner (HOHNER)

"AI-based Predictive Dynamic Production Planner" is an SME-driven experiment in Catalonia (Spain), led by Hohner Automáticos S.L, a leading manufacturer of incremental and absolute encoders, inclinometers, potentiometers, linear measurement solutions and accessories.

Hohner has two very different types of lines, the LS (serial line) and LNS (Non serial line) that require high flexibility and limited volumes. Currently, production planning is carried out manually and daily based on the existing manufacturing orders in the ERP, the available workers, and the functional work centres. Moreover, multiple validations are carried out throughout the manufacturing processes, providing traceability of the manufacturing quality. It results in a current inefficient management of the production planning, where some actions still rely on the experience of production responsible. In addition, demand forecast is not highly reliable since it depends on historical sales, thus leading to a basic estimation of the demand.

Exp 9 - AI-based Process Control (S/PARK, RADBOUD UNIVERSITY)

"AI-based Process Control" is a DIH-driven experiment in the East of the Netherlands led by Royal Eijkelkamp and RADBOUD UNIVERSITY.

This experiment involves the SME Royal Eijkelkamp, a company delivering solutions for (environmental) soil and water research and monitoring. This experiment has been recently established as a substitute to the original one, led by S/PARK, a pilot plant and laboratory facilities aimed to be extended with advanced process / production monitoring software and hardware to assist the SME in the upscaling developments and to get the SME acquainted with this kind of AI supported technology. Unfortunately, due to the pandemic crisis caused by Covid-19, the S/park initiative is currently on hold and Radboud University managed to find the new Royal Eijkelkamp experiment.

Exp 10 - AI-based Process Control (ARMAC, RADBOUD UNIVERSITY)

"AI-based Process Control" is an DIH-driven experiment in the East of the Netherlands led by ARMAC, a SME focused on industrial automation, and RADBOUD UNIVERSITY.

The experiment addresses one of the company's customers, SVP, which is a district heating (DH) system of the city of Purmerend. Despite this plant has been considered efficient, as the source fuel is kept ecologically sustainable, there is a need for further efficiency increase from the operational side. The system indeed is not driven by the supply, but the demand of customers for heat. The heat demand is estimated from the operator expertise, that use previous experience, the weather conditions, the day of the week and the season, as a basis for decision making. However, this kind of control is non-optimal, and might be inaccurate, mainly because the weather conditions can vary greatly in a short period of time, affecting the heating demand, and leading to heat loss.

EXP-12: Intelligent Computer Vision for Digital Twin and Reinforcement Learning for Assembly Line Balancing (INESC TEC)

"Intelligent Computer Vision for Digital Twin and Reinforcement Learning for Assembly Line Balancing" is a DIH-driven experiment in Porto, Norte region of Portugal, led by INESC TEC.

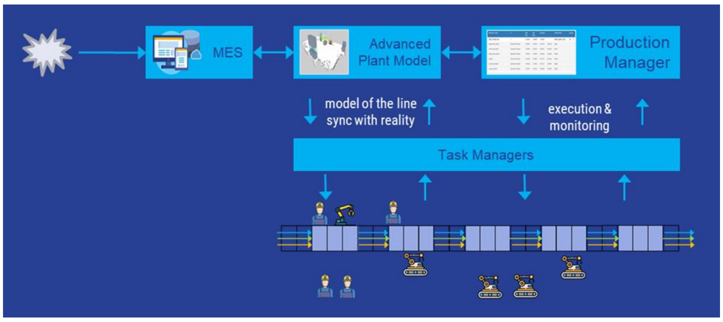

Figure 9 - Exp 12 AS-IS

Currently, in the addressed production line, the balancing solution leverages on mathematical optimization techniques, aims at minimizing the number of production resources and workstations to use in the line, constrained by the desired cycle time (takt time). In particular, the optimization method takes as input the task precedence per product type, the task processing time per resource, the skills implemented by each available resource and the desired cycle time. The plan of operations is developed by a Manufacturing Execution System (MES) and exported to the Advanced Plant Model (APM), the Digital Twin of the manufacturing area, which consolidates the information with the robotic programs that are coded in the form of state machine. During the execution of the operations in the assembly line, there are two main causes of uncertainty: machine failures and unavailability of operators.

Additionally, processing times are stochastic. Among other things, these factors contribute to deviations in the expected processing times defined by the MES system.

EXP-17: Industrial processes AI-based Optimization (TECNALIA)

"Industrial processes AI-based Optimization" is an DIH-driven experiment in Basque Country (Spain), led by Tecnalia.

The experiment involves Mecanifran, a Spanish SME in the automotive sector focused on the machining process of nuts and screws. The current industrial process is not very flexible and requires high quantities orders to have revenues. The quality of nuts and screws is quite strict, and very much related to the status of the tooling used for the machining. Currently, tooling is replaced quite soon before their performance is degrading in order to maximize the quality of the produced pieces. This behavior has important impact on the annual costs, so a maximization on the tooling usage, while maintaining the machining quality would impact considerably on the company accounts.

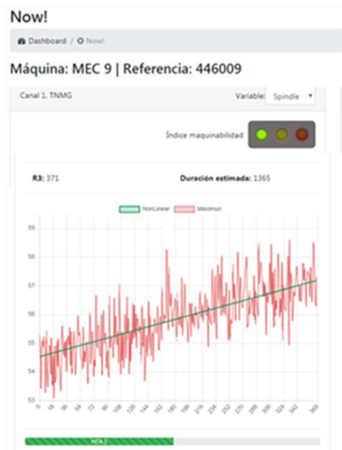

Figure 10 - Exp 17 AS-IS

3.2.1.2. Cluster 2 Main Challenges

- **Rigid and unreliable planning and scheduling systems**: Current approaches are not readily adaptable to changes (e.g. in demand and products, assets capacity and availability) and they usually are not able to consider a multitude of variable at the same time (e.g. assets and capacity are usually planned separately). This is often translated into unfeasible plans, large direct and indirect costs, excess inventories, and customer service inefficiencies (#Exp 05 – 10 – 12 - 17).
- **Knowledge management**: Operators' knowledge based on previous experience achieved in time is fundamental for running many companies' activities and take strategic decisions. Its knowledge is not automatically translated and acquired by current systems and personal expertise still rely on the operator presence in the company (#Exp 05 – 10).
- **Increase customization**: Increase the customization of products is a desired strategic target that usually leads to frequent machine downtimes and thus huge productivity losses, over costs and delays in deliveries (#Exp 05).

3.2.1.3. Cluster 2 TO-BE Scenarios

Exp 05 - AI-based Predictive Dynamic Production Planner (HOHNER)

This experiment introduces a planning and scheduling module for production process.

The expected solution consists of a sequencing & planning engine, so that in real time they modify the scheduling of the production and support the supply of raw materials, adapting it to the reality of the day to day in the shop floor. The solution considers all types of data, structured or not, that influence in the manufacturing results and therefore has an impact on productivity, quality, costs, service, maintenance, among others. In addition, the module includes a demand prediction module that estimates the future demand providing a new input to the planning algorithms. The planning and scheduling module is linked with the legacy systems in order to support the production manager and inventory manager in the day to day on the shop floor.

Exp 9 - AI-based Process Control (S/PARK, RADBOUD UNIVERSITY)

The experiment in collaboration with Royal Eijkelkamp will develop and incorporate monitoring AI solutions (based on the assets of SKU) for their products and/or processes, being measurement and monitoring technologies (sensors and sensor networks).

Exp 10 - AI-based Process Control (ARMAC, RADBOUD UNIVERSITY)

The AI will be applied to forecast the heat demand based on the weather conditions and forecast information at the city of Purmerend. It is expected that the energy efficiency will increase after the adoption of AI. This will help the operators along the decision making on heating demand, saving energy and keeping the system more efficient. It is expected that the AI system will reduce the heating loss.

EXP-12: Intelligent Computer Vision for Digital Twin and Reinforcement Learning for Assembly Line Balancing (INESC TEC)

The experiment aims to dynamically allocate production resources to manufacturing tasks to better face these uncertainties. A neural network will be trained to better decide which resource to allocate to a task. The general goal of the experiment is to re-balance the manufacturing line so as to minimize the number of production resources and workstations to use while keeping a constant cycle time aiming to achieve the imposed takt time. Then, the experiment aims to advance the limitations of the digital twin by combining the existing digital representation with the usage of computer vision integrated with artificial intelligence methods deployed either on the robot, the cloud, or in an edge layer.

EXP-17: Industrial processes AI-based Optimization (TECNALIA)

The experiment aims to develop a predicting model trained on historical data of machining control parameters and supervised by the quality control at the end of the lines. The tool will support operators in tooling change decision leveraging on the information provided by the online tool. On the other hand, the expected solution will consist of an optimization tool on top of the previous predicting model. This optimization tool will provide a set of solutions to maximize the tooling lifetime of the modelled machine. This solution will prescript the controlling parameters of the machine.

3.2.1.4. Cluster 2 Expected results

- **Increase of the Overall Team Effectiveness and productivity**: Having real-time information and intelligent systems able to considers current and expected work, would allow to better plan and coordinate the teamwork, improving the flow of material and orders in progress from the factory and maximizing their productivity (#Exp 05 – 12 - 17)
- **Increase production/energy efficiency**: A short and long-term planning would be efficient for the use of resources, improving and regulating the use of machines, avoiding peaks in operation without proper maintenance. Planning is expected to reduce machine setups, optimizing the quantities to be manufactured and avoiding machine setup times. This would also allow to have a more adequate maintenance plans for the machinery and thus extend the useful life of the machines. (#Exp 05 – 10 – 12 – 17)
- **Increase manufacturing lines flexibility**: The adoption of AI-based systems (e.g. neural networks) able to consider several different variables in real-time and providing new solutions for the manufacturing line would highly increase the line flexibility (Exp 12)

- **Minimize machine downtime**: Intelligent systems able to anticipate the machine failure would suggest the perfect time for replacements, in order to optimize the machines usage and decrease the maintenance costs. (#Exp 17)
- **Quality assurance**: The introduction of innovative AI-based tools might allow the assurance of the production processes as well as the products quality. (# Exp 17)
- **Inventory and/or production cost reduction**: Optimal planning, based on historical data, is expected to improve the internal processes (e.g. inventory management, heat & finished material production, among others). This would avoid costs stopped in warehouses, high costs in the acquisition of raw material for emergencies at the reception and a surplus of production. (#Exp 05 – 10 - 17)
- **Increase customer satisfaction**: Automatic and optimized planning is expected to improve delivery times and minimize the date changes initially set for deliveries, impacting final customer satisfaction. (#Exp 05)
- **Operators support & wellbeing**: Intelligent systems able to address several variables and providing objective information and optimal planning support operators along the decision-making process and reduce the stress peaks during production process. (#Exp 5 – 10 – 17)

3.3. Cluster 3: Quality Control and Predictive Maintenance

This cluster includes experiments willing to adopt Artificial Intelligence in the quality control and predictive maintenance domain, mainly to optimize quality control process and strategies, as well as after sales activities.

In particular, 5 Experiments belong to Cluster 3, as depicted in Table 3:

	Four Motors regions	*Vanguard regions*
Quality Control and Predictive Maintenance	• Exp 07 - Predictive Analytics based on few-shot learning (ARCULUS)	• Exp 13 - AI-enhanced control strategy for production environment (ART-ER) • Exp 14 - A Smart Predictive Maintenance Toolbox for drawing lines of car body element (AIN) • Exp 15 - Water leakage detection (UM) • Exp 16 - IDSS for predictive quality assurance (COMET)

Table 3 - Cluster 3 Experiments

3.3.1.1. Cluster 3 AS-IS Scenarios

Exp 07 - Predictive Analytics based on few-shot learning (ARCULUS)

"Predictive Analytics based on few-shot learning" is an SME-driven experiment in Ingolstadt/Munich (Germany), led by Arculus, a software and robotic solutions for intralogistics manufacturer, and supported by the FZI.

Figure 11 - Exp 07 AS-IS

Arculus currently operates an active Autonomous Mobile Robot (AMR) fleet, a block storage system, in a productive plant at the customer's site, where the dust contamination degree is one of the major challenges. Finer dust can lead to lumps forming that, if relevant, the laser scanner identifies as a massive object leading to a fault state. The contamination of the laser scanner cannot currently be detected automatically and a manual cleaning of all several laser scanners is currently carried out every two hours.

Exp 13 - AI-enhanced control strategy for production environment (ART-ER)

"AI-enhanced control strategy for production environment" is DIH-driven experiment in Emilia-Romagna Region (Italy), led by ART-ER.

Production line controlling strategy has always been a human-centered activity, due to the need for a clear and wide view and understanding of the potential issues coming from the different areas of the production environment, starting from the warehouse management to the final delivery. This activity then strongly depends on the previous SME experience and knowledge. In addition, processing information is extremely time-consuming, and not all the SMEs are interested in spending personnel efforts in elaborating data and interpreting them.

Exp 14 - A Smart Predictive Maintenance Toolbox for drawing lines of car body element (AIN)

"A Smart Predictive Maintenance Toolbox for drawing lines of car body elements", is an DIH-driven experiment in Navarra (Spain), led by Asociación de la Industria Navarra.

The current scenario is characterized by the fully manual process carried out in the predictive maintenance of the drive system of mechanical stamping presses. This process is based on the periodic measurement of the vibrations on the drive system (motor, flywheel, gearbox, crank and connecting rods, ...). In the current method a specialist technician performs the measurement of vibration signals at different points of the machine as well as the synchronism signals between each stamping cycle. Once the data has been collected, it is necessary to process the signals using previously developed algorithms to eliminate those components of the signal that have nothing to do with the condition of the drive system, but with vibration components due to the excitation of natural frequencies by the impacts that occur in each stamping cycle.

Exp 15 - Water leakage detection (UM)

"Water Leakage detection" is an DIH-driven experiment in Slovenia, led jointly by Mariborski Vodovod d.o.o., the main water supplier in Eastern Slovenian region (Slovenia), and University of Maribor.

The SME has developed its own modern sensor network system for monitoring water consumption. Some parts of the pipe network, due to financial limitations, are 50 years old. The monitoring consumption system provides real time data that are acquired by flow sensors and are recorded into the database. However, no adequate reasoning has been applied and thus no alarms for detecting water leakages within the pipe network are produced.

Exp 16 - IDSS for predictive quality assurance (COMET)

"IDSS for predictive quality assurance" is a DIH-driven experiment in Friuli – Venezia Giulia (Italy), led by COMET – Cluster Metalmeccanica FVG in close coordination with its relevant DIH IP4FVG and the University of Udine focused on quality control.

Currently, still low knowledge and awareness is reflected in the quality control domain within local SMEs, which are resistant to change and cannot understand the advantages from the introduction of AI in quality operations. However, predicting manufacturing quality is one of the crucial measures for quality management, which is hampered by companies' mindset, poor skills as well as lack of historical data for the development of predictive systems. The experiment focuses on the development and implementation of quality management systems. In particular, within the addressed use-case, the cobot aided visual inspection system leverages on a machine learning application that has been trained with a very low amounts of faulty pieces, with the use case also composed of an advanced machine vision system and a robotic arm that picks up the parts and places them to the assembly station once the quality test is passed. Business problems addressed there are related to automation and quality control and augmented operation speed, guaranteeing at the same time feasible safety conditions in human – robot collaboration plus flexible and configurable settings if process changes.

3.3.1.2. Cluster 3 Main Challenges

- **Critical variables detection and data management**: The collection of data from a running production line or other working environment is still a critical activity and needs the implementation of proper systems able to preserve the data without contamination. In addition, there are many critical variables which cannot be detected by ordinary systems or basic sensors and such variables threaten the reliability of quality systems, impacting also on production phases. (#Exp 07 - 13 – 14 - 15 – 16)
- **Time consuming activities**: Currently still many activities are performed manually and are very time consuming, causing both production slow-downs and frequent human errors that decrease quality performances. (#Exp 07 - 14).
- **Knowledge management:** Several activities strongly depend on the previous operators' experience and knowledge, which cannot be automatically translated and acquired by current systems (#Exp 13 - 14)
- **Facing rapid customer needs change**: Customer needs may change during the setup of a complete quality control system, this must be properly managed introducing systems able to improve operations flexibility. (#Exp 13).

3.3.1.3. Cluster 3 TO-BE Scenarios

Exp 07 - Predictive Analytics based on few-shot learning (ARCULUS)

The use of AI in predictive algorithms would trigger cleaning operations only as required when needed, driving the vehicle to a maintenance location where ergonomic cleaning operations are possible.

In addition, the AMR automatically controls an automated cleaning station based on the detection of the degree of contamination and is cleaned automatically. This means that manual intervention is no longer necessary.

Exp 13 - AI-enhanced control strategy for production environment (ART-ER)

The experiments concern the setup of an inter-regional grid of innovation laboratories in the field of AI in the frame of the AI&HMI activities. One of these laboratories will be coordinated by ART-ER and will provide service in the Controlling Strategy Solutions field. The AI-enhanced control strategy for production environment meets the need from SMEs to better their production environment control strategy by mean of application of AI technology.

Exp 14 - A Smart Predictive Maintenance Toolbox for drawing lines of car body element (AIN)

In the new scenario, the stamping facilities will have autonomous systems, based on AI, to anticipate failure with a system for notifying maintenance needs. In the transition to this situation, current systems will need supervision by expert personnel. This is the foreseeable situation after the implementation of the experiment. In this scenario, one of the main weaknesses for the extrapolation of the experiment results to the sector is the lack of monitoring systems in the machines, and, therefore, the absence of defect data necessary for the training of the fault classification algorithms. In the first place, data is necessary but, in most cases, it is not available, especially when it comes to old installations. This problem will gradually disappear thanks to the hardware cheapening and the emergence of low-cost IoT solutions. On the other hand, it is necessary to have defects, well characterized, for the learning of the defect classification algorithms (Machine Learning), for which it is necessary to have enough time for some defects to occur. When this information is not available, expert system techniques can be implemented that reproduce the analysis method of an expert in analysis and diagnosis of failures by vibration analysis.

Exp 15 - Water leakage detection (UM)

The goal of the experiment is to provide alarms that signal water leakage from pipe network system. AI will be used to detect and monitor water consumption. The remote sensing data can be used to detect wet zones. The goal is to automatically estimate wet zones over the waterpipe network, compare the results with the water consumption of the network and build up AI based reasoning for water leakage detection using satellite remote sensing data and ground data. The water leakage concept monitoring can be divided into two separate experiments. The first one uses advantages of water flow meters that are installed over the entire water pipe network and the concept of soil moisture estimation using the remote sensing data.

Exp 16 - IDSS for predictive quality assurance (COMET)

Starting from the assumptions arisen from the benchmark system represented by the cobot aided visual inspection system, currently functioning within the premises of the DIH-AMS (IP4FFVG Node in Pordenone), the experiment is focused on the implementation of an evolved use case for quality control to be installed within the premises of the Node of Udine.

3.3.1.4. Cluster 3 Expected results

- **Increasing efficiency of maintenance operations**: The minimization of manual activities is critical in order to increase efficiency. Manual activities have to be substituted with proper intelligent systems that would reduce time of costs for maintenance operations. (#Exp 07 - 14)
- **Optimized production management**: A better production line management will also allow productivity enhancement and reduction of dead costs, such as warehouse management and waste management. (#Exp 13 – 16).
- **Improve safety conditions**: A better coordinated production line management brings benefits in terms of safety for workers and final product quality. (#Exp 13).
- **Increased efficiency of quality operations:** Automated quality control might reduce manual inspection, thus increasing both the quality operations performances as well as decreasing quality costs. (#Exp 14 - 16).

- **Increase of final product quality**: Final product quality will also benefit from production management optimization and increased safety conditions, having less stressed workers able to improve their performances. (#Exp 13 - 14).
- **Increase human resources satisfaction and wellbeing**: AI tools supporting operators might lead to an increase and enriched working conditions. Some tools might also bring to a positive change in the way workers and production managers interact, also providing benefits to single workers in terms of satisfaction and to the whole team in terms of team-building. (#Exp 13)

3.4. Cluster 4: Robotics and Human Interaction

This cluster holds experiments willing to adopt Artificial Intelligence in Robotics and Human Interaction domain, mainly to support operators in daily activities with the use of expert systems, robotics arms, augmented reality devices.

In particular, 4 Experiments belong to Cluster 4, as depicted in Table 4:

	Four Motors regions	*Vanguard regions*
Robotics and Human Interaction	• Exp 01 - Machine Vision for Warehouse Optimization (GUALINI) • Exp 06 - AI-Supported Robot Trajectory Optimization (Kautenburger GmbH)	• Exp 08 - AI-enabled Operators Assistance through AR (BRAINPORT) • Exp 11 - Automatic Capability Matchmaking for Re-configurable Robotics Platform (TAU)

Table 4 - Cluster 4 Experiments

3.4.1.1. Cluster 4 AS-IS Scenarios

Exp 01 - Machine Vision for Warehouse Optimization (GUALINI)

"Machine Vision for Warehouse Optimization" is an SME-driven experiment in Lombardy (Italy), led by Gualini Lamiere International, a leading company in advanced sheet metal processing and heavy carpentry production.

In the current scenario, metal sheets arriving at the warehouse have to be settled and placed on the ground because of their huge weight and dimensions, and then they are labelled. The current labelling is inefficient, since label cover is made by the pile structure and the frequent handling of the sheets exposes the label to a physics degradation or rips. Moreover, sheets are hardly recognizable at a first glance. The research of the right sheet for production is very inefficient, causing huge loss of time and, thus, higher cost of production and consequently higher price for the customer.

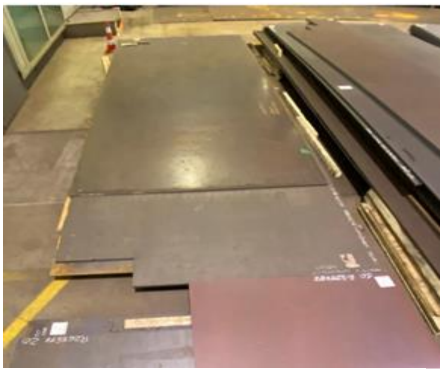

Figure 12 - Exp 01 AS-IS

Exp 06 - AI-Supported Robot Trajectory Optimization (Kautenburger GmbH)

"AI-Supported Robot Trajectory Optimization" is an SME-driven experiment in Germany, led by Kautenburger, a company providing services for machine and plant construction as well as steel and tank construction.

Figure 13 - Exp 06 AS-IS

Currently, in site Kautenburger GmbH, the robot arm is used to mill the aluminium workpiece with defined trajectories without any external Tool Center Point measurement devices and compensation strategy. The deviation of the milling paths is larger than desired due to the lack of rigidity of the robot arm, the requirement of fast milling and the workpiece material properties.

Exp 08 - AI-enabled Operators Assistance through AR (BRAINPORT)

"AI-enabled Operators Assistance through AR" is a DIH-driven experiment in the Brainport region, led by Brainport Industries and Brainport Development (represented by the High Tech Software Cluster) and focused on Human Machine Interaction and cobots in the assembly process to realise efficient manufacturing and production optimisation.

Exp 11 - Automatic Capability Matchmaking for Re-configurable Robotics Platform (TAU)

Automatic Capability Matchmaking for Reconfigurable Robotics Platform is a DIH-driven experiment in Tampere, led by Tampere University (TAU).

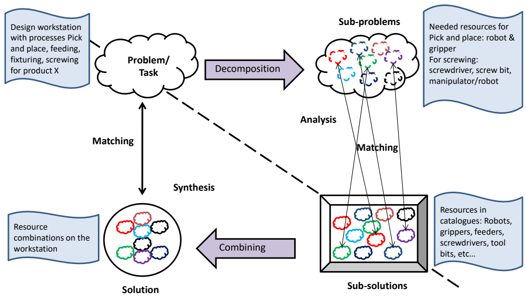

Figure 14 - Exp 11 AS-IS

The experiment focuses on the resource planning phase. When a new automatic production station has to be designed, the designer has to identify all the needed activities to be performed in the station, divide the problem in sub-problems and, for each of the phase, look for the needed resources/devices from different catalogues. Then, the combined capability of the combined resources and how it matches with the product requirements have to be analysed. In addition, the actual capability of the old available resources is not known and the design process relies on the nominal information provided in the resource datasheets.

3.4.1.2. Cluster 4 Main Challenges

- **Time consuming activities**: Currently still many activities are performed manually and are very time consuming, heavily relying on the tacit knowledge and experience of the operators. This cause production slow-downs increasing production costs and, consequently, the price for customers (#Exp 01 – 06 – 11).
- **Alienation and stress for the operators**: Repetitive not-added value activities impact on employee's well-being, that feel dissatisfied and prone to make mistakes in their work operations (#Exp 01).

- **Uncertainty of predicted results**: Still uncertainty in prediction models cause several additional errors, that might be even larger than the original error, hampering the accuracy of the final product/operation (#Exp 06).
- **Ensuring Data quality**: Data pre-processing skills should be implemented to deal with the noise and dirty data, thus ensuring data quality (#Exp 06).
- **Deployment time and cost**: Implementing HMI or robotics solutions is highly time and cost consuming, and the time and the cost of training phase before the deployment is hard to estimate in advance (#Exp 06).
- **Need for High qualified Employees /Specialist**: Employees with sufficient theoretical knowledge and experiences are required to deal with automatic innovative devices (#Exp 06).
- **Not standards/interoperable solutions or global catalogues**: Matching and comparison among different solution catalogues is difficult because they are not standard/interoperable. the amount of considered solutions is limited and somewhat random, and often dependant on the already established relations and collaboration with a few resource providers (#Exp 11).

3.4.1.3. Cluster 4 TO-BE Scenarios

Exp 01 - Machine Vision for Warehouse Optimization (GUALINI)

A machine Vision technology able to effectively recognize the proper sheet needed in production, could represent a valuable alternative to the already considered technologies (RFID, QR Code, Barcode, …). Indeed, this solution would run automatically, without devoted personnel, and would be compatible with any kind of material, decreasing the time for the identification of an inquired sheet place and provide instruction to the operator in the warehouse to bring forward the needed sheet to the production line.

Exp 06 - AI-Supported Robot Trajectory Optimization (Kautenburger GmbH)

The experiment will focus on the optimization of the robot machining capabilities through AI methods based on regression learning and reinforcement learning, designing a generalised toolchain which can identify the workpiece geometry, optimization of the CAM trajectory with better interpolation methods and optimal robot pose combinations, prediction the TCP error without external TCP measurement devices and compensate the TCP error in real-time.

Exp 08 - AI-enabled Operators Assistance through AR

An adaptive AI based Augmented Reality operator support system for manufacturing companies will increase competitiveness (productivity, quality, flexibility) and will be a solution to their problem of labor shortage. It will stimulate reshoring of production activities, improves added value of operators and development of their skills.

Exp 11 - Automatic Capability Matchmaking for Re-configurable Robotics Platform

The aim of the capability matchmaking is to support the production system designers and reconfiguration planners by automating the search for feasible resources and resource combinations to particular product requirements from large resource spaces. The matchmaking approach is implemented as a software component, which can be utilized by external design and planning systems through its Web Service interface. Primary goal of the matchmaking is to provide these systems information about resources or resource combinations that can perform a specific process step.

3.4.1.4. Cluster 4 Expected results

- **Increase of personnel productivity**: The introduction of operators support tools (Robots and/or HMI systems) that take over strategic manual tasks or support operator in increasing their performances might lead to a higher productivity, increasing the company OEE (#Exp 01 – 06 – 08).
- **Increase human resources satisfaction and wellbeing**: AI tools supporting operators might lead to an increase and enriched working conditions (#Exp 01 – 08)**.**
- **Production cost reduction**: As a consequence from higher productivity, production costs would decrease, thus impacting also on the final price to customers (#Exp 01 - 06).
- **Product quality improvement**: More precise and accurate support systems bring to higher product quality (#Exp 06).
- **Target markets enlargement**: The introduction of innovative AI solutions might lead to new market identification (#Exp 06).
- **Stimulating reshoring**: Adaptive AI based Augmented Reality operator support systems for manufacturing companies will increase the company competitiveness and attractiveness, thus stimulating the reshoring of production activities (#Exp 08).

4. Technology user journey and grand scenarios

This section provides an overview of the technology access and usage scenarios for each of the Key Exploitable Asset (KER) within the scope of AI REGIO.

In particular, the potential users/adopters of the KER are elicited, and thanks to a User Journeys template, the interaction of the different user groups with the available and future asset functionalities is described.

This chapter will mainly contribute to WP4 and WP5.

The information addressed in the following sections are detailed in Chapter 1 and Chapter 2 of the TECHNO Handbooks.

4.1. Data4AI platform (NISSA)

4.1.1. Technology Overview

Data4AI platform is a new generation of platforms for ensuring data quality for AI applications.

High level conceptual model of the platform is presented in the following Figure 15.

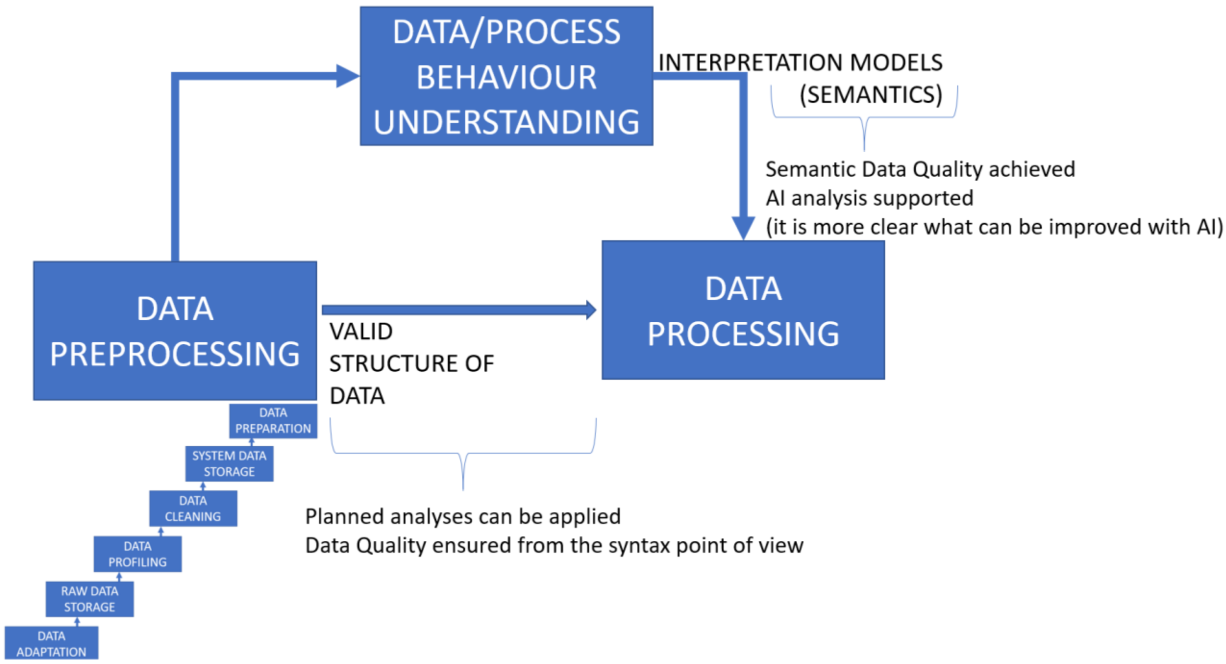

Figure 15 - Data4AI Platform - high level conceptual model

The model is briefly described as follows:

- Data Preprocessing is a processing pipeline which transforms raw data in the well-formed data (valid structure) that can be processed by various data analysis methods;
- Data/Process behavior understanding provides a view on the characteristics of the underlying process (the data is originating from);

- Data Processing is data analysis which can be done within or outside Data4AIPlatform;

As depicted in the Figure 16, Data Preprocessing ensures the Data Quality from the syntax point of view (it is in the valid form and can be processed automatically), whereas Data/Process behavior understanding provides a semantic context for data quality, i.e. for interpreting data in a way suitable for creating AI applications.

In the following figure we describe the Data Preprocessing pipeline.

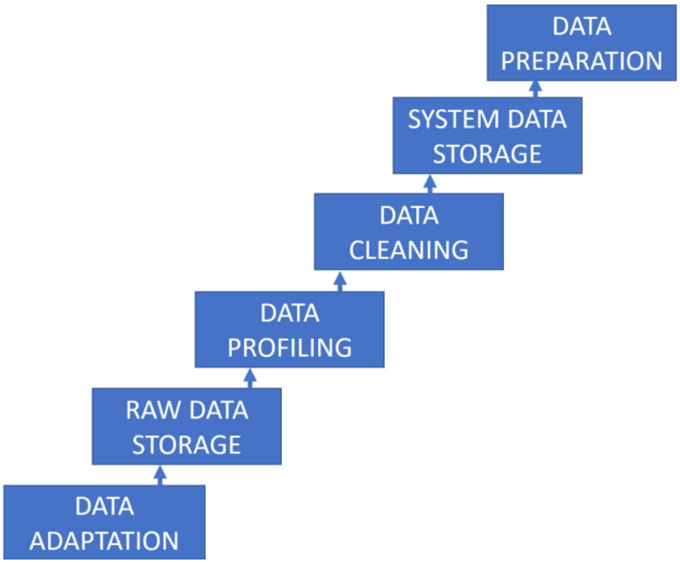

Figure 16 - Data Preprocessing pipeline

Data preprocessing steps are described:

- Adapter – Reads the raw data from the files (properly prepared) and writes data into the raw data storage;
- Raw data storage – Stores the raw data from the provided dataset into the previously defined format (d2msa, d2twin, etc.);
- Profiling – Data Inspection (overview profiling of the raw data stored in the raw data storage);
- Data cleaning – Data cleaning according to the info provided from data profiling (removing irrelevant data from the raw data);
- System data storage – Stores cleaned data after the profiling is done;
- Data preparation – Getting data from the system data storage and preparing the data for the analytics algorithms.

4.1.2. User Journey and Grand Scenarios

The potential users/adopters and the different interactions and expectations are described below.

Stakeholder Group Name	**Process Monitoring and Improvement**
Tasks	Ensuring the best possible performances of the process
Personal interests	To be able to automatize the process improvement approach
Required expertise (description and level)	Statistical process control, basics Root-cause analysis, basics
Social Environment	n.a.
Physical Environment	n.a.

GS1.1	**Understanding process behavior**
Stakeholder(s)	Process owner
Scenario	*Process owner is looking after KPIs of the process and some of them can be calculated from data and process specification (like cpk)* *Process owner is interested in the IMPROVEMENTS of the process* *However, KPIs are summary views on the process performances and usually don't reflect the process behaviour, but only its outcome. Consequently, they are not providing insights into improvement potential.* *Thanks to the introduction of AI REGIO Data4AI platform, Process owner can understand how the process behaves in time. In that way it is possible to detect periods of the process execution which are very instable or long periods of stability. A very important feature is the root cause analysis, which for each instability finds the most relevant causes. This analysis is multivariate, i.e. instabilities are related to several parameters together contributing to the process variations*

4.2. AI4manufacturing toolkit (CARTIF)

4.2.1. Technology Overview

An AI4Manufacturing Toolkit has been evolved from the MIDIH industry data analytics Platform with the goal to satisfy the requirements from ever more complex use cases, by introducing AI methods mainly for:

- Resolving complex situations characterized by uncertainty (missing data, incomplete models), so called unknown behavior;
- Processing highly unstructured and mainly contextual information, like video, sound, olfactory, to get hidden knowledge about the system behavior;

- Involving human experts in creating a deep understanding of the problems (root causes), as well as the opportunities for process/system improvement;
- Explaining in intelligible reasoning why and how a conclusion is reached. This key explainability factor makes for auditable processes and adjustments based on the human experts included in the loop who make the ultimate decisions.

AI4Manufacturing Toolkit aims to address one of the main challenges for manufacturing SMEs, which are usually not able to support a cutting-edge tool, such as AI, on legacy infrastructure challenged to meet the required needs for scale, elasticity, compute power, performance, and data management. Currently, organizations use different infrastructure solutions and approaches to support the data pipeline for AI. This approach generally leads to data silos. Indeed, some companies create duplicate copies of the data for the pipeline to avoid disturbing the stable applications. Instead, organizations need to adopt an infrastructure that supports varied data formats and access, processes and analyzes large volumes of data, possesses the speed to support faster compute calculations and decision making, manages risks, and reduces the overall costs of AI deployments.

Moreover, the AI4Manufacturing Toolkit is expected to be a set of data analytics tool and techniques where prepared and cleaned data can be exploited for enabling experimentation with AI technologies. Starting from the results of the MIDIH project in such area (namely the AI tools and methods offered within the D2Lab framework) the AI4Manufacturing Toolkit will provide services for boosting innovation in applying AI technologies in different business scenario (e.g. analyzing unknown behavior, processing highly unstructured and contextual information, support intelligible reasoning and digital services for assisting human beings).

Based on these premises AI4Manufacturing toolkit can be seen as a set of technologies, tools and platforms. Moreover, it should be a collection of operational tools, designed to provide support to system integrators and technology adopters to create new AI-based applications. As a holistic toolkit including data analytics tools and AI techniques, AI4Manufacturing toolkit will provide services for boosting innovation in applying AI technologies in different business scenarios.

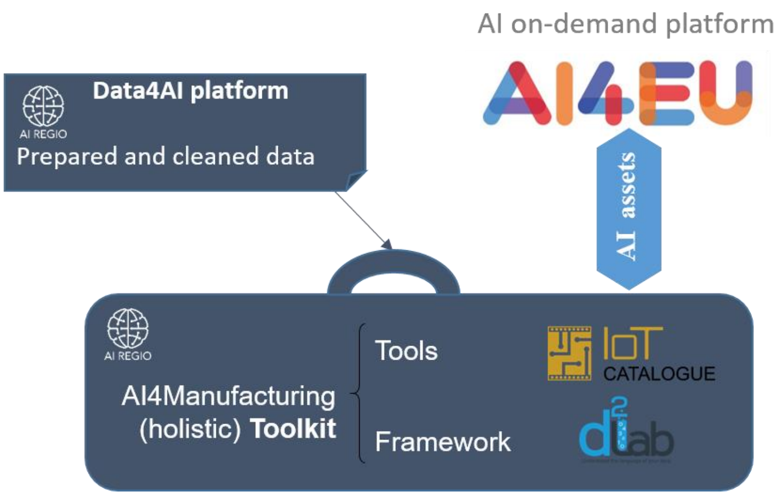

Figure 17 - AI4Manufacturing toolkit overview

As presented in the previous figure two components are key for the AI4Manufacturing toolkit, the DATA4AI platform and the, currently under development, European Artificial Intelligence on-demand platform or AI4EU platform.

The European AI on demand-platform (https://www.ai4eu.eu/) contains two kind of repository that can be exploited in AIIREGIO to build the AI4Manufacturing toolkit:

- AI4EU resources catalogue/repository, where AI4Manufacturing toolkit will be an extended catalog of tools that collects not only general information about them, but also source codes, documentation, licenses, etc. ...
- AI4EU experiment section, where AI4Manufacturing toolkit will be a model catalogue and visual composition for AI applications based on AI4EU experiments section. The AI4EU experiments section is not for production environment and its goal is limited to the configuration/on boarding of services not its execution.

All the 39 technological assets listed in AIREGIO DoA - Annex B would be feasible of being upload/share into AI4EU platform, either in AI resources catalogue, in AI experiments section, or in both. Together with the assets' owners, this decision should be made throughout the project. Moreover, the best way to build the AI4Manufacturing toolkit, based on AI4EU platform or not, will be established in the following WPs.

Following, both AI4EU resources and experiments background are described.

4.2.1.1. AI4EU resources background

AI4EU Resources (https://www.ai4eu.eu/resource-catalog) is a catalogue of AI resources that connects consumers and providers of AI resources in a meaningful way. The following types of AI resources are provided: datasets, apps, software components, libraries, Docker containers, AI models, Jupyter Notebooks and services. There is an established, reviewed, publication process to guarantee the quality and the completeness of provided AI resources.

Main information to be provided through web forms is related to description, documentation, performances, compliance with GDPR & ethics, IPR and support offered.

More information about AI4EU resources section will be found at https://www.ai4eu.eu/ai-resources.

4.2.1.2. AI4EU experiments background

AI4EU Experiments (https://acumos-int-fhg.ai4eu.eu/#/home) is an open source platform for the development, training, sharing and deployment of AI models based on ACUMOS (open source framework to build, share, and deploy AI apps, promoted by the Linux foundation). AI4EU experiments allow you through a dedicated technical environment of the AI4EU platform to interactively create and configure what it is called AI Pipelines. It empowers data scientists to move to an AI-centric process for producing software.

AI4EU Experiments is a complete system to package, share, license and deploy AI models in the form of portable, containerized microservices (as Docker containers). AI4EU Experiments Design Studio can be used to chain together multiple models, along with data translation tools, filters and output adapters into a full end-to-end solution which can then be saved as a composite solution. The AI4EU Experiments Marketplace catalogue contains information on the licensing and execution requirements of both reusable AI models and fully integrated solutions and this can be easily searched to make model selection a simple process.

More information about AI4EU experiment section will be found at AI4EU YouTube Playlist https://www.youtube.com/playlist?list=PLL80pOdPsmF6s6P6i2vZNoJ2G0cccwTPa

4.2.2. User Journey and Grand Scenarios

The main potential users/adopter of the AI4manufacturing toolkit identified up to now are the following which are described together with a first scenario explaining their main role:

- DIH
- Technology SME (AI solution developer)

4.2.2.1. DIH

Stakeholder Group Name	**DIH worker**
Tasks	Look for Technological provider to manufacturing SMEs
Personal interests	Provide support to manufacturing SMEs
Required expertise (description and level)	A person skilled in the manufacturing domain with a basic knowledge of AI techniques
Social Environment	Continuous collaboration with SMEs and AI experts
Physical Environment	Someone working in a DIH
Comments	Manufacturing SME must own some kind of dataset (e.g. a database, data lake or such) connected with the corresponding manufacturing process.

GS2.1	**Search AI technological asset in the toolkit and know how to work with it**
Stakeholder(s)	DIH as technological provider to SMEs
Scenario	A manufacturing SME requests DIH support to solve a manufacturing problem that requires the application of AI techniques. Then, experts involved in the DIH, with knowledge of both domains, artificial intelligence/data science and manufacturing, will then access the AI4Manufacturing toolkit to find available technological assets that help DIH solve the SME's problem. Once the DIH worker locates the asset, he/she is able to analyze all the documentation associated with the asset (license, manuals, examples, etc.) as well as download the source code (if free) to incorporate it into their own AI pipelines.

4.2.2.2. Technology SME

Stakeholder Group Name	**AI solution developer**
Tasks	Develop AI solution to be used within manufacturing environment
Personal interests	Promote their AI solution to the manufacturing community
Required expertise (description and level)	A person skilled in AI with some basic knowledge in manufacturing domain
Social Environment	Continuous collaboration with manufacturing SMEs workers
Physical Environment	Someone working in a DIH or research centre

GS2.2	**Manage AI technological asset in the toolkit**
Stakeholder(s)	Manufacturing AI solution developer: A technical user who analyses, designs and writes code to build apps. Developers' goal is to develop manufacturing applications powered by AI models.
Scenario	A company wants to put an AI manufacturing solution/resource in the toolkit. Once authenticated, the user is able to add a new tool or add a new release of a previous tool to the toolkit, providing as much as possible information in the established headings (type, license, IPR, …).

4.3. DIHIWARE platform (ENG)

4.3.1. Technology Overview

The DIHIWARE Platform is an integrated system leveraging on knowledge-driven services that, next to a Catalogues Management System, and harmonized with the collaborative side of the Platform, create an environment where providers and consumers of digital technologies related to AI development and adoption cannot just matching assets and needs, but they can collaborate to boost innovation.

The Platform is based on different Open Source components, integrated and distributed as Docker images, using a winning modular approach able to simplify the deployment procedure and guarantee the possibility to have custom-tailored solutions suitable for the variegated environments.

The DIHIWARE customization capabilities, next to a concrete adoption plan of the Platform, enables the delivery of specific tailored environments, based on selected DIHIWARE modules and in line with the stakeholders needs and requirements.

At the core of the DIHIWARE Platform you can find the Collaboration Portal (CP) and Catalogues Management System (CMS). Each of them provides a specific function and complements the functionality of the other. The platform is also equipped with two other components dealing with the users centralized authentication (Identity Manager) and platform resources research based on advanced search techniques (Knowledge Base).

The Collaboration Portal (CP) is the main subsystem, offering tools for knowledge management, social activity next to collaboration and innovation capabilities. It links users, processes, resources and acts as a powerful knowledge hub.

The Catalogues Management System (CMS) provides functionalities related to the back-end management, structure and storage of the catalogues as well as the front-end interface (integrated within the Collaboration Portal) allowing users to interact with them (e.g., view, filter and select). The system offers a single point of access for users leveraging on already existing information in different organizations by creating a federation of catalogues for a scalable system (data blending).

The high-level decomposition is shown in Figure 1.

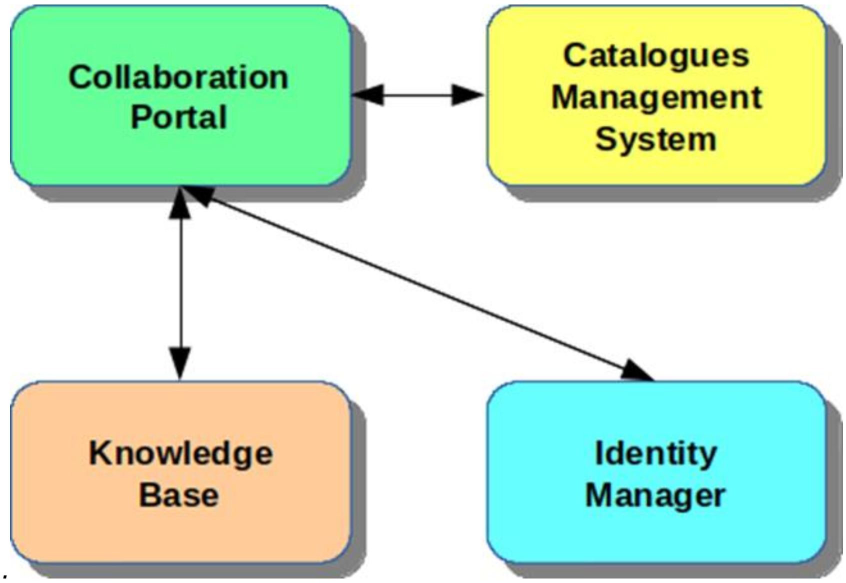

Figure 18 - DIHIWARE Platform architecture

4.3.2. User Journey and Grand Scenarios

The main users of the DIHIWARE Platform can be reconciled to the following three families:

- Manufacturing SMEs (demand)
- Technology SMEs (offer)
- DIH (broker)

4.3.2.1. Manufacturing SMEs

Stakeholder Group Name	**Manufacturing SMEs (manufacturing Industries)**
Tasks	Manufacturing companies operating in different domain, areas that market products/services in their regional area
Personal interests	Digitization, control system improvement
Required expertise (description and level)	Intermediate. An organization with a deep understanding of a particular topic able to understand and discuss the application and implications of changes to business processes, policies, and procedures in this area.

GS3.1	**Thomas is willing to acquire competences and learn about concrete adoption of AI technologies in similar business as in his own manufacturing SMEs**
Stakeholder(s)	**Manufacturing SMEs (manufacturing Industries)**
Scenario	Accessing the DIHIWARE Platform Thomas can: • Access to experts' advice and a real experimental environment, increase knowledge, train employees in innovative technologies; • Access to funding; • Access Innovative Digitalization processes and solutions related to an R&D environment by tiling of technological solution choice; • Learning how to apply AI and other digital technologies (i.e. up-to-date software and networking standards/technologies/methods/ development processes) to improve IT and control systems in the plant; • Learning how to apply digitization to improve control/automation technology embedded in own products; • Solving technical problems seeking for rental of premises, rental of cloud services and IT support and for advice/assistance with the adoption of specific technologies; • Gain support in strategy and business development; • Get technology transfer through a theoretical approach (competences and knowledge transfer and training) and practice (use of physical assets for simulations, pilot tests, etc.).

4.3.2.2. Technology SMEs

Stakeholder Group Name	**Technology SMEs (solution providers)**
Tasks	Innovative incumbents whose main characteristic is the high level of technological know-how, providing the market with new digital solutions.
Personal interests	Digital solutions promotion and access to new knowledge, technologies and potential collaborators.
Required expertise (description and level)	Advanced. Focus on Digital solution implantation and ability to provide practical/relevant ideas and perspectives on process or practice improvements which may easily be implemented.

GS3.2	**Sofia is eager to valorize her own technologies and business potentials**
Stakeholder(s)	**Technology SMEs (solution providers)**
Scenario	The Platform can provide SMEs with unprecedented opportunities to work directly will some of the main European key players in a specific domain in a unique environment. The platform should become a gateway to access a wide set of services (expertise, knowledge, technologies, consultancy) provided by key-players of the emergent Ecosystem.

	Accessing the DIHIWARE Platform Sofia can: • Access to experts' advice; • Access to new technologies; • Access to potential collaborators/new partners and customers; • Access to Real Life Proof of Concepts (e.g., Demos, simulations, pilot tests, etc.); • Access to rental of premises, rental of cloud services and IT support; • Learn about new software/networking standards, technologies and methods that are specific to the manufacturing domain, while examining their benefit and applicability; • Opportunities to showcase products/solutions; • Gain support in broadening the current business/market; • Get technology development support including the integration/connection with current technologies.

4.3.2.3. DIH

Stakeholder Group Name	**DIH**
Tasks	Honest brokers (link between consumers and providers) and services provider
Personal interests	Support a local ecosystem in developing AI-related skills, technologies and adoption success stories
Required expertise (description and level)	Intermediate. An organization with a deep understanding of the local needs, in terms of both demand and offer side, with already established connection with a wider network of stakeholders (other DIHs, policy-makers, business angels, …) able to understand and anticipate the needs of the local ecosystem, mediating cultural and societal differences

GS3.3	**Catarina is acting as an honest broker, connecting local demand/offer with a broader network of potential users/providers**
Stakeholder(s)	**DIH**
Scenario	The DIHIWARE Platform could be a DIHs wide platform enabling them to become trusted advisors in their relationship with services consumers/adopters, becoming a vibrant link between users and providers, exploring new opportunities, observing new trends within the industry and beyond, as well as seeing patterns between multiple sectors as well as across industries. The Platform can provide DIHs with unprecedented opportunities to work directly with all key players in a highly secure environment and significantly increase their opportunities in maximizing their role.

	Moreover, DIHs can become trusted advisors in their relationship with services consumers. They can move from knowledge transfer to knowledge creation. Being part of a DIH, or even of a network of DIHs, Catarina will be able to: • Connect with other DIHs through structured, actionable discussions on the DIHIWARE Platform; • Align to the network with strategic goals, gather feedback and information to build a common strategy and make better strategic decisions; • Align and focus the network on these strategic priorities to achieve specific goals; • Find the right knowledge, expertise and best practices from across the network; • Capture and share knowledge and ideas to improve quality and spur innovation; • Developing a clear overview of the DIHs related services provided in Europe and align to; • Upgrading the DIH Catalogues by identifying/triggering activities in the DIHs communities; • Creating a strategy to reinforce the specialization of these services, as well as supporting its uptake by relevant DIHs and DIH networks; • Participate in creating a vision and strategy on a self-sustaining business model for the network of DIHs, and to make this operational.

4.4. Collaborative Intelligence platform (STIIMA)

4.4.1. Technology Overview

In this preliminary phase of the project we are still engaged in the definition of the new concepts of Industry 5.0 and Collaborative Intelligence (e.g., analysing the requirements of the experiments).

A preliminary list of assets is proposed as follows:

- <u>A solution for Business Process Modeling (BPM) providing </u>*an Environment for orchestration* of human-centered processes workflow in terms of process management and Human-AI interaction. For realizing this environment, a particular focus will be dedicated to the links with Data Sovereignty Mechanisms (T5.2), Data Sharing Spaces (T5.5) and Interconnected Data Models and Ontologies (T5.4);

- *A solution of Digital Twin to simulate* human-in-the-loop. A potential solution of Digital Twin can be realized also exploiting the available AI REGIO Technology Assets.

4.4.2. User Journey and Grand Scenarios

At this phase, manufacturing SMEs have been identified as the main potential users/adopter of the above-mentioned assets in the field of Industry 5.0 and Collaborative Intelligence.

Stakeholder Group Name	**Manufacturing SMEs (manufacturing Industries)**
Tasks	Manufacturing companies operating in different domain, areas that market products/services in their regional area
Personal interests	Digitization, control system improvement
Required expertise (description and level)	Intermediate. An organization with a deep understanding of a particular topic able to understand and discuss the application and implications of changes to business processes, policies, and procedures in this area.

The possible Grand Scenario for a manufacturing SME is provide in the following table.

GS3.1	**John is willing to orchestrate human-centred processes in terms of process management and Human-AI interaction assessment.** **(this proposed scenario should be adapted by considering the requirements of a real case study, which could be one for example one of the analysed AI REGIO experiments. In this regard, it is planned the assessment and possible extension of some AI REGIO Experiments \Assets in the scope of Industry 5.0)**
Stakeholder(s)	**Manufacturing SMEs (manufacturing Industries)**
Scenario	Accessing the Collaborative Intelligence platform John can: • Access to models representing Human and AI processes; • Design the orchestration of human-centered processes workflow in terms of process management and Human-AI interaction; • Promote harmonization and orchestration between machines and the human factors, especially considering the cognitive and physical workload related to manufacturing operations; • Design the workflow of human-in-the-loop solution through their combination into business processes; • Use of an orchestration and enactment service to support the design of operational and interaction workflows and the configuration of specific applications and services; • Check the efficiency of each designed process. For this reason, a quantitative modelling of the process is used in order to simulate and to assess all the possible scenarios. Some KPI can be used such as Flexibility, Speed, Scale, Decision-Making, Personalization; • Enable comparison of different technological solutions and selection in accordance to the requirements of a specific scenario.

4.5. AI Data Spaces for Manufacturing (TECNALIA & CEA)

4.5.1. Technology Overview

AI REGIO data sovereignty solution will be based on Industrial Data Space (IDS) open source current initiatives. Accordingly, a comprehensive description of IDS is needed and provided in the section below.

The selection of the final IDS implementation will be carried out according to the requirements of AI REGIO experiments and DIH scenarios. That will be the basis for the AI REGIO data sovereignty solution, which will be later on complemented with AI-related innovations to cover the whole set of functionalities expected in those experiments and scenarios.

4.5.1.1. DATA SOVEREIGNTY THROUGH INDUSTRIAL DATA SPACE (IDS)

IDS is a secure data exchange model for industrial IoT. Each role that a participant can assume in IDS is described in detail in the sections below, along with the basic tasks assigned to them:

CATEGORY 1 – PRIMARY PARTICIPANTS

The main participants are required every time data is exchanged in IDS. The roles assigned to this category are: Data Owner, Data Provider, Data Consumer, Data User, and Application Provider. The role of primary participant can be assumed by any organization that owns, wants to provide and/or wants to consume or use data.

DATA OWNER

The Reference Architecture Model defines a Data Owner as a legal entity or natural person that creates data and/or executes control over it. Typically, a participant acting as the data owner automatically takes over the role of data provider as well. However, there may be cases where the data provider is not the data owner (for example, if the data is technically managed by an entity other than the data owner, as may be the case of a company that uses an external IT service provider to obtain data for their administration).

DATA PROVIDER

The data provider makes data available to be exchanged between a data owner and a data consumer. As already mentioned above, the data provider is in most cases identical to the owner of the data. To facilitate a data consumer request, the provider must provide a Broker with the appropriate metadata about the data. However, a Broker is not necessarily required for a data consumer and data provider to establish a connection.

DATA CONSUMER

The data consumer receives data from a data provider. Before the connection to a data provider can be established, the data consumer can search for existing data sets by querying an intermediary service provider (Broker). The Broker then provides the necessary metadata for the data consumer to connect to a data provider. Alternatively, the data consumer can establish a connection with a data provider directly (i.e without involving a Broker). In cases where the data consumer already knows the information to connect with the data provider, the data consumer can request the data (and corresponding metadata) directly from the data provider.

DATA USER

Just as the data owner is the legal entity that has legal control over their data, the data user is the legal entity that has the legal right to use the data of a data owner as specified by the usage policy. In most cases, the data user is identical to the data consumer.

APPLICATION PROVIDER

Application providers develop data applications to be used in IDS. Each data application must be published in the application store so that consumers and data providers can access and use it.

CATEGORY 2 – INTERMEDIARIES

Intermediaries act as trusted entities.

BROKER SERVICE PROVIDER

The Broker Service Provider is an intermediary that stores and manages information about the data sources available in IDS. The activities of the intermediary provider are mainly focused on receiving and providing metadata.

CLEARING HOUSE

Clearing house records all activities carried out in the data exchange course. Once a data exchange has been completed, both the data provider and the data consumer confirm the data transfer by recording the details of the transaction with the Clearing House. Based on this registration information, the transaction can be billed.

IDENTITY PROVIDER

The identity provider must offer a service to create, maintain, manage, monitor and validate the identity information of the participants in IDS. This is essential for the safe operation of IDS and to prevent unauthorized access to data.

APP STORE PROVIDER

The app store provides data apps. These are applications that can be deployed within the connector.

VOCABULARY PROVIDER

The vocabulary provider manages and offers vocabularies that can be used to annotate and describe data sets.

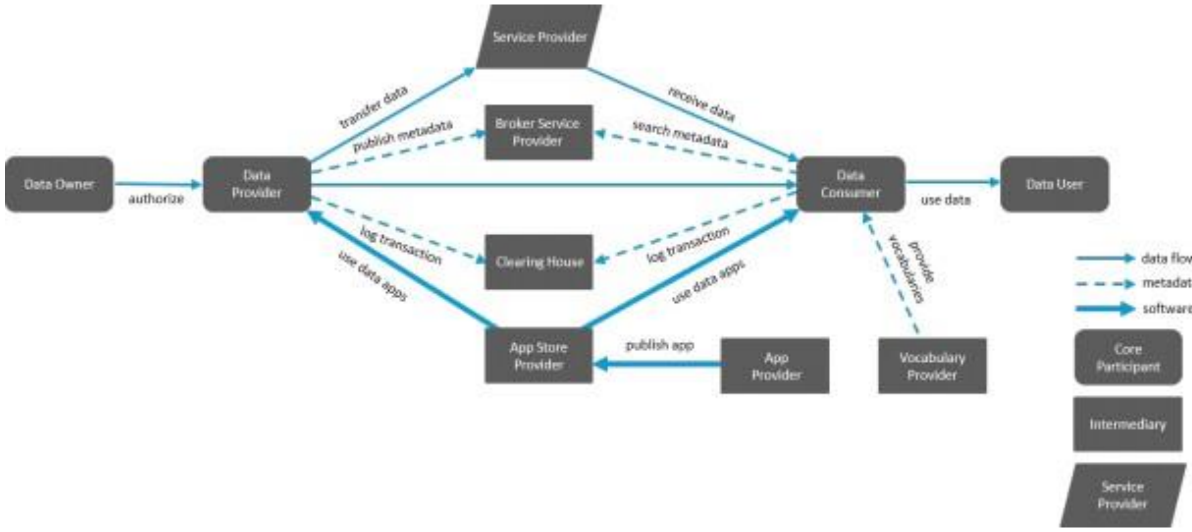

Figure 19 - Roles and interactions in IDS

4.5.2. User Journey and Grand Scenarios

The main users of the IDS architecture can be clustered in three families of stakeholders:

- Data providers:
  - Manufacturing SMEs as data providers.
- Data transformers and service providers:
  - App providers.
- Data/service consumers:
  - Industrial companies as data/services consumers.
- Brokers:
  - DIH.

4.5.2.1. Data providers:

Stakeholder Group Name	**Manufacturing SMEs as data providers**
Tasks	Manufacturing companies operating in different domain that market products/services
Personal interests	Digitalization, improve OEE, efficiency, new revenue sources.
Required expertise (description and level)	Level: intermediate in digitalization; High in industrial processes, value chain ecosystem and new market opportunities (open minded to new business lines, such as new revenues based on data empowerment). An organization with a deep understanding of a particular industrial process, able to understand and discuss the application and implications of changes to business processes, policies, and procedures in this area.

GS5.1	**Thomas company is sharing its industrial process data with the value chain and even getting revenues through it, in a secure way and maintaining control over it.**
Stakeholder(s)	**Manufacturing SMEs (manufacturing Industries)**
Scenario	Thomas has been requested many times by his providers for information about the configuration of control parameters of their production lines in order to understand better the expected quality of the provided raw material. He never gave them the requested information because he was afraid of data leaks to competitors, although the production quality would be highly improved with more customized materials. On the other end, his industrial clients require always lots of data for quality control and traceability in case of malfunctioning later on. Due to customer power, he never rejected the request, but he never liked not to know how these data were used. Now, through the AI REGIO IDS architecture, he is able to manage the permissions of who uses the industrial process data, which specific data and during how long if necessary. Even he has started to sell data to third parties through the platform, such as the manufacturers of the machines (GSx.3) they use in the line, with total control of how they use them. No leaks to competitors or other unknown stakeholders is possible with this tool.

4.5.2.2. Data transformers and service providers:

Stakeholder Group Name	**App providers**
Tasks	Companies that provide Apps that use data from providers and provides services to consumers based on these data. These consumers can be the owners of the data or others.
Personal interests	Process data and generate value from them
Required expertise (description and level)	Level: High level in digitalization These users process data to generate AI-based services to consumers

GS5.2	**AppDev Start-up processes industrial SMEs' data to provide valuable information to one or several stakeholders**
Stakeholder(s)	**Manufacturing SMEs (data provider), IT company (App provider), Other companies (processed data consumers)**
Scenario	AppDev has developed a new App for the optimization of performance of manufacturing machines, which is based on the collection and processing of industrial process data. The owner of these data is the one that buys and uses the machine, the industrial SME (GSx.1). On the other hand, the owner of the machine (GSx.3)

	is interested in maximizing the performance of the machine (difference with respect to competitors) and needs real data to do it. AppDev has developed an App that uses online industrial process data for the prediction of its behavior and prescript indications to the operators in the industrial plant, in terms of maximizing life expectancy of machine toolings and optimal configuration, while the quality of resultant products is assured. All the data transactions and its sovereignty are assured by IDS. The data are not used by anyone else, or for any other purpose than the one agreed by the two ends: manufacturing SMEs and machine manufacturer.

4.5.2.3. Data/services consumers:

Stakeholder Group Name	**Industrial companies as data/services consumers**
Tasks	Companies that improve their services based on someone else's data
Personal interests	Optimize their services based on third parties' experiences
Required expertise (description and level)	Level: medium level in digitalization Companies that use third parties' industrial data to improve their own services/products
Social Environment	n.a.
Physical Environment	n.a.
Comments	

GS5.3	**MachProd company optimizes their machines design based on real data collected from their industrial Clients**
Stakeholder(s)	**Manufacturing SMEs (data provider), IT company (App provider), Industrial companies (data/service consumers)**
Scenario	MachProd designs and builds manufacturing machines that have differentiated their services from their competitors, based on a strategy to optimize their machines performance, based on their clients' industrial process data when they use their machines. They offer to their clients (GSx.1) an AI-based service to optimize the performance of their machines in terms of maintenance and quality, through an IT company named AppDev (GSX.2). Additionally, they use these data (clients' data) to diagnose and analyze their machines behavior over time and redesign them to endure longer and produce better. They use these data with the agreement and the acknowledgement of their clients, which are confident on the usage of their data by MachProd, because

	they are managed by them through the IDS architecture of the AI REGIO platform.

4.5.2.4. Brokers

Stakeholder Group Name	**DIH**
Tasks	Honest brokers (link between consumers and providers) and services provider
Personal interests	Support a local ecosystem in developing AI-related skills, technologies and adoption success stories
Required expertise (description and level)	Intermediate. An organization with a deep understanding of the local needs, in terms of both demand and offer side, with already established connection with a wider network of stakeholders (other DIHs, policy-makers, business angels, …) able to understand and anticipate the needs of the local ecosystem, mediating cultural and societal differences
Social Environment	n.a.
Physical Environment	n.a.

GS5.4	**Basque DIH is acting as an honest broker, connecting local demand/offer with a broader network of potential users/providers**
Stakeholder(s)	**DIH, Manufacturing SMEs (data provider), IT company (App provider), Industrial companies (data/service consumers)**
Scenario	Thanks to the collaboration with AI REGIO, the Basque DIH has launched a new service that connects the businesses of local manufacturing SMEs (GSx.1), to industrial companies (GSx.3), while it offers new opportunities to regional Start-ups (GSx.2) that add value to that relation based on AI transforming Apps. The AI REGIO platform connects these stakeholders through and IDS architecture that assures the data owners the exploitation of their data in different ways, for their own benefit, but always managed according to their desire and rules.

5. Conclusions and next steps

The Scenario Analysis is the very first phase of the *"AI REGIO Requirements Engineering Methodology"* (see D2.1 for details). It addresses the collection of the AS-IS and TO-BE scenarios of the main pillars of AI REGIO project: the 13 Digital Innovation Hubs, the 17 SME- and DIH-driven experiments and the 5 AI technological tools.

Leveraging on proper workshops and tools, the DIH scenarios have been collected considering 6 identified Customer Journeys, that reflect the ideal customer paths of a DIH. In particular, the 6 CJs focus on:

- Technology user: manufacturing companies sharing the final goal of undertaking the Digital Transformation journey to increase their competitiveness. TUs are considered as the end-users/demand-side of the technology.
- Technology provider: or developers, are companies that develop technologies offered to manufacturing industries. They are more on the "offer-side" and their final aim is to be ready to launch the technology on the market.
- Students: High-school or University students who aims at implementing innovative solutions ideas within their educational path.
- Policy makers: regional, national or European politicians willing to be guided into the implementation of R&I policies.
- Start-ups: organizations willing to achieve a maturity level for the proposed ideas becoming structured enterprises. They are often quite similar to TP.
- Experimenters: organizations joining Open Calls and willing to successfully adopt/develop the proposed solution.

The related Blocking Points have been highlighted for each of the CJs phases.

The collected scenarios will serve as inputs for the requirement specification within the next phases of WP2 and WP3, when the Digital Transformation Matrix matching services and CJs will be completed by the 13 DIHs.

Concerning the 17 Experiments, their scenarios, weaknesses and expected results have been collected using the TRIAL Handbook Chapter 1 and summarized according to the identified clusters, that highlighted common challenges and expected benefits, namely: Product Engineering and Lifecycle Management, Factory efficient and sustainable manufacturing, Quality control and predictive maintenance, Robotics and Human Interaction. Chapter 1 and the scenario analysis outputs will contribute for the development of TRIAL Handbook Chapter 2 "Requirements", foreseen in WP2 and WP6 activities.

Finally, for each of the 5 technological assets that are going to be developed within WP4 and WP5, a clear overview, as well as user journeys and Grand scenarios for the identified stakeholders were provided. Also in this case, the scenario analysis outputs will be strategic information for the TECHNO Handbook Chapter 2 "Requirements" and technological assets development and evolution.