WorkPlan

From the general point of view, the research team is relevant and accumulates strong knowledge from all the areas involved, including Industrial Engineers (Major in Mechanics, Electronics, as well as Organisation and Management), but it also includes Software, Telecom and Aeronautics Engineers, and Architects.

To make it possible for the reviewers to track the researcher participation, the following acronyms are going to be used (The effort was carefully balanced, according to the engagement level of each of the researchers), where acronyms start with the shortcode of the subproject they work for:

Resource Name	Acronym	Focus	Engagement
Dr. Joaquín Ordieres Meré	A1.JOM	RT	100%
Dr. Miguel Ortega Mier	A1.MOM	RT	100%
Dra. Antonia Pacios Álvarez	A1.APA	RT	50%
Dr. Angel Paris Loreiro	A1.APL	RT	100%
Dr. Miguel Gutiérrez Fernández	A1.MGF	RT	100%
Dr Álvaro García Sánchez	A1.AGS	RT	100%
Dr. Sergio Rios Aguilar	A1.SRA	RT	50%
Dr. Ángel Uruburu Colsa	A1.AUC	RT	100%
Dra. Rocío Rodríguez Rivero	A1.RRR	WT	100%
Dr. Elcio Mendoça Tachizawa	A1.EMT	RT	100%
Dr. Jorge Pablo Díaz Velilla	A1.JDV	RT	100%
Dr. Dr. Javier Villalba Díez	A1.JVD	WT	100%
Ramiro García Galán	A1.RGG	WT	100%
Dr. Adolfo Crespo Márquez	A2.ACM	RT	100%
Dr. Antonio J. Sanchez Herguedas	A2.ASH	RT	100%
Dr. Johan Wideberg	A2.JWB	RT	100%
Dr. Marcos Calle Suárez	A2.MCS	RT	100%
Dr. Jose Miguel León Blanco	A2.JLB	RT	100%
Dr. Pedro Luis González Rodriguez	A2.PGR	RT	100%
Dra. Aida Estévez Urra	A2.AEU	RT	100%
Dr. Angel Mena Nieto	A2.AMN	RT	100%
Dr. Antonio J. Guillén López	A2.AGL	WT	50%
Dr. Vicente Gónzalez-Prida Gómez	A2.VPG	WT	50%
Dr. Juan Fco. Gómez Fernández	A2.JGF	WT	50%
Dr. Antonio de la Fuente Carmona	A2.AFC	WT	50%
Eduardo Candón Fernández	A2.ECF	WT	50%
Mauricio Rodríguez Hernández	A2.MRH	WT	50 %
Technical Staff (to be hired)	A1.TS1	-	100%
Technical Staff (to be hired)	A2.TS1	-	100%

Based on the wide areas covered by this research proposal (targeted application fields but also technology from integrating sensors on processes, advanced machine learning modelling, quantum computing, integration of Blockchain on data streams, and societal and economic impact of such innovations), it will be an excellent platform to foster the PhD education being promoted according to the proposed Training Plan for PhD.

Task scheduling

According to the proposed methodology, the Project decomposition is proposed to have a single WP dealing with the strategic decisions and monitoring at the coordinated project, while the work is being carried out at the subproject level (see Figure 1.)

Figure 1.- Proposed Workplan for the coordinated project and its subprojects.

To clarify the notation, the name of the subproject will be used all the time for WPs and Tasks, where A0 means the Coordinated project, and Ax, with x in [1,…,3] is referring to the individual subprojects. Tasks will be named as Ax-Ty.z, where x is referring to the project, y is referring to the WP number inside such project and z is a correlative integer counting the individual tasks inside the WP.

All the {A1,…,A3} subprojects have a tactical management layer described as WP1 for all of them, which is in charge of the local monitoring and development of the agreed general policies adopted at A0.WP1, while they have the autonomy to adopt detailed methodologies, resource allocation, and deliverable fulfilment.

In the work plan there are tasks that are scheduled throughout the entire project life. Obviously, it does not mean they require continuous resource allocation all the time, but when needed. A

clear example is the regular meetings for the MB or SC inside A0.WP1, because they are carried out as scheduled, but not continuously.
The resource responsible for each task is the first resouce in the Task, avoiding extra-information.

Now we are going to describe all the WPs, Tasks, and deliverables foreseen. Therefore, we start with the top-level management A0.WP1

A0.WP1.- Its ambition is to establish, and update when required the general policies to be implemented at the ubprojects level, focused on the scope integration and verification principles, global risk strategy, Configuration management policy, but also the dissemination strategy, looking to increase the impact because of the coordination of efforts carried out at subproject level.
A0-T1.1.- Global scope integration and Verification Rules [MB,SB].
Different meetings will be held from those focused at controlling the scope baseline, charged to MB (integrated by A3.DUM, A3.JGO, A2.ACM, A2.ASH, A1.MOM, and A1.JOM), to those carried out by SB (members to be appointed by MB during the kickoff) to coordinate the training carrier of the allocated YRs looking to bring to them extensive and suitable infrastructure for research and training purposes. All participating academic beneficiaries and linked partners by use cases are highly ranked institutions that can provide all the required infrastructure, including computing infrastructure, software and testing facilities.
Since this project is focussing on Digitalisation as a driver, it will foster the e-meeting adoption, although physical yearly based meetings will be promoted, looking to align them with specific scientific or technical events, and inviting the YRs when appropriate, activating the opportunity for them to participate in those events, make presentations, and facilitate their network creation process. The initially foreseen physical meetings are (Madrid during the academic year 2023-24, Burgos in 2024-25, Seville in 2025-26 and Burgos in 2026-27, because a final event to present the findings is foreseen, that is going to involve manufacturing companies as a primary target for project outcome deployment, and the manufacturing pole in Spain is mainly located in the Basque country region, which is very close to Burgos city).

A0-T1.2.- Global Risk, Change & Configuration Management [SC].
SC will be held by SC, mainly to adopt Risk management, Quality Control, and Configuration management policies and to review Risk Registers and contingency plans to be proposed to MB when the established thresholds are exceeded. Members of the SC will be appointed by the MB during the Kickoff e-meeting.

A0-T1.3.- Global Monitoring of Baselines [MB,SC, SB].
Different meetings will be held by the different boards: SB will establish detailed plans for the YR carrier as expected route according to the profile of the recruited people, and then agree on the milestones to be achieved and the reporting periods. The SC will establish the baseline for resource and deliverable development and adopt the control milestones. Finally, the MB will assess all the elaborated baselines and provide feedback to the different boards. They will be in charge of continuous improvement and lessons learnt management. The e-meetings will be handled according to the specific needs.

A0-T1.4.- Global dissemination Strategy [SC, SB].
The SC will be in charge for defining the dissemination strategy, considering different instruments such as international scientific journals, academic books, and conferences, congress, and seminar proceedings, project website, specific project profiles to be created and maintained in the main social networks (Twitter, Facebook, and LinkedIn), international networks of experts and public repositories for code or digital products (GitHub, Zenodo, etc.)
The already existing units speziallized in transference of results from the researcch in all the universities will be involved from the very beginning, to increase the opportunities.
The dissemination strategy must include a communications one, which will relay on KPIs, and the initial proposal to start the definition will be:

Communication Activity	*Target KPI*
Creation of light content for non-specialised audience in the channels adopted in this task, as well as contributing to "lighter" versions of project newsletters, leaflets, flyers, etc.	> 50 visitors in non-specialised area
Contribute to Exhibitions / workshops with free access, where visitors will have the possibility to realise in a lively way the DIGEST benefits. For example, visitors will have the opportunity to explore how technology contributes to different use cases.	1 exhibitions/ workshops > 50 non-specialised attendees
DIGEST recognition: will elaborate on building the DIGEST "image" to the external world. DIGEST will be made identifiable by making a brand with a logo, a motto, and design/template following its ubiquitous appearance. Harmonised design and templates will adorn the project website, flyers, reports, videos, presentations, and any dissemination or communication activity.	> 50 responders identified DIGEST
Promotion of the DIGEST activities and benefits to the general public will be conducted in cooperation with local authorities/institutions, also covered by local media (e.g. broadcasters, papers, magazines).	> 1 events > 3 appearances to local media

The advice collected from SB will be carefully considered. Again, e-Meetings will be handled according to the specific needs.

A0.WP1 Deliverables:

A0.D1.1 .- First year technical report for the AEI. *[M13]*
A0.D1.2 .- Second year technical report for the AEI. *[M25]*
A0.D1.3 .- Third year technical report for the AEI. *[M37]*
A0.D1.4 .- Project End Report, according to the PM^2 methodology. The final technical report for the AEI is targeted. *[M48]*

A1.WP1.- Its ambition is to handle the daily management of subproject A1 (DADIBAS), according to the adopted policies taken at the MB, and to provide the appropriate information to the SC and SB boards.

A1-T1.1.- Scope & Resource management of Subproject A1 [A1.MOM, A1.AUC].
This task focusses the attention towards a close control of the proper progress of all the tasks in the subproject and to verify the planned scope. Specific attention to resource allocation (fine tunning) will be taken.

A1-T1.2.- Monitoring of dissemination [A1.JOM, A1.EMT].
This task looks at defining and monitoring milestones regarding the dissemination activities from those considered in the A0-T1.4 that make sense in this subproject. This task will also track the progress of the pending activities linked to the dissemination strategy and will regularly monitor potential opportunities for dissemination, considering all the innovative ideas arising targeting specific Big Data challenges throughout all the steps of the data value chain, namely data collection, analysis and visualisation as a source for additional dissemination.
Special attention will be paid to the YR training plan, including industrial secondments and training at other research teams, in addition to their needs regarding scientific production.

A1-T1.3.- Risk and Quality Control [A1.RRR, A1.RGG].
This task looks at defining and maintaining alive the risk register for DADIBAS, including supporting the risk identifications, risk owner nomination, risk matrix, revising the risk threshold levels and mitigation or contingency plans, being responsible for asking actions to the IPs when required.
Also, this task will control the Quality Register for DADIBAS, according to the PM2 methodology. Logs will be operated internally by the Project management team.

A1.WP1 Deliverables:

A1.D1.1 .- Project Business Case *[M3]*
A1.D1.2 .- Project charter *[M4]*
A1.D1.3 .- Project Workplan *[M6]*
A1.D1.4 .- Project Final report *[M48]*

A1.WP2.- Its ambition is to improve technological processes highly impacted by asset status, but also being affected by human decisions where the existing knowledge can be extended. Therefore, improvements will be developed. In its core, the DADIBAS project proposes the use of digitalisation in an innovative way to ensure non-invasive dissemination of agreed information that can be used as anchors for more robust and integrated process-orientated servitization approaches using DLT (Blockchain 4.0) [43]. Therefore, the suitable processes must be carefully selected.

A1-T2.1.- Setup of the use case [A1.JOM, A1.RGG].
This task aims to identify technical processes from industrial sectors, where heavy industry will be considered as a preference because of the bigger energy and environmental impacts achievable when improvements are proposed. Selection will be made among several candidates.

A1-T2.2.- Advanced Quality Workflow [A1.AUC, A1.EMT].
This task aims to get better understanding on how the process work (Business understanding and data understanding steps from the CRISP/DM methodology), in a way technical requirements needed to create advanced models can be depicted.

A1-T2.3.- Microservice environment for project usage [A1.JOM, A1.SRA, A1.TS1].
While use case identification starts, the implementation of a technological platform able to support flexible microservices will be configured. It will involve the configuration of a local cluster capable of becoming hybrid in the future, to evaluate the flexibility found in such configurations, as well as the cybersecurity issues potentially found. This task will be a critic for A1-T[2-3].[3-6], as well as A1-T4.[3,6,7] because they will all use it.

A1-T2.4.- DeepLearning, Transfer Learning and Contrastive Learning tools [A1.MGF, A1.JVD].
Initially, quality assessment processes may match the requirements, although the proper identification of the use case will be done by task A1-T2.1. This task will look for data preprocessing (including collection and ingestion), and modelling (according to the CRISP/DM methodology). Because of the limited labelled data found in real use cases, Contrastive Learning will extend deep learning techniques to deal with partially labelled datasets. In the case of data augmentation will be required, Transfer learning will be applied for the final fine-tuning of the built models.

A1-T2.5.- Quantum technology for process assessment [A1.MOM, A1.JOM, A1.JVD].
Modern control processes in manufacturing test the limits of advanced analytics, especially when using machine learning and analysing multiple variables.
Quantum computing might help find new correlations in data, improve pattern recognition, and advance classification beyond the capabilities of classical computing. The combination of quantum computing and machine learning, as well as its application to optimisation is expected to have a significant impact on manufacturing, and it is what the DADIBAS project proposes to explore.

A1-T2.6.- Decision Transformers in Scheduling Optimization [A1.AGS, A1.RGG, A1.JVD].
To care about complex scenarios, to using Transformers as a Decision-making model is getting increasingly popularity and we strongly believe that combining ML with agent technology throughout Reinforced Learning (RL) is a powerful tool to navigate the changing conditions characterising complex scenarios, where decisions for processing goods at different facilities, depending of several factors must me made. Such decisions will dramatically impact further decisions ahead. Therefore, having the opportunity to explore the different paths will enrich the decision capability of agents ,and in the end help to propose the most effective options.

A1-T2.7.- Dissemination [A1.AUC, A1.MOM].
This WP is rather intensive in technology and in the creation of technical knowledge creation. Therefore, it is expected to contribute to the dissemination with at least four scientific papers (technical comparison of learners, QC capabilities, Decision Transformers for technical decision-making problems, Managerial implications for asset management), as well as three international conference presentations. The task will closely monitor dissemination within the WP according to the objectives arising from A1-T1.2.
A1-T2.8.- Reporting & Configuration management [A1.APL, A1.RRR].
This task will oversee the Deliverable production and the implementation of a suitable Configuration management solution, granting the releases of the products to be frozen and with copies under control during DADIBAS project life.

A1.WP2 Deliverables:
A1.D2.1 .- Use case description: Challenges & technological requirements *[M9]*
A1.D2.2 .- Digital models and process improvement *[M42]*
A1.D2.3 .- Dissemination report and KPIs *[M48]*

A1.WP3.- The focus of this WP is to consider the information linked to the behavioural dimension of process operators and to evaluate whether its recognition increases the organisational knowledge about such processes. Because this information tends to be affected by the General Data Protection Regulation (GDPR), a strong effort will be devoted to anonymisation through digital quasi-identifiers will be carried out, as well as the distribution of information. In fact, solutions to providing information in a secure way to digitally asymmetric stakeholders will also be explored.

A1-T3.1.- Design of mobile apps to collect information from different wearable devices & data collection [A1.EMT, A1.SRA, A1.TS1].
Since human operators are one of the strongest sources of process variability when KPIs are considered, DADIBAS will explore the contribution to the process coming from specific wearables, such as pressure in feet when operator is walking, position for the worker, heart rate to check the relevance for stress levels, etc. The idea is not just to collect the data in high frequency (depending on the variable) but to store them and to be able to merge them with process data. The interoperability of data expansions will be carefully addressed.

A1-T3.2.- Workflow for data ingestion from different users/workers [A1.EMT, A1.JDV].
A technological solution to gather several data streams from multiple data brokers must be considered because it will happen from different devices or workers. This task will also provide solutions to the A1-WP2 and A1-WP4 tasks. Scalability and robustness need to be carefully considered.

A1-T3.3.- Workflow for KPI extraction and interoperability [A1.EMT, A1.JDV].
Raw data ingestion is the starting point for knowledge extraction and consolidation (see **¡Error! No se encuentra el origen de la referencia.**), while data transformation in real time must facilitate proper process flow. Interoperability involves accessing real-time data that lead the way to a new approach for how companies can improve their production operations. It allows manufacturing partners (including customers, suppliers, and other departments) and their machines to share information accurately and quickly. Therefore, this task is going to serve other A1-WPs as well.

A1-T3.4.- Data Integration & Data availability through DLT [A1.JOM, A1.JVD].
Connected to task A1-T3.3, it is necessary to implement solutions to the designs produced there. Initially, NiFi® from Apache foundation will be considered, but Airflow® will also be considered for data integration and IoTA digital identity will be tested to provide digital identity to artefacts, people, and devices, enabling them to communicate. The IoTA stream will be tested as a convenient way to distribute real-time data among different stakeholders when system isolation between them is required.

A1-T3.5.- Process Model creation [A1.MGF, A1.RRR].
The goal of this task is to enrich existing digital models that were not considered the human information to be exposed to it as additional features, to verify the effectiveness in getting better-explained processes.

A1-T3.6.- Dissemination [A1.AUC, A1.MOM].
This WP is rather intensive in knowledge creation because it explores a hot topic, which is at the roots of the I5.0 paradigm. Therefore, it is expected to contribute to the dissemination with at least three scientific papers (technical solutions for behavioural data collection, IoT enriched digital models and effects, advanced real-time distribution of data without direct contact), as well as three international conference presentations. The task will closely monitor dissemination within the WP according to the objectives arising from A1-T1.2.

A1-T3.7.- Reporting & Configuration management [A1.APL, A1.RRR].
This task will oversee the Deliverable production and the implementation of a suitable Configuration management solution, granting the releases of the products to be frozen and with copies under control during DADIBAS project life.

A1.WP3 Deliverables:
A1.D3.1 .- Wearables and digital solutions for context enrichment in predictive models. *[M24]*
A1.D3.2 .- Data Integration, Interoperability, and Communication without contact. *[M30]*
A1.D2.3 .- Dissemination report and KPIs *[M48]*

A1.WP4.- The focus of this WP is to consider the applicability in infrastructures, either refurbished or new construction, by selecting or developing an integrated building asset data management system that represents lifecycle phases. The design of the BIM-DBMS includes the design of data acquisition, data storage, and data processing modules along with the user interface

A1-T4.1.- Setup of a suitable context for BIM [A1.APA, A1.APL].
A convenient infrastructure with actionable capabilities is required, while value creation from smart operated services must be clearly identified, to assess the most impacting case to be selected. Alternatives to extended services and information can be discussed.

A1-T4.2.- Asset modeling [A1.APA, A1.APL].
Most likely, the selected infrastructure is from a heritage background, i.e., was built or refurbished before 2019. By that date, it becomes mandatory for public buildings to carry out designs by using BIM. Therefore, it seems to be rather obvious that we will face a lack of a design BIM model for the selected infrastructure and this task will solve it. Revit® design tool and IFC standards will be adopted.

A1-T4.3.- Connection with existing logic infrastructure [A1.JOM, A1.APL, A1.TS1].
There is no further obligation after the design of the building from the regulations. However, the selection process carried out in A1-T4.1 will look to find infrastructures having AC and ACS controlled systems through PLCs (or other subsystems when selected by A1-T4.1), in such a way that by solving interoperable data exchanges consignments can be given. This task will look to implement the option for sending requests to the controlling subsystems and recovering the data at the time of interest.

A1-T4.4.- Setup of additional sensors including wearables when needed. [A1.APA, A1.JVD].
It is possible that neither environmental or presence sensors become available in the infrastructure to collect real parameters, nor the way to collect information from users as well.The definition of comfort and efficiency KPIs will also be also under consideration because the task aims to increase the information to users about the impact of the adoption of specific setup values. It will be an interesting managerial study to learn from practise to what end the information about energy or environmental effects moderate the wish for changing parameters.

A1-T4.5.- Model creation with Data Integration [A1.JOM, A1.AGS].
Advanced models regarding the energy demand and remaining useful life (RUL) expectations will be produced depending on operating demand for the involved assets will be produced, looking to satisfy the A1-T4.4 requirements.

A1-T4.6.- Management dimension for servitization and forecasting [A1.AUC, A1.SRA, A1.EMT].
The goal is to develop a study of the information needs and technical capabilities of assets to move them from owned toward a service-provided model. Indeed, the need for immutable information provided will be evaluated as a key aspect to certify when events happened and when the granted period for fixation started. Therefore, the analysis will not only be from the management point of view but will require the analysis of technical aspects, where A1-WP2 ideas will be needed.

A1-T4.7.- Dissemination [A1.AUC, A1.MOM].
Because of the interesting field addressed in this WP, which enables not just technical contributions but managerial ones, it is expected to contribute to the dissemination with at least four scientific papers (Comparison of strategies when organisations face BIM adoption, Digital improvement of BIM Designs, Operations, and Maintenance benefits when behavioural models consider asset health, Use case applications), as well as four international conference presentations. The task will closely monitor dissemination within the WP according to the objectives arising from A1-T1.2.

A1-T4.8.- Reporting & Configuration Management [A1.APL, A1.RRR].
This task will oversee the Deliverable production and the implementation of a suitable Configuration management solution, granting the releases of the products to be frozen and with copies under control during DADIBAS project life.

A1.WP4 Deliverables:
A1.D4.1 .- Use case description: Challenges & technological requirements *[M10]*
A1.D4.2 .- Digital models (BIM and operational models) and process improvement *[M45]*
A1.D4.3 .- Dissemination report and KPIs *[M48]*

A2.WP1.- The objective is to manage the daily operations of subproject A2 (AMADIT) in accordance with the policies established by the Management Board (MB), and to provide relevant information to the Steering Committee (SC) and Scientific Board (SB). The tasks associated with this WP are the same as those previously outlined for A1.WP1, so the task description will not be repeated and can be referred to as the corresponding tasks.

A2-T1.1.- Scope & Resource management of Subproject A1 [A2.ACM, A2.ASH, A2.MCS, A2.AEU].
A2-T1.2.- Dissemination monitoring [A2.ACM, A2.JWB, A2.JLB, A2.AEU].
A2-T1.3.- Risk and Quality Control [A2.ASH, A2.JWB, A2.PGR, A2.AMN].

A2.WP1 Deliverables:
A2.D1.1 .- Project business case *[M3]*
A2.D1.2 .- Project Charter *[M4]*
A2.D1.3 .- Project Work Plan *[M6]*
A2.D1.4 .- Project Final report *[M48]*

A2.WP2.- This package focuses on establish a reference framework for the advanced digitisation of engineering assets and processes in the context of the current development of digital twins. This includes methodologies for the management of the digital twin considering dynamic management of data, models, and microservices giving rise to a "living" DT that evolves at the same time as the asset it represents. It is proposed 4 milestones for this WP, corresponding with 4 evolutive versions of the asset digitalization framework by integration of

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results along the project. DT proposals will be built and tested over AZURE cloud platform technology combined with ad hoc IoT solutions, aiming to facilitate integrated DT use in a non-intrusive way with pre-existing information systems. The results of APM (A2.WP3) and AIP (A2.WP4) models and data will be inputs for the framework development, but also models and data provided by A1 and A2. Servitisation strategies based on DT will be studied supported by A1 results.

A2-T2.1.- Asset digitalization models [A2.ACM, A2.PGR, A2.AEU, A2.TS1].

Reference approaches in the standardisation of the treatment of assets (including RAMI 4.0, IMF, BIM/IFC) and the application of DT, CDT will be studied. It will address the description of the asset with the necessary level of detail, (technical structure, the hierarchy of components; description of failure modes; maintenance activities, prediction of failures, cost models, etc. Work will be done on 3 basic elements: data (data as the basis of the digital asset), model (models that increase knowledge of the asset, its state, and behaviour), and microservices (new functionalities of the digital asset). It will be studied how to manage these three elements, developing strategies for data management, model management, and microservices management, in order not only to design the digital twin but also to adapt and evolve it so that it can continue to faithfully represent the asset over time, throughout its useful life.

A2-T2.2.- Process and services digitalization models. Interaction between DTs in complex digitalization scenarios [A2.ACM, A2.ASH, A2.AEU, A2.TS1].

This task develops the digital twin approach applied to process and service design (DT of the process, and DT of the service). It is based of task A2-T2.1, transferring the conclusions on DT of the asset to the conceptualization and design of the DT of a process or a service. Asset/processes/services will use a standard basis for their digitization and it will be analyzed how to design and manage the interaction between the different DT and the potential that this new scenario implies.

A2-T2.3.- Architecture and integration design [A2.ASH, A2.PGR, A2.AEU, A2.AFC].

This task will look at the problem of determination of hardware/software architectures as fundamental element, not only for DT design but allowing the interaction between DT composing complex digitalization scenarios. The architecture (function blocks, systems, app, etc) that supports the different internal processes that make the digital twin work is part of the digital twin itself. Among other aspects, it allows delimiting how the data is treated, how and where they persist, and how and where the different calculation models (such as ML or simulation) and/or representation models (3D models, BI representation, etc.) will run. Defining this architecture is part of the twin design. This task makes an initial proposal for a basic architecture, identifying modules and functionalities that are used for the basic design of the twin, and later delves into a detailed architecture that can be programmed in a commercial platform. The use and connection of different elements such as ETL tools, databases, ontologies, data lake solutions, predictive apps, and simulations apps, among others, will be considered. Initially, it is proposed to use the Azure platform to prototype digital twin solutions on the use cases chosen in the project but other commercial platforms, and IoT/cloud tools will be considered. Platform concept and tools employed by A1 will be also considered comparing the results of both options.

A2-T2.4.- Definition of a framework for the management of data and digital models [A2.ACM, A2.AGL, A2.JGF, A2.MRH].

This task addresses the development of the reference framework, the main output of this sub-project. It will list and describe the key elements, propose the different phases of the asset digitisation process, and describe and organise the analytical and methodological tools that can be included in the framework. The framework will also describe how to deal with the elements of the reference architecture (data, models, microservices, apps, etc.) used for the design of the software/hardware platform supporting the DT. In addition, the framework will include the outputs drawn from the use cases throughout the project, which will allow for the improvement of the project. Four milestones are proposed for this task, corresponding to four evolutionary versions of the asset digitisation framework through the integration of the results throughout the project and the experience in the application of the framework itself.

A2-T2.5.- Use cases: selection, design, and execution [A2.ASH, A2.PGR, A2.AMN, A2.VPG, A2.ECF, A2.TS1].

A series of use cases will be used for the development of the whole project. A combination of laboratory and real use cases will be used, drawn from the EPOs collaborating with the project. Three application lines/sectors have been identified: i) Intelligent transport (especially rail): USE has a fully monitored scale railway track on which it is possible to test track defects, and collaborates with ADIF, TALGO, and AZVI; ii) smart grid: USE has a power electronics laboratory, with monitored power converter equipment where defects and equipment operation strategies can be tested, and collaborations with CEN, and MAGTEL; iii) oil and gas: collaboration with ENAGAS. In this task, the use cases will be designed according to the requirements not only of this A2.WP2, taking into account the framework and platform where the pilots will be implemented, but also the requirements of A2.WP3 and A2.WP4 for specific use cases of the APM and AIP models. The work for the implementation of the different use cases will be centralised in this task to connect all use cases with the DT management.

A2.WP2 Deliverables:

A2.D2.1 Framework for the design and use of digital assets: state of the art. Milestone 1. *[M12]*

A2.D2.2 Framework for the design and use of digital processes: state of the art. Milestone 2. *[M24]*

A2.D2.3 Framework for the design and use of digital assets in digital processes: state of the art, data & model management. Milestone 3. *[M36]*

A2.D2.4 Framework for the integration of digital assets and processes and their interaction with the final user: state-of-the-art, integration and interaction strategies. Milestone 4. *[M48]*

A2.D2.5 Use cases report. *[M48]*

A2.WP3.- The aim of this WP is to develop APM models for the development of digital maintenance strategies. APM models include models for the management and dynamic representation of risk as a basis for the control of asset performance, based on algorithms for the detection, diagnosis and prognosis of failures. They also Include models for the digitisation of maintenance decision-making, models for dynamic maintenance planning and scheduling based on the data, models to assess the impact of operation and maintenance on the environmental, and models to assess the impact of DT technology on the business to guide the development and implementation process in the company. Predictive maintenance tools are usually included in APM solutions, due to reduce corrective maintenance, increase availability, and reduce the risk of failure, especially when assets are critical.

A2-T3.1.- APM models for the detection, diagnostics and prediction model [A2.ACM, A2.JLB, A2.JGF, A2.TS1].

This task deals with detection, diagnosis and prediction models for the assets and their critical components identified in the use cases (A2-T2.5). These models use information composed of asset data supplemented with operation and maintenance data. The models will be applied at the failure mode level (failure mode monitoring). For this purpose, the development of the models includes: historical analysis, monitoring data, design of mathematical algorithms according to different methods/techniques (neural networks, decision trees, SVM, Bayesian analysis, deterministic analysis, etc.), determination of state descriptors and thresholds, and determination of RULs. In addition, dynamic risk assessment (DRA) and representation methods are included as input to the dynamic programming models (A2-T2.3). Software such as Rapidminer will be used for the initial design of the predictive algorithms. At a later stage the algorithms will be exported to Python or similar to facilitate the integration of the model into the platform and DT (A2-T2.4).

A2-T3.2.- APM models for digitalization of decision making [A2.ASH, A2.SMC, A2.AGL, A2.MRH].

*Methodology t*o optimise the use of the information available through APM solutions for the different decision-making processes related to assets and services. This task addresses modeling of decision-making centres (DMC, for example: workshop, maintenance scheduling, fleet management, maintenance engineering) and the specific information requirements of each centre, and its connection with the available APM information. How to connect the specific models for asset condition monitoring (A2-T3.1) and maintenance decision optimisation (A2-T3.3) with digital decision management.

A2-T3.3.- APM for dynamic maintenance planning and scheduling. [A2.ASH, A2.VPG, A2.ECF, A2.TS1].

*This task focu*ses on how to exploit the information provided by APM models in a dynamic way. This enables the continuous updating of planning and scheduling processes, which has a major impact on the availability of maintenance resources. This task develops dynamic maintenance planning/scheduling models based on the integration of data from predictive models with workshop resource availability data. Simulation and optimisation techniques (Semi-Markov process, Petri Nets, linear programming, etc.) , among other alternatives, will be used. Simulation software such as Vemsin or Anylogic; programming software such as Python or R and tools.

A2-T3.4.- Models for assessing the impact of DT technology in organisations [A2.ACM, A2.MCS, A2.AMN, A2.AFC].

*In this task, mode*ls are developed to assess the impact of technology on enterprises. They will allow to monitor the implementation and make decisions on the use of the models and the integration of new technologies and the implementation of APM solutions.

A2.WP3 Deliverables:
A2.D3.1 APM models for digital maintenance of railway use cases. [M24]
A2.D3.2 APM models for digital maintenance of smart grid use cases. [M36]
A2.D3.2 APM models for digital maintenance of oil & gas use cases. [M48]
*A2.D3.4 Mode*l to assess the impact of DT technology, in APM, on organisations. *[M48]*

A2.WP4.- The development of AIP models and applications is designed to improve complex long-term strategic and tactical decisions. Therefore, the development of these models must consider the challenges of the evolution of the ecological and digital transformation from a long-term perspective. AIP should be linked with smart APM models and integrated as a key element for digital transformation management.
This work package will select a set of scenarios until 2030 and 2050. Different hypotheses and trends will be established regarding the evolution of several technical, economic, and environmental variables and waste generation resulting from the operation of the asset and its maintenance. This must be done by considering not only the asset performance (technical APM models treated in WP3.3) but also the evaluation of the cost-effectiveness of the assets, as well as its associated risks (security, reliability, availability, and sustainability) by relying on the model of the British Institute of Asset Management and the family of ISO 55000 standards, and seeking to reduce emissions by 2030 and 2050.
To achieve this, different tools and models will be proposed and validated in this WP. These will include estimates and calculations of the carbon and water footprint, environmental costs, and circularity indicators for operations linked to the maintenance and management of assets and forecasting their evolution until 2030 and 2050. Additionally, CAPEX/OPEX budget allocations and overall asset management planning will be done. A global asset analysis methodology will be used that integrates Asset Health Index (AHI) models with Life Cycle Cost (LCC) and Total Cost of Ownership (TCO) models. AHI allows sorting of operational, degradation, and maintenance data over the life of the asset (equipment or complete vehicle). In combination with LCC models, it enables intelligent management of high-impact business decisions such as reinvestment, vehicle retirement, obsolescence, and replacement of

equipment/technology, asset buy-back models, investment analysis based on technical risk control and asset degradation, etc.

Task A2-T4.1.- Identify and categorise possible scenarios and the possible evolution of the ecological and digital transformation until 2030 and 2050. [A2.AMN, A2.ASH, A2.JWB, A2.PGR]

*This ta*sk involves the application of state-of-the-art scenario analysis and prospective techniques to the field of Asset Management. A document will be prepared that includes a detailed definition of each scenario, sub-scenarios, and the hypotheses adopted. The task aims to identify the possible trajectories to be followed by the key environmental, circular economy, and technical variables that are representative of the ecological and digital transformation of the company selected as a case study.

Task A2-T4.2.- Carbon and water footprint, environmental costs, and circularity indicators for operations linked to the maintenance and management of assets. [A2.AMN, A2.ASH, A2.MCS, A2.JLB]

*This task involv*es the calculation of the carbon and water footprint, the circularity indicators, and the environmental costs caused by the company's maintenance operations chosen as a case study in the past three years. A mathematical model will be designed based on this information, and its possible evolution until 2030 will be projected based on the scenarios and hypotheses established in deliverable D.4.2.1. This will also determine the necessary reductions to achieve a zero carbon footprint by 2050. The results of APM models will also be integrated into the environmental cost and circularity indicators model.

Task A2-T4.3.- AIP models / applications based on asset health indexing and its links to TCO models. [A2.ACM, A2.JWB, A2.JLB, A2.PGR].

*Asset He*alth Index (AHI) models with Life Cycle Cost (LCC) and Total Cost of Ownership (TCO) models. The AHI enables the sorting of operational, degradation, and maintenance data over the life of the asset (equipment or complete vehicle). By combining it with LCC models, it enables intelligent management of high-impact business decisions such as reinvestment, vehicle retirement, obsolescence and replacement of equipment/technology, asset buy-back models, investment analysis based on technical risk control and asset degradation, etc.

Task A2-T4.4.- Digital Twins and AIP models for long-term strategic planning. [A2.ACM, A2.JWB, A2.MCS, A2.JLB].

*Introduce th*e environmental costs and some significative circularity indicators in the Digital Twins and AIP models. The results, predictions, and trajectories obtained will be used to facilitate better decision-making in a strategic and long-term asset planning context.

A2.WP4 Deliverables:

A2.D4.1 Selection of scenarios where to apply long-term AIP digital tools for strategic management. Milestone 1_Conceptualization. [*M12*]

A2.D4.2 Procedure for incorporating the carbon and water footprint, environmental costs, and circularity indicators to the AIP tools and Apps. Milestone 2_Design. [*M24*]

A2.D4.3 AIP AHI & TCO Apps. Milestone 3_Building. [*M36*]

A2.D4.4 AIP DTs for strategic management. Milestone 4_Commissioning. [*M48*]