INNOVATIVE MODELLING & ASSESSMENT CAPABILITIES
THROUGH MAAS FOR MANUFACTURING ECOSYSTEM RESILIENCY

Grant Agreement N°101138648

WP7: Coordination and Management of the Project

D7.3 – DMaaST Management Alignment

Lead Beneficiary/ies: IDENER

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EXECUTIVE SUMMARY

This deliverable stems from the activities conducted during task T7.2 – Technical and scientific management, T7.3 – Project monitoring, Quality Control and Risk Management, and T7.4 – Administrative and financial management. All of them pertaining to Work Package 7 of DMaaST project. This WP is in charge of the coordination and management of the overall project, guaranteeing that the results, deliverables and milestones are achieved in time and form. Concretely, these tasks aim to establish a functional framework for the project and high-quality results. The principal goal of this deliverable is to stablish a clear framework and provide understanding on the whole project tasks relationships.

For the development of this deliverable, the initial definitions from the project proposal were taken into account and updated. Specifically, the presented KPIs were reviewed to determine their validation methods and their relationship to the tasks. Then, the methodology for achieving the diverse TRLs was reviewed to stress the steps to accomplish TRL6 at the end of the project. Additionally, the groups responsible for project technological advancements have been redefined and completed, based in the four working groups (WG) identified in the proposal phase. This identification was followed by the definition of their work and connecting it with the tasks from the diverse WPs of the project.

To support this information, in order to provide a clear overview, diagrams were created to illustrate the relationship between the working groups and all the project tasks. These diagrams serve as a reference for future work and help clarify any uncertainties during the implementation phase. The working groups have been largely defined on a one-to-one basis with the work packages, with the exception of the SMAP working group, whose work, being the overall outcome of all partial project developments, is distributed across different tasks in various WPs. These diagrams enable clear organization and tracking of project developments.

Overall, this deliverable contributes to the coordination and clarification of any doubts regarding the work to be carried out within DMaaST.

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ABBREVIATIONS

Abbreviation	Definition
KPIs	Key Performance Indicators
KA	Knowledge Assets
SMAP	Smart Manufacturing Assessment Platform
DSS	Decision Support Systems
MO-DDSS	Multi-Objective Decision Support Systems
DKG	Decentralized Knowledge Graph
EU	European Union
DPP	Digital Product Passport
DT	Digital Twins
TRL	Technology Readiness Level
DMP	Data Management Plan
MaaS	Manufacturing as a Service

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1. Introduction

DMaaST project aims to enhance the resiliency and adaptability of the manufacturing ecosystem through a Smart Manufacturing Platform (SMAP) with four key layers. The first layer establishes a data foundation using ontologies and Decentralized Knowledge Graphs (DKG) for trusted, real-time, cross-organizational data integration. The second layer develops a two-level cognitive Digital Twin (DT), modelling both individual manufacturing services and entire value chains, combining human expertise with data-driven algorithms and physical models. The third layer employs a Multi-Objective Distributed Decision Support System (MO-DDSS) to optimize production decisions. The final layer presents the information through user-friendly scoreboards. Additionally, in a transversal way, a dedicated module for assessing production sustainability and circularity, improving traceability via the EU Digital Product Passport (EU-DPP), will be created. DMaaST enables the adoption of Manufacturing as a Service (MaaS). The SMAP and the project innovations will be validated in aeronautics and electronics use cases.

In the project context, this deliverable seeks to offer a comprehensive overview of the project's development by mapping out the interrelations between work packages (WPs) and tasks. This is achieved through the creation of detailed relational diagrams, the identification of key working groups, and the revision of the proposal's Key Performance Indicators (KPIs), among other essential details. These elements are designed to facilitate better organization and streamline collaboration among project partners. In general, the D7.5 provides a clear roadmap for the project's trajectory, ensuring alignment with its overall objectives and guiding the consortium towards successful final delivery. This deliverable pertains to WP7, which is in charge of the coordination of the project.

1.1. Purpose of this document

The objective of this document is to provide a fundamental structure for the initial stage of DMaaST, which is essential for guaranteeing a unified team coordination, establishing explicit goals, and identifying KPIs. By addressing these aspects early on, this deliverable intends to establish a systematic strategy that will guide the project's development and guarantee that all team members conform to the project's objectives and methodology.

Building on top of the team alignment, a systematic approach was adopted, which involved project analysis, teamwork, and planning. The main focus was on developing a framework that would facilitate communication and coordination among the project partners, ensuring smooth progress and successful outcomes. The framework would serve as a reference working model for project activities, guiding the partners' participation and responsibilities in each WP.

With this aim, within each WP, and taking into account the working group defined in the proposal's methodology, the partners were tasked with defining their technical requirements and expected outcomes. This information served as the initial details for

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the flowcharts presented in section 5. These diagrams outline the relationships between tasks, identifying data or information needed for each one, and their outcomes. The visual representation will ensure clarity and transparency throughout the work carried out within the project duration.

This document also delineates the essential performance indicators that will assess the accomplishment of each assignment and the overall progress at initial stage. By defining these KPIs, this deliverable guarantees a transparent and unbiased baseline for assessing performance, enabling progress monitoring, early detection of problems, and well-informed judgements regarding any required modifications.

Overall, this paper serves as a manual for incorporating the results of each specific activity into the larger project structure. It outlines the dependent relationships between tasks and specifies how the outcomes will be incorporated into the following phases of the project. A holistic perspective is essential for integrating all project components and efficiently handling any possible consequences or overlaps.

1.2. Objectives

Due to the complexity of projects involving multiple partners with diverse expertise, traditional project delivery methods often fall short in terms of outcomes and timelines. In contrast, an Integrated Project Delivery (IPD) approach tackles these challenges by increasing the participation of all consortium members, promoting collaboration through shared goals, transparent communication, and risk-sharing. This approach requires a high level of engagement and coordination across all phases, especially in the early stages when critical decisions need to be made.

Considering the above, this deliverable will focus on the following aspects, that are related to an IPD:

- **Formation of Working Groups and Collaboration Structure:** Outline the roles of each working group, their specific activities, and how they interact with one another.
- **Unified Understanding of Project Objectives:** Provide a clear interpretation of the project's goals, fostering a shared vision of success across all team members.
- **KPI Development and Monitoring Framework:** Revisit the key performance indicators presented in the proposal and define the methods for tracking and assessing them throughout the project.
- **Resource Allocation and Workflow Mapping:** Illustrate the required resources, activities, and outputs for each working group, using detailed flowcharts to show the relationships between groups.

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2. Integrated Project Delivery

2.1. Methodology of the project, relationships between the developments

DMaaST project designs its methodology to ensure a structured and efficient progression from Technology Readiness Level (TRL) 3 to 6 over a four-year period. By following a clearly defined four-stage process, the methodology aims to transition innovative technologies from conceptual development to practical application, integrating them into real-world scenarios, and validating their effectiveness. Figure 1 summarizes the stages, duration and TRL associated. Each stage builds upon the previous one, refining technologies, validating concepts, and preparing for use cases' demonstration. The goal is to achieve a comprehensive and effective implementation of digital manufacturing technologies that address current industry challenges and demonstrate tangible benefits. In what follows, a brief description of each phase is presented.

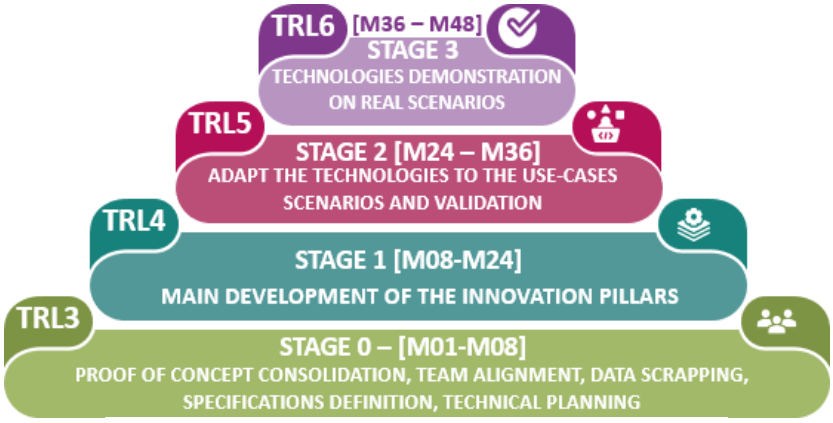

Figure 1. TRL progression scheme

- **Stage 0 - Consolidate TRL3 [M01-M08]:** In Stage 0, the focus is on consolidating the initial TRL3 level by aligning the project team and defining the project's objectives and technical specifications. This phase involves comprehensive technological research to establish the foundational pillars of innovation, including the development of digital interaction frameworks and data requirements. In this line, from a technological perspective, the design and methodology for cognitive Digital Twins (DTs) will be laid out, the initial framework for the platform will be drafted, the data sources available for the technological developments will be identified, among other developments. This will ensure a solid base for the subsequent stages. The outcomes of this stage, documented in D4.1, include a well-defined work strategy and a cohesive team approach that sets the stage for the project's advancement. On the other hand, this stage serves for consolidating the IPD, for identifying roles and responsibilities as well as defining the pathway for developing the work.
- **Stage 1 - Reaching and consolidating TRL4 [M08-M24]:** The project develops and validates its core technologies during Stage 1, with a focus on achieving TRL4. In the proposal phase, four technical key working groups were identified, each responsible for specific aspects of the technology development: data management, cognitive DTs, model-based optimisation and decision support

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systems, and sustainability. These working groups work collaboratively to refine their respective technologies, ensuring that they are functional and integrated. The stage concludes with the validation of these technologies in controlled environments, laying a robust foundation for the transition to TRL5.

- **Stage 2: Reach and Consolidate TRL5 [M24-M36]:** Stage 2 aims to bridge the gap between TRL4 and TRL5 by adapting and validating technologies with real-world use cases. The stage involves, for instance, integrating digital twins and optimisation algorithms into practical scenarios, assessing their performance, and making necessary adjustments based on feedback. Additionally, the effectiveness of data management solutions will be tested in cross-organisation data communication and traceability. Similar processes will take place with all the technologies developed in order to ensure reaching for TRL5. This stage provides a comprehensive perspective on the technologies' potential and helps refine them for broader application, ensuring that they meet real-world needs and constraints.
- **Stage 3: Reaching and consolidating TRL6 [M36-M48]:** In Stage 3, the project transitions to TRL6 by fully integrating and demonstrating the developed technologies in real-world scenarios. This involves incorporating all technologies into the Smart Manufacturing Architecture Platform (SMAP) and ensuring their interoperability through cloud services and user-friendly interfaces. The technologies will be deployed in production environments for practical testing, and evaluate their effectiveness based on technical and commercial prospects. The stage also includes strategies for communication, dissemination, and exploitation, fostering a community of stakeholders interested in the project's outcomes and ensuring its impact and success.

2.2. Technical and Administrative working groups: identification, leaderships and brief description

As previously described, the identification of working groups is a key aspect within the Integrated Project Delivery approach, with the goal of making the work more efficient and maximizing effective collaboration among partners. Each working group focuses on the development of a specific technology, in the case of technical groups. Administrative working groups are also defined, such as those for coordination, and Dissemination, Exploitation and Communication. These are described in detail in section 5. In what follows, a brief description of each group is presented, as well as the identification of the leadership.

1. **Sustainability, Circularity, and Human-Centered Approaches Working Group (WG1):** This WG will develop a resulting comprehensive module for both human-related aspects and circularity and sustainability. In this sense, the WGs can be further divided in two:
    - **WG1.1 - Sustainability, Circularity, Recyclability aspects' subgroup:** Led by HOLO focusing on developing and combining sustainability algorithms, including life cycle cost and assessment algorithms.
    - **WG1.2 - Human-centered approach subgroup:** Lead by GND, and training programs for human-centered design in digital tools.

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2. **Data Working Group (WG2):** Led by TRACE, focussing on developing and validating technologies for data understanding, interoperability, and secure cross-organisation data integration.

3. **The DT Working Group (WG3):** This WG works on creating digital copies of manufacturing processes and use-case value chains. They develop the DTs by using cognitive modelling techniques, that include human knowledge and expertise. In this WG, two subgroups can be identified
    - **WG3.1 - Manufacturing services DTs subgroup:** Led by KIT, in charge of replicating the use cases' services
    - **WG3.2 - Value chains DTs subgroup:** Led by IND, in charge of replicating the main stages of the use cases value chains

4. **MO-DDSS Working Group (WG4):** Led by IDE and ETHZ, focusing on developing DRL algorithms, implementing FTL algorithms, automating training and analysis, and optimizing MO techniques.

5. **SMAP Working Group (WG5):** Led by IDE, supported by IND for the development of the interfaces of the platform and TRACE, regarding data streaming services and modules' communication. This WG, will work by hand with all the groups.

6. **Demonstration Working Group (WG6):** Led by IND, the main purpose of this working group, in which all the partners will participate, is the demonstration of the technologies within the use cases environments.

7. **Communication, Exploitation and Dissemination Working Group (WG7):** Led by EEIP, supported by GND for the exploitation activities.

8. **Coordination and ethics aspects' related Working Group (WG8):** Led by IDE who, in collaboration with all WPs leaders will foresee the correct development of the activities of the project.

The partners leading each working group are responsible for ensuring that the group's objectives are met. It is important to mention that the use cases will contribute to each WG, providing the information available for the technological partners to proceed with their developments. The WG leaders also organize active communication among the group members and are in charge of updating the entire consortium when necessary.

2.3. Identification of the relationships and dependencies between WPs and WGs

This section identifies each working group along with their associated WPs. From the project's inception, the work packages were designed so that their division aligned with what each partner would work on and develop, all with a view toward the eventual integration of the modules into the SMAP. In this regard, there is almost a one-to-one relationship between the WGs and the work packages, as shown in Table 1.

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Table 1. Summary of WG responsibilities and related tasks/WPs

WG	Main responsibilities	Colum Title	
		WP	Tasks
WG1	**WG1.1** Develop Sustainability, Circularity assessment module	WP1	T1.1, T1.2, T1.4
	WG1.2 Human Centered approaches		T1.3, T1.4
WG2	Develop Decentralized Knowledge Graph (DKG) for DMaaST use cases and modules information exchange and enable data interoperability	WP2	T2.1-5
WG3	**WG3.1 -** Development of Manufacturing Ecosystem Double-Level DT' Module - SERVICES	WP3	T3.1, T3.2 T3.4– Manufacturing Services DTs + Integration
	WG3.2 - Development of Manufacturing Ecosystem Double-Level DTs' Module – VALUE CHAIN		T3.1, T3.3, T3.4 – Value Chain DTs + Integration
WG4	MO-DSS Module	WP4	T4.1, T4.3, T4.4
WG5	SMAP development	WP4 – Interfaces, services search engine	T4.2 - Interfaces
			T4.5 - Digital warehouse
		WP2 – Data aspects	T2.5 - Data streaming services for modules' interoperability
		WP5 - Modules integration	T5.1 – Cloud integration
WG6	Demonstration	WP5	T5.2 – Deployment
WG7	Dissemination, Exploitation Communication	WP6	T6.1-5
		WP5	T5.3 - technical and economical evaluation opportunities of MaaS
WG8	Coordination of the project, Ethical considerations	WP7	T7.1-4 – Coordination
			T7.5 – Ethical aspects

In some cases, several WPs participate in the working group activities, as can be observed in WG5. The tasks for SMAP implementation are distributed across work packages 2, 4, and 5, since several key elements are required for its proper development. These include not only the technical setup of the modules in the cloud, which will be handled in WP5, but also the groundwork for interoperable, secure, and effective data

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exchange starting from WP2 in data streaming services. Simultaneously, WP4 focuses on developing interfaces that are as intuitive and user-friendly as possible. Figure 2 summarizes the main aspects from the projects and their associated tasks and relationships.

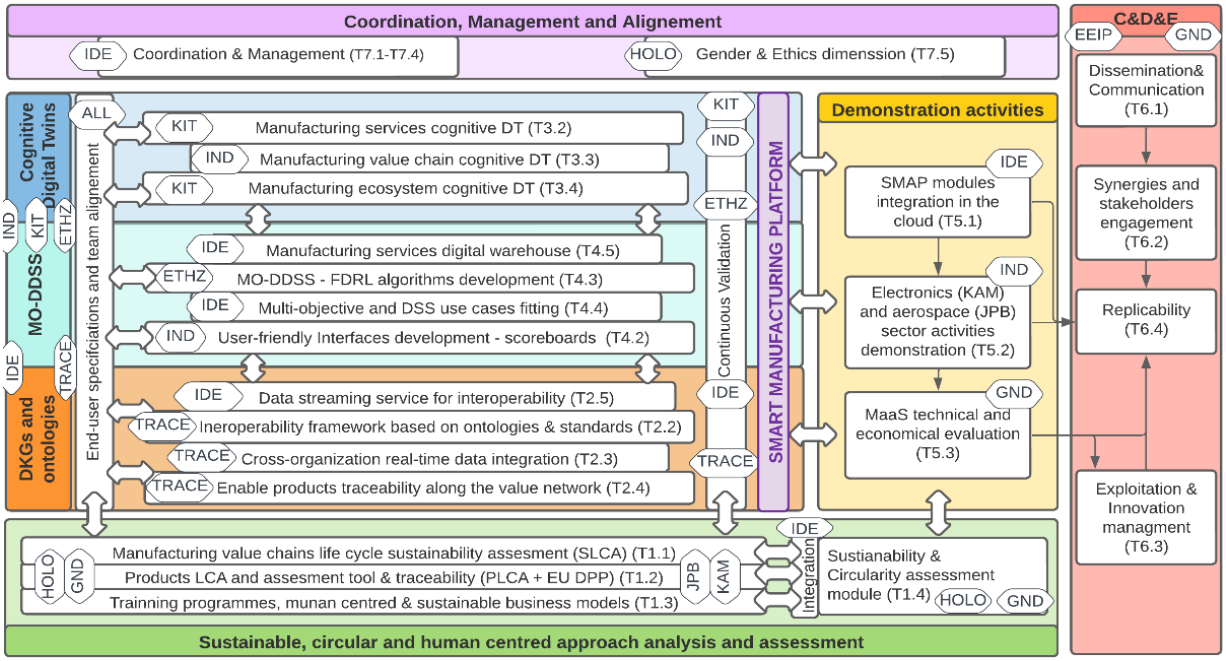

Figure 2. DMaaST main technologies and relationship among them.

By fostering consistent, open dialogue and coordination across all working groups, the DMaaST project can ensure that the various technologies being developed data architectures, cognitive DTs, model-based optimisation systems, and sustainability frameworks are integrated smoothly. This interconnected effort enables the project to move forward in a cohesive manner, ensuring that each technological innovation supports the others. Lastly, this holistic and collaborative approach will allow the project to demonstrate its technologies' full potential in real-world manufacturing environments.

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3. Technical requirements for the main project developments

DMaaST project offers a transversal solution that integrates multiple developments into a cohesive platform. Therefore, strong technical coordination is essential. This section is centred on the technical WPs and outlines the main developments that are related to each of them. Additionally, the design and development process must carefully consider the specific needs, constraints, and unique characteristics of each technology, as they will undergo validation in the manufacturing facilities of the two use cases.

3.1. WP1 – Sustainable, circular and human centred approach analysis and assessment

The primary objective of Work Package WP1 is to create a sustainable (A), circular (B), and human-centered (C) methodology for value-chain analysis. As follows is described how each aspect is addressed:

A. **Sustainability.** Covering the sustainability aspects entails developing instruments for evaluating the sustainability of life cycles by combining life cycle analysis (LCA), life cycle costing (LCC), and social-life cycle analysis (S-LCA). Specifically, the work involves examining value chains, establishing algorithms, and doing environmental, economic, and social impact evaluations, with a special emphasis on recycling, waste minimisation, and human rights. The objective is to enhance value chains by offering automated assessments of sustainability and associated costs.

B. **Circularity.** A primary area of concentration for WP1 is the Product Life Cycle Analysis (PLCA), which places significant importance on product traceability. The objective of this work is to enhance industrial processes by identifying components that contribute value and those that generate waste, therefore increasing efficiency using lean manufacturing techniques. Furthermore, within this WP, the integration of reverse logistics strategies will be considered, therefore facilitating improved management of end-of-life products and advancing the concepts of the circular economy. Additionally, traceability technologies will be taken into account to precisely monitor product lifecycle data, hence improving decision-making and sustainability results.

C. **Human-centred.** The incorporation of human-centred aspects encompasses the creation of training programs and business models that specifically target human-centered design and sustainability. These programmes seek to enhance the digital and soft skills of industrial workers. To do so, some questionnaires will be share with the use cases, in order to assess the Digital Maturity of the workers. These inputs will be taken into account in the platform development.

In conclusion, the final objective is to develop a Sustainability and Circularity Assessment (SCA) module that integrates all methodologies and generates automated reports and suggestions for enhancing manufacturing processes, identifying remanufacturing prospects, and optimising value chains to achieve greater sustainability.

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3.2. WP2 – Ontologies and DKG for cross-organisation real-time data integration

WP2 focuses on improving data accessibility, traceability, and interoperability. Therefore, the main objectives are the development of a framework for integrating cross-organizational real-time data using ontologies and a Decentralized Knowledge Graph (DKG). In addition to the expected impact beyond the project, those tools will also serve as foundation for DMaaST innovative technologies facilitating their development.

Key operations involve the identification of pertinent data sources, the definition of Knowledge Assets (KAs), and the pertinent data extraction from various systems/data sources. Among their tasks, it is foreseen to create automated data converters for directly transforming the information from the sources to the KAs. These activities will facilitate the establishment of an open interoperability framework, which will allow for smooth integration also using existing standards and ontologies. Additionally, under WP2, secure data pipelines will be developed, using blockchain technology for reliable data sharing. This will enable organization-wide real-time data interchange.

In parallel, there will be created data streaming services that effectively optimise the processing of real-time data, to ensure the seamless functioning of DMaaST modules, and seamlessly incorporate the obtained knowledge into manufacturing operations.

Lastly, the creation of KAs will also take into account traceability aspects of the assets throughout the value chain. This includes ensuring compliance with the EU Digital Product Passport (DPP) initiative.

3.3. WP3 – Manufacturing Ecosystem double-level cognitive digital twins

The main objective of WP3 is to digitally replicate the use cases manufacturing ecosystem using a double-level cognitive digital twin (DT). As well as consolidating the methodology implemented for its further replication beyond the project.

The activities commence by examining and defining the industrial processes and value chains of the use cases, establishing the foundation for the digital duplication of these systems. To understand the intricacies of the manufacturing ecosystem, DMaaST will identify and assess crucial components such as inputs, outputs, technologies, and value-adding aspects.

As part of their foundation, the cognitive DTs will consider expert knowledge information, mathematical modelling and data-driven information, leading to reliable simulation models. The DTs will simulate manufacturing services and phases of the value chain, creating various scenarios to predict possible threats and assess risks.

Finally, the integration of both value chain and services DTs in the Manufacturing Ecosystem DT, will enable the evaluation of the manufacturing value-networks and identification of bottlenecks, potential risks and their impact in the production at local

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level. Consequently, allow for the anticipation of effects on production lines, providing a potent instrument for enhancing decision-making, productivity, resiliency and efficiency in the sector.

3.4. Work package WP4 – Smart Manufacturing Assessment Platform

WP4 focuses on the development of the SMAP. The SMAP has a multi-layered framework and aims to bring together DMaaST technologies in order to improve understanding and decision-making in the manufacturing industry. This entails defining the platform's architecture and infrastructure to ensure successful integration of all components. The architecture is designed to facilitate dynamic decision-making, optimize human input, and address the complexities of modern production processes.

The creation of intuitive user interfaces that enable immediate interaction with the platform is an essential component of WP4. The purpose is to design these interfaces in a manner that enhances the clarity of information presentation and integrates user input, empowering decision-makers to accurately interpret and take action based on the given data.

In this line, WP4 is also in charge of preparing the Multi Objective – Distributed Decision Support System that will adjust and optimise according to the data and situations faced, offering strong backing for managers and operators. In this sense, the initial definition of the algorithms, the selection of the kind of algorithms, the procedures to follow will start the activities related to the Decision Support. Then, one task will be focused on the development of Multi Objective Algorithms, whereas another will focus on the selection of Federated Learning algorithms, with the aim of including distributed and anonymised information.

Lastly, WP4 entails the creation of a digital warehouse to store and oversee manufacturing services and their digital prototypes. To streamline the process of searching and evaluating services, this repository will provide an extensive catalogue. The incorporation of these components seeks to cultivate a more effective and adaptable manufacturing culture, capitalising on both technical advancements and user-focused design.

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4. Key performance indicators (KPIs)

This section consolidates the project KPIs and outlines the methodology for evaluating and tracking them throughout the project. This document provides a comprehensive description of how each KPI is measured, with technical KPIs dedicated to the specific processes that utilise DMaaST technologies. It is important to acknowledge that any limitations faced may necessitate modifications to the stated measuring methods during subsequent phases of the project. Notwithstanding, these modifications will aim to enhance the precision and neutrality of the measurements.

Objective 1 – Anticipate and enhance the understanding of unforeseen events' impacts in the production

Table 2. Objective 1 specific objectives description, KPIs and verification

Specific objective	Tasks	Measurement – KPIs	Verification
SO1.1. Anticipate unforeseen events within the manufacturing industry production	T3.2, T3.3	Reaction time to internal and external threats – Anticipating unplanned >30 min stops >10 min in advance	Identify critical points in the production and measure their impact in time if stopped. Measure reaction time to changes in the critical points.
		↑50% Inspections efficiency	- Frequency of the inspections to ensure best performances. - Overall Equipment Effectiveness (OEE). - Inspection coverage.
SO1.2. Identify external events impacts and/or possible risks on the industrial production	T3.4	Define at least 10 Risk assessment indicators (KRIs).	Map use cases' value-chain bottlenecks; improve impact on production evaluation.
SO1.3. Improve the understanding of unforeseen events impacts	T3.3, T3.4, T4.2	Provide timely scoreboard views user-friendly interfaces on manufacturing line status coming from DT's simulations and show expected impacts/risks enhancing user understanding.	Surveys for user understanding (SUS, PSSUQ) and satisfaction (CSAT, UEQ) – rate 15% above the average.

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Objective 2 – Enhance value-chains' responsiveness and resiliency to varying events

Table 3. Objective 2 specific objectives description, KPIs and verification

Specific objective	Tasks	Measurement – KPIs	Verification
SO2.1. Availability of manufacturing services (logistics, production and software services) and easy evaluation of those	T3.2, T3.4, T4.5	manufacturing services available and accessibility **↑12%**	- Number of manufacturing services suitable for the end-users' requirements
		↓50% time on manufacturing services evaluation and incorporation;	- Time took to scale-up the production with and without DMaaST technologies - Time took to incorporate new manufacturing process/services to the production
		↓30% reversions after installation	- Frequency of inspection action - Failures of new manufacturing services
SO2.2. Increase capacity to swiftly adapt logistics and production and optimise production	T3.2, T4.4	Supply chain total lead time **↓10%**	- Measure the time it takes for the products selected in the use cases (to be detailed in D4.1) to move through the entire supply chain, from the initial stages of sourcing raw materials to the final delivery to the customer - Identify bottlenecks
		inventory holding costs **↓10%**	- Inventory holding costs for the products selected in the use cases
		↓25% downtime due to logistics (starving/saturation).	- Measure the idle time, due to logistics, of the manufacturing process of the use cases selected for the demonstration sites - Identify impact of logistics delays - Identify manufacturing process bottlenecks related with the logistics
SO2.3. Ensure the resiliency to failures, guaranteeing useful outputs and reliable production	T4.3, T4.4	Measure the efficiency under non-optimal conditions; useful and actionable solutions >90% of the time, KPIs impact and trade-offs.	- Define non-optimal scenarios in relation to all DMaaST modules and use cases - Simulate the scenarios and evaluate the performance of

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even under non-optimal conditions			the modules under those conditions, as well as use case KPIs - Evaluate with the end-users the viability of the solutions suggested by the technologies
SO2.4. Enhance the transversal decision-making and planning within manufacturing industries	T4.3, T4.4	↓30% decision-making time	Time took by the end-users' operators to evaluate a scenario, plan a strategy and act, with and without DMaaST technologies
		Increase revenue or reduce costs by at least 5%	- Evaluate the impact of all improvements on the economic aspect. - Calculate the cost per product with and without DMaaST technologies support.
		Optimal non-dominant solutions (2 per objective	- Customisation option of the MO-DDSS - Solutions and strategies suggested

Objective 3 – Boost the transition to MaaS

Table 4. Objective 3 specific objectives description, KPIs and verification

Specific objective	Tasks	Measurement – KPIs	Verification
SO3.1. Upgrade of the manufacturing networks self-adaptation and agile response to external threats	WP2, WP3, WP4, WP5 T5.2.	Increase the manufacturing network availability, performance and quality of the production. Evaluate the Overall equipment effectiveness (OEE) ratio (↑10%)	Calculate the OEE of the demo cases manufacturing value-networks
SO3.2. Efficiently interconnect all the modules developed in the SMAP and ensure the overall efficiency to deliver actionable tools	T5.1.	SMAP uptime >98%	Benchmarks tests
		Mean time to resolution (minutes scale)	
		Consumption of computational resources	
SO3.3. Analyse the technical and economic viability	T5.3, T6.5	The technical and economic analysis of the technologies developed and the MaaS	Calculate ROI (Return on Investment) >20%

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and opportunities of MaaS		approach for demo cases value-networks will be performed	
SO3.4. Reliable and actionable models	T3.4, T4.3, T4.4.	scenarios generated accuracy (>90%)	Generate historical scenarios of the manufacturing plants and compare with the historical register
		provide useful suggestions >70% of the times.	- Simulate and evaluate the scenarios that would have occurred following suggestions. - Validate with the demo cases the viability and usefulness of the suggestions
SO3.5. To demonstrate the reliability, feasibility and upscale potential of the technologies developed within the project in relevant and real scenarios	WP5	Calculate the use cases specific KPIs.	- The KPIs measurement will be detailed in D4.1 as part of the use cases characterisation. - Later on those will be calculated during the validation and demonstration activities.

Objective 4 – Enable trusted and secure cross-organisation real-time data integration

Table 5. Objective 4 specific objectives description, KPIs and verification

Specific objective	Tasks	Measurement – KPIs	Verification
SO4.1. Improve the data interoperability and real-time integration	T2.1, T2.5	Data latency (ms)	Benchmarks tests
		Processing time (ms)	
		Results reliability under non-optimal conditions (>90%)	
		Data sources (>12)	- Data flow map - Identify and count the data sources connected
SO4.2. Ensure a standardised and	T2.3	Use cases knowledge and data sharing in a	- Fulfilment of ISO 27001 or SOC 2.

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secure method of data sharing		secure and trusted way.	- Block-chain implementation
		Cross-organisation data integration between use cases	- Data/information availability from one use case to another - Complete value-chain picture in terms of data flow and traceability
SO4.3. Enhance and ease the understanding and exploitation of the data and knowledge sources	T2.2	new knowledge assets (KA) generated (>30)	- List of knowledge assets - Access to the KA through the DKG
		knowledge discovery time (↓60%)	- Efficiency of the search engine of the DKG - Time spent searching information with and without the DKG
		data sources (>12)	- List of data sources feeding the DKG - Data flow diagram/map
		production stages covered (3)	- Data flow diagram/map - Origin of the data and link with their physical entities' sources
		Demonstration sites (KAM, JPB) adoption (>50%)	- Demonstration sites interested in continuing to use the tools after the project
SO4.4. Improve the traceability of the knowledge and products across the value-network	T2.4	Trace the knowledge generated along the DKG on both use cases	Use cases DKG operative and accessible by the end-users
		Trace the products along the manufacturing production	Track at least one product along the whole production line – Product flow-map

Objective 5 – Implement a sustainable, circular and human centred approach within assessment

Table 6. Objective 5 specific objectives description, KPIs and verification

Specific objective	Tasks	Measurement – KPIs	Verification
SO5.1. Evaluate the sustainability and socio-economic aspects of the use-cases' value-chains	T1.1	↑8% energy efficiency ↓5% Footprint ↓15% waste reduction **Their calculation will be detailed as part of D1.1.*	Perform an LCA, LCC and S-LCA and fuse them in a Life Cycle Sustainability Assessment (LCSA) tool
SO5.2. Implement a circular approach	T1.2	↑15% recyclability	- PLCA report; - traceability availability

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to address and enhance resiliency in the value-network		Remanufacturing opportunities identified - ↑20% equipment reuse.	and no – results comparison. - Lean production and reverse logistics strategies (D1.1) - Identification of key suppliers, materials required and recyclability options
SO5.3. Promote human-centred sustainable business models to approach LCSA and PLCA reports	T1.3	Engage society and manufacturing industries to a more sustainable consumption thanks to more informed decision. Propose ≥2 new sustainable business models	- Submission and approval of D1.4. - D1.4 will include a complete description of the new sustainable business models.
SO5.4. Ease the understanding of value-chain status, impacts and opportunities in terms of sustainability and circularity	T1.4	Automatise the reports generation and graphically present the results for a better and quick understanding.	- Accessible and executable tool/app which generates the reports

Objective 6 – Promote the MaaS, and project's modules and platform within the manufacturing industries

Table 7. Objective 6 specific objectives description, KPIs and verification

Specific objective	Tasks	Measurement – KPIs	Verification
SO6.1. To increase social awareness, understanding and acceptance of industry stakeholders and the general public towards MaaS and DTs	T6.1	**20** scientific publications	DOIs of the articles
		>3 use-cases centred webinars	Minutes and attendance list
		>5 conferences	
		>300.000 social networks followers potential	Social media metrics
		social media (1 post/week, 2 web articles/month, >30.000 web users/year)	Social media metrics
SO6.2. To promote clustering, networking and synergetic activities	T6.2	**<30** dissemination events. * *Diss. Event = any activity organised or participated by*	- Minutes of the event. - Social media posts.

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with other related projects		*DMaaST partners in which the advances and information of the project is shared*	
		Collaboration with sister or related EU projects	-Conjoined events -Conjoined activities
SO6.3. To conduct appropriate exploitation and business cases to enhance market opportunities	T6.3	Exploitation strategy with 5-year roadmap beyond end	- Submission of last PEDR version including a section for the beyond project exploitation
		Plan for Exploitation and Dissemination of Results (PEDR)	- Submission of the corresponding deliverables (D6.1, D6.3, D6.4, D6.5)
SO6.4. Promote the MaaS approach within the industries	T6.4	Engagement of **>4** manufacturing companies or technologies provider. A company engaged should fill in the next points: - Contact established - Company suitable as potential use case, replicability of DMaaST technologies - Company interested in DMaaST technologies	Contacts of the companies interested and description of the potential replication or scale-up of DMaaST technologies
		>200 key stakeholders reached	Excel file (or similar) gathering all the stakeholders' information and interest in the project results

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5. Workflow information for each WG and WP

Once the roles and responsibilities of all partners within each WP have been established and the KPIs from the project have been discussed; detailed workflows for each WP/WG will be explained. These workflows will be visualised through a series of flowcharts, one for each WP, highlighting their interactions with other WPs, and consequently with the other groups' specific tasks, responsibilities, deliverables, and the flow of information. Together, these flowcharts will present a comprehensive view of the entire operational framework.

The following figure illustrates the relationships between tasks, deliverables, and general information flows as an overview of the project:

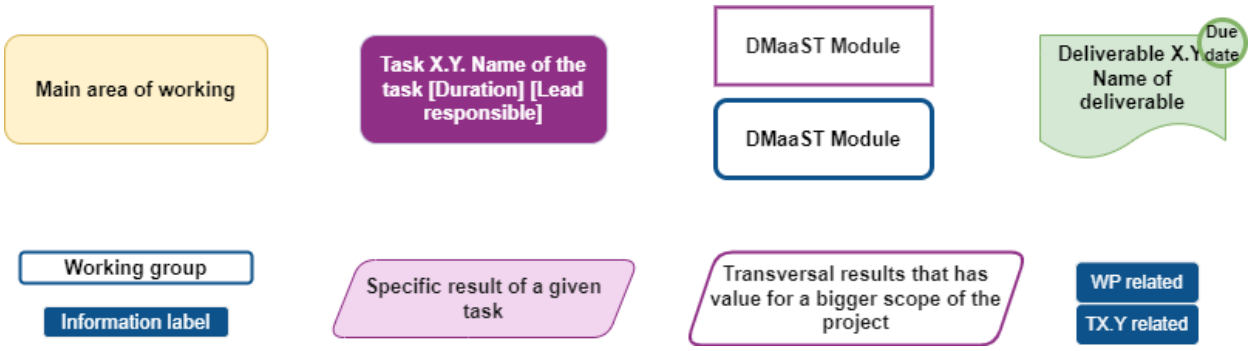

Figure 3. Workflow diagrams legend

5.1. Workflow information for WG1 – Sustainability, Circularity, and Human-Centered Approaches

As introduced above, WG1 focuses on developing comprehensive tools and methodologies to evaluate and optimise sustainability across industrial value chains. The primary objective is to integrate environmental, social, and economic factors into a life cycle sustainability assessment (LCSA), which will guide industries in adopting circular and human-centred approaches. By emphasising traceability and circularity in product life cycles, WG1 aims to provide data-driven insights for improving sustainability performance.

In Diagram 1, the four tasks of this work package are shown. The first three, whose initial technical focus will be summarized in D4.1, begin at the start of the project, each focusing on a specific aspect: T1.1 focuses on definitions related to algorithms for the development of the LCSA, and T1.2 emphasizes the investigation of traceability aspects within the production chains of the use cases. T1.2 particularly receives information from WP2, which is responsible for data management and processing, specifically from T2.4, which deals with traceability aspects from a data perspective.

These first two tasks, led by HOLOS, form the foundation of the developments related to sustainability and circularity within the project. They will result in the methodologies and identification of algorithms that will later be used in the module integrated into the SMAP.

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All the information generated from these tasks will be summarized in D1.1, which will be a partial result by M9.

The other task that has started in the project's first month, T1.3, is led by GND and focuses on human-centered perspectives and sustainable business model analysis. This task will receive input from T7.5, led by HOLOS, responsible for generating guidelines on gender equality within the project, which will provide useful information for the development of training programmes, human centred considerations for digital tools, etc. This task will result in a series of general guidelines to be considered for the development of the SMAP, which will be summarized in D1.2.

The final outcome of this working group and work package will be a comprehensive module integrated into the SMAP. Therefore, Task 1.4 will deliver a comprehensive sustainability and circularity assessment module that compiles all the data, algorithms, and strategies from previous tasks into a user-friendly interface that generates automated reports, graphical analyses, and recommendations for stakeholders to improve their sustainability performance. The WG1 will actively work towards improvements in their module, given the WP5's demonstration results.

In the next page, Figure 4 graphically summarizes the workflow for the WG1:

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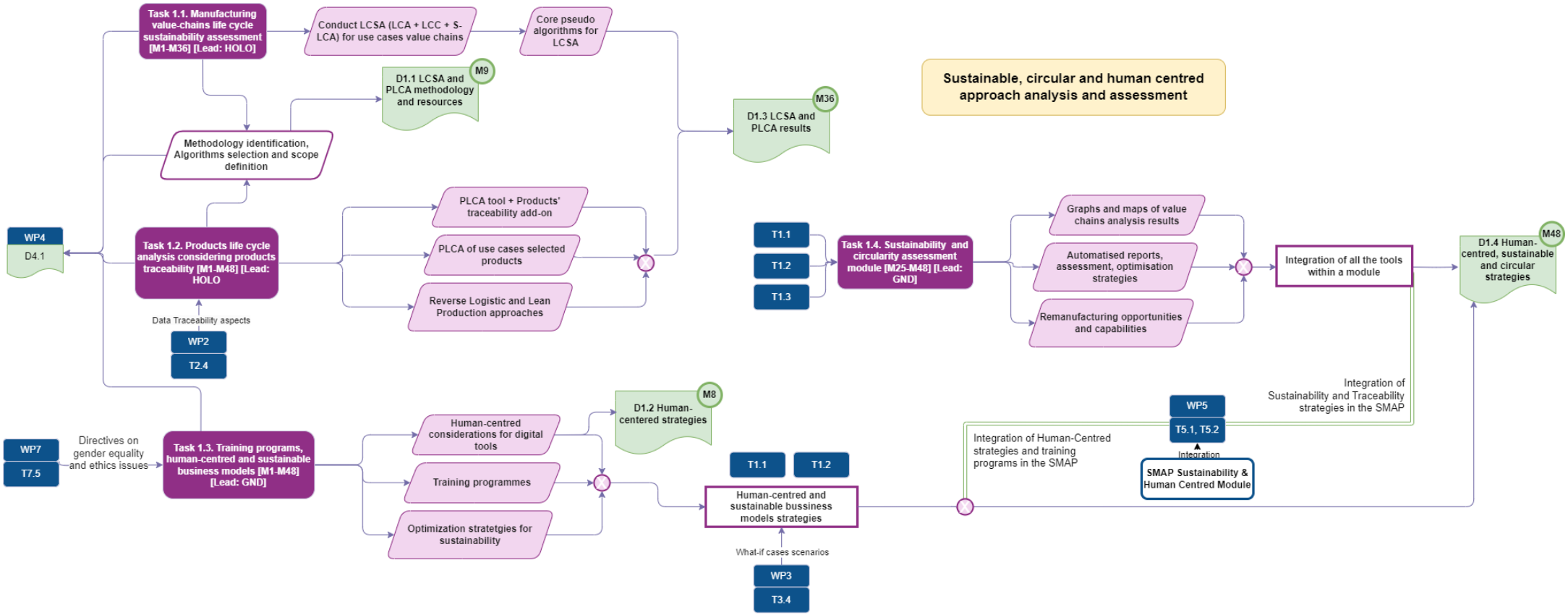

Figure 4. Workflow information for WG1 – Sustainability, Circularity, and Human-Centered Approaches

5.2. Workflow information for WG2 – Data Interoperability and Security through DKG

The goal of WG2 is to enable real-time data integration across organizations by utilizing ontologies and the DKG. It aims to identify accessible data sources to support the DMaaST project, structure this data using standardised formats, and ensure trusted, secure data integration. This process will enable data and product traceability across the value chain, as well as data interoperability for real-time exchanges within the SMAP framework.

The main work development of the WG2 is carried out within WP2, which involves the global management of information and data in the project. All technical developments are generally based on the data structure resulting from WP2. The first task, T2.1, led by IDE, focuses on identifying available data sources from the use cases. This identifies data flows and the systems or machinery providing the data within the use cases. The results of this task will feed into the initial tasks of the other WPs and will also be documented in D4.1.

Starting in M6, the T2.2 and T2.3 will begin developing the Decentralized Knowledge Graph (DKG) and mapping information to make it available for the remaining project's technologies. These tasks are led by TRACE.

During the overlapping months, T2.1 and T2.2 will work closely together to identify formats, existing ontologies, standards, and more. This task will lay the foundation for creating Knowledge Assets from the identified data sources. It will also focus on defining the interoperability framework for communication between modules within the SMAP (WP5). Then, T2.3 runs in parallel to T2.2, focusing on cross-sharing data and creating data converters to automatically transform new data into KAs. Additionally, data-sharing pipelines will be created, following blockchain principles to ensure the security of shared information and restricted access to authorized personnel only. This task will also validate the DKG. D2.1 will document the developments from T2.2 and T2.3.

In month 10, T2.4 and T2.5 will begin, utilizing the partial results of the earlier tasks, such as the ability to identify data sources within the DKG and the creation of KAs. T2.4, led by TRACE, focuses on enabling traceability information and data usage in the production chain where possible, facilitating the integration of the EU Digital Product Passport through the DKG's KAs. This process will be explained in D2.2, and the results of its application in D2.3. On the other hand, T2.5 aims to implement data streaming services for the SMAP modules. This task will receive inputs from the initial infrastructure developed in WP4, specifically from T1.4, and it will align with all tasks from WP2. All relevant information will be included in D2.4.

Figure 5 graphically summarizes the workflow for the WG2:

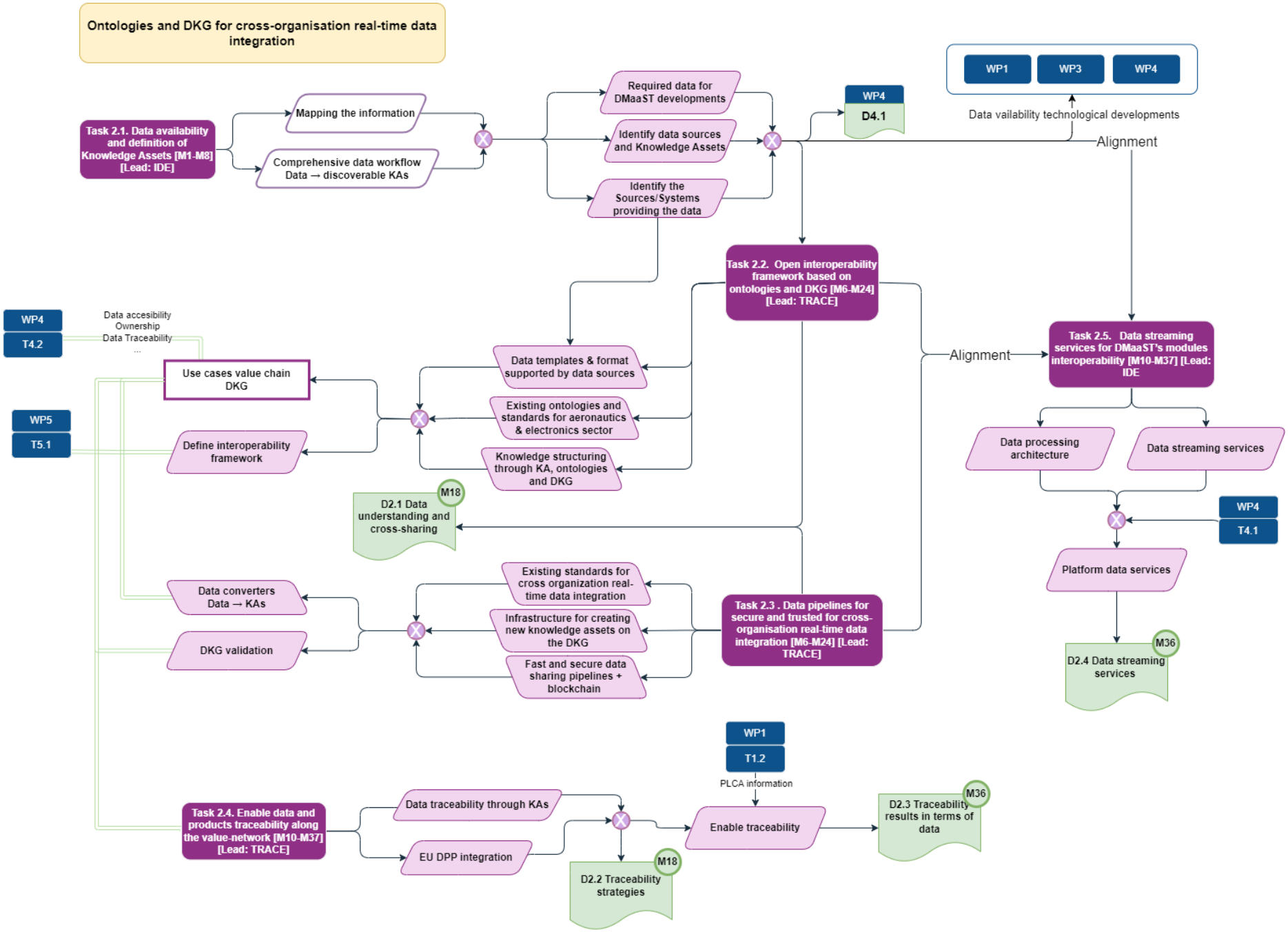

Figure 5. Workflow information for WG2 – Data Interoperability and Security through DKG

5.3. Workflow information for WG3 – Validating Cognitive Modelling for Digital Twins

The third WG is responsible for developing the Manufacturing Ecosystem Double-Level Digital Twin. It is related to WP3, which has four tasks in total. First, T3.1 aims to characterize the use cases in terms of their services and main stages of the value chain, which will later be replicated in dedicated tasks. This task is led by KIT. Within the task, KIT focuses on the characterization of the use cases at the service level, while IND focuses on the characterization of the value chain stages. This process will be shared in Deliverable 4.1. The information gathered under this task will sttle the baseline for the next ones.

In M8, the development of the digital twins begins under tasks T3.2 (services) and T3.3 (value chain stages), which receive information from the data sources identified in WP2. Both tasks work in parallel and will share information from their respective progress. Specifically, T3.2 also investigates the potential for remanufacturing services. All the partial results of the services DTs will be documented in D3.1. Meanwhile, IND will define the architecture of the value chain DT, taking into account the production services identified and replicated in T3.2. In the final phase of these tasks, the developed DTs will be validated. As cognitive DTs, they will receive insights from workers considered to have expert knowledge.

Finally, T3.4 will integrate the previously described developments into the Manufacturing Ecosystem Double-Level Cognitive Digital Twin module, which will be capable of generating scenarios and helping to assess potential threats to production chains. This module will be integrated into the platform in WP5. Information regarding the integration will be included in D3.3. This task continues until the end of the project to allow for improvement based on the results from the demonstration tests conducted in WP5.

Figure 6 graphically summarizes the workflow for the WG3:

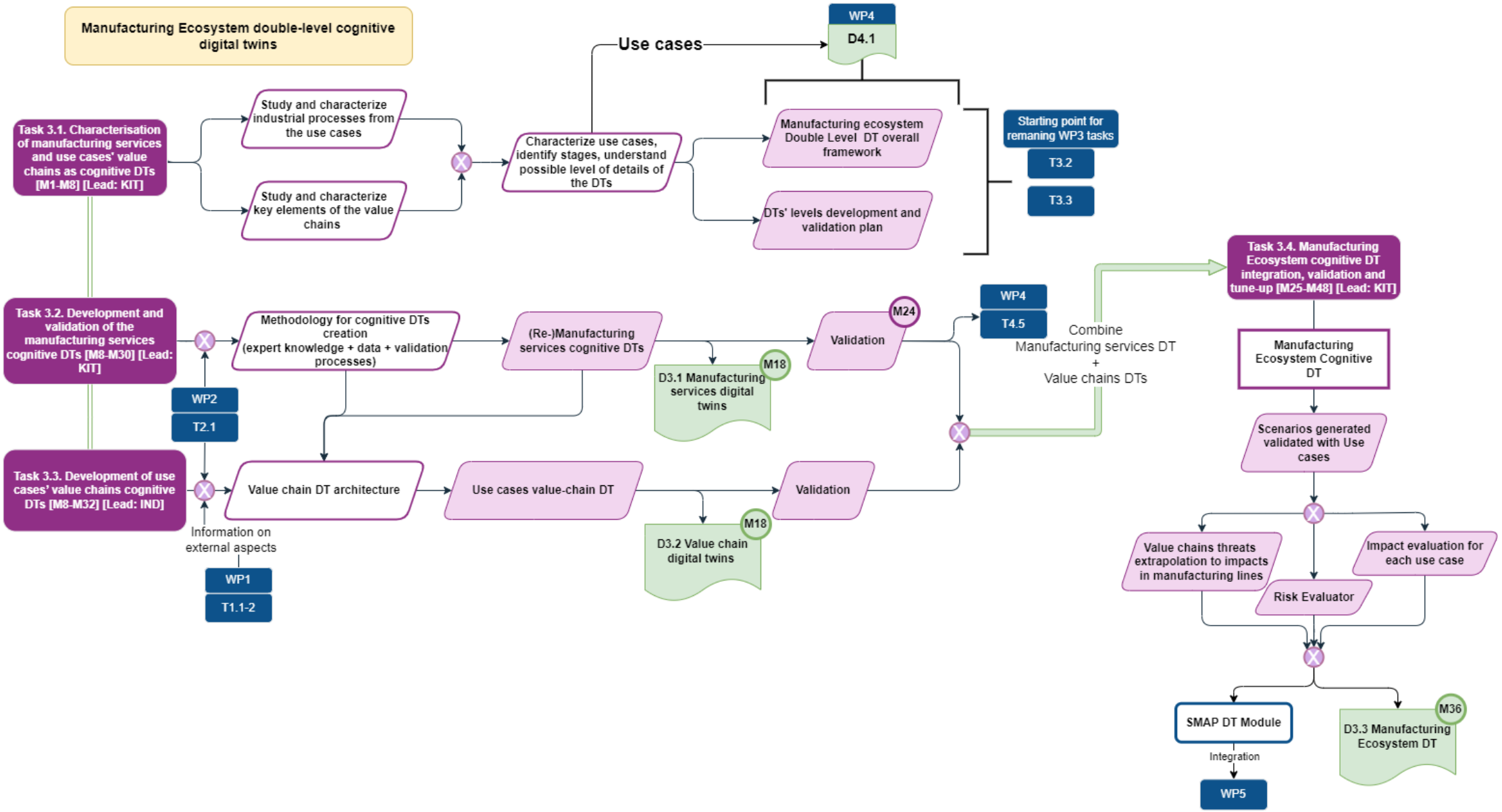

Figure 6. Workflow information for WG3 – Validating Cognitive Modelling for Digital Twins

5.4. Workflow information for WG4 – AI Algorithms and Optimization Techniques

WG4's work is primarily framed within WP4, focusing on the development of the Multi-Objective Distributed Decision Support System (MO-DDSS). The workflow begins with T4.1, where the objectives of the use cases are defined, and a research is made with the aim of identifying the kind of algorithms that best fit the MO-DDSS requirements. This leads to an initial definition of the problem to solve and the algorithms to be used, which will be included in D4.1.

Then, the development of the algorithms continues in T4.3, led by ETHZ, with a focus on ensuring distributed and secure data acquisition. The algorithms will be trained using information from WP2, and hyperparameter tuning will be carried out. The resulting algorithms will be integrated into an MLOps pipeline, allowing continuous updates of the parameters as the data evolves. In parallel, IDE will be in charg of developing multi-objective algorithms under T4.4. These algorithms will incorporate a human-in-the-loop approach, therefore, periodic communication with the experts working in the use cases will take place. The first version of these is expected to be available by month 24.

The final developments from both T4.3 and T4.4 will be combined to form the MO-DDSS module, with all documentation captured in D4.2. Finally, the full integration with the SMAP will occur under WP5 and WG6 (refer to section 5.6 for the details).

5.5. Workflow information for WG5 – SMAP development

WG5, led by IDE, is responsible for the design and conception of the platform. The initial development occurs in T4.1, where the platform's modules are defined by all partners and respective working groups, alongside the framework and initial interface conceptualization. This framework will be validated with all partners, and the construction of the interfaces will proceed in T4.2. Finally, the integration takes place within WP5, specifically in tasks 5.1 and 5.2.

Under this working group, IDE will be responsible for creating a warehouse of manufacturing services, which will receive information from the replicated services in WP3, specifically from T3.2, along with their associated data sources. The task associated to this is T4.5, and it will result in a service catalog available on the platform, along with a service search engine. The information related to the usage and opportunities that this catalogue will provide will be documented in D4.4.

Figure 7 graphically summarizes the workflow for the main work relationships in WG4, WG5:

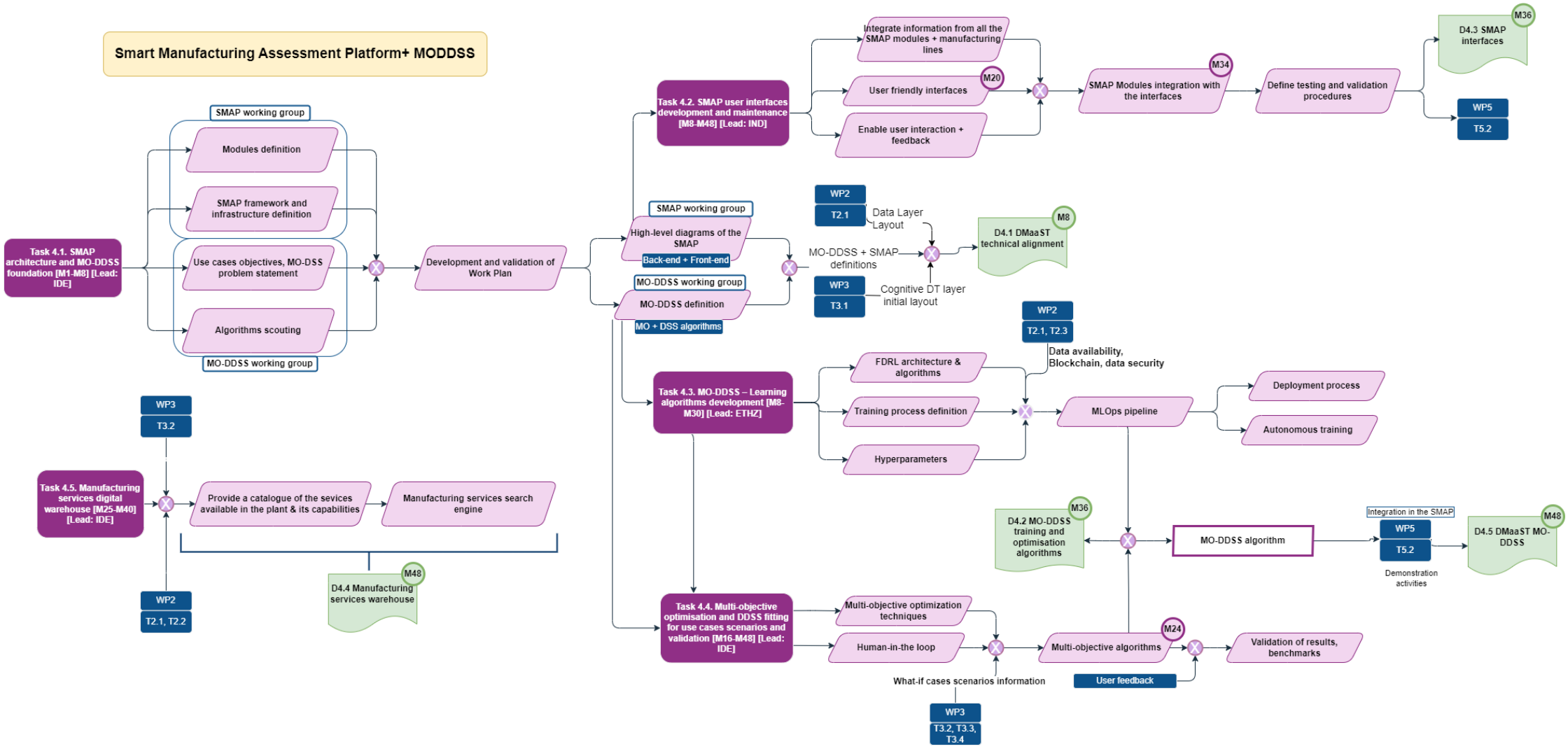

Figure 7. Workflow information for WG4 – AI Algorithms and Optimization Techniques

5.6. Workflow information for WG6 – Demonstration and evaluation activities in realistic environments

The primary objective of WG6 is to demonstrate and evaluate DMaaST's modules and SMAP deployment in cloud environments under realistic conditions. It focuses on integrating and coordinating demonstration activities, gathering data from end-users, and fine-tuning the technology to evaluate its technical and economic viability. The goal is to guarantee the efficient deployment of DMaaST's solutions, their seamless cloud interconnection, and compliance with MaaS technology requirements. These efforts are primarily related to WP5, which is divided into three tasks. The first task, led by IDE, focuses on the global integration of all SMAP modules and making the platform available in the cloud for more direct user access. This task gathers information from all modules developed across the various WGs/WPs.

The second task is more focused on deployment within the use cases. This task handles the major part of the demonstration tests for the use cases, and monthly meetings will be held to ensure proper control of the process. To assess the results, a final evaluation of the KPIs will be conducted. All demonstration-related information will be compiled in D5.1, to be delivered at the end of the project. In parallel, the demonstrations will aim to identify opportunities for MaaS both economically and technically. This task, led by GND, is closely linked to the developments in WG7, which focuses on dissemination, communication, and exploitation.

Figure 8 graphically summarizes the workflow for the WG6:

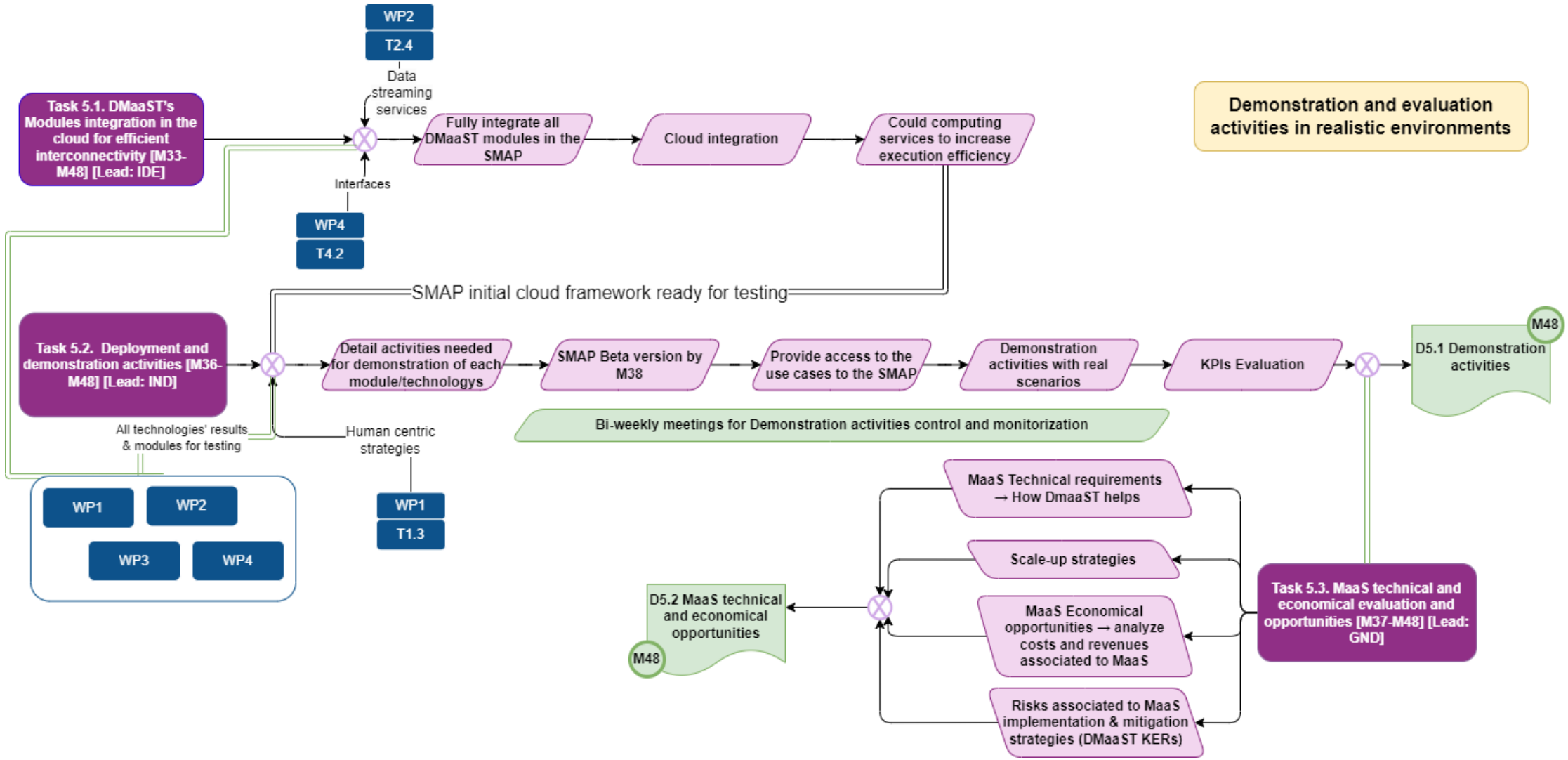

Figure 8. Workflow information for WG5 – Demonstration and evaluation activities in realistic environments

5.7. Workflow information for WG7 – Communication, Dissemination and Exploitation

The purpose of WG7 is to effectively communicate the project's outcomes during and after its implementation. This involves developing a comprehensive communication and dissemination strategy aligned with EU Open Science principles, promoting cross-sectoral collaborations, and facilitating the market uptake of the project's results. As stated before, WG6 is basically related to WP6, which focuses additionally on defining key exploitable results and addressing any potential barriers to their exploitation while establishing a robust Intellectual Property Rights (IPR) strategy and encouraging further engagement from the manufacturing sector to scale up the project's innovations.

Key outputs of WG7 include the development of a dissemination and communication plan, communication materials, stakeholder engagement initiatives, and a detailed exploitation strategy. WG7 will produce several materials, such as a project website, social media content, workshops, and events, to raise awareness and facilitate collaboration. Additionally, WP6 will create a business plan for the commercialisation of project results and the sustainability of the DMaaST network, along with IPR and innovation management strategies to safeguard the generated knowledge and ensure long-term utilisation of the project's assets.

Other work packages intricately connect to WG7's tasks, acting as a bridge between technical outcomes and their broader societal, industrial, and academic impact. While its exploitation and IPR tasks ensure the sustainable use of the knowledge and innovations developed in the project beyond its lifespan, its communication strategy amplifies the results produced by the technical work packages. Furthermore, the stakeholder engagement and clustering activities under WP6 support the establishment of synergies across various sectors and projects, reinforcing collaboration and knowledge exchange at a European level.

Figure 9 graphically summarizes the workflow for the WG7:

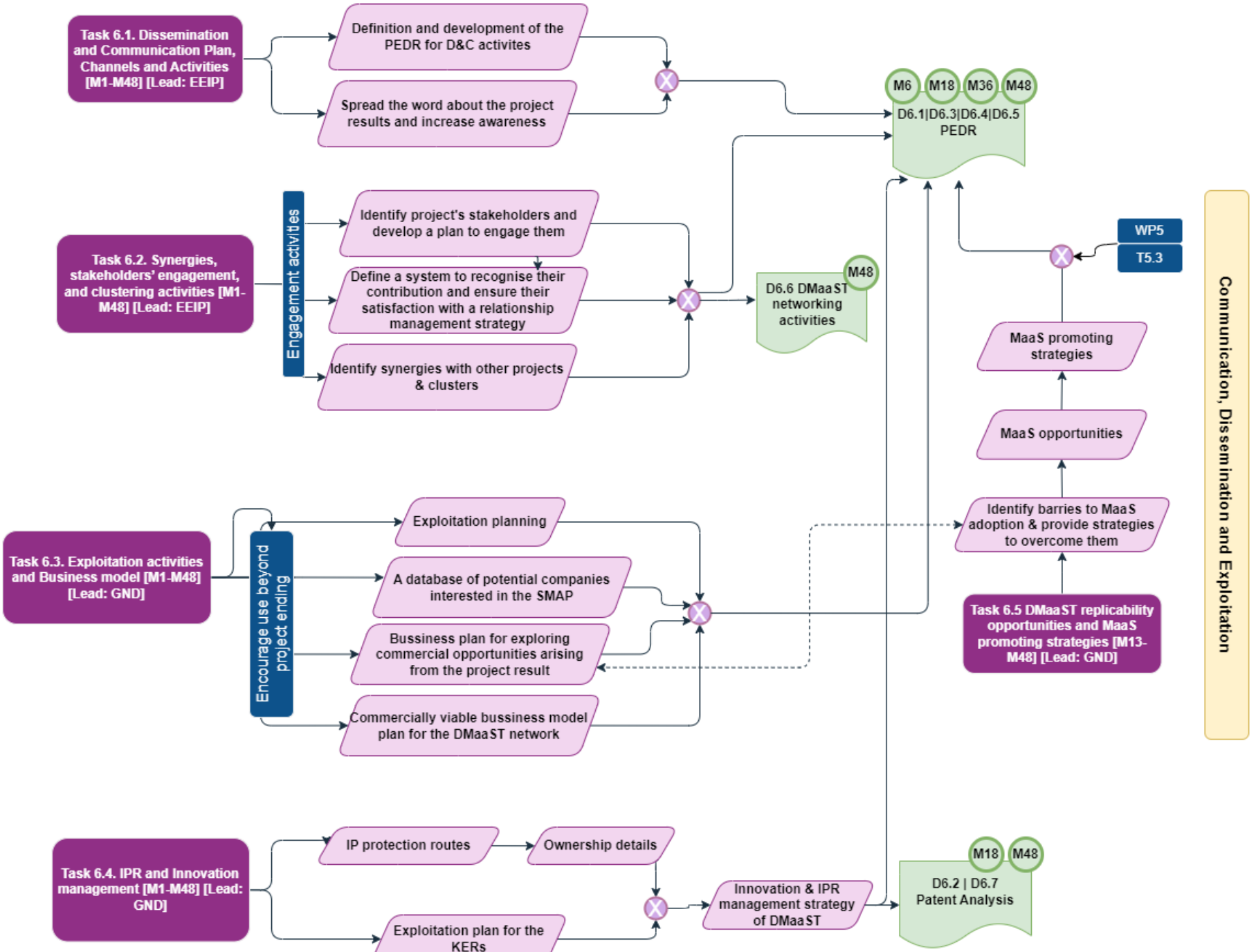

Figure 9. Workflow information for WG6 – Communication, Dissemination and Exploitation

5.8. Workflow information for WG8 – Coordination and Management of the projectFigure 9:

WG8 ensure seamless coordination and management of the project across its four-year duration. It focuses on aligning the project's goals and team members from the outset, ensuring efficient execution of all tasks in terms of time, quality, and costs. This includes defining a clear framework for management, setting decision-making processes, and implementing tools for effective collaboration. WG8 will make sure the integration of gender and ethics considerations, promoting inclusivity and fairness throughout the project's lifecycle.

As a result, WG8 will create a working framework that establishes KPIs and organises team alignment. Documentation will be delivered, as this document, to achieve its purpose and have every team member on the same page. Additionally, WG8 is responsible for scientific and technical management, ensuring timely progress toward milestones, monitoring technological advancements, and implementing a comprehensive Data Management Plan (DMP). A specialized office will conduct financial and administrative oversight to ensure efficient budgeting, while a gender and ethics strategy will prevent biases and ensure ethical research practices in compliance with EU guidelines.

WG8 provides essential coordination and management support, intricately linking to other work packages. It ensures the alignment of all scientific, technical, and administrative activities with the broader project objectives. For instance, WP7's oversight of quality control and risk management is crucial for the successful delivery of technical outputs across various work packages, while its monitoring of financial and ethical aspects influences the overall project's sustainability and integrity. This integrated approach fosters team cohesion and guarantees the efficient and ethical achievement of project outcomes.

In parallel, in this WG, HOLOS will take care of ethics and gender requirements as a transversal aspect in the project.

Several deliverables will be submitted as part of the project management and control to ensure proper follow-up on all developments. Key deliverables include D7.1, the Project Management Plan, the D7.2 on the directives for gender equality and ethics issues, and the Data Management Plan, which follows this report in M6. Additionally, a Technical Report will summarize the technical advancements and necessary details for the review meeting, organized around M9-10. WG8 will also coordinate the information to be gathered for the project review.

Figure 10 graphically summarizes the workflow for the WG8:

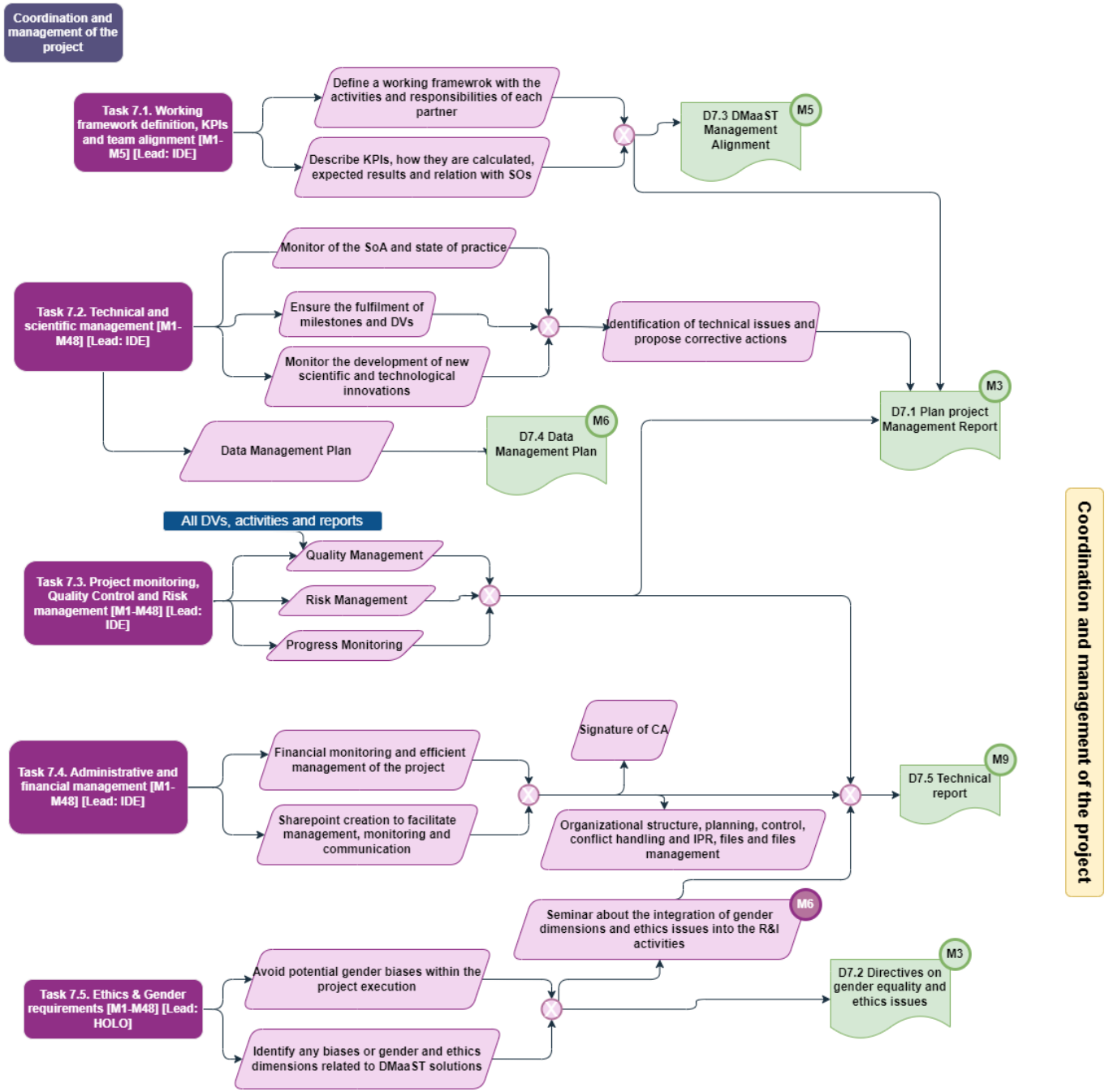

Figure 10. Workflow information for WG7 – Coordination and Management of the project

CONCLUSION

Ultimately, this deliverable offers a summary of the project's fundamental structure, establishing the groundwork for its implementation and results. The roles, duties, and interactions among the partners are specified. Additionally, several working groups have been assigned, developing a robust operational framework that will effectively guide the project through its many stages. The definition of each group's tasks and objectives ensure that each participant understands their role in achieving the overarching goals, promoting cooperation and harmonious coordination throughout the project.

The information presented in this deliverable is critical for ensuring the effective implementation of all tasks. Through task integration and coordination among the different working groups, the methodology facilitates a unified approach to accomplishing the project's goals. This systematic methodology not only enables efficient workflow administration but also enables ongoing monitoring and modification, ensuring that the project stays on schedule and adjusts to any unexpected obstacles.

Furthermore, the diagrams display inputs, outcomes, and roles, improving transparency and accountability within the project. Every working group has a comprehensive understanding of its responsibilities and how its work is interconnected with that of other groups. Maintaining adequate clarity is crucial for ensuring efficient communication and collaboration, which ultimately propels the project towards its intended results.

Moving forward, the subsequent stages of the project will expand on this structure, using the defined methodology to direct future development and execution. The comprehensive workflows and clearly defined responsibilities will continue to facilitate the project's advancement, ensuring meticulous execution of all operations and effective achievement of the project's objectives.

In general, this deliverable offers the essential framework and direction for the effective implementation of subsequent activities. DMaaST strategically positions itself to progress with assurance, leveraging the collaborative efforts of all working groups to achieve the project's goals and deliver significant outcomes.