ONE4ALL - Agile and modular cyber-physical technologies supported by data-driven digital tools to reinforce manufacturing resilience

Project nr: **101091877**

D7.1 ONE4ALL team alignment

Version: 1.0

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ONE4ALL Consortium Partners

N.	Partner	Acronym	Country
1	IDENER RESEARCH & DEVELOPMENT (Coordinator)	IDE	ES
2	INNOPHARMA TECHNOLOGY	INO	IE
3	CRIT	CRIT	IT
4	EXELISIS	EXE	GR
5	UNIVERSITY OF SOUTHERN DENMARK	SDU	DEN
6	AUTOMATIONWARE	AUTO	IT
7	MADAMAOLIVA	MOL	IT
8	HOLOSS	HOLO	PT
9	DORTMUND UNIVERSITY	TUDO	DE
10	ORIFARM	ORI	CZ

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Executive Summary

This deliverable (7.1 – ONE4ALL work requirements, objectives, team alignment and KPIs definition) is the result of the execution of task 7.1 from ONE4ALL project. As the project coordinator, IDENER is responsible for delivering this report. The aim of this document is to establish a properly defined working framework for the development of the project, in which the activities of each partner are also defined.

Several working groups were established during the aforementioned task, in order to define partner participation and roles in each work package which contributes to the optimization of the project's organization and enhancing the quality of its results. For each working group a workflow diagram has been created in which the information and materials inputs and outputs of each task have been connected, including deliverables submission dates, thereby contributing to the improvement of the project's organization and the achievement of its objectives. Moreover, as an essential part for the correct implementation of the project technologies, the definition of the KPIs and how those will be calculated is reflected in this document, which will serve as guidance and reference along the project execution.

This deliverable has been validated by all the partners and will be used as reference for any doubts regarding project execution in the future.

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List of acronyms

AFO	Administrative and Financial Office
AI	Artificial Intelligence
CA	Consortium agreement
DMP	Data Management Plan
DPO	Data Protection Officer
DSS	Decision support system
DT	Digital Twin
FAIR	Findable, Accessible, Interoperable, Reusable
IIOT	Industrial Internet of Things
IOP	Intelligent Orchestration Platform
I5.0	Industry 5.0
IPR	Intellectual Property Rights
KER	Key exploitable results
KPI	Key Performance Indicator
LCA	Life Cycle Analysis
LCC	Life Cycle Costing
RCPM	Reconfigurable Cyber-physical Production Module
S-LCA	Social Life Cycle Assessment
SDK	Software Development Kit
SME	Small and medium-sized enterprise
SO	Specific objective
SoA	State of art
WG	Work group
WP	Work package

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1. Introduction

The ONE4ALL project aims to transform manufacturing plants, particularly SMEs, towards Industry 5.0 (I5.0) by enhancing their resilience in response to unexpected social needs with human-and-sustainability-centred technologies. It utilizes plug-and-produce reconfigurable cyber-physical production modules (RCPMs) consisting of self-reconfigurable mobile robots integrated with IIOT devices to monitor in real-time. These modules and processes addressed are digitally replicated through data-driven digital twins (DTs) and controlled by a self-learning AI-based decision support system (DSS). All of them are open-source approaches that will be interconnected and efficiently managed by an intelligent orchestration platform (IOT) with a friendly user-interface for assisting the decision-making. This facilitates the digital upskilling of the workforce together with a designed training programme designed in the project. The project's potential will be demonstrated in agri-food and pharmaceutical sectors, providing replicable solutions to their high-demand and fluctuating market challenges.

The development of all these modules requires an accurate and efficient coordination of all partners involved, especially in terms of technical requirements, methodologies and interaction between partners. WP7 is in charge of this coordination together with addressing gender dimensions and ethics issues. Concretely, Task 7.1 focuses on establishing a properly working framework and detailing the activities of project partners. Additionally, the task aimed to provide a detailed description of the project goals, Key Performance Indicators (KPIs), and their calculation methods.

1.1. Purpose of this document

This deliverable provides an overview of the work completed as part of Task 7.1 within the ONE4ALL project. The content of the deliverable can be divided into two aspects. On the one hand, the organisational part comprises the definition of the working groups (WGs), alignment of consortium partners and description of activities, which are addressed in sections 2, 3 and 6. On the other hand, the definition of specific goals, KPIs and how they will be measured is part of Section 3.

Regarding the team alignment, a systematic approach was adopted, encompassing comprehensive analysis, team collaboration, and careful planning. The primary focus was on developing a framework that would facilitate effective 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 work package (WP).

One of the initial steps involved aligning the consortium, bringing together all project partners to establish a common understanding of the project's goals and expectations. This alignment was crucial for fostering a collaborative environment and promoting a shared vision of success. By leveraging Integrated Project Delivery, a collaborative alliance of working groups was formed, enabling partners to contribute their expertise and skills in a coordinated manner.

The working groups were tasked with defining their technical requirements and expected outcomes, which served as the basis for creating a comprehensive flowchart for each group. These flowcharts depicted the alignment of team members, outlined the activities to be performed, identified the data or materials required for each task, and allocated responsibilities to the respective partners. This visual representation of the workflow ensured clarity and transparency throughout the project, allowing for efficient task execution and progress tracking.

Concerning the goals and KPIs, significant efforts were made to define them, those definitions would serve as metrics for evaluating progress and success. The KPIs were carefully crafted to align with the project's Strategic Objectives (SOs) and reflect the desired outcomes. A detailed description of each KPI was provided, along with its calculation and monitoring methods. However, their calculation could vary in latter stages of the project according to issues encountered. The objective will always be increasing the accuracy and fairness of their calculation. Furthermore, this report delves into the expected results associated with each KPI and highlights their relevance to the overall project objectives.

1.2. Objectives

Considering the content described above, the objectives of this deliverable are listed below:

- Definition of the working groups, their activities and interactions between them.
- Provision of a common interpretation of the project's goals and expectations, promoting a shared vision of success.
- Establishment of KPIs and methods to measure and monitor them.
- Depiction of the required resources, activities carried out and outputs of each WGs, as well as the relations between WGs, in comprehensive flowcharts.

2. Integrated Project Delivery

2.1. Purpose of the methodology

The ONE4ALL project is segregated into four primary stages, with a key emphasis on facilitating a seamless progression from the start at TRL4 to the conclusion at TRL6. The subsequent overview provides a brief description of each stage, highlighting their main objectives.

- **Stage 0. Team alignment, technical scouting and planning [M1-M5]:** During this stage, the key milestone involves laying a unified groundwork for commencing the development of project technologies, as well as devising strategies for management, communication, and work.
- **Stage 1. Development of the innovative solutions proposed [M5-M18]:** At this level, each leader of the work packages has established a roadmap for the development of technologies, and each partner is cognizant of their responsibilities. The work groups (which will be expounded upon in the subsequent section 2.2) are defined, and the goal is to attain an operational iteration of all the technologies by concluding this stage at TRL4.
- **Stage 2. Pre-industrial validation in a relevant environment [M18-M30]:** Thanks to the preliminary version of each technology, the second stage will concentrate on examining the prototypes. This phase is also pivotal for rectifying and enhancing the technologies while guaranteeing the essential characteristics for scalability. Through the trials and evaluations conducted during this phase, TRL5 will be accomplished and fortified, thus allowing the attainment of the ONE4ALL objectives.
- **Stage 3. Installation of ONE4ALL technologies in end-users' facilities for their demonstration [M30-M36]:** In this stage, the key aspect involves the installation of the technologies, the planning and preparation for the demonstration activities within pertinent industrial contexts. The strategy formulated in the initial stage will be instrumental in facilitating the accurate development and resolution of issues during the demonstration. The successful completion of this phase ensures the attainment of TRL6. Particular emphasis will be placed on simplifying the deployment of the ONE4ALL technologies while accommodating scalability.
- **Stage 4. Demonstration in relevant environments [M36-M48]:** The final stage aims to solidify TRL6 by demonstrating the appropriate utilisation of the technologies within the use cases' sectors, the pharmaceutical and agri-food industries, while concurrently assessing their performance and impact. The entire consortium will partake in maintaining the developed technologies and refining their capabilities based on the outcomes. The data accumulated during the preceding phases will bolster replicability and transferability to the involved stakeholders.

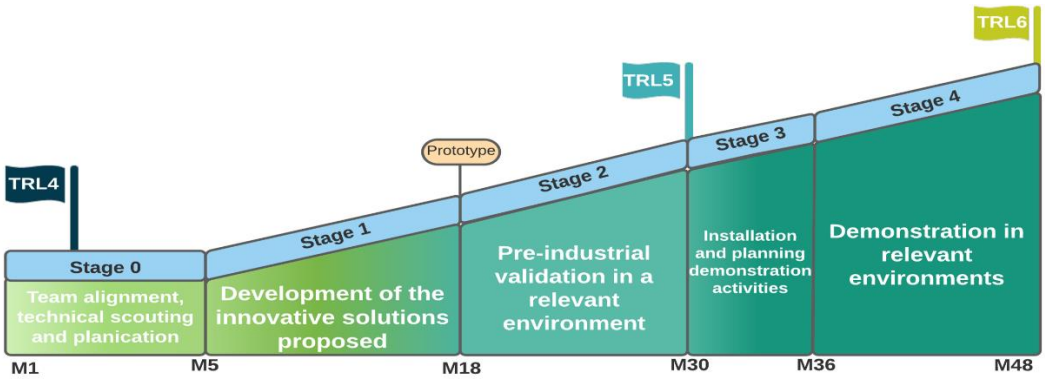

Figure 1. Stages of the proposed methodology.

2.2. Identification of working groups, roles and responsibilities

To streamline the development process, the technologies have been divided into distinct working groups, each consisting of relevant partners involved in the specific technology's advancement. This approach eases the organisation of the project activities and the definition of the strategies to be followed. Furthermore, a work package (WP) related to each group has been created when outlining the ONE4ALL workplan, overseeing the development of each technology. In the following, a brief description of the **technical work groups** is made for clarification for the following sections, whereas the total of the seven WGs (technical and non-technical ones) are described in detail in Section 5.

1- Digital Modules work group: is responsible for the development of Digital Twins (DT) and the self-learning Decision Support System (DSS), with the aim of simulating and predicting, and improving decision-making capabilities, respectively. The primary partners involved in this Work Group are SDU, along with participation of technological partners. WP2 covers the activities related with those developments.

2- Physical Components work group: The creation of reconfigurable cyberphysical production modules (RCPMs) – which are constructed by self-reconfigurable cobots - to perform diverse actions and IIOT devices to gather necessary information fall under the purview of this work group. The primary partners involved in this group are AUTO, responsible for cobots, and INO, responsible for sensors. The activities of this work group are consolidated under WP4.

3- Digital Maturity and Sustainability assessment module work group: WP1, led by INO, is responsible for overseeing the development of this assessment module, together with the support of IDE. This module is developed by two sub-work groups:

- Human-centred sub-group: INO & TUDO are the main partners involved and they are in charge of the social impact, identifying workforce needs, safety, and skills.
- Sustainability centred sub-group: HOLO is responsible for the sustainability approaches within the project development, which includes environmental aspects such as monitoring and optimising resource consumption, but also economic and social aspects

4- IOP work group: The main goal of this group is to securely interconnect ONE4ALL's technologies and connect with the demonstration sites through a data infrastructure based on open-source tools. Moreover, orchestrate the services offered by each module, and develop multiple user-friendly interfaces to facilitate remote access for the workforce and better understanding of manufacturing line status. The primary partners involved in this Work Group are IDE, along with technological partners. WP 3 is tasked with overseeing the development of the IOP, as well as the deployment and testing.

It is worth noting that the use cases will be involved in all the Work Groups, providing essential information, and that WP5 (Led by CRIT) is exclusively devoted to the development of demonstration activities.

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

The interrelation of all the Work Groups throughout the project is critical for the proper development of the project's technologies. Therefore, from project coordination to the establishment of the foundations for efficient and effective communication between the groups in the first stage, it is essential to highlight the importance of this cooperation. In what follows, an interrelated description of how each WP and discipline will be developed is outlined. As well as reflecting the interrelation through Figure 2.

As defined in section 2.1, once all partners have defined the project's starting point and goals, the development phase begins, which is divided into three “branches”: digital technologies (WP2), physical technologies (WP4), and the connection between both through IIOP (WP3). The activities for each thread include design, development, and prototyping. AUTO will lead the physical technologies activities, aiming to construct an operative prototype of self-reconfigurable cobots and tools that meet end-users' requirements (MOL and ORI) by M18. INO will integrate IIOT devices with the cobots in end-users' facilities to ensure the required data is gathered. In parallel, SDU will lead the development of data-driven digital tools, including the architecture of DTs and self-learning DSS, with the first version to be presented by M18, but it will be in continuous development and tuning throughout the project. Additionally, IDE will lead the IOP activities, with a first version of the IOP's backend (including the data-fusion pipeline, cloud database, and the orchestrator architecture using Kubernetes and containerisation services) expected by M18. INO will also be responsible for integrating IIOT devices with the cobots in the end-users' facilities.

This will be followed by the testing phase, in which ONE4ALL technologies will be validated in a relevant environment so that TRL5 is reached. Therefore, SoA I4.0 technologies will be available at SDU facilities where the testing phase will take place. All the partners will work together, led by SDU, to ensure interconnectivity and sharpen the performance, considering safety and sustainability of the technologies. In particular, the use-cases will give details concerning their facilities to anticipate and avoid disruption in the upcoming stages; and fast-forward the deployment of the IOP and all its services and interfaces modules. Moreover, the testing stage will ensure the fulfilment of all the standards identified by CRIT, as well as the safe human-robot collaboration (INO/AUTO). By the end of the testing stage, the first version of all the technologies coupled together through the IOP is expected; ready to be deployed for the demonstration activities, which are adaptable to different sectors.

The installation and demonstration (TRL6) will be led and planned in advance by CRIT. AUTO will manage the installation of the RCPM in both use cases’ facilities, and IDE will be in charge of the deployment of the IOP. Lastly, in parallel to all the abovementioned activities, sustainability (HOLO) and human (TUDO) aspects, led by INO, will be analysed, and assessed, starting from the digital maturity and sustainability assessment tool. Throughout the tool, the initial levels of digital maturity will be identified for the end-users (facilities and workforce) and their sustainability. Along the whole project, activities will be committed to improving the initial levels.

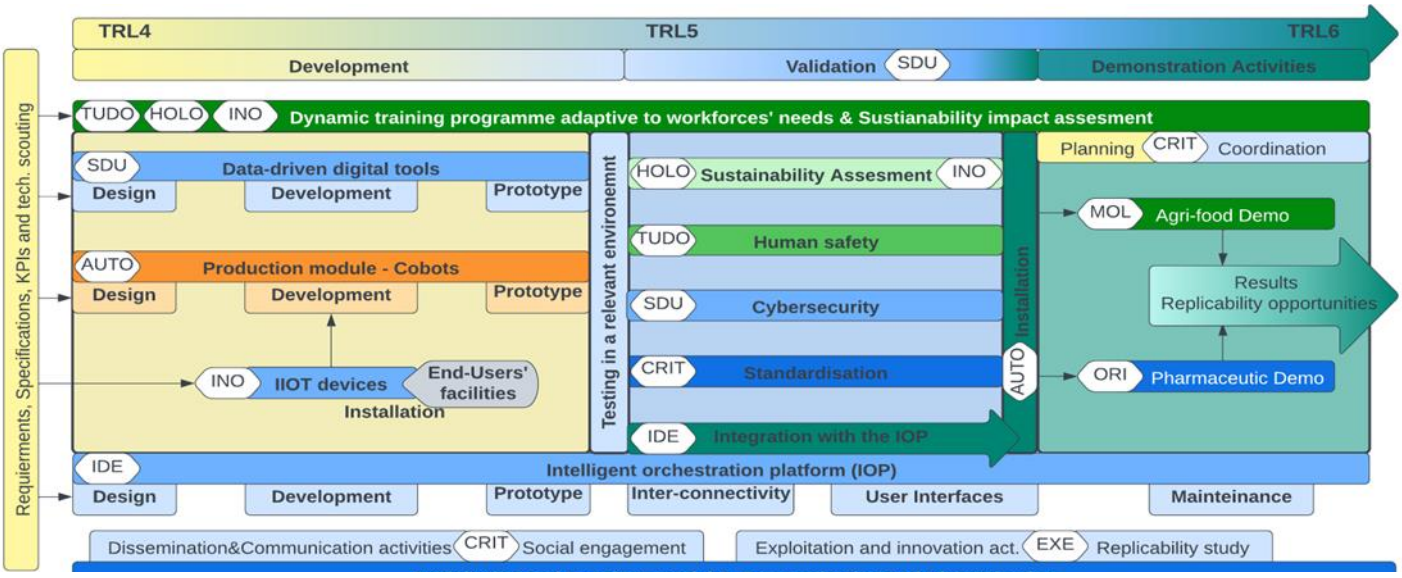

Figure 2. Consortia, disciplines and TRL interrelation.

3. Technical requirements for the main project developments

Given the transversal solution proposed in the ONE4ALL project, where several developments interact between them as part of the solution, coordination at the technical level is crucial. Therefore, it must exist a clear methodology to register the synergies between the WP in charge of each development. In this section, how the WPs interact regarding the technical requirements demanded by each development and the objectives they must achieve are described. Moreover, since all the tools will be validated in the manufacturing facilities of the two use cases, their needs, constraints and other particularities must be taken into account in their design and development.

3.1. WP1 – Human and sustainability impact assessment

In this WP, the main development is the Digital maturity & Sustainability assessment module, which in turn comprises other developments that aim at upskilling the digital maturity of the workforce and assessing sustainability. The first one is materialised with the design of an adaptive training programme that considers the workforce's safety and needs. This requires collecting the inputs from the workers through questionnaires and the fulfilment of safety standards, or, otherwise, designing them. Moreover, the training programme will be used as a way to detect gender and ethical biases, which will be considered in the development of the rest of the tools. Ultimately, the aim is to boost a faster transition to sustainable, resilient and human-centred production.

Regarding the assessment of sustainability, on the one hand, the life cycle sustainability assessment tool will be developed to evaluate the environmental, economic and social aspects. To this end, it will make use of data on prices, consumption of resources and environmental performance. On the other hand, the resource consumption monitoring and optimisation tool will closely interact with the above to map and optimise the resource consumption of the developments.

Finally, the Digital maturity & Sustainability assessment module will integrate these developments and the product quality monitoring and assessment tool, which in turn, will be integrated into the IOP. In addition, the results of the assessment will be shown by the DSS. Therefore, the inputs and outputs of the module are key for successful integration.

3.2. WP2 – Data-Driven Digital Twins (DTs)

This WP comprises the development of data-driven DTs and a self-learning DSS for supply chain simulation, prediction, and adaptive support at various levels. For these implementations, compiling the requirements and specifications is essential to cover the needs of the manufacturing plants. Indeed, a single task (T2.1) is in charge of providing the technical requirements and ontologies for the development of the DTs and DSS. Moreover, the results of the product quality assessment, which also include the relation with customers' demand, are required for these developments.

Both developments strongly interact with each other and demonstrators' facilities. The DTs will generate synthetic data as a result of simulating different scenarios, which will be training data to improve the solutions offered by the self-learning DSS. Therefore, the outputs of the DTs must be known by the DSS, and the technical requirements of both developments must be known for their integration into the IOP. All in all, the ultimate objective is to improve the reconfiguration and adaptation capabilities of the manufacturing lines to increase their flexibility. To this end, the DTs contribute to the simulation of complex processes, and the DSS enhances their control and supports novel workforce in their adaptation period.

3.3. WP3 – Intelligent orchestration platform (IOP)

Concerning technical requirements, the development of the IOP requires technical research of open-source protocols suitable for its architecture (T3.1) and cybersecurity standards for the IOP infrastructure and all integrated tools (T3.2). Regarding the latter, the fulfilment of AI ethics, security and trustworthiness must be guaranteed. These steps are essential to develop the IOP based on FAIR principles and protocols, highlighting the importance of defining the requirements before developing it.

The main objective of the platform is to interconnect and efficiently manage all the modules and their interfaces. For this purpose, the technical details and I/O of other modules from WP1, WP2 and WP4 must be considered. In addition, the IOP aims at presenting real-time monitorisation information through a user-friendly interface supporting workers in their control tasks, improving the performance of the processes. All these goals contribute to the enhancement of the flexibility of the production lines, making use of open-source protocols and flexible architectures.

3.4. WP4 – Innovative reconfigurable cyber-physical production modules (RCPMs)

This WP comprises two main developments, the self-configurable cobots and the installation of IIOT devices. Given that they are physical implementations, defining their specifications and requirements in detail is a determining factor in designing a workplan and avoiding risks, both in their design and in their installation. For this reason, an entire task (T4.1) is conceived for that purpose. Moreover, these implementations must fulfil existing standards or those created for the ONE4ALL solutions related to safe interaction between cobots and human workers, AI in manufacturing environments, environmental and energy management, and quality management.

The IIOT devices, together with high-quality sensors, will capture real-time information, increasing the data acquisition and improving interoperability of data sharing. These systems will be integrated into the cobots. These are characterised by their self-reconfigurability and modularity, which are boosted by their capacity to move and use different tools. This is in line with the general goal of enhancing the flexibility of manufacturing lines and their reconfiguration and adaptation capability.

4. Key performance indicators (KPIs)

This section gathers the projects KPIs and explain how they will be measured and tracked during the project execution. Although it has been explicitly included in the measurement of each KPI, technical KPIs are exclusively referred to the concrete processes in which the ONE4ALL developments are deployed. In the same line, average values of the last year prior to installation of ONE4ALL technologies will be used as baselines to measure the improvement achieved with those developments. Finally, it is necessary to highlight that the described measurement procedures might change in further stages of the project due to constraints encountered. Nonetheless, these changes will be focused on increasing the accuracy and fairness of the measures.

Specific objective	General KPI	Measurement
SO1.1. Enhance the flexibility of a manufacturing line through reconfigurable production modules	**>3** activities attended by the cobots	In the ONE4ALL project, an activity is defined as a task performed by a cobot that requires a different configuration, either performed by another cobot or involving self-reconfiguration of the cobot.
	↑20% supply chain response time	The response time is defined as the time elapsed from receipt of an order to scheduling its execution and preparing the necessary resources. In both use cases, these measurements will be taken for a set of orders of different types in terms of volume, workload, and priority, among others, especially focused on unexpected orders.
	↓50% idle time	The idle time is defined as the time that the activities, where ONE4ALL's technologies are implemented, are stopped due any reason (e.g. unexpected events, reconfiguration time, …)
	↑20% throughput	This KPI is a consequence of the previous ones, as the increase in working time while there are orders to be processed leads to an increase in throughput. Since this depends on the workload and other processes on which ONE4ALL technologies do not work, it is measured with the unitary process time. This will be compared with the average unitary process time of each addressed process. The objective will be translated into a reduction of 20% of the unitary process time.
SO1.2. Enhance the reconfiguration and adaptation capability of the manufacturing line	**10%** faster in-site reconfiguration to unexpected variations	This KPI measures the time employed to reconfigure the infrastructures and organise the workforce to start the manufacturing of a new product or different order from that was already scheduled. This time will be measured in different scenarios with increasing levels of complexity. With the aim of achieving a fair comparison, the testing scenarios will be based on similar situations observed in the historical data.
	↓50% reconfiguration time	In contrast to the KPI above, which refers to the scheduling of the reconfiguration, this one

		refers to the execution of the reconfiguration. Thus, it is measured as the time from when the reconfiguration is scheduled until the RCPMs and other elements are ready to start it.
SO1.3. Facilitate the integration promoting open-source protocols and flexible architectures	Ensure the use of open-source software and protocols among **100%** of ONE4ALL developments.	This KPI will be achieved with the submission of D3.1, D3.2 and D3.3, in which the open-source software and protocols considered and used in the developments are presented. Additionally, the source codes will be uploaded in a dedicated GitLab or GitHub open repository.
	Plug-and-Produce technologies successfully integrated into **two plants** with several existing systems.	This KPI will be achieved with MS11 and the submission of D5.2, which coincides with the finalisation of Task 5.2, which involves the integration and installation in the end-users' plants.
SO1.4. To demonstrate the potential of the technologies developed in relevant environments	ONE4ALL innovative technologies scaled up and demonstrated at TRL6 in a **1-year** campaign in **2 manufacturing lines (1** from **pharmaceutics** and **1** from the **agri-food** sector).	The achievement of MS13, which comprises the submission of deliverables 5.4 and 7.6, indicates the accomplishment of this objective.
SO1.5. Identify and fulfil the standards related to ONE4ALL technologies and define new ones if required	Identify standards applicable to ONE4ALL technologies and fulfil them; Contact/participate **≥1** standardisation working group	Within T4.3 CRIT will identify all the standards ONE4ALL's technologies must fulfil, and the actions required to do it. Which will be presented in D4.3. Those will act as measurement for the KPI and fulfilment of the objective. Additionally, as part of T4.3, CRIT will ensure the fulfilment of all the standards identified. If required official standardisation bodies or working group will be contacted.
SO2.1. Increase the data acquisition and improve interoperability of data sharing	100% monitorisation of the key parameters identified.	As part of Task 4.2, IIOT devices for real-time monitorisation will be installed to monitor key parameters. Reaching the present KPI involves to accurately gathered data from different sources and devices along the supply chain.
SO2.2. Develop an intelligent orchestration platform to interconnect and efficiently manage all the modules and their interfaces	**<10%** overheads	This KPI implies tracking several parameters, which some are part of other KPIs. The reduction of the overheads of the IOP entails the reduction of parameters like cost per transaction, resource utilisation (such as CPU, memory and storage), time to process and error rates. Moreover, increasing the system availability contributes to this KPI.
	<1min execution time	Time-performance analysis of the IOP when deployed
	Latency (**ms**)	
	Connectivity with all ONE4ALL technologies	The achievement of MS11 determines this KPI.
	Platform availability	This KPI measures the percentage of time that the IOP service is available and functioning

		correctly (without downtimes). It is the ratio of time a system or component is functional to the total time it is required or expected to function. That time will be tracked once the IOP service was deployed in the facilities of the industrial partners.
	Scalability	This KPI measures the ability of the cloud service to handle increases in traffic or usage. The KPI is measured by tracking the number of users or requests the service can handle at once and the number of IOT devices connected to the platform over time.
SO2.3. Improve understanding among end-users to ease the deployment and further use of the modules interfaces	Development of user-friendly UIs with remote/local access integrated with a help desk and digital upskilling tools.	The achievement of MS9 and the delivery of a Software Development Kit (SDK) in D3.7 determines this KPI.
SO2.4. Ensure the cybersecurity of the connections and cloud database	Anonymise the data, especially the data gathered from the workforce, to protect privacy.	The achievement of this KPI implies the fulfilment of FAIR principles defined in D3.2 and D3.3 and the guidelines presented in the Data Management Plan (D7.8), which must be supervised by the DPO.
	Point-to-point encryption for secure connections	To measure this KPI, the number of connections that are encrypted using TLS (Transport Layer Security) compared to the total number of connections will be tracked.
	Identity and Access Management to control access to sensitive data and infrastructure resources	This KPI will be measured tracking the number of unauthorized access attempts or successful breaches and compare it to the number of IAM policies in place.
	Regular backups to ensure the restoration of code and data in case of a disaster or security incident	To measure this KPI, the frequency of backups and the completeness of backup data, including testing backups, will be tracked.
	Response time of connections with the cloud service	This KPI will be measured by recording the time between a user request and the response from the cloud service. These measurements will be taken once the IOP was deployed in the industrial facilities.
SO3.1. Increase workforce digital skills and understanding about ONE4ALL technologies	**↑50%** workforce satisfaction	The KPI will measure the workers satisfaction with the novel technologies developed within ONE4ALL; and the comparison will be done with workers' satisfaction with current technologies and working practices. As part of MS4, periodic questionnaires will be conducted to the workforce, where specific questions to measure work satisfaction will be included. The final value of the KPI will be settled at the end of the project.

	↑60% digital skills	Workforce interviews and questionnaires will be conducted. Those will include specific questions to identify and measure workforce's digital skills and points of improvement. MS4 will settle the baseline value for the workforce's digital skills; and MS10 the improvement. The comparison of the results before ONE4ALL solutions implementation (i.e. Digital Maturity Assessment and training programmes) and after will settle the KPI. The final value of the KPI will be settled at the end of the project.
	↑50% job quality	Workforce interviews and questionnaires will be conducted. Those will include specific questions to identify and measure workforce's satisfaction with their jobs (i.e. activities addressed within ONE4ALL) to define the quality of the activities performed. MS4 will settle the baseline value for the job quality of the activities to be addressed and improved by ONE4ALL solutions; and MS10 the improvement, so far, achieved through ONE4ALL solutions. The final value of the KPI will be settled at the end of the project to determine the impact of ONE4ALL technologies in the activities addressed and overall, in the job quality related to those activities.
	User engagement with the IOP	This KPI measures how frequently users interact with the platform and how much time they spend using it. To measure this KPI, user activity will be tracked, such as logins, clicks, and time spent on the platform.
SO3.2. Strengthen physical human-robot interaction standards to ensure a safe environment for workers	**0** accidents	No worker may be physically harmed or injured as a result of interaction with the different RCPMs during the operations involved in the processes in which they work.
	↑50% workforce acceptance	Periodic interviews including questionnaires will be conducted to the workforce, where specific questions to measure workforce acceptance of the collaborative robots will be included. The comparison will be made taking into account the knowledge acquired through the training programmes and digital maturity assessment, along the project, on new technologies such as ONE4ALL innovations.
SO3.3. Map and optimise resource consumption taking advantage of the manufacturing line	**↑20%** energy efficiency	In order to measure this KPI, the percentage of energy obtained through renewable sources and the reduction of energy consumption in the addressed processes are considered.
	↓18% resource	It is defined as the consumption of different

modularity	consumption	resources to produce a unitary product or process a single batch. In this KPI, the considered resources are the working hours of dedicated workers, process time, energy consumption and other secondary materials used in the process (i.e., water, air, chemicals, etc.)
	↓10% raw materials consumption	Considering raw materials as the main products processed in each activity, the reduction of their consumption entails enhanced exploitation of them. For that purpose, the reduction of products discarded, and products damaged by the ONE4ALL developments.
	Footprint	Thanks to the sustainability assessment module, the footprint of use-cases execution will be evaluated, and, as a result of having the information, enhanced for reducing it.
SO3.4. Monitor the products' quality and relation with customers' demands	**↓10%** products discarded	This KPI comprises the reduction of products discarded, products damaged, and incorrectly processed in the activities addressed by ONE4ALL technologies. This will be monitored for each process in order to detect specific scenarios with lower performance of the tool, analyse the circumstances and not affect other processes.
	↑10% reutilization of the products discarded	This KPI is related to the above in the sense that the reduction of the discarded products implies that they will be reutilised in the manufacturing line of the target product or another.
	↑14% products quality	Within T2.2 there will be identified the use cases products quality standards and checks. Those will be evaluated before and after the implantation of ONE4ALL technologies in order to determine this KPI value. The achievement of this KPI is a partially a consequence of the two previous ones
SO3.5. Considering gender and ethics biases among the whole project and all the technologies delivered	**>1** specialised seminar on gender and ethics dimension	These seminars will be registered in the project reports (D7.3, D7.4, D7.5 and D7.6) and D7.7. Additionally, the minutes of the meeting will serve as validation point for the objective KPI.
	>3 human factors considered	These factors will be registered in the project reports (D7.3, D7.4, D7.5 and D7.6) and D7.7.
SO3.6. To evaluate the sustainability and socio-economic aspects	ONE4ALL technologies and manufacturing value chains holistically assessed in a Life Cycle Sustainability Assessment (**LCSA**)	This KPI is reached with the achievement of MS7 and the publication of D1.5 (M21) and D1.6 (M45) about Life Cycle Analysis (**LCA**), Life Cycle Costing (**LCC**), and Social Life Cycle Assessment (**S-LCA**).
SO4.1. To increase	**25** scientific publications	The target number of scientific publications

social awareness, understanding and acceptance of industry stakeholders and the general public towards I4.0/5.0 transformation		will be achieved as a consequence of the ONE4ALL developments and Task 6.1. These will be registered in the corresponding deliverables (D6.1 -D6.4) and periodic project reports (D7.3 – D7.6). The DOIs of the publication will serve as check points.
	12 conferences	The target number of conferences will be reached thanks to the plan developed in Task 6.1. These will be registered in the corresponding deliverables (D6.1 -D6.4) and periodic project reports (D7.3 – D7.6). The post of the events through ONE4ALL communication channels and outline of the events will serve as verification.
	>30 policy makers intercepted and participated in events	The target number of policymakers will be reached thanks to the work done in Task 6.2. These will be registered in the corresponding deliverables (D6.6 and D6.7) and periodic project reports (D7.3 – D7.6).
	300 key stakeholders reached	The target number of stakeholders will be reached thanks to the work done in Task 6.2. These will be registered in the corresponding deliverables (D6.6 and D6.7) and periodic project reports (D7.3 – D7.6).
	Social media (**1** post/week, **2** web articles/month, **>25.000** web users/year);	This KPI will be achieved thanks to the work done in Task 6.1. These will be registered in the corresponding deliverables (D6.1 -D6.4) and periodic project reports (D7.3 – D7.6).
SO4.2. To promote clustering, networking and synergetic activities with other related projects	**>30** participations in dissemination events	This KPI will be reached thanks to work done in Task 6.2. These will be registered in the corresponding deliverables (D6.6 and D6.7) and periodic project reports (D7.3 – D7.6). The post of the events through ONE4ALL communication channels will serve as verification.
	2 hackathons organised with **>100** attendees	The target number of hackathons will be achieved thanks to the work done in Task 6.2. These will be registered in the corresponding deliverables (D6.6 and D6.7) and periodic project reports (D7.3 – D7.6). The post of the events through ONE4ALL communication channels and outline of the events will serve as verification.
SO4.3. To conduct appropriate exploitation and business cases to enhance market opportunities	**Exploitation** strategy with 5-year **roadmap** beyond end and PEDR **plan in M6**, with year basis updates M18/32/48.	This KPI will be reached thanks to the plan developed in Task 6.1. This will be explained in the corresponding deliverables (D6.1 -D6.4).
SO4.4. Replicability in other sectors and manufacturing lines	**>2** signed collaboration agreements from at least one different sector from the ones participating	This KPI will be reached thanks to work done in Task 6.5, which will be explained in deliverable 6.5, and the achievement of MS12. The mean of verification will be the

	within the project	collaboration agreements.

5. Workflow information for each WG

5.1. Workflow information for WG1 – Human and sustainability impact assessment

The **digital maturity** of ORI and MOL personnel will be assessed using INO's tool. TUDO's social experts, with INO's support, will plan a training program to enhance workforce digital and non-digital skills for ONE4ALL. This programme will be integrated as an online help desk (T1.4). In addition, safety rules will be established between TUDO and AUTO to ensure job safety and wellbeing. All these tasks will consider any gender and ethical biases (T7.5). Task outcomes will be updated regularly in D1.1.

The **environmental performance** of the project will be evaluated based on recyclability, waste reduction, and GHG emissions (LCA). Moreover, as part of the LCC, economic evaluation will estimate costs and externalities, and S-LCA will evaluate social variables. D1.2 will outline the process, required resources, and statistics based on the information about robots manufacturing processes provided by AUTO and MOL and ORI, respectively. The final edition of D1.2 (M45) will publish the holistic analysis results.

Starting M19 the following process will be followed: Resource consumption should be mapped out, classified (as value-added, non-value-added, and waste), and identified at the consuming points. Additionally, it should be understood why high resource consumption occurs and a strategy to increase energy efficiency will be proposed.

The sustainability assessment module created in T1.4 will integrate the tools created in tasks T1.1, T1.2, T1.3, and T2.2. INO's sustainability and digital maturity tool will be scaled up and integrated with new capabilities. IDE will create the module's interface and integrate it with the IOP. SDU will incorporate evaluation results into T2.4 DSS. D1.4 will include the module's architecture, version, and performance.

The Figure 3 graphically summarizes the workflow for the WG1:

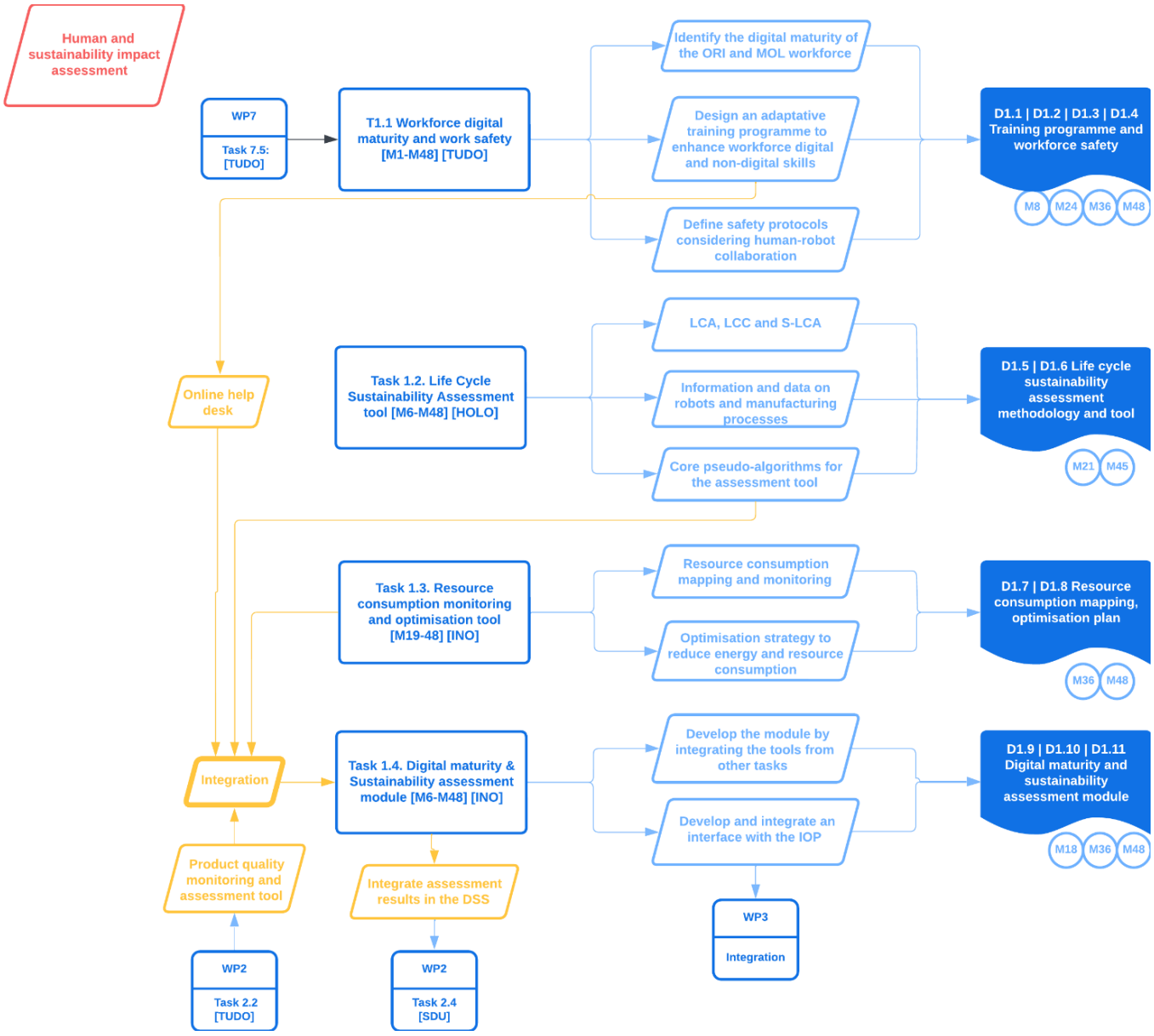

Figure 3. Workflow information for WG1 - Human and sustainability impact assessment.

5.2. Workflow information for WG2 – Data-Driven Digital Twins (DTs)

Active contact with stakeholders and demonstrators is needed to establish KPIs and requirements for DTs. A detailed architecture and development process (algorithms and methodology) will be defined, covering technical specifications and ontology formation used in T2.3 and T2.4.

INO will define quality standards of the products processed by MOL and ORI with their assistance and those necessary parameters that cannot be accessed will be monitored as part of T4.2. In the one hand, TUDO supported by the use cases (MOL and ORI) will research customer needs to better identify products requirements and quality standards. On the other hand, SDU will combine results to predict demand and evaluate quality strategy. INO will lead the development of the final tool (T1.4) so that end consumers will receive information through an interface.

Four stages are taken to meet T2.1 KPIs:

1. Develop custom methodologies to extract simulation models from continuous data using the DT.
2. Test the methodology in the DT module and validate it using production data in SDU's Industry 4.0 Lab
3. Prepare a final version for deployment in demonstration activities and IOP (T5.2)
4. Adjust the DTs based on demonstration outcomes.

The DSS module will optimize manufacturing systems in demo sites based on T2.1 KPIs. It will use DTs from T2.3 to simulate "what-if" scenarios and optimize configurations. The self-learning DSS will showcase system flexibility and a final version will be presented by M30 for the integration with the IOP. It will be maintained and tuned based on WP5 outcomes.

The Figure 4 graphically summarizes the workflow for the WG2:

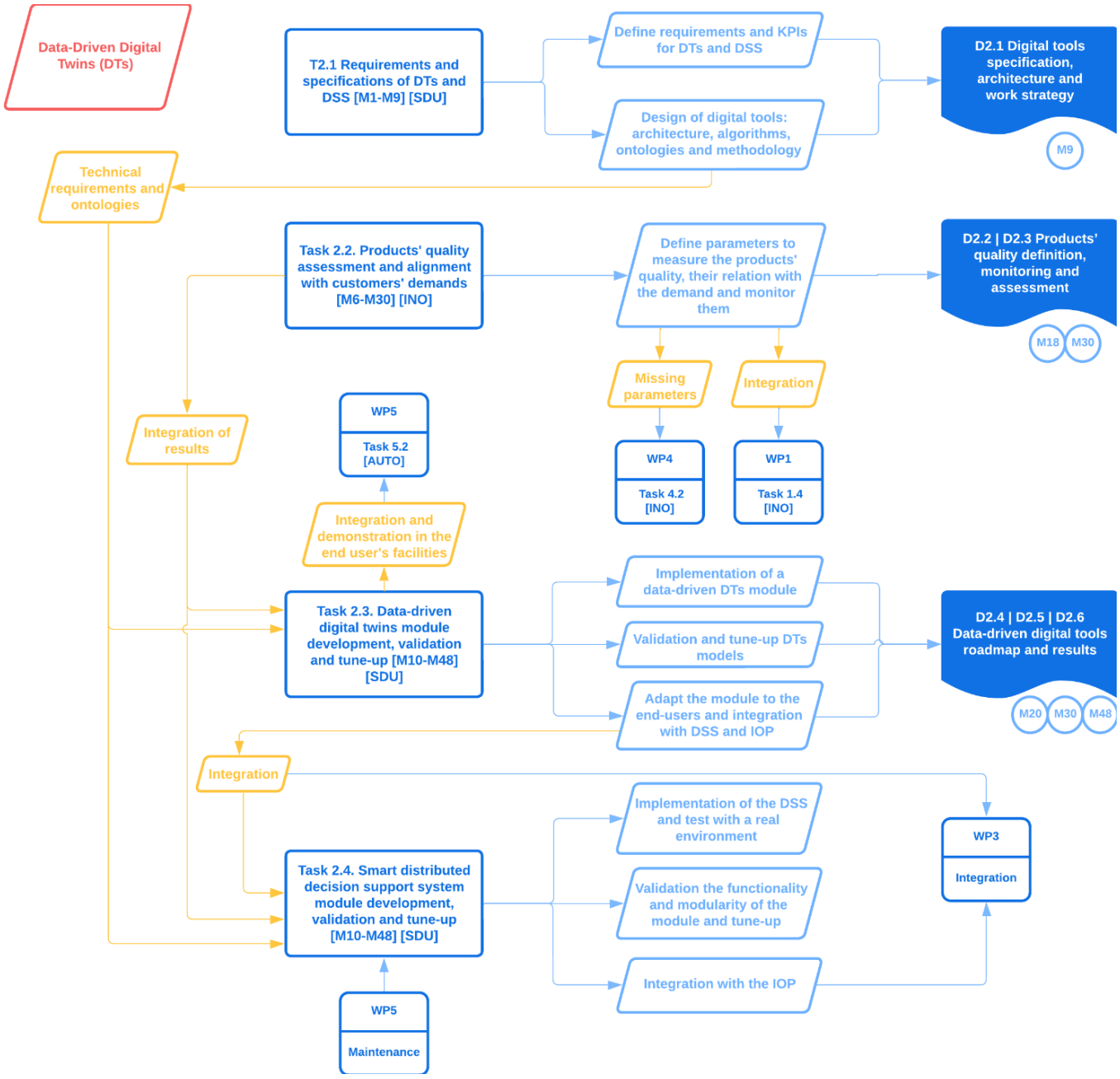

Figure 4. Workflow information for WG2 – Data-Driven Digital Twins (DTs).

5.3. Workflow information for WG3 – Intelligent orchestration platform (IOP)

CRIT will collaborate with IDE, AUTO, and SDU to research architectures and open-source protocols for ONE4ALL. Current and past projects, documentation, and technologies will be evaluated to establish unique demarcation points. D3.1 report will set the basis for T3.2, T3.3, and T3.4.

SDU will create cybersecurity strategies for ONE4ALL based on T3.1. IDE will ensure seamless operation of digital tools. SDU and IDE will research EU standards for reliable and secure AI and provide guidance in D3.2 (M10). Guidelines will be updated in M30 with information on their application.

IDE will develop a data fusion and processing framework, following FAIR principles and protocols from T3.2, to collect and format data on the edge. A three-tier data workflow model will be created, and the SDK will include documentation and an ontology for implementation. ONE4ALL's tools will be set up with orchestration using Docker, Jenkins, and Kubernetes.

To design module interfaces, data and capabilities are determined first. The ontology in D3.3 by M18 details the relationship between the interface and modules. The second step is creating interfaces and online connectivity according to the guidelines of T3.1 and T3.2. DSS (T2.4) and maturity and sustainability assessment module (T1.4) integration show all information from the IOP and provide an assessment to users. WP4 and WP1 physical components require INO and AUTO participation. MOL and ORI will assist with IOP installation from M30-36. WP5 outcomes indicate continuous platform maintenance.

The Figure 5 graphically summarizes the workflow for the WG3:

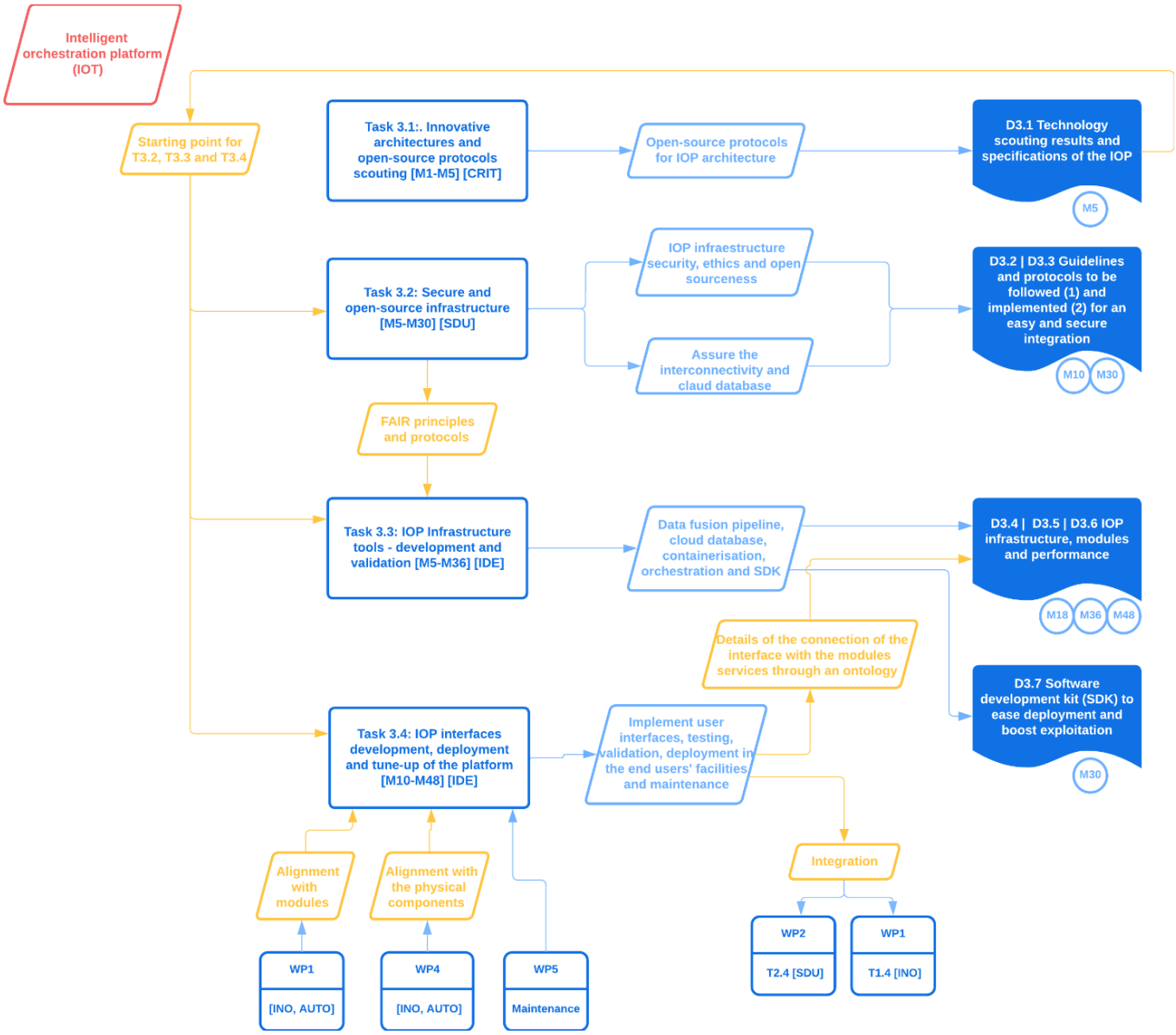

Figure 5. Workflow information for WG3 - Intelligent Orchestration Platform (IOP).

5.4. Workflow information for WG4 – Innovative reconfigurable cyber-physical production module (RCPM)

Partner expertise areas will inform descriptions of RCPM relevant to them, for use as design reference by AUTO for robots. D4.1 will govern the entire WP and WP5 installation step.

INO will select and install high-quality sensors to collect data from various sources and devices along the supply chain. The construction and integration of the collaborative robots will be managed by AUTO, and IDE will support the integration of the IOP.

CRIT will evaluate current manufacturing management standards related to robot-human interaction, AI use, environmental/energy management, and quality control, and work with UNI and CEN to enhance them. They will also engage with national standardization agencies and create a standardization roadmap (D4.3) for future ONE4ALL initiatives.

AUTO will build a collaborative robot composed by a robotic arm with 6 joints and replaceable grippers, and an autonomous mobile robot (AMR) with 8 axes. The details of the design as well as the applications and specifications will be detailed in the deliverable 4.1. The system's accuracy and dependability will be validated using the AUTO mechatronics and electronics laboratory. An embedded PC with remote access via industrial WiFi will control the system using ROS. By Month 19, the system prototype will be relocated to SDU I4.0 facilities for testing and integration with digital tools. AUTO will install 4 robots in total. Lastly, the RCPM will be tested and verified in SDU's I4.0 Lab, where the manufacturing lines for the use cases will be set up and tested from M19 to M30. This will help achieve TRL5 and optimize the technologies.

The Figure 6 graphically summarizes the workflow for the WG4:

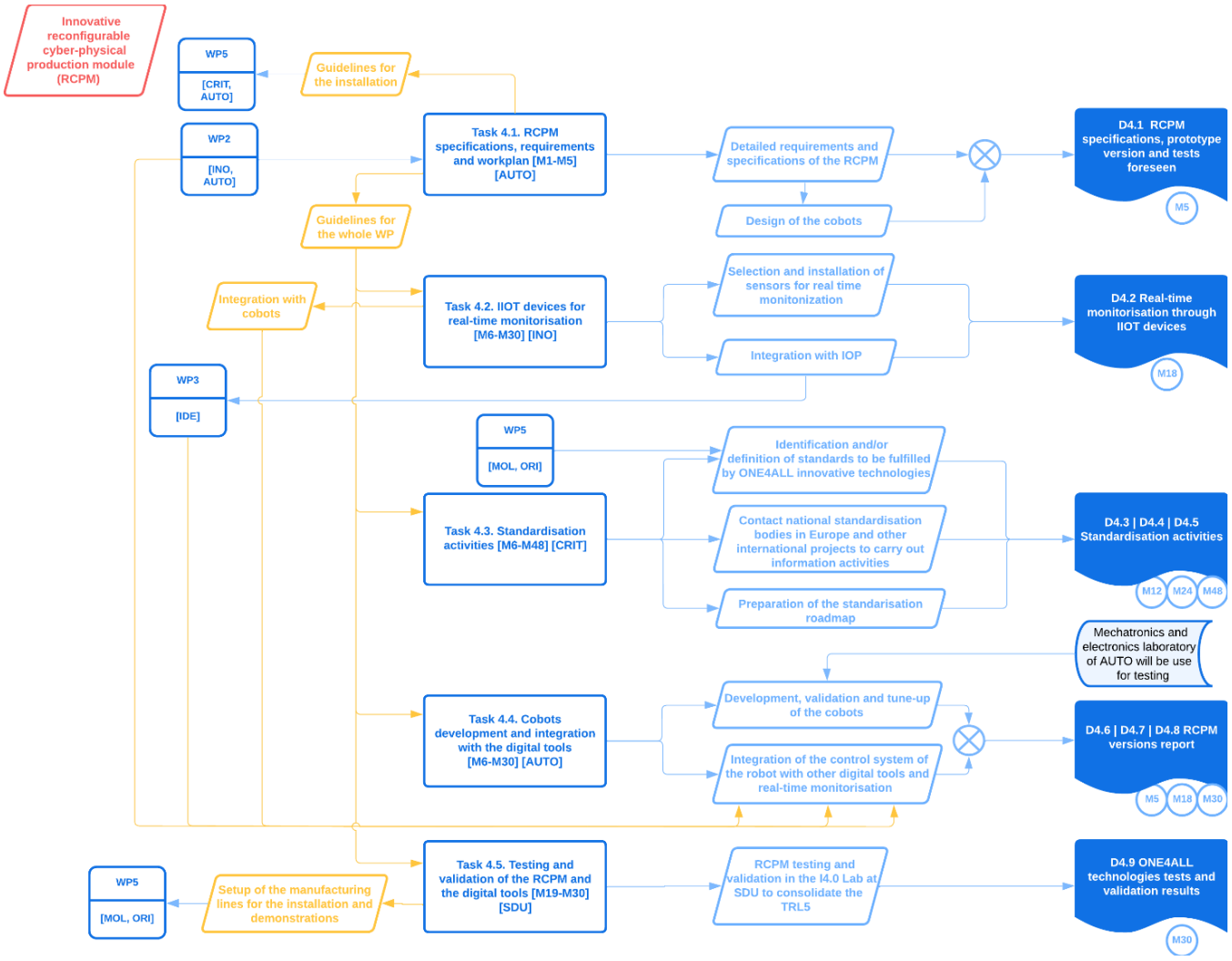

Figure 6. Workflow information for WG4 – Innovative reconfigurable cyber-physical production module (RCPM).

5.5. Workflow information for WG5 – Demonstration activities and evaluation

The pilots' precise needs and specifications will be determined based on the initial high-level descriptions, WPs 1-4, and T7.1. A risk management strategy will be developed, and a roadmap will be created to guide the pilots' activities. T5.1 will oversee the pilots' demonstrations from M30 to M48 and continuously monitor progress. CRIT will organize and harmonize operations for both pilots, with support from MOL and ORI.

All the ONE4ALL technologies will be configured for each demonstration site and placed in their facilities in accordance with the strategy outlined in T5.1 and detailed in D5.1. The partners in charge of creating each digital module as well as the end users will assist AUTO in leading the installation activities.

The plan outlined in T5.1 will be followed for the demonstration activities. The RCPM is anticipated to encounter a variety of events and working settings as a result of the demonstration activities' lengthy duration (1 year), which will demonstrate the system's modularity, adaptability, and reinforcement of the manufacturing facilities' resilience and agility. The following attributes — agility, efficiency, anticipation, sustainability, self-reconfigurability, and secure workforce collaboration—will be demonstrated in two different manufacturing facilities:

- Food industry demonstration [MOL]: The RCPM will handle packaging distribution and raw material sorting tasks in MOL facilities. Both involve managing different batch sizes of items with unique attributes, which puts a strain on RCPM and all of their technological resources.

- Pharmaceutical industry demonstration [ORI]: Show the influence of ONE4ALL in the loading of the goods and picking of the orders, in the package packaging for the consumers, and in the storage optimization. Also, an effective schedule for those activities will be offered. The demand variability in this demonstration case varies every day.

The Figure 7 graphically summarizes the workflow for the WG5:

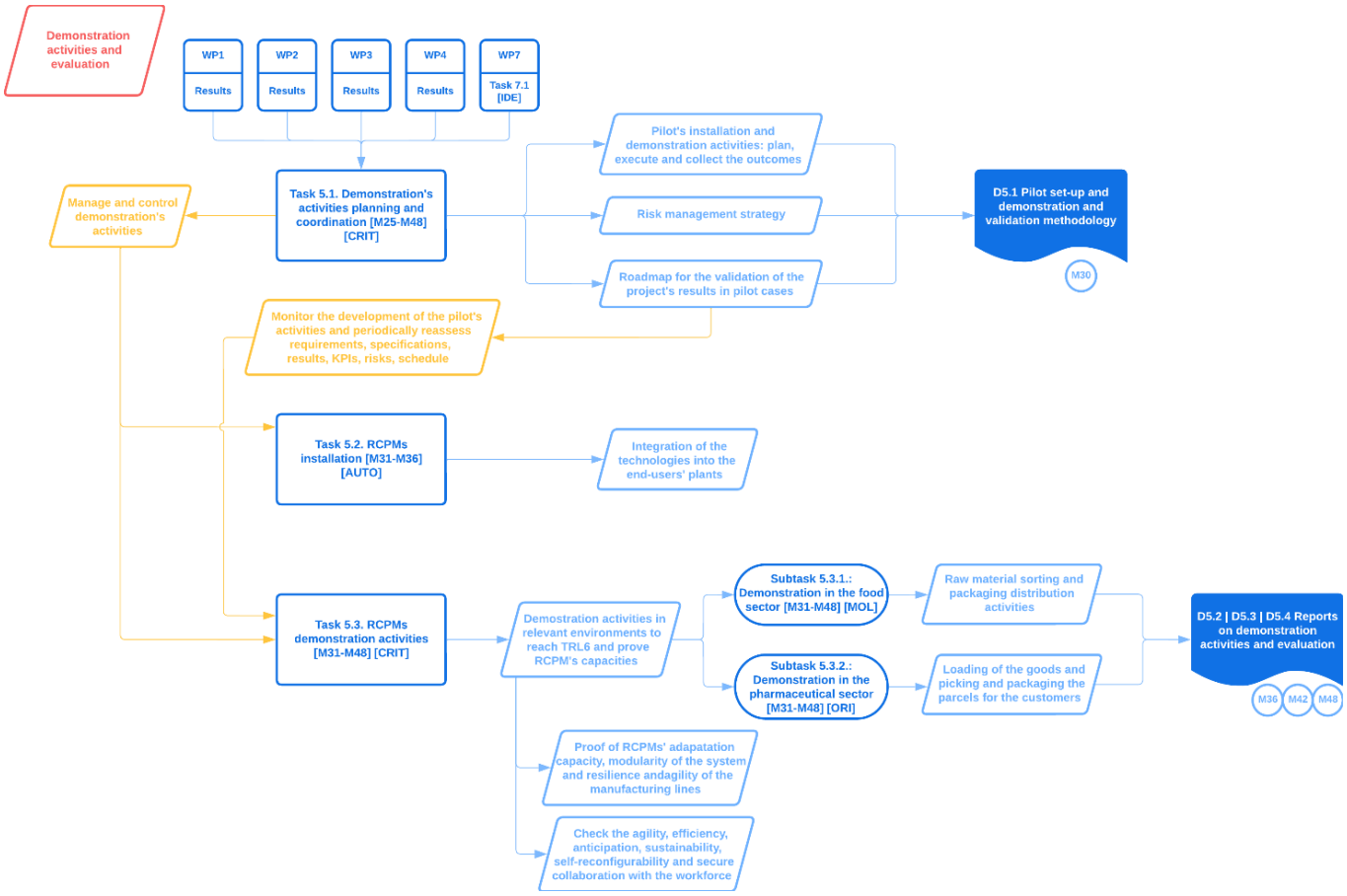

Figure 7. Workflow information for WG5 – Demonstration activities and evaluation.

5.6. Workflow information for WG6 – Dissemination, Exploitation and Communication

The PEDR will outline project goals, communication strategies, and social media platforms. CRIT and EXE will develop it, while social media and events will be used to engage the ONE4ALL network and target groups. Results will be shared with industry journals and media outlets. The first version will be provided at M6 and updated regularly.

This assignment aims to identify key stakeholders and develop a strategy to engage them, including a rewards system and relationship management. Events, webinars, and hackathons will be organized to involve them throughout the project. Two hackathons/promotional events will be held with at least 100 participants each. Results will be evaluated against the project's goals at the end.

D6.1 will show the initial exploitation plan, with revisions in later versions. Market analysis will focus on flexible manufacturing and modular tech in end-user industries. Business strategy CANVAS will be presented at M18, tracking KERs' TRL maturity and linking outcomes to EU Innovation Radar. Analysis will be done on external environment, competition, and risks for each KER's exploitation routes. Financial support for market uptake will be provided, and a 5-year revenue model developed. Business model strategies will be included in the IOP.

A ROL list will be prepared for all outcomes. An IPR workshop will be hosted by EXE in M12 to inform partners of IP protection options. Patent mapping analyses will be conducted on modular technologies in end-user industries. Partners will fill in for patents by M24. All partners will be invited to complete questionnaires and attend consortium meetings to offer patent mapping information.

EXE will conduct a study to replicate ONE4ALL technologies in other industries. The DTs will play a crucial role in this process by evaluating the production parameters and techno-economic indicators. Partners will provide technical expertise to identify potential replication sectors. EXE will create a plan for the study and establish annual replicability meetings. D6.2 will provide details about the replication research, and a final workshop will be held to present the results and offer commercialization recommendations.

The Figure 8 graphically summarizes the workflow for the WG6:

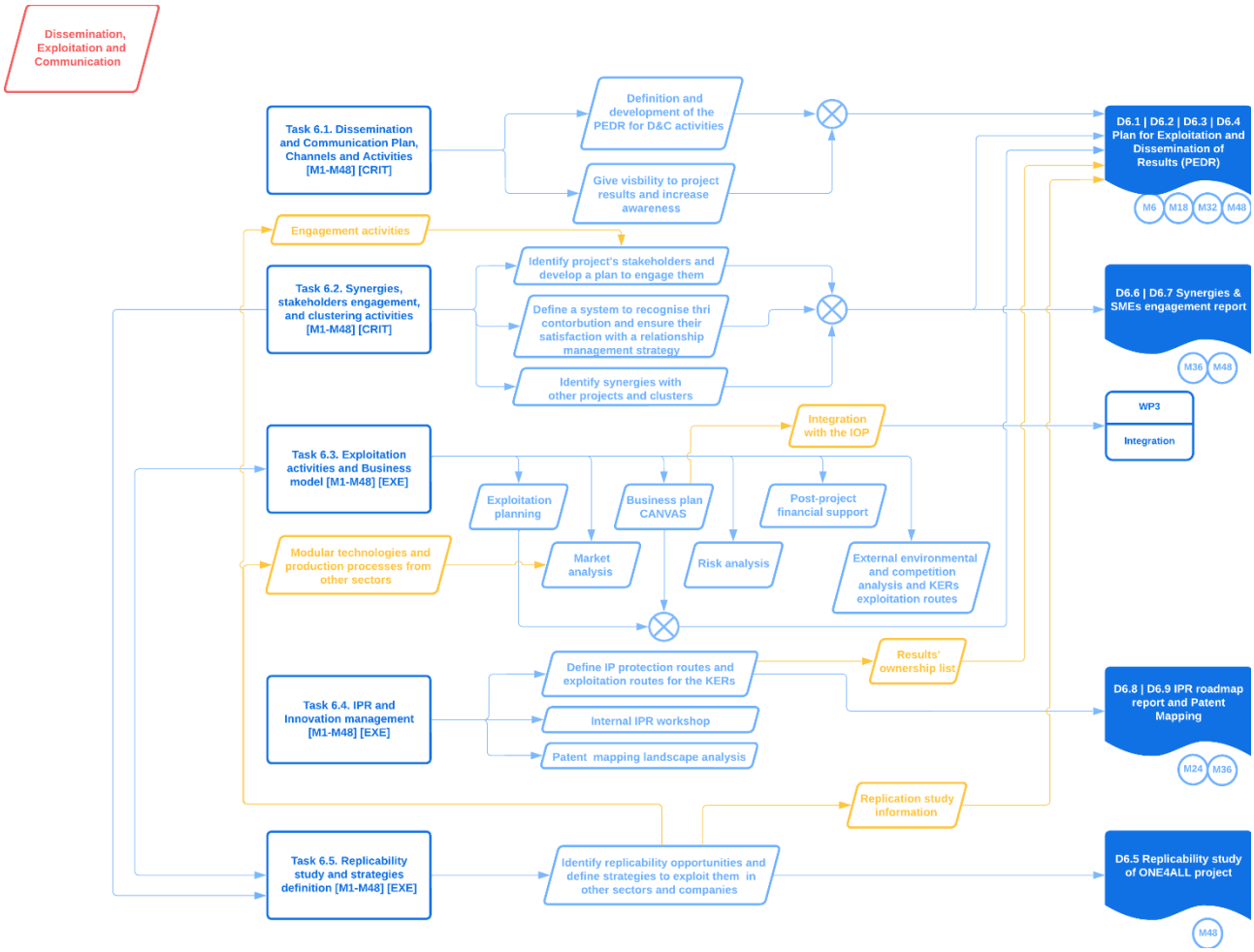

Figure 8. Workflow information for WG6 – Dissemination, Exploitation and Communication.

5.7. Workflow information for WG7 – Management and Coordination

Idener will form a cooperative alliance of working groups to optimize the quality and timeliness of project outputs by aligning the consortium and scheduling their operations. Analyse the technical requirements and anticipated results of each working group to create a reference working framework for project activities, including flowcharts and partner responsibilities. Describe the KPIs specified in the proposal in detail, including methodology, anticipated outcomes, and relationship to SOs.

IDE will manage and ensure the fulfilment of the mentioned results, with CRIT contributing to technology scouting and standardization. The DMP will consider the project lifecycle, data protection, IPR, and open science principles for collected data.

The Administrative and Financial Office (AFO) will supervise financial monitoring, and an intranet service (Microsoft Teams – SharePoint) will be used for management, monitoring, and communication. The Consortium Agreement (CA) will define roles, work processes, and IPR management. PMP includes file and archive management, planning and control, conflict and IPR handling, and dispute resolution.

TUDO will maintain gender balance in ONE4ALL research teams and decision-making processes by monitoring and encouraging gender-sensitive practices. They will also oversee adherence to ethical standards and host an online consortium meeting to suggest ways to incorporate gender issues and ethics into research and innovation activities. This will be documented in D7.3 and updated as the project progresses.

The Figure 9 graphically summarizes the workflow for the WG7:

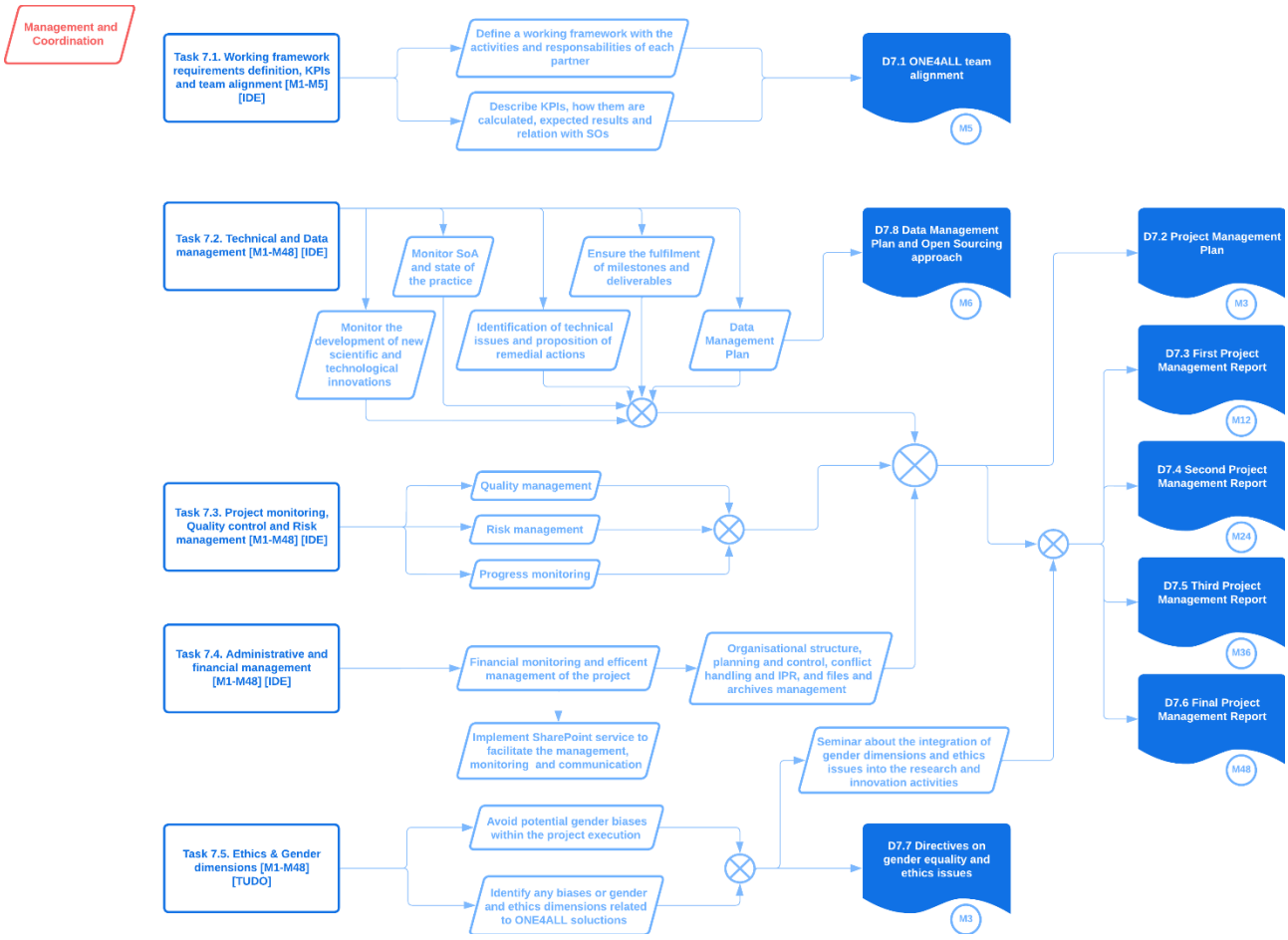

Figure 9. Workflow information for WG7 – Management and Coordination.

6. Conclusions

In conclusion, this document presents a comprehensive overview of the completed work under Task 7.1 within the ONE4ALL project. It focuses on two main aspects: the organizational part, involving the definition of working groups, alignment of consortium partners, and activity descriptions; and the establishment of specific goals, key performance indicators (KPIs), and measurement methods.

The team alignment process employed a systematic approach to ensure effective communication and coordination among project partners. A framework was developed to facilitate seamless progress and successful outcomes by guiding the participation and responsibilities of each partner in the project's work packages. Through consortium alignment, a collaborative environment was fostered, leading to a shared vision of success.

Considerable effort was dedicated to defining relevant KPIs (section 4) that align with the project's strategic objectives. Each KPI was carefully crafted, with detailed descriptions and calculation methods provided. It is important to note that the calculation of KPIs may be subject to adjustments as the project progresses, always with the aim of enhancing accuracy and fairness.

The working groups played a critical role in defining technical requirements and expected outcomes. To provide clarity and transparency, comprehensive flowcharts were created to depict team member alignment, task activities, required data or materials, and allocated responsibilities (section 5). These visual representations were instrumental in facilitating efficient task execution and progress tracking throughout the project.

Overall, this deliverable successfully achieved its objectives, including the definition of working groups and their activities, the establishment of a common interpretation of goals, the definition of KPIs and measurement methods, and the presentation of comprehensive flowcharts illustrating the resources, activities, and outputs of each working group. These achievements lay a solid foundation for the ONE4ALL project, providing a clear roadmap for future progress and ensuring successful outcomes.