H2020 - INDUSTRIAL LEADERSHIP - Information and Communication Technologies (ICT)

ICT-38-2020: Artificial intelligence for manufacturing

Grant Agreement: 957362

# Explainable Manufacturing Artificial Intelligence

XMANAI

MAKING AI UNDERSTANDABLE

## WP6: Demonstrators Setup, Operation and Business Value Exploration

## D6.2: Project Evaluation Plan and First Round of Demonstrators Implementation Plan

**Deliverable Leader:** Politecnico di Milano

**Due Date:** 30 April 2022

**Dissemination Level:** Public

**Version:** F1.0

**Short Abstract**

D6.2 - "Project Verification and Validation Framework Definition" presents the XMANAI methodology and the Evaluation framework to assess the impact of the XMANAI platform and solutions on the demonstrators, at the end of the project. The document describes the questionnaire used for the assessment (stressing the role of the Explainability component in changing the current decision making process), it presents the steps to be performed to run the Evaluation Framework and it explains how to generate the final report, to measure the impact on the production and decision making processes, but also to verify if the technical and business expectation are satisfied.

Additionally, it provides a preliminary overview of the demonstrators' Implementation Plan and it describes the activities to be performed in next months by the demonstrators and technology providers to implement and adopt the XMANAI platform.

Document Log

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| **Type** | Report |

History

| Versions | Description |
|---|---|
| **D0.1** | First draft of the Table of Content |
| **D0.2** | Executive Summary, Chapters 3, 4, 5 |
| **D0.3** | Chapters 1, 6 |
| **D0.4** | Chapter 2 and document finalisation |
| **R0.1** | Revision of internal reviewer 1 or 2 |
| **F1.0** | Final |

# Executive Summary

Deliverable D6.2 – "Project Verification and Validation Framework Definition" has a twofold objective. On one side, it provides a **preliminary overview of the demonstrators' Implementation Plan** (GANTT charts and tasks description), since the implementation activities are expected to start at M18. The deliverable describes the activities to be performed in next months and the expected scenarios, step by step, in order to understand which are the different delivery and implementation phases for each demonstrator and to monitor progresses.

On the other side, the core of the deliverable is **the presentation of the XMANAI Evaluation Framework**, the XMANAI methodology to measure the impact of the platform on the demonstrators and the online questionnaire as the fundamental tool to assess the pilots' profile. The starting point to develop the XMANAI methodology was the original version of the 6Ps methodology, conceived to describe the digital transformation driven by Artificial Intelligence in a measurable way, for the manufacturing industry. The 6Ps methodology is based on the concept that to assess a complete profile of an enterprise is not enough to measure the technical aspects (Product, Process and Platform), but also the socio-business dimensions are relevant (People, Performance and Partnership). The current deliverable describes **the changes that T6.2 applied to tailor it for XMANAI's purposes**, stressing the key role of the Explainability component. The changes applied to the original questionnaire are discussed in details and the new questions introduced are explained in order to understand the XMANAI's rationale to assess the impact of Explainable AI on the demonstrators (and on manufacturing industry in general). Beside the updated version of the 6Ps methodology, the final XMANAI questionnaire includes also the **"Explainability block", to measure the impact of the platform on the decision making process**.

Within D6.2, **the XMANAI methodology is presented**: the steps to be performed (by T6.8) to run the Evaluation Framework are described, together with a preliminary draft of the activities of next months. The questionnaire is expected to be compiled twice by each demonstrator (one before the adoption of the platform and one after that), to measure the impact on the production and decision making process, but also to verify if the technical and business expectations are satisfied. With the information collected in the online survey and during the interview, a detailed report will be generated, displaying information in a measurable and user-friendly way.

**The deliverable can be used as a sort of manual**, both for the demonstrators (to whom the Evaluation Framework is addressed) and the technological partners, aiming to measure the impact of the XMANAI platform leveraging on the results of the Evaluation Framework. To demonstrators, it is explained how to compile the questionnaire, when to do it and the purpose of doing it; to technological partners, the steps of the methodology to be performed are detailed and it is explained how to generate the final report, summarizing the key concepts of the assessment. The current document should be complemented with the online questionnaire (to perform the survey) and with the Excel template (to generate the charts for the final report).

Finally, **the validation process** followed by T6.2 to get to the final version of the questionnaire is presented: besides the partners directly involved in the design and development, all the XMANAI partners have been involved to verify the applicability of the answers and to provide feedbacks and comments that have been later integrated.

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# 1 Introduction

The main aim of Section 1 is to provide a brief overview of the deliverable. For additional details readers should refer to Section 2 – Section 5.

## 1.1 XMANAI Project Overview

The XMANAI envisages to conduct effective dissemination, communication and stakeholder engagement activities from the very early stages of the project where all partners are committed to mobilize the appropriate stakeholders, hence maximizing the outreach. The dissemination and communication activities are meticulously planned to ensure that the project's advancements are widely diffused to the intended targeted audiences with appropriate mechanisms in a timely manner, and that the key stakeholders for the project's exploitation and market uptake are early engaged and actively participating to the various project's implementation phases. Communication methods are identified and made available to support XMANAI partners in creating a strong presence in the community, maximizing the online potential to attract a wide range of stakeholders throughout the current pandemic crisis.

This document defines the baseline strategy and guidelines for creating a context where XMANAI research dissemination and communication can be maximised. In detail, this document:

- Contextualizes the work to be developed, clearly stating the objectives, the key messages, the project's target audience and the channels to be used for dissemination and communication in the different outreach phases.
- Provides procedures and reporting templates, namely the "Events reporting template" and the "Publications reporting template".
- Details the actual dissemination and communication plan, specifying a framework to identify responsibilities, outcomes and to monitor progress and KPIs of the different activities. The plan is organized by categories and mechanisms that will be put in place, namely:
    - Online Presence and Media, that includes the diffusion of XMANAI using online channels such as the website (and the measurement of its traffic), blog, and social media presence (LinkedIn, Twitter, YouTube).
    - Communication Materials, including flyers, brochures, videos, banners, that will be published and updated as the project evolves to show the objectives, advances, benefits, and exploitable results generated by XMANAI for different target groups.
    - Events (Face-to-Face and Remote), for collaboration of the project with other projects and initiatives, as well as for knowledge exchange during conferences and events of scientific and industrial nature.
    - News and Publications, including the publication of papers and articles in industrial and academic press, as well as the creation and contribution to eNewsletters, press-releases and other traditional media (both online and printed).

1. Presents the first proposal for the XMANAI Advisory Board composition, currently being analysed by the consortium and then to be sent for approval by the EC.
2. Provides an overview on the actual status of the planned activities, including already evidences of the work developed. Main accomplishments of the period include: the release of the project website and private area; publication of the first blog post; set up of the social media channels and development of the project identity, including the presentations template; development of the leaflet; establishment of liaisons with EFFRA and DFA, as well as the first contacts with the ICT-38 projects, and; media communications announcing the project launch.

This report is sought to be used as a living document, hence maintaining a very similar structure, the plan will be updated at M18 with new actions and activities to be performed, including as well as a report of what has been conducted during the first reporting period.

## 1.2 Deliverable Purpose and Scope

D6.2 – "Project Evaluation Plan and First Round of Demonstrators Implementation Plan" has a twofold objective:

- As the main deliverable of Task T6.2 – "Project Verification and Validation Framework Definition", it aims **to describe the Validation Framework that has been designed to measure the impact of the XMANAI platform** on the four demonstrators. The deliverable presents the XMANAI methodology, including a detailed description of the questionnaire used to assess the profiles of the demonstrators. Each step of the methodology is depicted in details and each section of the questionnaire is presented, explaining the purpose and how to compile it.
- In preparation to Task T6.3 – "Demonstrators Operation Planning and Coordination" starting at M18, D6.2 provides a preliminary **overview of the demonstrators' Implementation Plan**, describing the main activities and tasks to be performed in next months for the implementation of the XMANAI platform.

## 1.3 Impact and Target Audiences

The deliverable is a public document, so open to everyone interested in the topic of evaluation assessment for XAI in Manufacturing.

Inside the XMANAI project, all partners are considered target audience: demonstrators are the final users of the Evaluation Framework and the target of the implementation plan; the other partners are directly involved either in the evaluation or in the implementation process (or in both), so they are expected to be well-aware of the Framework and of the Implementation plan.

Outside XMANAI project, the demonstrators' Implementation Plan is less relevant; however, the Validation Framework defined in T6.2 can be of interest to anyone dealing with AI for Manufacturing. Even if some sections of the questionnaire have been defined specifically for XMANAI, the assessment has a general approach and it is applicable to many other use cases and/or projects.

## 1.4 Deliverable Methodology

D6.2 consists of different sections, following each a different methodology.

The section containing to the demonstrators' Implementation Plan has been compiled in collaboration with the demonstrators and the related technology providers that assist the pilots in the implementation phase. WP6 provided the template to include the required information (the Trial Handbook Chapter 4, containing, among the others, the GANTT chart template to be filled) and the demonstrators supported by the technology providers drafted the preliminary version of the plan.

The section about the Evaluation Framework has been written by T6.2 summarising the information collected from all the partners. The activity has been performed in two steps: first of all, T6.2 defined the XMANAI methodology and designed the first version of the assessment, starting from the original version of the 6Ps assessment; then, the new version has been presented to XMANAI partners that validated it providing feedbacks and comments that have been later incorporated.

## 1.5 Dependencies in XMANAI and Supporting Documents

D6.2 has many dependencies with other XMANAI activities, especially in WP6:

- T6.8 - "Business Cases Evaluation and Impact Assessment", which is the natural sequel of T6.2, will leverage on D6.2 to perform the evaluation assessment, as the current document contains the description of the methodology to be followed and the related guidelines. A section at the end of the deliverable sketches next steps for T6.8.
- The starting point for T6.3 - "Demonstrators Operation Planning and Coordination" and T6.4-7, related to the implementation of the XMANAI solutions in each demonstrator, will be the Implementation Plan provided in the current document.

Following complementing documents are in support of the current deliverable:

- Regarding the activities of T6.2 and the definition of the Evaluation Framework,
  - The **online survey** (link), to perform the assessment that helps to measure the impact of the XMANAI platform on the pilots;
  - The **Excel template**, to generate automatically the summary charts, displaying in a more user-friendly way the information collected in the online questionnaire (bullet point above). The Excel template is the fundamental tool to create the final report.
- Regarding the activities related to the definition of the implementation plan,
  - The **Trial Handbook Chapter 4**, still in progress, containing, among the others, the implementation plan for each demonstrator, complemented with a number of additional information not reported in the current deliverable.

## 1.6 Document Structure

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

**Section 2 - Demonstrator Operation Planning** presents the preliminary version of the Implementation Plan of the four demonstrators, in preparation to next months' activities. Four each pilot, the GANTT chart is presented specifying the main tasks foreseen, their duration and the involvement of other partners.

**Section 3 – The 6Ps methodology** presents the original version of the methodology (conceived to measure the impact of AI in Manufacturing) and describes the changes that T6.2 applied to tailor it for XMANAI's purposes, stressing the key role of the Explainability component. The 6Ps assessment is described in details, providing the list of questions included in the questionnaire [§3.1]; the changes applied within T6.2 (new questions added or modifications of existing ones) are highlighted explaining the rationale behind [§3.2].

**Section 4 – The XMANAI Validation Framework** is the core of the deliverable. It presents the "Explainability block" that has been conceived specifically for XMANAI's purposes, to complement the 6Ps assessment (presented in Section 3), listing all the questions and their objective [§4.1]. Additionally, Section 4 introduces the XMANAI methodology for its Validation Framework, describing all the steps to be followed (by T6.8) to correctly measure the impact of the XMANAI platform [§4.2] (including, of course, the compilation of the online questionnaire [§4.2.1]). Finally, Section 4 provides the main guidelines to produce the final report, explaining how to understand the charts automatically generated in the Excel template [§4.2.2].

**Section 5 – Framework review and future application** summarises the validation activity that was run both inside T6.2 and involving all the XAMANAI partners [§5.1]. An example to better understand how the methodology works and how the results are presented is provided, taking data and information directly from the XMANAI demonstrators. Finally, Section 5 drafts a preliminary planning for T6.8, which is expected to inherit the XMANAI methodology defined in T6.2 and to apply it to the demonstrators [§5.2].

## 1.7 Ethics

At this stage, no personal/sensitive information is collected. The XMANAI methodology has been defined but not yet applied; the information collected in the questionnaire has only a validation purpose and it doesn't necessarily reflect the real situation of the demonstrators. However, the answers provided by the demonstrators won't be disclosed.

Conversely, when the assessment will be compiled with the purpose of really measure the impact of the XMANAI platform (in T6.8), the demonstrators will be required to detail their company's profile, generating some personal information to be handle with care.

# 2 Demonstrator Operation Planning

The objective of this chapter is to provide a detailed overview of the planning of deliveries and implementation phases for each demonstrator, within WP6. Next months' activities will be described, detailing the scenarios to be executed by the pilots.

T6.4 – T6.7 are expected to start at M18, so D6.2 will provide the planning for coming activities.

## 2.1 Demonstrator 1: FORD implementation's planning

Ford use case will be implemented with the following detailed plan in the time frame M18-M42:

**Phase 1 - Demonstrator Requirements & Data Sources Collection:** This phase is in charge of analyzing the different requirements needed by the demonstrator in terms of explainability and collecting and inspecting the different available data sources in order not only to provide the most suitable solution from a ML perspective but only the most suitable one in terms of explainability.

- T1.1 - Collection of Explainability requirements

After the definition of each use case, it is important to differentiate between the AI requirements and the Explainability Requirements. This task has the objective of establishing the explainability needs (e.g. understand why a plan is better than another one or infer the root causes of a detected anomaly) and the way of how this explainability can be reached by the end-user by means of text plots, bar plots or other dedicated explanation diagram.

- T1.2 - Data ingestion

This task consists of the collection of the data sources that will be employed by the XAI ML System. It will consider both the input data that can be used and profitable by the predictive system and the way the data is collected to be used by this system.

**Phase 2 - Use case 1: Holistic overview of the production:** This phase engloves all the tasks required to cover the problems intended to be solved within the first use case described by Ford. These tasks include all the actions performed from the exploratory analysis of the input data sources to the deployment of the predictive system.

- T2.1 - Data processing and data analytics

This task is related to the different analysis of the input data sources, exploratory analysis and the various feature engineering processes to extract meaningful information as features that can feed the predictive systems.

- T2.2 - Development of intelligent predictive models

This task includes the development of the code and the training processes of the Machine Learning algorithms that aim to solve the concrete problems specified in each use case. The selection of the concrete algorithm is based on the AI needs of the use case and the way the predictions will be explained is based on the explainability requirements specified in the Phase 1.

- T2.3 - Evaluation

The trained models have to be evaluated in order to assure that it complies with the demonstrator requirements. For this purpose, the models will be validated attending to a validation protocol that

will evaluate the models not only from a Machine Learning perspective but also from an explainability (validity of the explanations) and business perspective.

- T2.4 - App development

This task include all the activities related to the development of the specific dashboards in order to show predictions and explanations and the way the end user will be warned through notifications on the on-premise system at the Ford Valencia Engine Plant.

- T2.5 - Deployment in production

Once a model is validated, it has to be deployed to be used in production and perform inferences and explanation for new future data.

**Phase 3 - Use case 2: Automated Production Planning:** This phase engloves all the tasks required to cover the problems intended to be solved within the second use case described by Ford. These tasks include all the actions performed from the exploratory analysis of the input data sources to the deployment of the predictive system.

These tasks are the same as the first use case but focused on automated planning of the production.

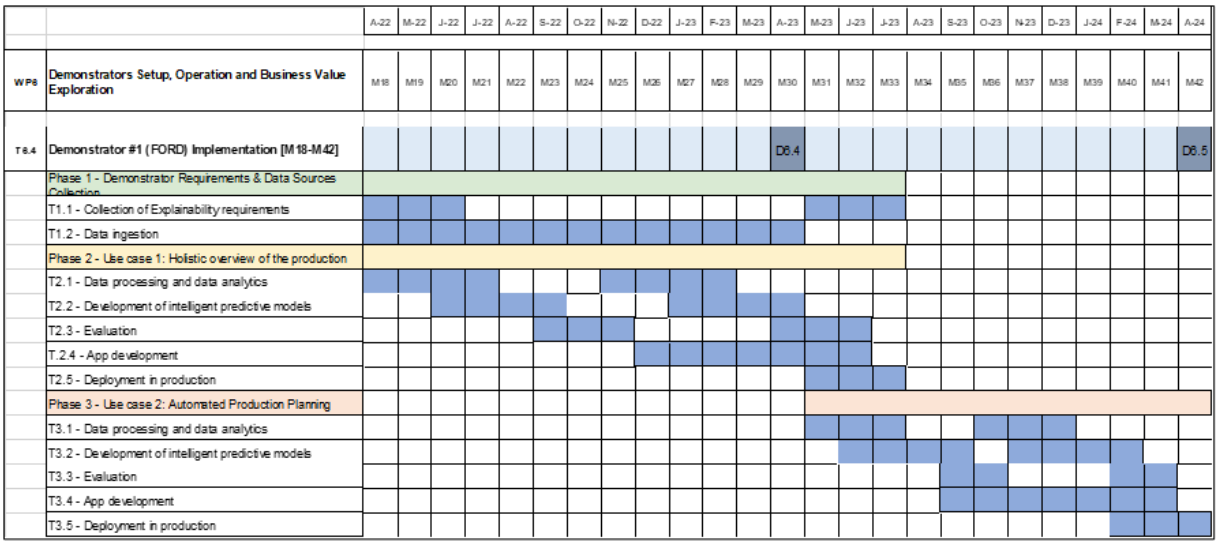



*Figure 1 Gantt Chart of Ford Implementation*

## 2.2 Demonstrator 2: WHIRLPOOL implementation's planning

Whirlpool Use case will be implemented with the following detailed plan in the time frame M18-M42:

- Collection of explainability requirements
- Private infrastructure creation
- XMANAI on premise environment deployment
- XMANAI Data ingestion
- SCENARIO
    - Data processing and data analytics - (experimentation)
    - Creation of explainable AI pipelines
    - Creation of explainable dashboard

- Users' evaluation

The Scenario task will include a re-loop after the first validation phase by the users to capture all the feedback provided, as per the Gantt plan below:

| | A-22 | M-22 | J-22 | J-22 | A-22 | S-22 | O-22 | N-22 | D-22 | J-23 | F-23 | M-23 | A-23 | M-23 | J-23 | J-23 | A-23 | S-23 | O-23 | N-23 | D-23 | J-24 | F-24 | M-24 | A-24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Demonstrators Setup, Operation and Business Value Exploration** | M18 | M19 | M20 | M21 | M22 | M23 | M24 | M25 | M26 | M27 | M28 | M29 | M30 | M31 | M32 | M33 | M34 | M35 | M36 | M37 | M38 | M39 | M40 | M41 | M42 |
| | apr | may | jun | jul | aug | sep | oct | nov | dec | jan | feb | mar | apr | may | jun | jul | aug | sep | oct | nov | dec | jan | feb | mar | apr |
| **Demonstrator #2 (WHIRLPOOL) Implementation [M18-M42]** | | | | | | | | | | | | | D6.4 | | | | | | | | | | | | D6.5 |
| Collection of Explainability requirements | X | X | | | | | | | | | | | | X | X | | | | | | | | | | |
| Private infrastructure creation | X | X | X | X | | | | | | | | | | | X | X | | | | | | | | | |
| XMANAI on premise environment deployment | | | X | X | X | X | | | | | | | | | | X | X | | | | | | | | |
| XMANAI Data ingestion | | | X | X | X | X | | | | | | | | | | X | X | | | | | | | | |
| SCENARIO | | | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Data processing and data analytics - (experimentation) | | | | | X | X | X | | | | | | | | | | | X | X | X | | | | | |
| Creation of explainable AI pipelines | | | | | | | X | X | X | | | | | | | | | | X | X | X | X | | | |
| Creation of explainable dashboard | | | | | | | | X | X | X | | | | | | | | | X | X | X | X | | | |
| Users' evaluation | | | | | | | | | | | X | X | X | | | | | | | | X | X | X | X | X |

*Figure 2 Gantt Chart of Whirlpool Implementation*

## 2.3 Demonstrator 3: CNH implementation's planning

CNH Use case will be implemented with the following detailed plan in the time frame M18-M25 and will be reviewed after this first period with a new dedicated version on D6.3:

**Phase 1 - Sensors' installation:** in this phase we will send the purchase request for the sensors, call the suppliers who will install the sensors on the CNC center of the heller 400.

**Phase 2- Data collection:** In this phase, the data of the sensors visible in real-time on the Smart Observer internal platform will be collected and sent to the XMANAI platform for a couple of months in order to collect enough data to drive the algorithm more efficiently. This phase concerns also the choice of the sampling frequency and the different implementation parameters.

- Task 2.1 First round of data collection: This task is necessary to collect data of the sensors for the creation of the first dataset to start training the model with the vibrational sensors already installed in the machine;
- Task 2.2 Second round of data collection: In this task, the data collection will continue to adding new data to the first dataset to expand it with data related to the new installed temperature and current sensors.
- Task 2.3 Collection of explainability requirements: This task is crucial to understand which is the explanatory method that best suits the case study and the end user needs in order to make the AI result more understandable and usable during the user experience inside the plant.

**Phase 3 -Model development:** The development phase of anomaly detection algorithm is splitted into two parts in relation to the data collection phase in which are individuated two parts for the first round of collection and the second for optimization. This is the phase for training and test the DBSCAN algorithm.

- Task 3.1 Model training part 1: This task is related to the first training of DBSCAN algorithm with the dataset created in the Task 2.1
- Task 3.2 Model testing part 1: This task is related to the testing phase of the first round of model training in order to optimize the parameters selected for the algorithm
- Task 3.3 Model training part 2: In this task, the new dataset created in task 2.2 can be used for the training of the DBSCAN algorithm
- Task 3.4 Model testing part 2: This task is related to the testing phase of the algorithm trained in the task 3.3

**Phase 4 - Model deployment:** The final phase is the model deployment in which the algorithm should be adapted to the XMANAI platform and the model execution in the CNH plant after which the second round of 6P assessment should be performed.

- Task 4.1 Model adaptation to platform: This task is related to the adaptation and integration of the final version of the XAI model into the XMANAI platform for the execution inside the plant
- Task 4.2 Model execution: In this phase, the XMANAI platform has to be tested after its execution inside the plant with the blue-collar operators that work inside the plant and will work with the XMANAI platform to check the properly working condition of the platform
- Task 4.3 Creation of explainability app: This task includes all the activities related to the development of the dashboard in which show AI predictions and the related explanations completed by the warning way the end user will be warned through notifications at the CNH Industrial Plant.

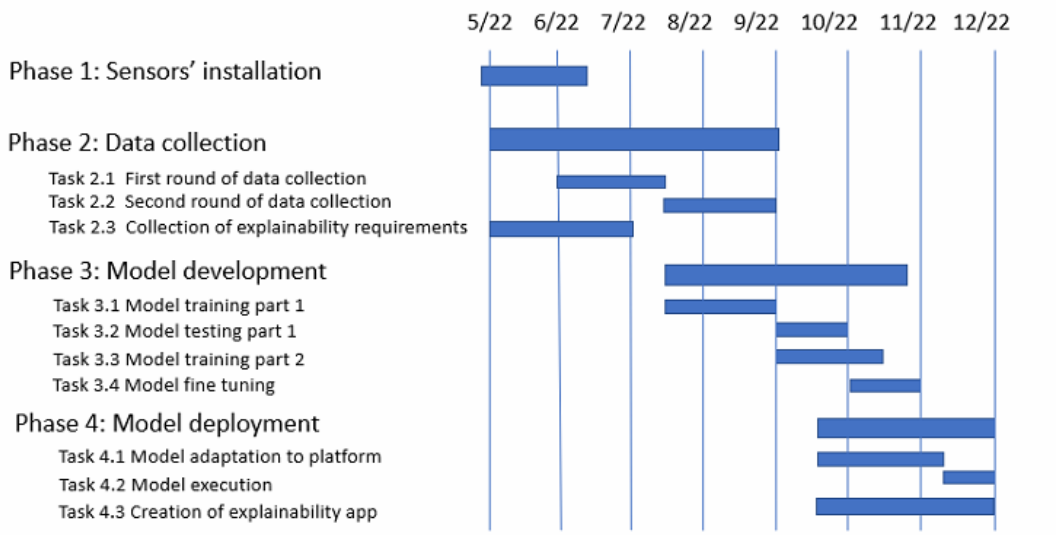



*Figure 3 Gantt Chart of CNH Implementation*

## 2.4 Demonstrator 4: UNIMETRIK implementation's planning

UNIMETRIK Use case case will be implemented with the following detailed plan in the time frame M18-M42:

**Phase 1 - Pilot definition and scope**: The objective of Phase 1 is to define the actual scope of the demonstrator taking into account the future scenario for the operation of the demonstrator. To do so, the business objectives and requirements of the UNIMETRIK use case will be analyzed.

- *T1.1 Identification of the scope and current procedures for the recommendation of measurement:*

Both Demonstrator leader and technical partners will work on the identification of the scope for the UNIMETRIK demonstrator taking into account the current procedures. They will also work on the definition of the explainability needs to be fulfilled by the XMANAI solution regarding the business requirements for the UNIMETRIK demonstrator.

- *T1.2 Definition of the Data Sources*
- *T1.3 Definition of the instrument & procedure to perform the measurements and obtain the data*

**Phase 2 - Definition of the functionalities to be fulfilled by the XMANAI solution:** The main objectives of Phase 2 are to identify the problems and functionalities to be developed for the demonstrator, and related to them, to define the technical requirements to fulfil the pilot scope.

- *T2.1 Identification of functionalities*

Aligned to the business requirements analysis previously held, a deeper elicitation of the functionalities that the XMANAI solution must offer will occur, based on the cost of poor decisions when no explainable AI system is available.

- *T2.2 Definition / Formulation of problems to be solved in order to serve the identified functionalities.*

Linkage to the data sources to be used as inputs/outputs to AI algorithms, that will be applied to solve the defined problems

- **T***2.3 Demonstrator Requirements and New Models and Algorithm request*

Based on the business requirements and functionalities already identified, the technical requirements, algorithms and AI models will be defined to fulfil the pilot scope.

**Phase 3 - Pilot implementation:** The main objective of this phase is to generate, develop and integrate the data, algorithms and training pipelines for the implementation of the first version of the UNIMETRIK pilot

- *T3.1 Generation of the Data*

Related and based on the work held on T2.1 and T2.2, during this task will be held the generation of the data needed for the AI models

- *T3.2 Hybrid explainable AI models development and construction*

During this task, Hybrid AI models will be developed starting with traditional machine learning techniques and the combined with novel libraries for model explainability, taking into account their applicability for the UNIMETRIK demonstrator.

- *T3.3 Training of Artificial Intelligence System*

The hybrid AI models previously defined must be trained, validated and tested on the generated data to fulfil the scope of the UNIMETRIK demonstrator with respect to performance, efficiency and generalization.

- *T3.4 Generation of explanations*

Generation & visualization of explanations for the solutions of the trained AI models. Assessment of the quality of explanations, with respect to the extent to which these enhance the interpretability of results to the business user. Creation of an Explainable Dashboard for the demonstrator.

**Phase 4 - Evaluation of the demonstrator:** The main objectives of this final phase are on one hand to carry out the double assessment created on T6.2 regarding the Business cases and the impact of the explainability on those business cases for the UNIMETRIL scenario. This evaluation will be done twice, one taking into account the actual scenario where the XMANAI platform is not available, and the other one after the final version of the demonstrator over the XMANAI platform.

- *T4.1 Evaluation of the impact before the use of the XMANAI platform*

In order to evaluate the impact of the digital transformation and the benefits deriving from the adoption of an Explainable solution, the UNIMETRIK demonstrator leader will take on an assessment before the use of the XMANAI platform over its specific use case.

- *T4.2 Evaluation of the demonstrator's operation and execution using the XMANAI platform*

Once the implementation of the pilot has concluded, it will be evaluated its operation and execution using the XMANAI platform on its alpha, beta and final version, in order to perform the final tuning of the algortihms, hybrid AI models and training system.

- *T4.3 Evaluation of the impact after the use of the XMANAI platform*

Related to T4.4, after the implementation of the demonstrator over the XMANAI platform, the UNIMETRIK demonstrator leader will take on once again the previous assessment over its specifici use case. The difference between initial and final level will allow to measure the XMANAI's platform impact.

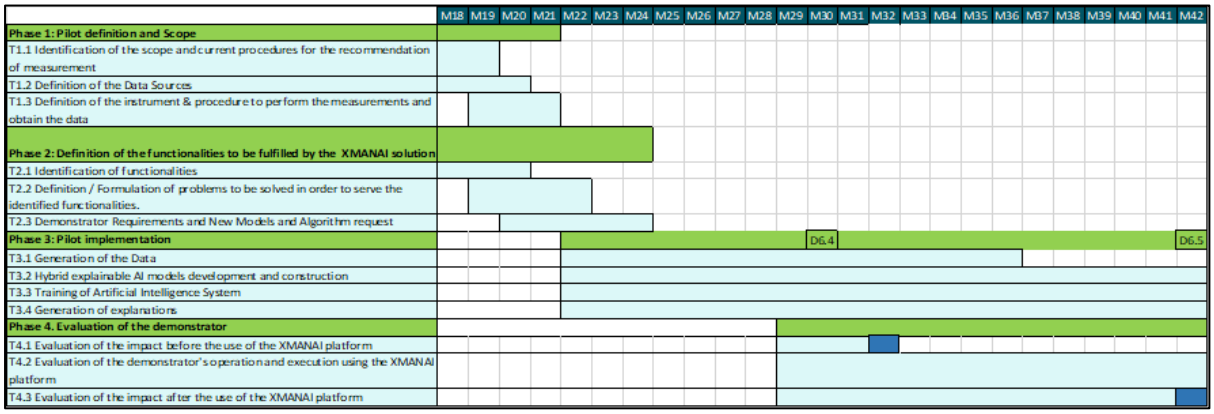



*Figure 4 Gantt Chart of Unimetrik Implementation*

# 3 The 6Ps methodology

The objective of this chapter is to provide a detailed overview of the 6Ps methodology that has been the starting point to define the Evaluation Framework, describing the main features, scope and uses but also highlighting what was missing for XMANAI purposes and has been integrated by T6.2.

## 3.1 Overview of the original tool

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

The methodology includes an assessment defined from a tactical perspective (aiming at helping companies to generate strategies for approaching and moving forward Industry 4.0) and it serves as a starting point and a basis for new ideas and roadmaps. It helps the enterprises to highlight the main gaps to be filled with a digital transformation process since it is required to evaluate both the current and the expected level, for each pillar and sub-dimension.

The migration journey has been developed inside universities boundaries and it has been already used in MIDIH[1] European project, as well as AI REGIO[2], CAPRI[3] and DIH4AI[4].

The methodology is based on five main steps:

1. **Set-up of a team bringing together different organizational areas**: The identification of right people able to detect the main gaps in the several dimensions of the productive process is fundamental to drive the company toward the digital transformation.
2. **Identification of the AS-IS profile of the manufacturing enterprise**: The manufacturing enterprise's strategy, competitive strengths and weaknesses, etc. must be analysed. Then, its current profile must be mapped into each dimension and development stage of every migration pillar.
3. **Definition of the target TO-BE profile of the manufacturing enterprise**: The future vision and desired profile of the manufacturing enterprise must be defined considering the links to the business and competitive priorities, and thus mapped onto each dimension and development stage of the 6P pillars.
4. **Identification of actions, feasibility and prioritization**: This step is about identifying the actions needed to migrate from the AS-IS to the TO BE and considering the links to the business strategy as well as benefits and costs, risks and dependencies, evaluating to what extent investments are justified and what actions should be prioritized.
5. **Development of the Migration Plan towards Industry 4.0**: Finally, the migration plan is developed. To this respect, different approaches can be adopted. However, often the most successful one is to focus on simple actions with short-term pay-offs at first (quick wins) before implementing more complex and long-term projects.

To develop the Evaluation Framework as per T6.2 requirements, WP6 leveraged on steps 1, 2 and 3 as they provide effective tools to take into account all the several aspects that may be impacted by a transformation process (as the adoption of the XMANAI platform, for instance); at this stage, steps 4

[1] https://www.midih.eu/
[2] https://www.airegio-project.eu/
[3] https://www.capri-project.com/
[4] https://www.dih4ai.eu/

and 5 are out of scope, as the goal is to measure the impact of the project and not to develop a migration plan.

To be precise, the XMANAI Evaluation Framework is widely based on the 6Ps assessment used in Steps 2 and 3 to define, respectively, the AS-IS and TO-BE profiles. It is extremely useful since it guides the analysis along many dimensions and aspects, that must be taken into account to perform a detailed and correct measurement of the impact.

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


*Figure 5 6Ps Digital Transformation Tool – The six pillars*

Each pillar P is composed of at least six different dimensions of analysis of Industry 4.0 (rows). Each analysis dimension is broken down into five sequential development stages (columns) from the least to the most advanced one with respect to Industry 4.0 and AI adoption.

For each dimension, the company is required to identify two profiles choosing the correspondent levels: the current profile and the expected one, to be reached as result of the Transformation Journey. In the context of the XMANAI project, the demonstrators will be required **to identify the profile before and after the adoption of the platform**, in order to compare them and measure the impact.

### 3.1.1 The Product dimension

6Ps' **Product dimension** has the objective of evaluating in a quantified way to which extent the manufacturing enterprise is digitally mature in terms of Product or Product-Service System that offers to the market. This is the first dimension analysed as the subject of the analysis constitutes the direct link that manufacturing enterprises have with their customers thus significantly affecting the overall performances of the firms. However, in the context of XMANAI project, it seems to be less impacted as the XAI solutions are not designed to be embedded directly in the product.

The six different fields of analysis that are taken into account are related to: **Sensors and actuators** (to understand how the product is equipped); **Communication and Connectivity** (to measure how the product is able to communicate with external devices); **Storage and Exchange of information** (to measure if the product is able to storage data); **Monitoring** (to assess if the product is able to self-monitor its status); **Product-related IT services** (to measure the level of service related to the product);

**Business Models enable by the product** (to measures how the digital maturity of the product impact on company's business model).

The picture below describes, for each sub-dimension of the Product pillar, the five sequential development stages from the least (INITIAL) to the most advanced one (EXPLOITED).

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

*Figure 6 6Ps - The Product Dimension*

### 3.1.2 The Process dimension

6Ps' **Process dimension** has the main objective of assessing the level of digital maturity in each of the most relevant processes that characterize the manufacturing sector and so manufacturing enterprises. In the context of the XMANAI project, the Process dimensions seems to be one of the most impacted, as the XAI solutions are conceived especially to support the company during its daily tasks.

The six analysis fields are related to: **Design & Engineering** (to evaluate how these two processes are enabled by digital technologies); **Production Management** (to evaluate how the production happens); **Quality Management** (to assess how quality is managed to avoid quality issues); **Maintenance Management** (to measure how much digital technologies characterize the practices related maintenance activities); **Logistics Management** (to assess the digital maturity level of the logistics processes); **Supply Chain Management** (to evaluate to which extent digital technologies are exploited in this field).

| | LEVEL-1 INITIAL | LEVEL-2 MANAGED | LEVEL-3 DEFINED | LEVEL-4 INTEGRATED | LEVEL-5 EXPLOITED |
|---|---|---|---|---|---|
| **DESIGN & ENGINEERING** | No digital model of the process is present. There are only one-way exchanges between design and production functions | Some preliminary digital models do exist as static representation of the process. Notifications between production and design functions are bidirectional, but tracked in a document | Simulations are developed inside the CAD and supported by digital models. Production function is involved in all the design process. Modifications are tracked via different digital models, with an internal encoding | Simulations are developed and validated in CAD environment; digital models are compared versus physical prototypes. Production function is totally involved in the design phase. Modifications are automatically identified and managed in CAD. | Full Digital Twin simulations developed in CAD environment are used. Production function is totally involved within the design phase and skills of the two functions are shared. Different digital process options are managed and assessed in a single development environment. |
| **PRODUCTION MANAGEMENT** | Repetitive production processes are partially automated but not connected, with significant human intervention. Repetitive support processes are not automated. | Repetitive production processes are almost automated and connected via multiple channels and protocols. Repetitive support processes are not automated. | Repetitive production processes are fully automated and interoperable, with no human intervention. Repetitive support processes are partially automated. | Automated and interoperable production processes are reconfigurable through plug-and-play automation and capable of real-time communication. Repetitive support processes are partially automated. | Flexible and interoperable production and support processes are capable of real-time communication, scalable and converged with enterprise and facility automation platforms to form highly autonomous networks. |
| **QUALITY MANAGEMENT** | Quality processes are carried out through human inspections and simple systems (e.g. excel control charts) (descriptive quality) | Quality management systems are able to model correct quality patterns and identify deviations. (diagnostic quality) | Quality management systems are able to identify deviations and diagnose potential causes. (preventive quality) | Quality management systems are able to diagnose problems and predict future states of assets and systems. (predictive quality) | Quality management systems are able to diagnose problems, predict future states and autonomously execute decisions to adapt to changes (cognitive quality). |
| **MAINTENANCE MANAGEMENT** | The company does not use any digital tool to track maintenance activities and adopts a descriptive approach | The maintenance activities are tracked with simple tools (e.g. excel sheets) and plans and procedures are loaded into CMMS/ERP. The company adopts a diagnostic approach | The maintenance activities are tracked and analysed with simple tools (e.g. FMEA on excel sheets) and reconfigurable plans and procedures are loaded into CMMS/ERP. The company adopts a predictive approach | Maintenance activities are traced and monitored through dedicated software (e.g. CMMS, SCADA, MES, etc.) procedures and plans are validated periodically. The company adopts a prescriptive approach. | Maintenance activities are traced and monitored through dedicated software (e.g. CMMS, SCADA, MES, etc.) procedures and plans validation is part of the maintenance activity. The company adopts a cognitive approach. |
| **LOGISTICS MANAGEMENT** | Logistics processes are defined and executed by humans, with the support of analogue tools | Defined logistics processes are completed by humans with the support of digital tools. | Digitized logistics processes and systems are securely integrated across all hierarchical levels of the automation pyramid. | Integrated logistics processes and systems are automated, with limited human intervention | Automated logistics processes and systems are actively analysing and reacting to data |
| **SUPPLY CHAIN MANAGEMENT** | Process barely monitored and managed reactively. Systems not updated nor integrated | Process lowly monitored, managed on experience. Systems antiquates or not integrated. | Use of good practices. Process fairly monitored, partially integrated and automated | Use of best practices and common and shared standards. Process overall planned and monitored. Systems mainly integrated, automated and managed in an overall integrated way among divisions. | Process is systematically monitored, developed with advanced technologies and systems that are managed in an integrated way among divisions. Information exchange is fast, robust and secure. |

*Figure 7 6Ps - The Process Dimension*

### 3.1.3 The Platform dimension

The **Platform dimension** suggests migration pathways towards Digital Platforms supporting vertical integration (from the shop floor to the enterprise level), horizontal integration along the value chain and end-to-end engineering. Together with the Process P, the Platform dimension is one of the most impacted by the XMANAI project, whose main output is exactly a platform to support Explainable AI. To make it more suitable to the project's needs, the Platform dimension has been slightly changed, as presented in Paragraph 3.2.2.1.

In this respect, six technological fields of analysis are considered: **CPS and embedded systems** (to measure how much the firm is able to use the data collected from the field); **Industrial Internet of Things** (to measure the ability of the factory in using and integrate IoT devices); **Industrial Internet** (to measure how factory assets are linked to the common internet platform); **Industrial analytics** (to evaluate the capacity of the company in exploiting analytics); **Vertical interoperability of data and events** and **Horizontal interoperability of data and services** (to measure the capabilities of manufacturing companies in collecting, manipulate and manage data that are necessarily heterogenous in an integrated way).

| | LEVEL-1 INITIAL | LEVEL-2 MANAGED | LEVEL-3 DEFINED | LEVEL-4 INTEGRATED | LEVEL-5 EXPLOITED |
|---|---|---|---|---|---|
| **CPS AND EMBEDDED SYSTEMS** | No Digital Manufacturing Platforms in Smart / Embedded Systems | Just the capability to collect and store data from the field and elementary elaboration (datalogger) | In addition to storage/computation, the capability to integrate additional sensors, to understand the ambient and to react correspondingly | In addition, the capability to set up and manage Machine2Machine and Machine2Human interaction sessions | The capability to use the collected information (from machines, from sensors and from human interaction to take decisions and behave autonomously) |
| **INDUSTRIAL IoT** | No capability to sense the ambient and react | Dumb sensors provide data but cannot neither commanded nor configured remotely | Sensors ecosystems are governed and controlled by dedicated hardware usually at the edge of the network | A computable model of the asset allows running simulations and forecasting behaviour | Ecosystems of smart objects are interoperable through open standards |
| **INDUSTRIAL INTERNET** | Real World devices are controlled and managed by hard wired protocols | Real World devices are controlled and managed by multi-protocol gateways | Events gathered by gateways are processed and anomalous situations detected by threshold analysis | More complex knowledge and rules are used to determine correct and anomalous patterns | On-the-fly configurable HCI primitives and adaptive and cognitive analytics reports |
| **INDUSTRIAL ANALYTICS** | No Digital Manufacturing Platform for analytics functionality | Analytics techniques are used to filter and visualise data sets (streams or repositories) | The system under analytics is modelled and dynamic behavioural simulations allowed as well as model verification and validation form real world data | Verified model are used to instantiate what-if scenarios, to forecast them and to predict future behaviours | The future predicted scenarios are confronted with current plans and decisions in Enterprise Applications, so that new business decisions are generated |
| **VERTICAL INTEROPERABILITY OF DATA AND EVENTS** | Data Events at Shopfloor unexploited | Data generated by real world are collected by dedicated Data Loggers and Gateways | Data generated by real world are transferred through the gateways to the cloud | Bidirectional data flows between real world and cloud allowed by an architecture of distributed HW/SW components | At runtime and on-the-fly the configuration of the distributed architecture could be dynamically adapted |
| **HORIZONTAL INTEROPERABILITY OF DATA AND SERVICES** | Data/Events silos | Data coming from different plants are integrated ad- hoc in a unique repository | Different data formats and protocols are semantically harmonised and interoperated | Different Enterprise Applications in different factories are integrated as a service | Collaborative business processes and workflow are implemented in the value chain |

*Figure 8 6Ps - The Platform Dimension*

### 3.1.4 The People dimension

6Ps' **People dimension** aims at assessing the skills owned or to be owned among manufacturing enterprises' human capital. This dimension is not divided into 6 areas directly, due to the high variance in the roles operating in the sector; this pillar has been at first divided into 5 macro-professions, namely: **Blue Collars, Operators I4.0, Digital Transformation Professional, I4.0 Professional, Managers & C-Levels** and then six fields of interest have been identified as well.

These areas are: **Industry 4.0 Strategy** (to measure the level of awareness about industry 4.0); **Smart Operations** (to evaluate how much digital technologies are exploited in favour to traditional tools); **Smart Supply Chain** (to assess the level of digitalization of tools used in this field), **Smart Product-Service Engineering** (to evaluate the skills and tools used in the production development phase), **Industry 4.0 Infrastructure** and **Big Data** (to assess the level of skills in the field of big data).

The People dimension is the most relevant one to measure the effect and effectiveness of Explainability component of the XMANAI solutions. Actually, Explainability is a feature that impacts mainly the workers as it increases the trustworthiness and understandability of algorithms, that in theory could work even without it, but that would be hardly accepted by workers. This is why the People dimension has been analysed in details and some changes have been applied, as described in Paragraph 3.2.1.

The figure below shows the 6 fields composing the People dimension and their divisions into the 5 macro-professions.

| | | LEVEL 1 – INITIAL | LEVEL 2 - MANAGED | LEVEL 3 – DEFINED | LEVEL 4 – INTEGRATED | LEVEL 5 – EXPLOITED |
|---|---|---|---|---|---|---|
| INDUSTRY 4.0 STARTEGY | MANAGER | Knows and understands the trends related to I4.0 and AI technologies and their implementation in the competitive environment | Analyses the transformation of the value chain by adopting industry 4.0 and new AI technologies | Provides leadership for creation of an I4.0 strategy, implements AI technologies by including risks and opportunities | Forges relationship and alliances with the various stakeholders of the industry 4.0 ecosystem | Applies strategic thinking, stakeholder management and organisational leadership to develop and implement and integrated strategy to exploit the capability of I4.0 and AI technology to improve the business |
| SMART OPERATIONS | BLUE COLLAR WORKERS | Use of standard HMI | Use of wearable devices to monitor production | Analytical skills to interpret production data | Use of new production tech., e.g., AI, Collaborative robots, 3D printing, etc. | Plan, monitor, analyse information, inspect (with AR) determine causes of problems/failures and perform corrective actions |
| | I4.0 PROF/MANAGER | Use of common software (e.g., excel) | Use of enterprise systems (ERP, MES, PLM) | Analytical skills to analyse production data autonomously and interpret production data | Redesign process end -to end to improve their performance through AI and I4.0 technologies | Plan, coordinate, optimize, smart production system |
| SMART SUPPLY CHAIN | OPERATOR 4.0 | Use of common software (e.g., excel) | Use of wearable devices | Analytical skills to interpret data | Use/interaction of new smart warehouse, picking and automatic guided vehicles (new tech. such as AI, VR etc.) | Plan, monitor, analyse information, inspect (with AR) determine causes of problems/failures and perform corrective actions |
| | I4.0 PROF/MANAGER | Use of common software (e.g., excel) | Dynamic management in real time through monitoring and tracking technologies | Collaborate with different external actors and integrate them in the digital / intelligence supply network | Analyse market demand, supply network data, social media and other data, and predict future scenarios by using skills related to AI tech. | Plan, coordinate, optimize, the collaborative digital / intelligence supply network |
| SMART PSS ENGINEERING | OPERATOR 4.0 | Use of technical Drawing Programs (CAD) | Drawing in 3D | User skills for 3D printing AR/VR | Design of smart products (integration of sensors, antennas, chips and other components) | Model-based design and simulations |
| | I4.0 PROF/MANAGER | Product-oriented organization and business models | Understanding the importance to follow the whole lifecycle of the product and support services | Design of smart products customized through sw user interface and services, integration with the enterprise IT systems | Design, recycle and management of product – service lifecycles and business models | Open innovation of smart and repurpose PSS lifecycles and B.M. with a digital ecosystem of partners |
| INDUSTRY 4.0 INFRASTRUCTURE (IT-OT) | DT PROF | Contribute to the design and general functional specification and interfaces | Use of modelling language and programming tools | Evaluation of pros and cons of different sensors, software, protocols and select the most adequate to needs of the enterprise (including cybersecurity) | Specify, refine, update and make available a formal approach to implement solutions, necessary to develop and operate the architecture oriented toward industry 4.0 | Investigating latest technologies and devising innovative solutions for integration of new technology into existing systems to meet future business industry 4.0 and Artificial intelligence requirement. |
| BIG DATA | DT PROF | Selecting and collecting useful big data | Cleaning, organising, and rationalising the data | Selecting and implementing technology such as AI for analysing big data | exploiting big data automatically by tech. of ML and AI | Using big data creatively and innovatively |

*Figure 9 6Ps - The People Dimension*

### 3.1.5 The Partnership dimension

The **Partnership dimension** relates to the identification of the partners needed for digitalization and for achieving the desired business goals. It describes the workflows whose purpose is to support the transition towards more collaborative relationships with key stakeholders in the digital ecosystem, in order to create strong and collaborative partnerships that are crucial for the enterprise. Partnership is intended as a lever to be sustainable in the long term and XMANAI ecosystem can be the place where partnerships may arise.

Accordingly, partners included in the dimensions, with whom the level of engagement the company has established or is willing to establish is measured, are: **DIHs**, **Research and Innovation, Education and Training Providers, IT Solution Providers**, **Suppliers and Customers**.

| | LEVEL-1 INITIAL | LEVEL-2 MANAGED | LEVEL-3 DEFINED | LEVEL-4 INTEGRATED | LEVEL-5 EXPLOITED |
|---|---|---|---|---|---|
| **DIGITAL INNOVATION HUBS** | No relationship with Digital Innovation Hubs | Informal communication one-off share of information | Supportive relationships but no formal activities in place | Engaged in mutual projects and initiatives | Formal agreement in place, partners work toward developing enhanced capacity |
| **RESEARCH & INNOVATION** | No relationship with research /innovation organizations and programs | Participation to events and workshops oriented to research and innovation | Active interest in Research & Innovation initiatives | Occasional participation to R&I programs | Systematic Participation and common Research & Innovation programs |
| **TRAINING & EDUCATION** | No competence assessment and training programs on Industry 4.0 | Occasional competence assessment and educ./training programs for a few roles | Regular competence assessment, training and education programs, also in collaboration with VET schools, universities, etc. | Use of Technology-Enhanced Learning in collaboration with VET schools, universities, etc. | Lifelong learning programs for the whole staff leveraging technology-enhanced learning. On-going collaboration with education through staff exchange, learning factory., etc. |
| **IT SOLUTIONS PROVIDERS** | No continuative relationship | IT partnership as a necessary provision of basic digitalisation services (suppliers) | IT partnership as a collaboration environment to develop together reliable solutions | IT providers as reliable partners in identification of new business opportunities | IT providers as offering game changing value and new business models |
| **SUPPLIERS** | Transaction relationship: partnership just related to the supply of goods/services | Cooperation relationship: partnership also related to the supply and usage of goods/services | Coordination relationship: partnership also related to whole ecosystem of goods/services suppliers | Collaboration relationship: partnership directed to a mutual but occasional business opportunity | Dynamic collaboration relationship: strategic long-term multi –dimensional partnership in a win-win situation |
| **CUSTOMERS** | No partnership with Customers | Cosmetic customer partnership. standard product is offered in different ways to different customers using special packaging, etc. | Transparent Customer Partnership. Customization without direct interaction with customers | Adaptive Customer Partnership. Customer customizes the good or service as desired using customizable functionality embedded into the offering | Collaborative Customer Partnership. Customers actively participate in Co-creation and co-production |

*Figure 10 6Ps - The Partnership Dimension*

### 3.1.6 The Performance dimension

6Ps' **Performance dimension** aims at investigating the way in which the indicators of the manufacturing enterprises are defined, measured and monitored. Differently from what it may seem at first glance, it doesn't provide the value of the indicators themselves: for instance, comparing the AS-IS and TO-BE level, the objective is not to check if an indicator is expected to improve, but if the way the indicator is measured is expected to become more accurate.

To make it more suitable to the project's needs, the Process dimension has been slightly changed, as presented in Paragraph 3.2.2.2.

The dimension is divided into 6 areas, namely: **Operational/Technical** (to monitor the performances of machines and production activities such as OEE); **Economic** (to monitor KPIs focused on economic and financial results such as ROI); **Environmental** and **Social** (to measure these performances and covering all the aspects of the triple bottom line); **Product-Service Lifecycle** (to assess how, to which extent and according to which criteria the Product is assessed by the firm once offered to the market); **Supply Chain** (to assess the modalities through which manufacturing enterprises are able to measure the overall performances of their entire Supply Chain).

| | LEVEL-1 INITIAL | LEVEL-2 MANAGED | LEVEL-3 DEFINED | LEVEL-4 INTEGRATED | LEVEL-5 EXPLOITED |
|---|---|---|---|---|---|
| **OPERATIONAL/ TECHNICAL** | Operational performance is often not measured or understood | Descriptive Performance - Measurement and analysis of business KPIs are largely retrospective | Diagnostic Performance - Measurement of KPIs is clear. Attempt to understand the causes that affects events and behaviours | Predictive Performance - Measurement of KPIs is prospective. Statistical models and forecasts techniques to understand the future KPIs | Prescriptive Performance – future-oriented. Optimization and simulation to find the best course of action and operational KPIs measurement |
| **ECONOMIC** | Economic performance is often not measured or understood | Descriptive – Measurement of economic KPIs is largely retrospective | Diagnostic - Measurement of economic KPIs is clear. Attempt to understand the causes of events and behaviours | Predictive - Measurement of economic KPIs is prospective. Statistical models and forecasts techniques to understand the future | Prescriptive – future-oriented. Optimization and simulation to find the best course of action and economic KPIs measurement |
| **ENVIRONMENTAL** | Environmental performance is often not measured or understood | Descriptive – Measurement of environmental KPIs is largely retrospective | Diagnostic - Measurement of environmental KPIs is clear. Attempt to understand the causes of events and behaviours | Predictive - Measurement of environmental KPIs is prospective. Statistical models and forecasts techniques to understand the future | Prescriptive – future-oriented. Optimization and simulation to find the best course of action and environmental KPIs measurement |
| **SOCIAL** | Social performance is often not measured or understood | Descriptive - Measurement of social KPIs is largely retrospective | Diagnostic - Measurement of social KPIs is clear. Attempt to understand the causes of events and behaviours | Predictive - Measurement of social KPIs is prospective. Statistical models and forecasts techniques to understand the future | Prescriptive – future-oriented. Optimization and simulation to find the best course of action and social KPIs measurement |
| **PRODUCT-SERVICE LIFECYCLE** | No product life cycle assessment | A few life-cycle aspects are included in some KPIs but occasionally | Life Cycle Costing (LCC) towards recycling, de-re-manufacturing KPIs | Life Cycle Costing + Environmental LCA towards Circular Economy | Life Cycle Costing + Environmental LCA + Social LCA towards Sustainability and Green Deal |
| **SUPPLY CHAIN** | Performance is often not measured or understood | Only the most important physical performance of suppliers (e.g. punctuality, quality, operational flexibility) | Physical and Economical performance (purchase price, non-quality costs, delivery delays, lack of flexibility, etc.). | Physical, economical, sustainability performance for almost all the suppliers. | Physical, economical, sustainability and integration with other external sources (e.g., social media, weather) |

*Figure 11 6Ps - The Performance Dimension*

## 3.2 Toward Explainability – new XMANAI features

It must be noted that the 6Ps model as presented in the previous chapter is a powerful tool, but it does not originally include specific dimensions describing AI and Explainability. That is why it has been decided to review the proposed 6Ps model, firstly to understand the relevance of the actual model for AI and Explainability, and then to understand how they could be included within the framework.

### 3.2.1 The PEOPLE Pillar

Among the different pillars, the people pillar has been identified as the one more suitable for introducing dimensions related to explainability. This decision has been made considering the fact that, while AI is usually a technical field focusing on developing technical solutions, with the introduction of explainability the focus is shifting toward users, hence people. Explainability is inherently connected to the interaction toward AI and users, because in the end the results of the explainability features are used by users to take decisions and to understand the context of the AI interpretation.

The main objective of the People pillar is to support digital skills development and professions, evaluating several dimensions that relate to the need of new digital skills to fully integrate advanced digital solutions such as Industry4.0 tools, big data or smart supply chain solutions. The introduction in the organisation of AI, and even more of XAI, requires the understanding of how people and AI interact, and how people leverage the XAI results for producing value for the organisation.

Four new dimensions have been added to include in a comprehensive way the evaluation of how AI, and especially XAI, will be implemented, and what this means for the organisations and the people working in them. To define the new dimensions, we considered the guidelines for Human-AI interaction proposed by (Amershi, 2019) and the Level of Automation Taxonomy proposed by (Save, 2021) as reference on how to consider the different levels of integration of the humans-AI interactions. Here below the new dimensions are presented.

#### 3.2.1.1 Teaming

A first dimension that has been added is the one related to teaming. With teaming we mean the **interaction between humans and AI, and how humans and AI work together to perform tasks**. The relation between these two actors has been considered as a scale, according to the 6Ps structure: from no interaction and humans performing all the tasks, to a level where it is the AI performing the tasks and humans monitoring and interrupting if needed. The users considered in this dimension are the **Industry4.0 operators** managing to use the AI system within the production processes.

Question asked to respondents:

*What is the level of interaction between the Industry4.0 Operator and Artificial Intelligence? To what extent humans and AI work together to perform tasks?*

| | |
|---|---|
| **Level 1 – Initial** | No interaction with AI. Task done by humans |
| **Level 2 – Managed** | Basic interaction with AI: AI suggests operations |
| **Level 3 – Defined** | Intermediate interaction with AI: AI suggests and corrects operators' tasks |
| **Level 4 – Integrated** | Integrated interaction with AI: operators confirm AI decisions |
| **Level 5 – Exploited** | Advanced interaction with AI: operators monitor and interrupt AI tasks if needed |

#### 3.2.1.2 AI Integration

A second dimension that has been added is AI integration to describe **the maturity of a process of integration of AI within production**. This dimension is meant to be compiled with the eyes of **managers** which should evaluate how to integrate AI within production processes. The evaluation goes from the no usage of AI to the AI implementation to effectively integrate the humans/AI interactions. So, the perspective here is the effort that organisations should spent to integrate AI within the processes and the effect that it has on the people working in the organisation.

Question asked to respondents:

*To what extent is AI integrated within production?*

| | |
|---|---|
| **Level 1 – Initial** | No usage |
| **Level 2 – Managed** | AI implementation in targeted areas and pilot projects |
| **Level 3 – Defined** | Organisational use of AI with investments in data, technology, algorithms |
| **Level 4 – Integrated** | Scaling AI by embedding it in production processes |
| **Level 5 – Exploited** | Adapting the organisation to ensure a better integration of AI and humans effectively work together |

#### 3.2.1.3 Explainability

As said before, explainability is strictly connected to people, to the interaction of people with AI and it impacts the way the AI outcomes are used to take decisions. For this reason an explainability dimension has been added in the people pillar. The dimension takes under consideration the perspective of the **Industry4.0 Operator** and wants to evaluate **the level of transparency of the AI models implemented** so that human users will be able to understand and trust decisions.

Question asked to respondents:

*What is the level of transparency of the AI models implemented so that human users will be able to understand and trust decisions?*

| | |
|---|---|
| **Level 1 – Initial** | No use of AI/Use of black boxes systems |
| **Level 2 – Managed** | Humans can review decisions from AI systems but without any explanation of results |
| **Level 3 – Defined** | Visualisation and debugging tools are presented to check AI decisions |
| **Level 4 – Integrated** | AI models provide an explanation of the results based on the different features |
| **Level 5 – Exploited** | AI full explainability allows interoperability with other automated system that understand the decisions made |

#### 3.2.1.4 AI Development

The AI development dimension is an evaluation about how AI, and XAI, are developed and introduced within organisations, if **AI is developed inside the company or acquired as a black-box solution from ICT providers**. The idea is to understand how organisations develop AI tools, if they buy tools from ICT suppliers as black-box or if they have internal knowledge and competences, to the final level where there is an active collaboration in R&D with other partners. The users considered in this dimension are the **Managers**.

Question asked to respondents:

*Is your staff able to deal with AI models and graphs, in order to optimize processes and workflows?*

| | |
|---|---|
| **Level 1 – Initial** | There is no use of AI, or only partly defined ideas |
| **Level 2 – Managed** | There are plans to adopt AI-based working methods to address specific issues in the company |
| **Level 3 – Defined** | AI-based tools to support some operations are adopted; AI know-how is brought in by our ICT service providers as a black box |
| **Level 4 – Integrated** | AI-based tools to support some operations are adopted; to improve/refine models and to maintain the existing ones, we have a dedicated department in the company or at least some professional figures with expertise in it |
| **Level 5 – Exploited** | AI-based tools to support operations are adopted; we collaborate with our ICT providers in the research and development of AI tools, so reaching a high level of exploitation |

To summarise, the four sub-dimensions added in the People pillar, addressed to Managers and Operator 4.0 are le following:

| | | LEVEL 1 – INITIAL | LEVEL 2 - MANAGED | LEVEL 3 – DEFINED | LEVEL 4 – INTEGRATED | LEVEL 5 – EXPLOITED |
|---|---|---|---|---|---|---|
| TEAMING | OPERATOR 4.0 | No interaction with AI. Task done by humans | Basic interaction with AI: AI suggests operations | Intermediate interaction with AI: AI suggests and corrects operators' tasks | Integrated interaction with AI: operators confirm AI decisions | Advanced interaction with AI: operators monitor and interrupt AI tasks if needed |
| AI INTEGRATION | MANAGER | No usage | AI implementation in targeted areas and pilot projects | Organisational use of AI with investments in data, technology, algorithms | Scaling AI by embedding it in production processes | Adapting the organisation to ensure a better integration of AI and humans effectively work together |
| EXPLAINABILITY | MANAGER/OPERATOR 4.0 | No use of AI/Use of black boxes systems | Human can review decisions from AI systems but without any explaination of results | Visualisation and debugging tools are presented to check AI decisions | AI models provides an explaination of the results based on the different features | AI full explainability that allow for interoperability with other automated system that understand the decisions made |
| AI DEVELOPMENT | MANAGER | There is no use of AI, or only partly defined ideas | Plans to adopt AI-based working methods to address specific issues in the company | AI-based tools to support some operations; AI know-how is brought in by our ICT service providers as a black box | AI-based tools to support some operations; to improve/refine models and to maintain the existing ones, we have a dedicated department in the company or at least some professional figures with expertise in it | AI-based tools to support operations; we collaborate with our ICT providers in the research and development of AI tools, so reaching a high level of exploitation |

*Figure 12 The XMANAI People dimension*

### 3.2.2 Other dimensions

As noted in 3.2.1, Explainability essentially concerns the interaction of AI with people, and therefore the People dimension was the most explored in the 6Ps in relation to Explainability.

On the other hand, the use of XAI always takes place in the context of an operation, and therefore it is quite logical that the 6Ps is also reviewed with a focus on the processes that can be more directly affected by the adoption of XAI.

These considerations emerged in the many meetings we had with the demonstrators, who pointed out which processes lent themselves to such investigations, and how.

Of the various proposals to modify the questionnaire in an Explainable sense, not all were adoptable. Therefore, we identified the two sections where the 'Explainable' changes to the 6Ps have the greatest impact: they are Platform and Performance, as explained in detail below.

#### 3.2.2.1 Platform

In contrast to the People section, where new questions were introduced, in the Platform section we merely modified existing questions and adapted them to the new context of XAI.

Only question 3.5 - "Vertical interoperability of data and events" and the corresponding answers were changed.

To the original question "**To what extent is your Platform able to support a computational continuity between Physical Assets and Digital Cloud?**" it was added "**How is information shared and synchronized among the functions?**", integrating a question of operational significance with the already existing technological one.

Consequently, the relevant answers have been modified as follows (underlined part added):

| | |
|---|---|
| Level 1 – Initial | Data Events at Shopfloor are unexploited; connections among functions to exchange information are occasional, and driven by operativity |
| Level 2 – Managed | Data generated by real world are collected by dedicated devices; information is not centralized; connections among functions and with company's ERP are partially formalized and implemented |
| Level 3 – Defined | Data generated by real world are stored into the cloud; information is centralized; the interfaces among the APIs of the various functions and with the ERP have been partially developed |
| Level 4 – Integrated | Data flows bidirectionally between the real world and the cloud; information is centralized; the API of the various functions interface effectively with each other and with the ERP |
| Level 5 – Exploited | The configuration of the distributed architecture can be dynamically adapted, and so the interfaces among APIs and ERP |

#### 3.2.2.2 Performance

As in the case of Platform, it was not necessary to add questions in this section, but it was sufficient to integrate some of them.

In this case, the need was expressed to find out how much Explainable AI was perceived as improving performance and what was the degree of acceptance and awareness among staff.

Operators, in fact, may feel threatened by the automation of some of their tasks, or may not believe that a simple computer program can execute complex tasks correctly. This is where explainability plays a big role. Trust in a system is key, especially in an enterprise tool that has an impact on day to day business.

The questions to which changes have been made are 6.1 – "Operational/Technical" and 6.4 – "Social".

The first one, "**What approach does your company adopt for measuring operational performances (e.g. OEE, impact of AI on efficiency)?**" (where the additional part is underlined) asks if new KPIs have been planned or introduced to measure performances after the introduction of XAI.

The second one, "**What approach does your company adopt for measuring social performances (e.g. welfare for employees, impact of AI on reduction of workloads for operators, situational awareness)?**" focuses on the important aspect of the impact on staff, their awareness and acceptance of AI.

In both cases it was considered sufficient to amend the questions only, as the answers were already comprehensive enough.

# 4 The XMANAI Validation Framework

The objective of this chapter is to provide a detailed overview of the final Validation Framework (that includes, of course, the 6Ps methodology described in Chapter 3) and of the XMANAI methodology.

## 4.1 The Explainability building block

The 6Ps assessment presented in Chapter 3, modified for XMANAI purpose, represents the core of the XMANAI Validation Framework developed in T6.2, since it allows to have a full picture of which are the relevant dimensions impacted by the platform and which are not. However, it alone is not enough to provide a complete analysis of the impact of the Explainable (X) component.

There are two perspectives from which we can evaluate the impact of X component:

- The new dimension included in the 6Ps assessment (in the People pillar, to be precise) measures the **level of explainability adopted in the production process** comparing the AS-IS and TO-BE profile. It answers to the question: *what type of Explainable solution is applied in your plant?, What before XMANAI?*
  If you start from level 1 till level 4, this is a big progress; if you start from level 4 till level 5, it is a smaller progress even if the final level is higher.
- A second approach evaluates **the benefits deriving from the adoption of an Explainable solution.** It answers to the questions: *why you should adopt an XAI solution, instead of simply an AI solution?*, *How much better do you understand the output thanks to the X component?* and it aims to measure the impact on the decision making process.

The second perspective is of great relevance for XMANAI and it has been included in the Evaluation Framework as an additional block, independent from the 6Ps assessment, called "Explainability Block". The structure is slightly different from the 6Ps since in this case it doesn't make sense to evaluate both the AS-IS and TO-BE as in the majority of the use cases, there isn't any AI model in place, so it is difficult to measure how the X component makes the model more understandable, since there isn't any term of comparison.

Leveraging on the results of T1.2 – "Human Aspects in Decision Making and AI" (available in deliverable D1.1 – "State of the Art Review in XMANAI Research Domains"), this new block analyses an additional pillar of the productive process, namely the "Decision Making". The objective is to stress the fact that the added value of the XMANAI platform is that it "explains models", not simply that it delivers AI, and that the impact deriving from its adoption is measured also in terms of "**how much the X component has impacted the decision making process?**"

The "Explainability Block" consists of the "Decision Making" pillar (based on seven dimensions), plus a number of additional questions.

### 4.1.1 The Decision Making pillar

Taking into account the main aspects and factors that may influence the decision making process (as highlighted in D1.1), the pillar measures the impact of the XMANAI platform/solutions (and specifically of the Explainable component) on them.

In this case, it is required to assess the situation at the end of the project, after the adoption of the platform, expressing directly the impact deriving from it. Measuring the "**impact**" of the XMANAI platform we are measuring "**how much the decision making process is modified** after the adoption **and how many additional changes are required to the company to properly adopt it**".

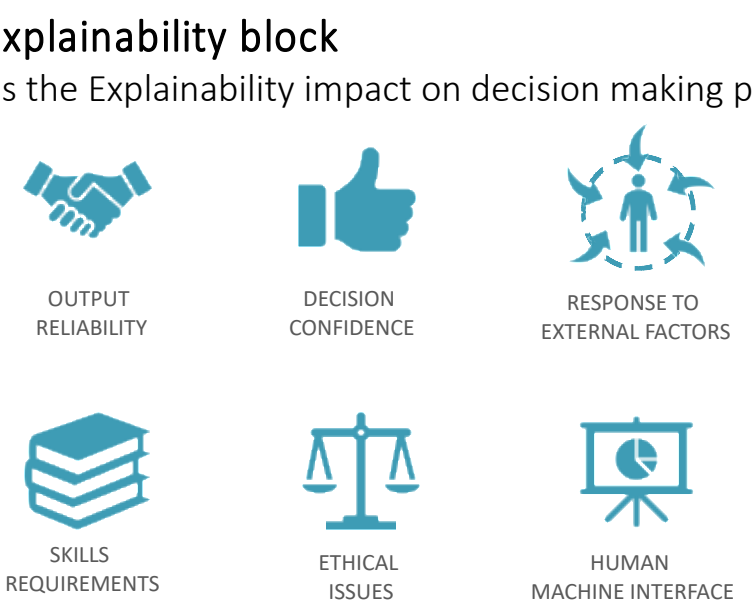



*Figure 13 The six dimensions of the Explainability block*

#### 4.1.1.1 Output Reliability

This dimension has been conceived to understand if **the Explainable component makes the AI output more reliable** and so, used as a driver for decision making. The minimum impact corresponds to a situation where, even if the XMANAI platform provides the X component, decisions are made without the support of AI; the maximum impact corresponds to a situation where not only data scientists benefit of the X component to evaluate the model's performance, but also managers to make decisions.

Question asked to respondents:

*Is the output of the AI model considered more reliable thanks to the Explainability (X) component?*

| | |
|---|---|
| **LEVEL 1 – MINIMUM IMPACT** | No trust in machine (neither of XAI); to make decisions we still rely only on human evaluation |
| **LEVEL 2** | In terms of reliability, the X component doesn't provide an added value with respect to the AI model |
| **LEVEL 3** | The X component helps the data scientist to better evaluate the reliability of the model (and modify it if necessary) |
| **LEVEL 4 – MAXIMUM IMPACT** | The X component helps also the business user/plant operator to rely on the model (and make decisions based on its output) |

#### 4.1.1.2 Decision Confidence

This dimension has been conceived to understand if **the Explainable component makes the decision making process easier and more accurate**, as it provides a support and more evidences/insights. One of the most effective way to explain the choice selected by the AI model is to show the other available scenarios and to highlight the aspects that made the first one more valuable. Having at disposal the different scenarios is expected to influence how decisions are made at human level.

The minimum impact corresponds to a situation where, even if the XMANAI platform provides the X component, decisions are made without the support of AI; the maximum impact corresponds to a

situation where the X component allows to evaluate different scenarios that before were not taken into account.

Question asked to respondents:

*Do you feel more confident in your decisions thanks to the Explainability (X) component?*

| | |
|---|---|
| **LEVEL 1 – MINIMUM IMPACT** | No trust in machine (neither of XAI); to make decisions we rely only on human evaluation |
| **LEVEL 2** | In terms of confidence in the decision, the X component doesn't provide an added value with respect to the AI model |
| **LEVEL 3** | The possibility of evaluating different scenarios create confusions since it describes scenarios that otherwise wouldn't be evaluated |
| **LEVEL 4** | The X component allows to evaluate different scenarios and to being more confident in the decision made originally |
| **LEVEL 5 – MAXIMUM IMPACT** | The X component allows to evaluate different scenarios and to drive the decision toward the best one (that can differ from the original one) |

#### 4.1.1.3 Response to external factors

This dimension has been conceived to understand if the **Explainable component is of any support in case the decision making process in affected by external factors**. As highlighted in D1.1, many external factors may influence a decisions, bringing not to the best choice: for instance, the lack of time or the complexity of the scenario prevent to evaluate all the possible options and, in this case, AI (and XAI even more) can support the activity.

The minimum impact corresponds to a situation where, even if the XMANAI platform provides the X component, decisions are made without the support of AI; the maximum impact corresponds to a situation where the X component has a positive impact, speeding up decisions.

Question asked to respondents:

*Is the way of making decisions under pressure changed thanks to the Explainability (X) component?*

| | |
|---|---|
| **LEVEL 1 – MINIMUM IMPACT** | No trust in machine (neither of XAI); to make decisions we rely only on human evaluation |
| **LEVEL 2** | In terms of capability of making good decision even under pressure (e.g. lack of time), the X component doesn't provide an added value with respect to the AI model |
| **LEVEL 3** | In case of time pressure, the X component makes the decision longer since it requires more time to evaluate more parameters |
| **LEVEL 4 – MAXIMUM IMPACT** | In case of time pressure, the X component speeds up the decision since it provides a number of hints to better understand the problem |

#### 4.1.1.4 Skills Requirements

This dimension has been conceived to understand if the **Explainable component requires additional competence and skills to properly benefit from it**. The minimum impact corresponds to a situation where, even if the XMANAI platform provides the X component, decisions are made without the support of AI so there is no need of additional skills; the maximum impact corresponds to a situation where it is required to hire new professional figures to properly use the XMANAI platform.

Question asked to respondents:

*Is any additional skill required in your company to manage the Explainability (X) component?*

| | |
|---|---|
| **LEVEL 1 – MINIMUM IMPACT** | There is no need of additional skills since the XAI solutions is not taken into account to make decisions |
| **LEVEL 2** | There is no need of additional skills to use and understand the XAI solution, since the company has already many AI experts |
| **LEVEL 3** | There is no need of additional skills to use and understand the XAI solution, since the X component makes it more understandable |
| **LEVEL 4** | It will be required to train workers to properly use the XMANAI platform |
| **LEVEL 5 – MAXIMUM IMPACT** | It will be required to hire new professional figures to properly use the XMANAI platform |

#### 4.1.1.5 Ethical issues

This dimension has been conceived to understand if the **Explainable component may prevent from any possible ethical issue related to AI**. As highlighted in D1.1, important ethical issues may concern replacing of careers, risk to loose human skills, lack of transparency, ascription of responsibility, etc. The minimum impact corresponds to a situation where the company doesn't make decision that may cause ethical issues; the maximum impact corresponds to a situation where both data scientists and decision makers can benefit of the X component to understand if data are affected by biases.

Question asked to respondents:

*Do you think that the Explainability (X) component will prevent from any possible ethical issue?*

| | |
|---|---|
| **LEVEL 1 – MINIMUM IMPACT** | The company doesn't make decisions that can cause ethical issues |
| **LEVEL 2** | In terms of ethical issues avoidance, the X component doesn't provide an added value with respect to the AI model |
| **LEVEL 3** | The X component helps the data scientist to better define the model since it helps to highlight possible bias in the training data |
| **LEVEL 4 – MAXIMUM IMPACT** | The X component helps to better understand the AI output in order to prevent possible ethical issues due to bias in the training data |

#### 4.1.1.6 Human machine interface

This dimension has been conceived to understand if the **Explainable component in the shape of a "visualising tool" is effective to properly understand the AI outputs**. One of the most effective way to explain the choice selected by the AI model is to visualise the data used to run the algorithm and several different human-machine interfaces can be used. The minimum impact corresponds to a situation where, even if the XMANAI platform provides the X component, decisions are made without the support of AI; the maximum impact corresponds to a situation where "the visualisation tool" is very useful but using it is not straightforward and requires experience and high competences.

Question asked to respondents:

*How much "visualising" information is effective as Explainability (X) component?*

| | |
|---|---|
| **LEVEL 1 – MINIMUM IMPACT** | No trust in machine (neither of XAI); the company doesn't make any use of "data visualisation" |
| **LEVEL 2** | Visualising the AI model's results thanks to a dedicated interface doesn't provide any added value in terms of Explainability |

| | |
|---|---|
| **LEVEL 3** | Visualisation of the AI model's results is a very powerful tool and it is suitable for any type of user, besides its competences |
| **LEVEL 4 – MAXIMUM IMPACT** | Visualisation of the AI model's results is a very powerful tool but it requires experience and high competences to be used |

#### 4.1.1.7 Internal Communication

This dimension has been conceived to understand if the **Explainable component eases the sharing of information among different departments** of the same company, that previously didn't share results as they couldn't be understood. The minimum impact corresponds to a situation where the company doesn't need to share information, so, even if the XMANAI platform provides the X component, no advantage is foreseen; the maximum impact corresponds to a situation where different departments share complex data and results that can be better understood thanks to the X component.

Question asked to respondents:

*What type of data/information are your company departments able to share one to each other?*

| | |
|---|---|
| **LEVEL 1 – MINIMUM IMPACT** | Company's departments are quite siloed and there is no need to share data among them |
| **LEVEL 2** | Company's departments share raw data or simple aggregation to present results, but they don't need to share AI models outputs (as forecast) |
| **LEVEL 3** | Company's departments share also AI models outputs (as forecast), but they are very sectoral and they are scarcely understood by other departments, even if supported by visual tools |
| **LEVEL 4 – MAXIMUM IMPACT** | The X component helps to better understand the AI output also in other departments. Charts, graphs and visual tools help the Internal Communication |

### 4.1.2 Additional questions

To provide a complete picture of the impact deriving from the adoption of the XMANAI platform, to each demonstrator it is required to evaluate how much each of the following professional figure is impacted (considering a range from 1 – "Not impacted at all" to 5 – "Strongly impacted"; in case the professional figure is not present in the company, the option "Not applicable" must be selected):

- **Plant Operator**: it represents one of the final users of the XMANAI platform and solutions; not directly impacted in the development and maintenance phase, but in case it is expected to benefit from the XAI adoption, it is required to evaluate if additional skills and expertise are needed and how its daily tasks are expected to change.
- **Business Users**: it represents the main user of the XMANAI platform and solutions, expected to be supported not in the productive process but in the decision making process. It is not directly impacted in the development and maintenance phase, but it will benefit from the final solution. The goal is to understand how much the decision making process will be impacted by its adoption and to evaluate if additional skills and expertise are needed.
- **Data Scientist**: very often in small manufacturing companies, the data scientist is not present. However, it represents a key figure for the development, adoption and maintenance of the XMANAI platform and solutions. So, in case it is present, it is required to evaluate if additional skills and expertise are needed; in case not, it is required to evaluate who will cover the role performing its tasks.
- **Data Engineering**: similarly to the Data Scientist, very often in small manufacturing companies, the data engineering is not present. However, it represents a key figure for the

development, adoption and maintenance of the XMANAI platform and solutions. So, in case it is present, it is required to evaluate if additional skills and expertise are needed; in case not, it is required to evaluate who will cover the role performing its tasks.

Furthermore, also following KPIs are measured, evaluating both the initial and final level:

- **Plant Efficiency**, expected to improve;
- **Plant Availability**, expected to improve, for instance by reducing the number of stoppages and/or the maintenance period;
- **Environmental impact**, expected to decrease, for instance by reducing the number of defective parts and reducing wastes;
- **Human involvement**, expected to improve, for instance by reducing the workload;
- **Workers well-being,** expected to improve by increasing the quality of the tasks performed, avoiding for instance repetitive tasks. This type of KPI can be measured leveraging on ad-hoc questionnaire, to be compiled by workers, as it is not straightforward to identify a single numerical parameter to evaluate it;
- **Accuracy** of the forecast and of the measurements, performed nowadays without the support of XAI;
- **Production**, expected to increase;
- **Product quality**, expected to increase;
- **Product Sales**, expected to increase.

Not all the KPIs are applicable to each use case. The demonstrator is required to evaluate if the indicator is in the scope of the experiment and to explain how it is measured.

## 4.2 The XMANAI methodology

Within Task T6.2, XMANAI has developed a five-steps methodology to evaluate the platform and to test the success of the implementation, measuring the impact on the demonstrators. This activity will be performed within Task T6.8 – "Business Cases Evaluation and Impact Assessment".

1. **Set-up of a team able to perform the assessment.** The goal is to identify the people having a full picture of the activities run inside the company and inside the project, in order to correctly assess the profile of the company before and after the adoption of the XMANAI platform. The team will be in charge of compiling the assessment and discuss the results.
2. **Identification of the profile of the manufacturing enterprise BEFORE the adoption of the XMANAI platform – 6Ps assessment.** The manufacturing enterprise's strategy, competitive strengths and weaknesses must be analysed and its current and expected profile must be mapped into each dimension of the 6Ps assessment. The demonstrator, before the adoption of the platform, is required to compile the questionnaire evaluating both its current profile and the one expected at the end of the project (AS-IS and Expected TO-BE). The assessment is conceived as an online questionnaire (the detailed description is available in paragraph 4.2.1).

**Adoption of the XMANAI platform**

3. **Identification of the profile of the manufacturing enterprise AFTER the adoption of the XMANAI platform – 6Ps assessment.** The manufacturing enterprise's strategy, competitive strengths and weaknesses are analysed also at the end of the project, after the adoption of the XMANAI platform. The demonstrator, at this stage, is required to compile again the 6Ps assessment in order to evaluate the profile actually reached with the adoption of the platform

(actual TO-BE). Comparing the TO-BE with the AS-IS allows to have an effective picture of the productive dimensions that have been impacted.

4. **Evaluation of the impact deriving from the adoption of the XMANAI platform, compiling the Explainability building block.** To measure the added value of the Explainable (X) component and to evaluate the benefit deriving from it, the demonstrator is required to fill the Explainability building block, after the adoption of the XMANAI platform, measuring the footprint on the company. This block will be compiled only once, as it doesn't make sense to evaluate the AS-IS scenario before the adoption of the platform because the demonstrators are not using XAI yet and there isn't any term of comparison. The assessment is conceived as an online questionnaire (the detailed description is available in paragraph 4.2.1).
5. **Use cases evaluation and impact assessment.** Information collected in steps 2, 3 and 4 are used to measure the impact of the platform on the four demonstrators. Additionally, an interview will be run to discuss directly with the demonstrators the values assigned in the assessment: a face-to-face interview is fundamental to better understand the meaning of the answers, collecting more details and to avoid possible misunderstanding. The analysis will be run according to the guidelines described in paragraph 4.2.2.

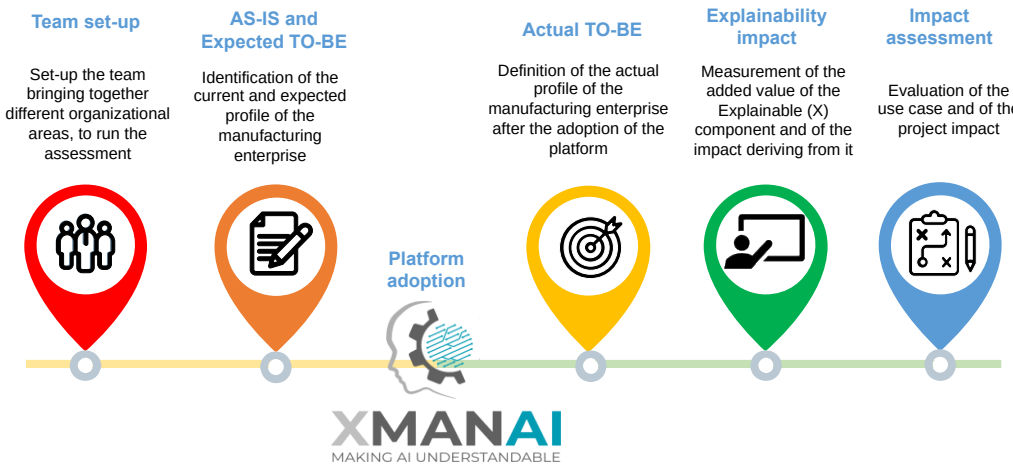



*Figure 14 The XMANAI methodology for the platform Evaluation Framework*

## 4.2.1 The Validation Framework questionnaire

The successful implementation of WP6 in terms of effectively testing the XMANAI methods and infrastructure and providing the necessary feedback to evaluate the platform relies on the execution of the demonstrators in a coordinated and unified manner, from a business and technical perspective.

In Task T6.2 we have worked towards providing an inclusive demonstrators' evaluation framework as well as a general guideline document to be used to **monitor** and **align** the **demonstrators' phases.** The evaluation framework will be studied extensively and defined in complete detail in the current paragraph, as it will lead to valuable remarks and conclusions about the viability and the sustainability of the platform and the business cases.

The current paragraph is conceived as a sort of guideline to better understand the online questionnaire, without entering into all details of the deliverable.

**Assessment Scope**

The 6Ps survey has the main objective of describing a company's current profile and compare it with the desired future level. The gaps between as-is and to-be levels will be used to define together the

best Digital Transformation (DT) strategy and action plan for the development of a tailor-made migration roadmap towards Industry 4.0.
The "Explainability block" measures the "impact" of the XMANAI platform on the decision making process, assessing "how much the decision making process is modified after the adoption and how many additional changes are required to the company to properly adopt it".

In the context of XMANAI project, the 6Ps survey together with the "Explainability block" represents the evaluation framework to assess the impact of the XMANAI platform on the demonstrator. The survey will be compiled two times by the four pilots: the **first one to assess the digital level before the adoption of the XMANAI solution** and to estimate the one at the end of the project; then, a **second time at the conclusion of XMANAI** to check which dimensions have been really impacted by the platform adoption. Both surveys will be performed within T6.8's activities.

**Assessment Structure**
The questionnaire on which the **Evaluation Framework** is based is available at this link. As mentioned, **it consists of two main blocks**, that are presented separately.

- The 6Ps assessment, to be compiled both before and after the XMANAI platform adoption
- The decision-making assessment and KPIs, to be compiled only after the XMANAI platform adoption (at the first iteration, it is possible to skip it and go directly to the end of the survey).

To evaluate the impact of the XMANAI platform on the four pilots, the **6Ps methodology** has been inherited from AI REGIO and tailored for XMANAI's scope.

The 6Ps pillars have been chosen to better describe a company's business through three technical pillars and three socio-business pillars. Technical Pillars include Product (and related Services), Processes and obviously Platform dimension which is the necessary ingredient for any Digital Transformation. Socio-Business Pillars are describing how Digital Transformation implies deep changes in the People roles and competencies, in the Partnership you decide to follow and put in place, in the new framework of Performance Indicators your company aims at pursuing.


*Figure 15 6Ps Digital Transformation Tool – The six pillars*

With respect to the original tool, in order to have a full picture of the impact of the platform, the XMANAI version includes the explainability component, that is reflected mainly on the workers. Four new dimensions have been defined for XMANAI, included in People pillar:

- Teaming - to evaluate the level of interaction between humans and AI
- AI integration – to evaluate the maturity of a process of AI integration within production
- Explainability – to evaluate the level of transparency of the AI models implemented
- AI Development – to evaluate if AI is developed inside the company or acquired as a black-box solution from ICT providers.

The online survey is divided into 6 parts, one for each pillar (P) assessed, and each block contains multiple-choice questions. For each question is asked to specify your current level (AS-IS) and your expected level (TO-BE) to be achieved at the completion of XMANAI project, thanks to the XAI platform's adoption.
In case a pillar is not relevant for the use case, it is possible to skip it and move directly to the following one. Conversely, it is not possible to skip single questions inside a block, but if an answer can't be provided, it is enough to select "Not Applicable".

**The Decision-Making assessment and KPIs** is about the evaluation of the benefits deriving from the adoption of an Explainable solution. The goal is to measure the impact of the each component on following aspects, related with decision making:

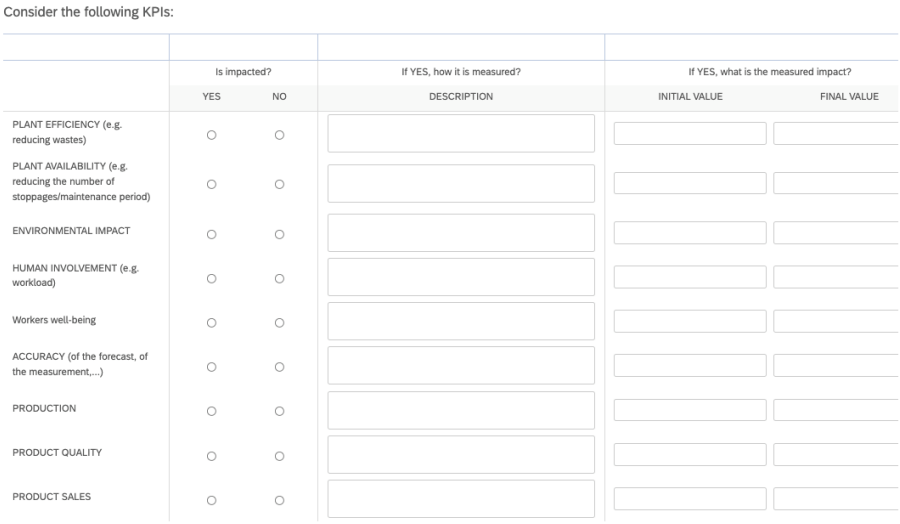
- Output Reliability
- Confidence in decisions
- Response to external factors
- Skills requirement
- Ethical issues
- Human-machine interface
- Internal Communication

For each aspect listed above, a question is provided in the questionnaire.
Once you decide to fill the "Explainability block" (at the second iteration), all questions must be answered but if an answer can't be provided, it is enough to select "Not Applicable".

Finally, the KPIs identified by the pilots (WP6) are evaluated, in order to complement the measurement of the impact of the XMANAI platform on the pilots:

- Plant Efficiency
- Plant Availability
- Environmental Impact
- Human Involvement
- Accuracy
- Production
- Product Quality
- Product Sales

For each KPI, the demonstrator is required to evaluate if it is relevant for its use case; in case of a positive answer, to explain how it is measured and to provide the initial and final value to calculate the impact.


Consider the following KPIs:

| | Is impacted? | | If YES, how it is measured? | If YES, what is the measured impact? | |
|---|---|---|---|---|---|
| | YES | NO | DESCRIPTION | INITIAL VALUE | FINAL VALUE |
| PLANT EFFICIENCY (e.g. reducing wastes) | ○ | ○ | | | |
| PLANT AVAILABILITY (e.g. reducing the number of stoppages/maintenance period) | ○ | ○ | | | |
| ENVIRONMENTAL IMPACT | ○ | ○ | | | |
| HUMAN INVOLVEMENT (e.g. workload) | ○ | ○ | | | |
| Workers well-being | ○ | ○ | | | |
| ACCURACY (of the forecast, of the measurement,...) | ○ | ○ | | | |
| PRODUCTION | ○ | ○ | | | |
| PRODUCT QUALITY | ○ | ○ | | | |
| PRODUCT SALES | ○ | ○ | | | |

*Figure 16 The online questionnaire - Example of KPIs section*

**Assessment Compilation**

The demonstrator would find the questionnaire through this link and it will take about 45 minutes to complete it.

At the first iteration, only the 6Ps assessment will be compiled, while the "Explainability block" can be skipped; at the second iteration, both the blocks must be compiled.

All the information provided in the questionnaire will be managed confidentially following all data privacy policy of the project assessment, won't be available any sensible and personal information and all answer will be anonymous.

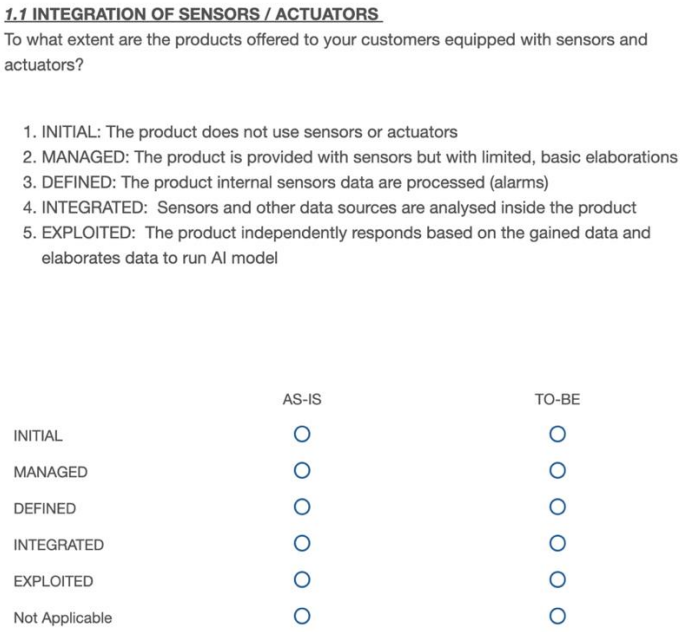



*Figure 17 Example of question in the online questionnaire [6Ps assessment]*

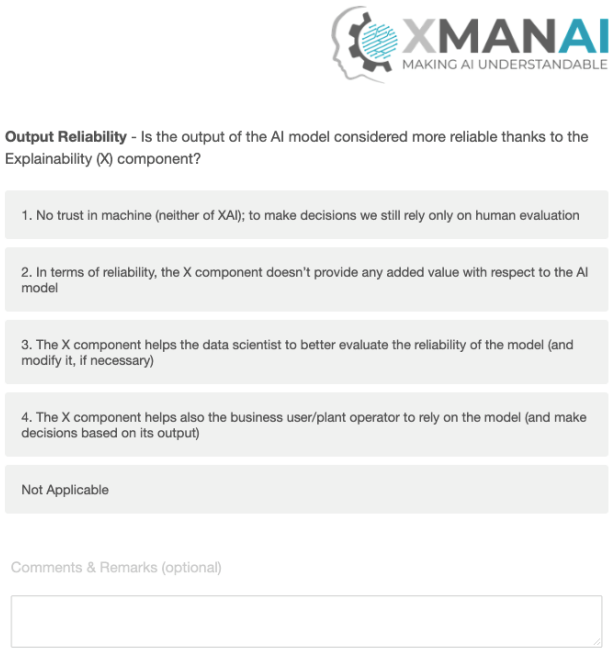



*Figure 18 Example of question in the online questionnaire [Explainability block]*

At pictures before you will find some examples about how it looks like the survey provided for 6Ps assessment. Each block has an introductory section, explaining the context and providing some guidelines. Also, it is possible to use the “free text” box to add any comment or to better explain an answer.

### 4.2.2 Toward the impact measurement

The online questionnaire is a fundamental tool to support the collection of the required information, presenting a structured set of questions. However, it’s worth to be highlighted that **the online compilation per se is not enough to finalise the validation assessment**. As questions are quite generic, **a one-to-one meeting is expected to be run after the compilation**, at the end of the project, aiming to:

- [6Ps assessment] Check if the answers have been correctly understood and no misunderstanding is occurred. A specific attention will be payed to the People pillar, expected to be impacted the most.
- [6Ps assessment] Compare the “expected TO-BE” with the “actual TO-BE” and comment the mismatches, trying to identifying the reasons the caused them.
- [Explainability Block] Discuss in details the changes that occurred, identifying if additional actions are required after the end of the project.

The information collected in the online questionnaire and during the interview will be used to realise a report, in order to show in a measurable and comprehensible manner the impact of the XMANAI platform on the pilot.

A template (Excel file) has been prepared, to insert the answers exported from the online questionnaire tool and manually adjust them (according to the information collected during the interview). The template automatically generates some charts that help to visualise the results and so, to measure the impact on the pilot.

Regarding the 6Ps assessment, following charts are generated.

- To have a full picture of the six pillars of the 6Ps assessment and of related dimensions, a summary radar chart is provided.
  Even if not many details are visible, at a first glance it helps to understand which are the most impacted dimensions and to compare them: the blue line represents the AS-IS profile, the orange line the actual TO-BE (the latter is expected to show always values equal or higher than the former). Furthermore, starting from the red slice and going clock-wise, the pillars are: Product, Process, Platform, People, Partnership and Performance.
  In the example below, the Product is the only pillar not impacted at all, while the Process dimension seems to be the one expected to be impacted the most. With very few exceptions, the initial level is no higher than 3, while with the adoption of the XMANAI platform many dimensions are expected to reach level 5.

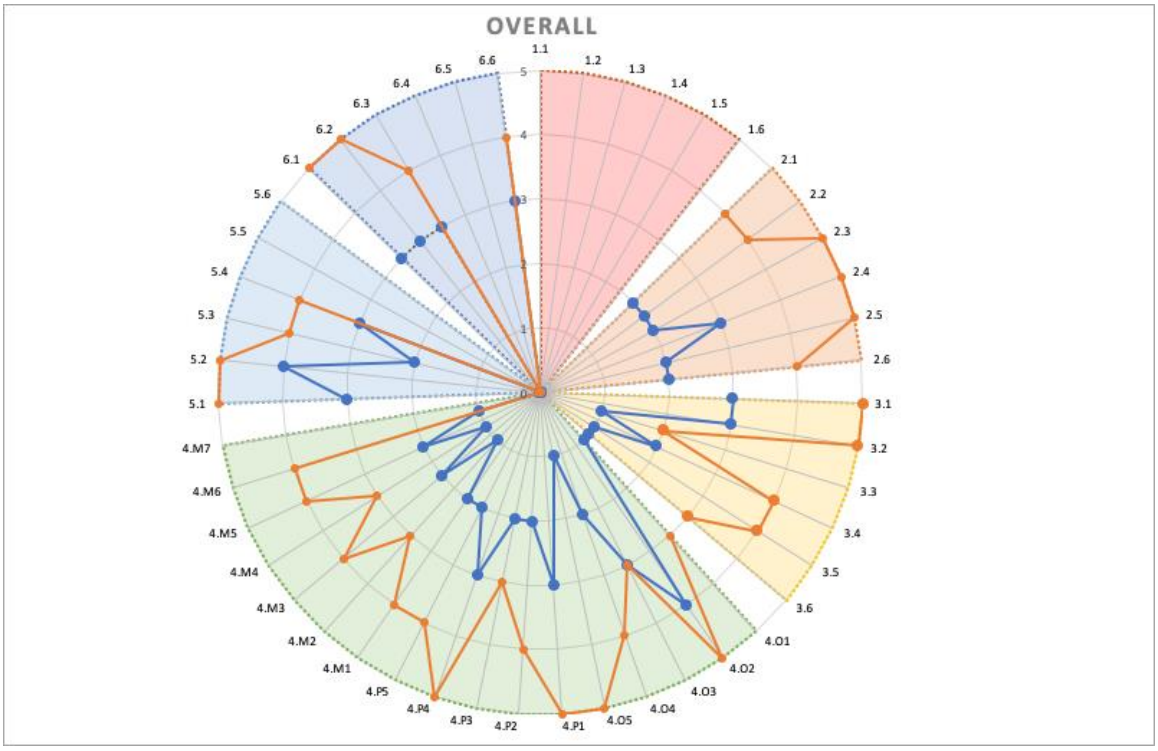



*Figure 19 6Ps overall radar chart - an example*

- For each of the of the six pillars of the 6Ps assessment, a radar chart is generated comparing the AS-IS and the TO-BE profiles.
  The picture below shows the Process pillar as an example: similar to previous picture, the blue line represents the AS-IS profile, the orange line the actual TO-BE.

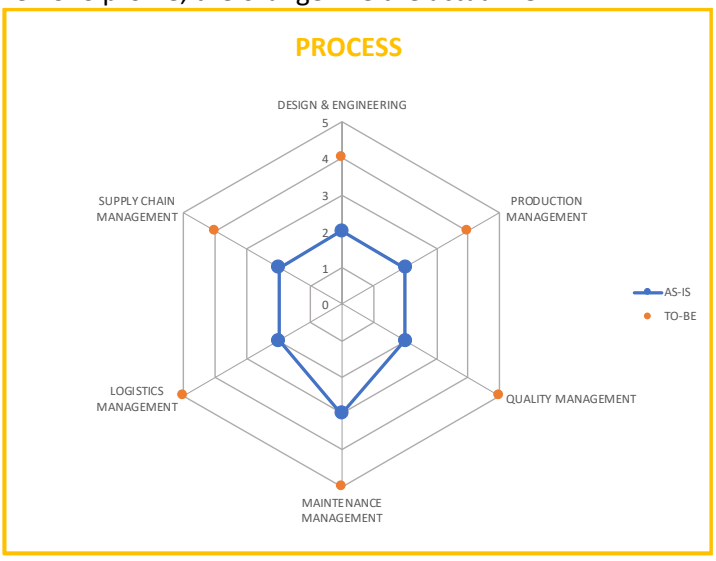



*Figure 20 The Process pillar radar chart - an example*

For each dimension the average improvement is provided, calculated as the average of the difference between the final and initial level of the dimensions applicable in the specific use case. (In the example above, the average improvement is of 2.3 levels, all the dimensions are relevant for the use case and impacted by the adoption of the XMANAI platform.)

- An alternative way to visualise the impact of the XMANAI platform on the several dimensions is the Tree-map, measuring the difference between in initial and final profile for each dimension impacted.

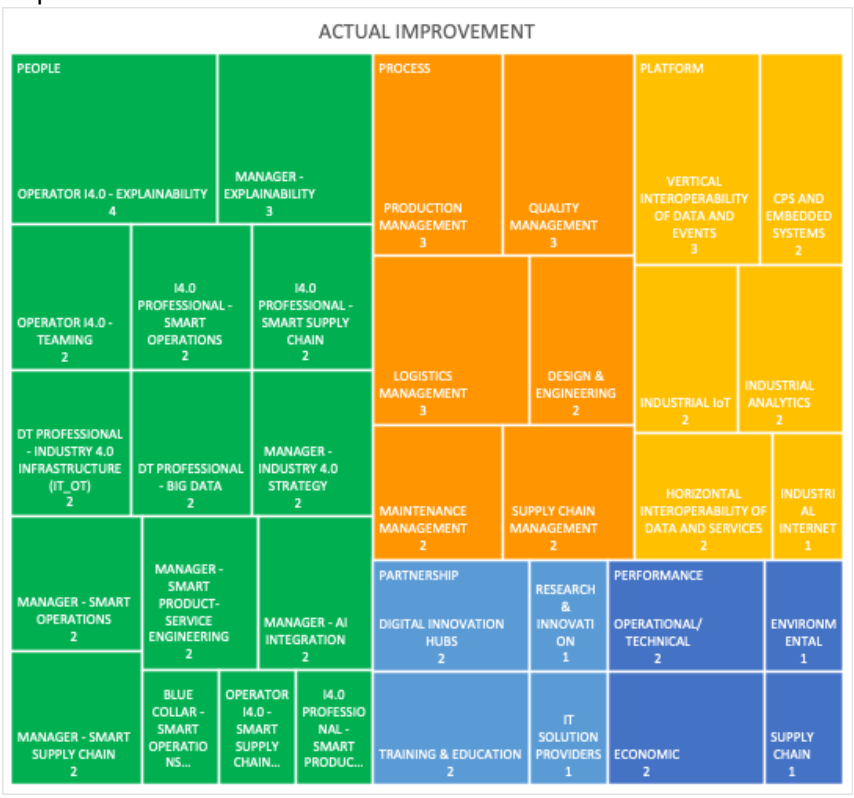



*Figure 21 The Tree-map of the actual improvement - an example*

- The results of the first and second iteration assessments (before and after the adoption of the platform) are compared.
  - The two AS-IS profiles are expected to be the same; however, in case of any mismatch, the one-to-one interview will help to clarify it.
  - The analysis of the **difference between the expected and the actual TO-BE** is more tricky. Provided that the expected TO-BE has been defined being aware of the project's aim (and this will be discussed during the one-to-one interview), **the comparison allows to understand if the expectations have been fulfilled**.
    The final report must contain this analysis, to be deepened in order to highlight the factors that prevented the achievement of the expected scenario. From the business perspective of the project, it represents an interesting starting point to be further investigated.

Regarding the Explainability block, following analysis is provided:

- The impact on the seven "Decision making dimensions" (Output Reliability, Decision Confidence, Response to External Factors, Skills Requirements, Ethical Issues, Human machine interface and Internal Communication) is summarised with a radar chart.

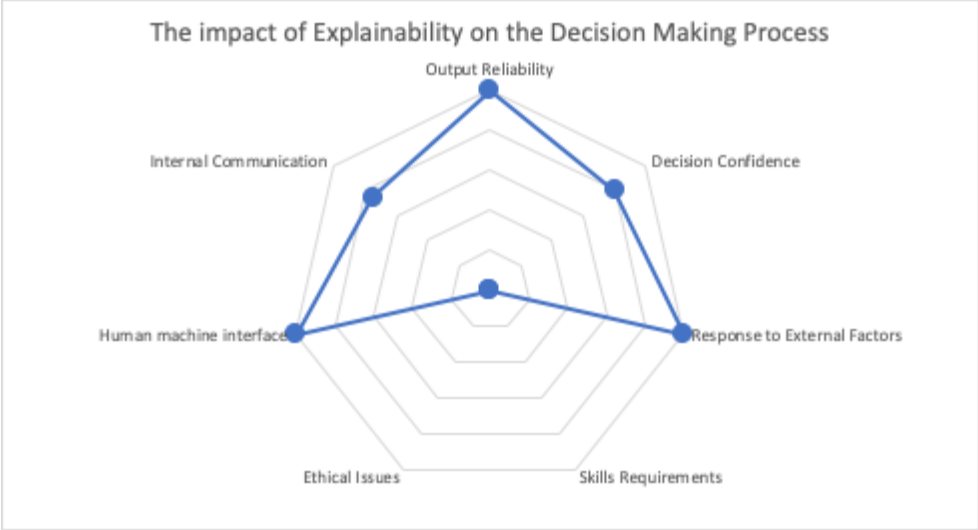



*Figure 22 The Decision making pillars radar chart - an example*

Each level of the radar chart indicates "how much" the dimension is impacted; it means "how differently that aspect is thanks to the adoption of the platform". It includes both positive outcomes, but also additional activities that the company is required to perform to effectively adopt the platform.

Such information will be collected during the one-to-one meeting and will be included in the final report. In case of additional activities required to complement the adoption of the platform (for instance, training for workers) that are time consuming, a planning is expected to be drafted by the demonstrator.

- According to the structure of the online questionnaire, the impact of the platform on the different professional figures is directly provided by the demonstrator. A radar chart is used to display such information in an effective way: for each professional figure (Plant Operator, Data Scientist, Data Engineering and Business User) the impact is measured within a range from 1 to 5 (0 if the worker is not present in the company).

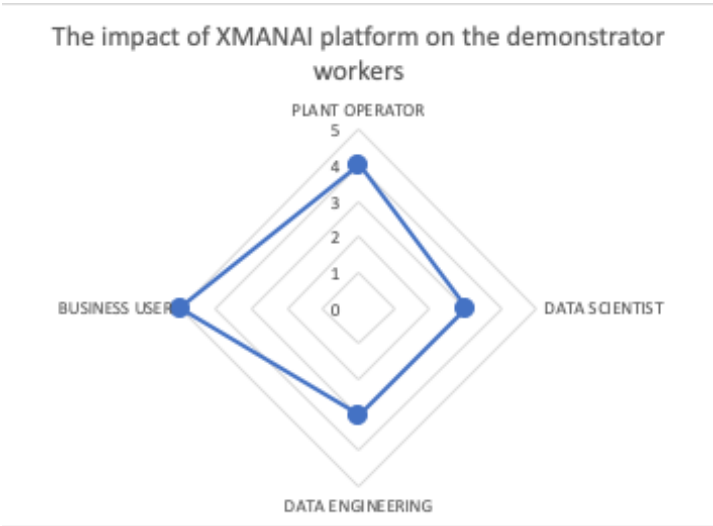



*Figure 23 The impact on workers radar chart - an example*

Similarly to what was said in previous bullet point, this evaluation must be complemented with additional information to be collected during the one-to-one meeting, understanding what type of "impact" is foreseen, if it is expected to be positive or negative and if further

activities are needed besides the project (and in case, it is important to collect the requirement and define a plan).

- A bar chart is used to display how the values of some KPIs has changed as a result of the adoption of the XMANAI platform.
  For instance, in the below picture, the Plant Efficiency is increased of almost 10% while the Environmental impact has been reduce of about 2%.

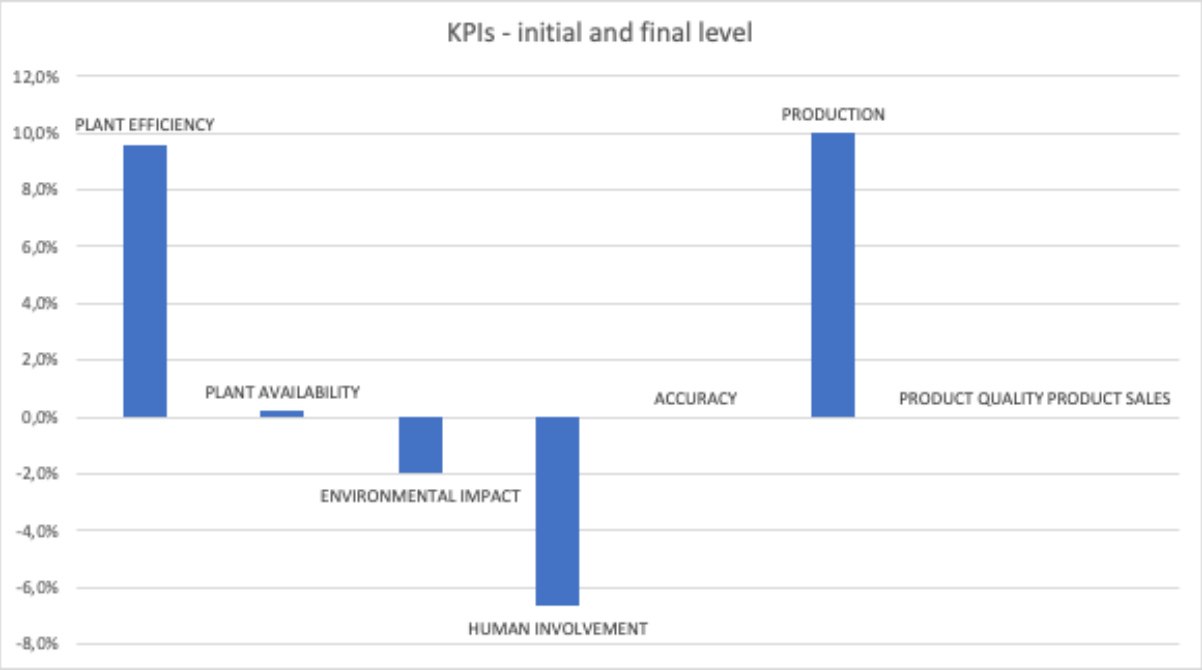



*Figure 24 Delta between KPIs' final and initial level - an example*

During the compilation of the questionnaire, the demonstrators are required to describe how the KPIs are calculated and the type of information/data required. Actually, the calculation of some KPIs is quite intuitive (as, for instance, the “number of sales”); conversely, in other cases it may be not so trivial and there may be more than a way of doing it.

This values should be compared with the expected values defined at the beginning of the project; during the one-to-one meeting possible mismatches must be discussed to understand if the original forecast had been badly estimated or if the XAI solutions is not fulfilling the expectation.

# 5 Framework review and future application

The objective of this chapter is to describe the validation activity run with the XMANAI partners (both pilots and technical partners) and to provide some guidelines for T6.8 that is expected to inherit and apply the methodology in next months.

## 5.1 Framework review by XMANAI partners

The current version of the Evaluation Framework is the result of several months of collaborative discussion among the partners of T6.2 and it includes also the feedback received by the other partners during the final validation step.

As already mentioned, the starting point for the development of the Evaluation Framework has been the already existing version of the 6Ps assessment, already tailored to describe the transformation deriving from the AI adoption, but not much oriented to measure the impact of the "Explainability" component. Hence, the first analysis performed in T6.2 drove to the introduction of three new dimensions, Teaming, AI integration, Explainability, as presented in paragraph 3.2.1. Furthermore, T6.2 designed the Explainability block, with the purpose of better addressing the topic of Explainability AI on the decision making process.

The Evaluation Framework has been validated in collaboration with all the XMANAI partners, both the demonstrators (who will be the final users of the questionnaires) and the technology providers to check if any key aspect was missing.

On the 22nd February, a general meeting was organised to present the tool, asking to all the partners to go into the questionnaire and to validate it, adding comments and feedbacks when required; demonstrators pretended to compile it having in mind their use case, to verify if questions are comprehensible and relevant for the pilot.

The feedback collected from the XMANAI partners have been addressed in the final version of the Evaluation Framework:

- The "AI Development" question (see paragraph 3.2.1) has been included in the People pillar to answer to the specific need of assessing the ability of the company to deal with AI models, optimize and work with AI graph models and explainability systems. The XMANAI project doesn't have an educational purpose (as training the demonstrators to develop AI), so the dimension is not expected to be impacted. However, to have a complete assessment it has been agreed to include it.
- In the Platform pillar, the "Vertical interoperability of data and events" has been slightly changed. Now it answers to the question: "To what extent is your Platform able to support a computational continuity between Physical Assets and Digital Cloud? How is information shared and synchronized among the functions?", to include also the analysis about the internal communication channels used to synchronize the work between the different stakeholders involved in the same company. This analysis acquires a relevant meaning in case of multi-stakeholders projects as XMANAI is.
  The change to question 3 stems from the observations of one demonstrator, who pointed out that the Process section did not take into account aspects of Communication Methods, used in the synchronisation of operations and in reporting and feedback systems, both of which could be improved by the adoption of XAI.
- Additionally, in the Explainability block the question about "Internal Communication" has been included as it is relevant for the project to assess if the Explainability component is speeding-up the communication among different departments as the information are more comprehensible also by non-experts.

- The demonstrators (CNH in particular) suggested also to better reason about the reduction of workload of operators deriving from AI adoption and the increasing of situational awareness deriving from the Explainability component, as in some use cases it is expected a significant impact on the daily tasks especially of blue collars. This topic is now investigated in the Performance pillar, where now it is required to specify if/how it is measured "the impact of AI on efficiency" (Operational/Technical) and if/how it is measured "the impact of AI on reduction of workloads for operators" (Social). Additionally, in the set of KPIs it has been included also the measure of "Human involvement" and "Workers well-being".

### 5.1.1 Test cases from the demonstrators

As anticipated, the demonstrators participated to the validation of the questionnaire, in order for T6.2 to have concrete feedbacks from the final users of the platform. The exercise was extremely useful to verify that the assessment succeeds in effectively catching the aspects of the production process that are impacted by the XMANAI platform, even if the four use cases differ each other and they involve different aspects of the productive process.

- The "**AI for product demand planning**" use case, driven by Whirlpool, impacts the sales and planning activities: neither the Product and the productive Process are expected to be subjected to changes; however, the Platform will be improved (at least the part concerning the planning activities) and, of course, the decision making process.
- The "**AI for production optimisation**" use case, driven by Ford, impacts the activities of the entire production lines, as it aims to set an alert system to control unwanted stoppages and guarantee efficiency: both the productive Process and Platform will be impacted, not the Product; additionally, the decision making process in planning activities will benefit from XAI.
- The "**AI for process/product quality optimisation**" use case, driven by CNH, impacts the maintenance activity of the plant (at long/short term) and the production planning: similar to the previous case, both the productive Process and the Platform will be impacted, not the Product. Furthermore, it will be reduced the workload of operators and increased the situational awareness (People) and the decision making process in planning activities will benefit from XAI.
- The "**AI for hybrid measurement planning**" use case, driven by Unimetrik, is quite different with respect to the previous ones, as in this case, the product is not a physical object but it is the combination of a Product-Service (given by the metrological tools combined with the metrologist experience) and with "Platform" it is not meant the "classical plant equipment". However, also considering a non-standard scenario, the XMANAI methodology has been conceived to catch the impact, for instance on the Product-Service (including the decision making process), on the Platform and on the People pillars.

So, in three use cases out of four (Whirlpool, Ford and CNH), the XAI solutions are not touching the physical product, so the Product dimension is not expected to be impacted.

In the case represented by the chart below, the demonstrator preferred to completely skip the compilation of the section; which is allowed in the XMANAI questionnaire. (However, during the official compilation, within T6.8, it may be interesting to describe the initial profile (AS-IS), even if expected to remain the same also after the adoption of the platform (actual TO-BE)).

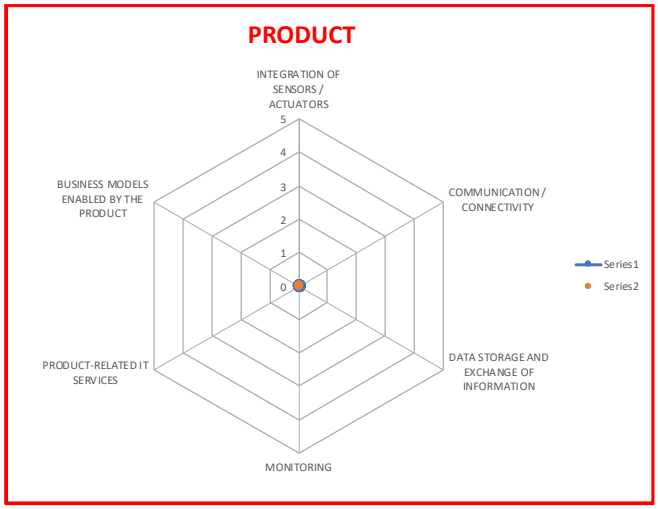



*Figure 25 The Product radar chart - skipped dimension*

Different is the situation for Unimetrik: in this case the Product is not a physical object (as it may be for Whirlpool, Ford and CNH that sell, respectively, white goods, cars and tractors), but it is a service (the metrological measurement). Even in this case, it is not possible to talk about "digitalisation" of the Product-Service, meaning for instance the integration of sensors; however, the XMANAI platform is expected to improve the Communication/Connectivity and the Data Storage: with the solution the metrologists will automatically have access to the information of previous measurements work, currently manually handled.

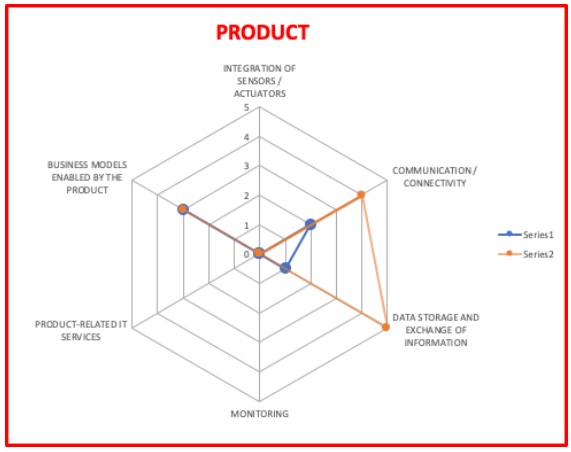



*Figure 26 The Product radar chart - AI for hybrid measurement planning*

Another interesting example is the case of "AI for product demand planning", where XAI is used to make more efficient the sales forecast based on a large amount of data to be analysed.

In this case, the Process dimension is not expected to be impacted, as the use case doesn't involve the production process, but only a specific phase related to the sales management. So, the impact is not expected on the Process pillar, but on the Decision Making dimension.

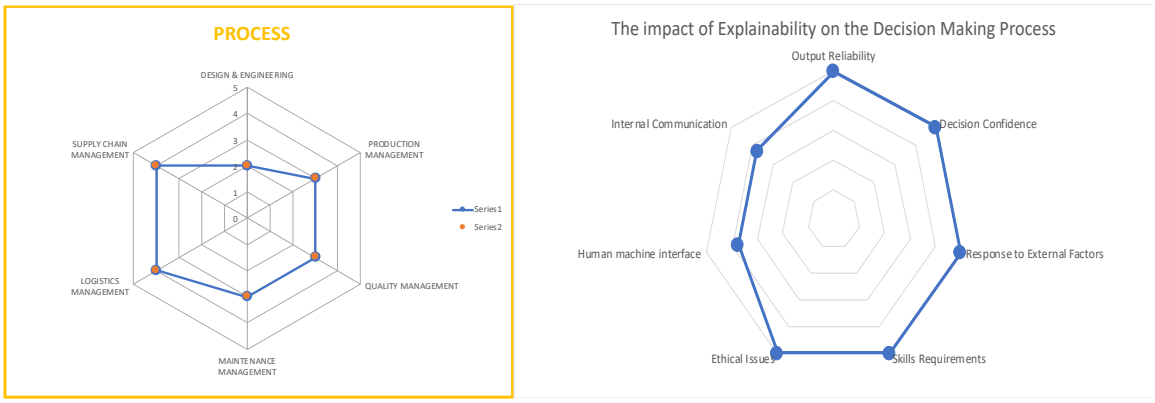



*Figure 27 The impact on the decision making process*

Conversely, in the "AI for production optimisation" use case, where the platform will be adopted in different phases of the productive process, the radar chart of the Process pillar will reflect the expected changes.

In the "AI for production optimisation" use case, the XAI will be used to monitor the processes, affecting also how KPIs are measured, making them more flexible and able to elaborate more complex analysis.

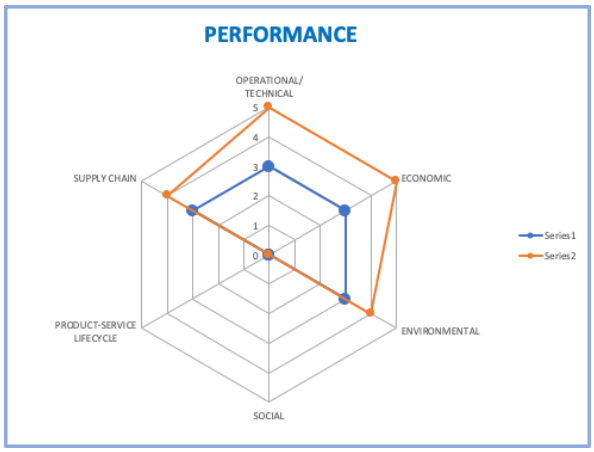



*Figure 28 The Performance radar chart - XAI impacting the KPIs measurement*

According to the use case, different stakeholders will be involved in the implementation and/or will benefit from the final solutions, and the XMANAI questionnaire will record how the relationship is improving as a direct consequence of the adoption of the platform, as following charts show:

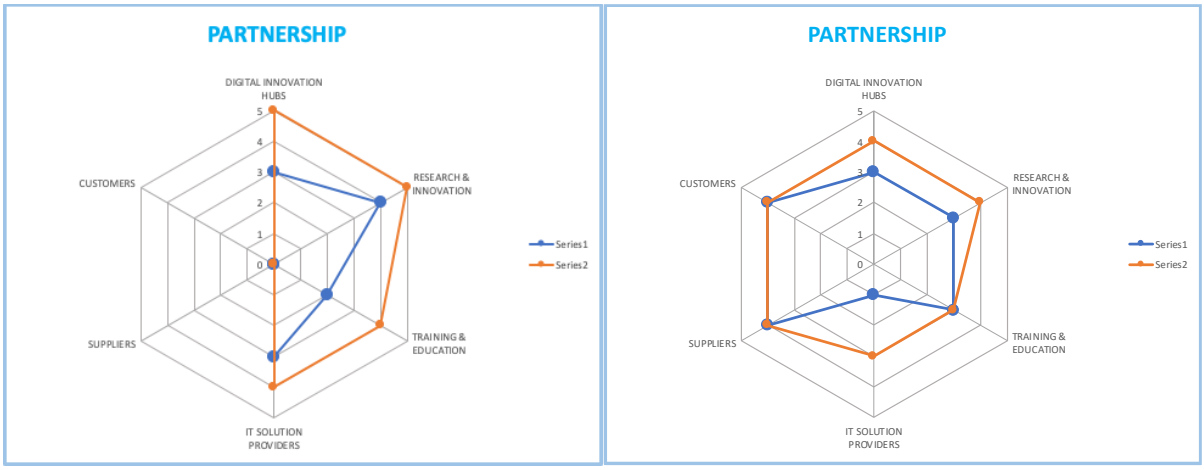



*Figure 29 AI for production optimisation (left) and AI for hybrid measurement planning (right)*

Finally, considering that the XMANAI solution is designed to be applied to specific departments/activity inside the plants, not all the workers are expected to be impacted. However, the XMANAI methodology presents several professional figures/tasks, in order to identify those that will be mostly affected by the use case. The following radar chart is an example to provide an overview of the different professional figures that will be impacted in the "AI for product demand planning ".

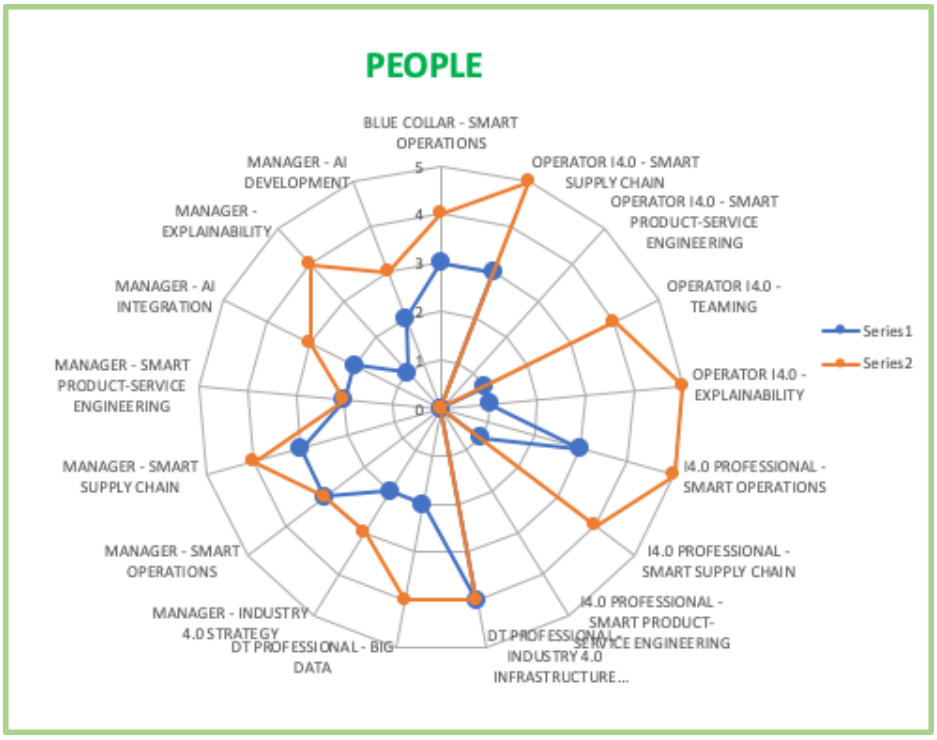



*Figure 30 The People radar chart - AI for product demand planning*

## 5.2 Toward T6.8 – How to apply the XMANAI Validation Framework

Task T6.8 – "Business Cases Evaluation and Impact Assessment" aims to put in practice the evaluation framework once the operations of the demonstrators start, collecting data and feedbacks, assessing what has been impacted and the role of the Explainability, evaluating the correct application of the platfom. It is the natural sequel of T6.2 – "Project Verification and Validation Framework Definition". In T6.2, the Validation Framework has been defined and the detailed description is reported in the current deliverable; T6.8 aims to guide the demonstrators in the compilation of the Framework, to collect the results and elaborate the final report in order to display in a measurable way the impact of the XMANAI platform and solutions.

The guidelines and the main steps of the XMANAI methodology are described in paragraph 4.2 and they will be followed accurately within the activities of T6.8, starting at M18 and lasting till the end of the project.

It is not possible to define a precise GANTT of the activities foreseen in the Task; however, we can sketch a draft timeline to display the main steps of the XMANAI methodology.

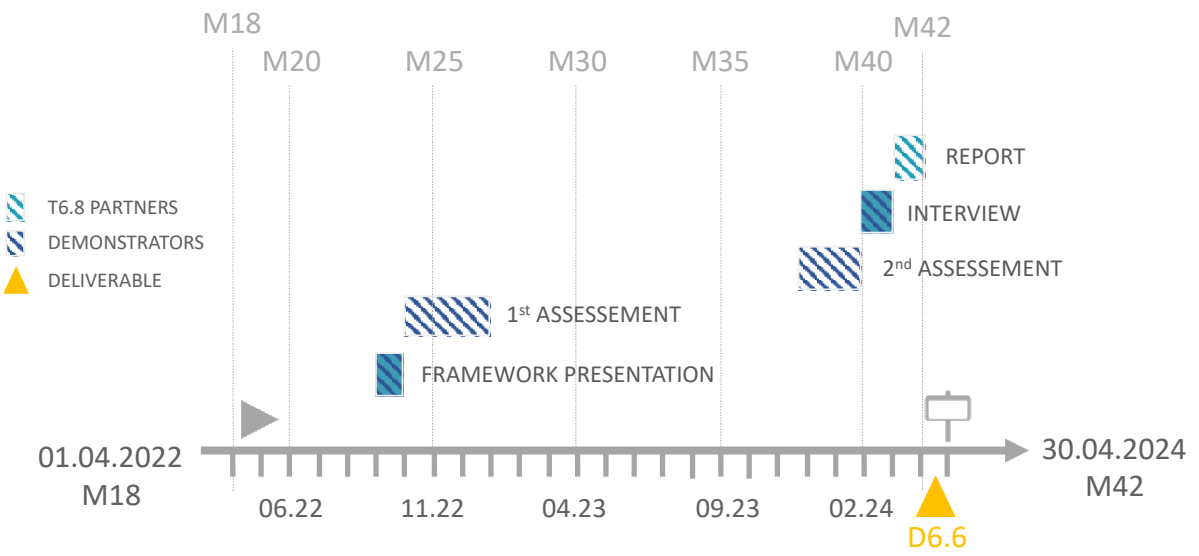



*Figure 31 Draft timeline for T6.8*

As mentioned, this is just a preliminary draft for the activities of T6.8 and it will be discussed in details in the context of the Task.

- **Framework Presentation:** it involves all the partners of T6.8 and it aims to present to the demonstrators the Evaluation Framework (6Ps assessment and Explainability block), explaining the purpose, the timeline, the effort required for the compilation. At this stage, demonstrators will be asked to "Set-up of a team able to perform the assessment" (Step 1 of the XMANAI methodology).
  This activity will be performed at the beginning of T6.8, soon after the kick-off of the Task.
- **First Assessment:** it involves only the demonstrators that will be required to compile the 6Ps assessment in the online questionnaire, before the adoption of the platform, to evaluate both the current profile and the one expected at the end of the project (AS-IS and Expected TO-BE). It corresponds to the Step 2 of the methodology "Identification of the profile of the manufacturing enterprise BEFORE the adoption of the XMANAI platform – 6Ps assessment".
  This activity will be performed at the beginning of T6.8, before the adoption of the XMANAI platform. The demonstrators will have at disposal some weeks to compile the assessment and to ask for further information.
- **Second Assessment:** it involves only the demonstrators that will be required to compile again 6Ps assessment, but after the adoption of the platform, in order to evaluate the profile actually reached (actual TO-BE). Additionally, they will fill also the Explainability building block, to measure the added value of the Explainable (X) component and to evaluate the benefit deriving from it. It corresponds to both the Step 3 and 4 of the methodology, "Identification of the profile of the manufacturing enterprise AFTER the adoption of the XMANAI platform – 6Ps assessment" and "Evaluation of the impact deriving from the adoption of the XMANAI platform, compiling the Explainability building block".
  This activity will be performed at the late stage of T6.8, after the adoption of the XMANAI platform. The demonstrators will have at disposal some weeks to compile the assessment.
- **Interview:** it involves all the partners of T6.8 and during this period the one-to-one interviews will be run with each demonstrator in order to validate the answers of the

online questionnaire and collect further details. This activity is included in Step 5 of the XMANAI methodology “Use cases evaluation and impact assessment”.
This activity will be performed soon after the demonstrators have finalised the compilation of the assessment; each interview will last about one hour each.

- **Report**: it involves only the technical partners of T6.8 that will analyse the results of the online questionnaires and of the interviews to produce the final reports, in order to show in a measurable and comprehensible manner the impact of the XMANAI platform on the pilots. The same information will be also revised to be included in deliverable D6.6.

# 6 Conclusions and Next Steps

D6.2 - "Project Verification and Validation Framework Definition" provides a detailed description of the XMANAI methodology and its Evaluation Framework, describing in details the steps that brought T6.2 to define its final version. Furthermore, the document is a manual that explains the key features of the Validation Framework and how to apply it during next months. In particular, the questionnaire used for the assessment is extensively described, to provide additional information both to demonstrators that will be required to compile it and to the partners interested to measure the impact of the XMANAI platform on the pilots.

It is a key document for T6.8, whose activities will be run based on it. In next months, before the complete integration of the platform in the demonstrators' plants, the methodology will be presented and the demonstrators will be asked to compile the questionnaire assessing their current and expected profile. At the end of the project, after the platform adoption, they will compile it a second time, to assess the level reached and stressing the impact of Explainable AI on daily tasks and on the decision making process.

Regarding the demonstrators' Implementation Plan presented in details in Section 2, activities are expected to start at M18 and carried on until the end of the project.

# List of Acronyms/Abbreviations

| Acronym/ Abbreviation | Description |
|---|---|
| **AI** | **Artificial Intelligence** |
| **API** | **Application Programming Interface** |
| **CPS** | **Cyber-Physical System** |
| **DFA** | **Data Factory Alliance** |
| **DT** | **Digital Transformation** |
| **EC** | **European Commission** |
| **EFFRA** | **European Factories of the Future Research Association** |
| **ERP** | **Enterprise Resource Planning** |
| **KPI** | **Key Performance Indicator** |
| **ICT** | **Information Communication Technology** |
| **IT** | **Information Technology** |
| **OEE** | **Overall Equipment Effectiveness** |
| **R&D** | **Research and Development** |
| **ROI** | **Return Of Investments** |
| **XAI** | **Explainable Artificial Intelligence** |

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