Deliverable D 20.3
Project Exploitation Strategy

Project acronym:	FP3 - IAM4RAIL
Starting date:	01/12/2022
Duration (in months):	48
Call (part) identifier:	HORIZON-ER-JU-2022-01
Grant agreement no:	101101966
Due date of deliverable:	31/10/2023
Actual submission date:	08/02/2024
Responsible/Author:	Mónica Pelegrín Preixens ADIF
Dissemination level:	SEN
Status:	Issued

Reviewed: (yes)

This project has received funding from the European Union's Horizon Europe research and innovation programme under Grant Agreement No 101101966.

Document history/Revisions history table		
Revision	*Date*	*Description*
0.1	17/11/2023	First issue
0.2	28/11/2023	Internal review
0.3	05/12/2023	Version approved by the TMT and SteCo
0.4	23/01/2024	Quality check
1.0	08/02/2024	Final version submitted to the JU

Report contributors		
Authors	Organisation	Details of contribution
Beneficiaries' representatives	All FP3-IAM4RAIL Beneficiaries & Affiliated Entities	Individual exploitation plan including its affiliated entities

Table of contents

List of Tables

1. Executive Summary

D20.3 represents the plan of the FP3-IAM4RAIL project to exploit the projects' results for its whole duration. It shall include the plans of each beneficiary including their affiliated entities.

The FP3-IAM4RAIL project has been at the forefront of pioneering research and development in the field of railway infrastructure and rolling stock maintenance management. Therefore, it is imperative to outline a comprehensive exploitation plan to maximize the impact of our innovations on the railway industry and society at large.

The FP3-IAM4RAIL Exploitation Plan outlines a strategic approach to maximize the impact of project innovations on the railway industry. By effectively integrating FP3 - IAM4RAIL technologies, encouraging collaborations and creating sustainable business models, we aim to drive positive change in maintenance management of the railway infrastructure and rolling stock. Through this plan, we envision a future of more efficient, sustainable and advanced railway systems that benefit both industry stakeholders and society.

2. Abbreviations and acronyms

Abbreviation / Acronym	Description
AI	Artificial Intelligence
AM	Additive Manufacturing
AR	Augmented reality
CBM	Condition-Based Maintenance
CCT	Communication Coordination Team
EP	Exploitation Plan
ERA	European Union Agency for Railways
FP	Flagship Project
GA	Grant Agreement
IAMS	Intelligent Asset Management System
IMs	Infrastructure Measurements
JU	Joint Undertaking
KER	Key Exploitable Results
KPI	Key Performance Indicator
LCC	Life Cycle Cost
MAWP	Multi Annual Work Plan
R&I	Research & Innovation
TMS	Traffic Management System
WP	Work Package

Table 1: List of abbreviations and acronyms.

3. Overall exploitation plan

3.1. Delivery of the innovations to the market: the concept

The FP3-IAM4RAIL project is committed to delivering innovations that have the potential to revolutionise railway infrastructure management. By strategically engaging with the market, collaborating with stakeholders and ensuring the scalability and practicality of our solutions, we aim to make a lasting impact on the railway industry, promoting efficiency, sustainability and safety in railway operations. Through our dedication to market delivery, FP3-IAM4RAIL contributes to shaping the future of railway infrastructure management.

3.2. Delivery of the innovations to the market: the implementation

The main objectives of the FP3-IAM4RAIL project regarding the implementation of innovations in the market would be to translate research findings and technologies into practical, industry-ready solutions, as well as to establish collaborative partnerships with industry stakeholders, promoting the integration of FP3-IAM4RAIL innovations into existing railway operations. Finally, it is also important to facilitate the widespread adoption of FP3-IAM4RAIL innovations by railway operators, infrastructure managers and maintenance providers.

WP20 will be in contact with all the FP3-IAM4RAIL technical Work Packages to deliver a solid and ambitious exploitation plan.

The FP3-IAM4RAIL project focuses on seven different integrated demonstrators for rail assets which are key for research and innovation in the rail sector. Integrating asset condition information obtained via advanced monitoring with decision-making tools and into the traffic management system. The project will combine available information with artificial intelligence and digital twins are covered as key topics through a European cross-border, interoperable and holistic integrated approach. Other topics such as interventions using technologies as robotics or additive manufacturing are seen as relevant for improving asset management in the rail sector.

FP3-IAM4RAIL, with 93 partners, aims to reinforce the next generation of Intelligent and Integrated Rail Asset Management providing and demonstrating innovative solutions covering fixed and rolling stock assets, minimising the life cycle costs of assets and extend their lifetime, while meeting safety requirements and improving the reliability, availability and maintainability of the rail system.

The FP3–IAM4RAIL project focuses on providing innovative technical requirements, methods, solutions and services –including technical requirements and standards for future developments– based on the latest cutting-edge technologies to minimise asset lifecycle costs and extend service life while meeting safety requirements and improving the reliability, availability and capacity of the railroad system. Both infrastructure and rolling stock are addressed.

3.3. Key Exploitable Results (KER)

This table with the Key Exploitable Results (KER) will be monitored during the whole life of the project. The exploitation plan will be performed taking into consideration all project KERs which will be, at the end, the Results Ownership List to be produced in the project.

Id.	KER – Key Exploitable Result	Involved WP
KER 1	Platform data acquisition from signalling equipment and sensors, data collection and storage and data analysis for Operation & Maintenance and TMS needs.	3, 4, 8, 9
KER 2	Decision Support System (DSS) methods and algorithms solution for Data Analytics, TMS and Operation & Maintenance link.	3, 4, 8, 9
KER 3	On-board monitoring and inspection technologies for rolling stock (e.g., additional sensors or using the signal coming from traction system).	5, 6
KER 4	Predictive algorithms or ML based analysis for on-board monitoring data capable of supporting the railway maintainers, owners, and operators of the asset management decision-making process.	5, 6, 7
KER 5	European Railway Checkpoint for mixed traffic for different operational conditions and climate-types.	7
KER 6	Decision support for long term planning of renewal or investments & disposal of civil structures.	8
KER 7	Decision support for maintenance optimization and management of dynamic maintenance programs within maintenance concept.	8
KER 8	Solutions beyond the state-of-the-art for innovative anomaly detection and prediction of track structure components conditions that will allow preventing failures before they occur.	9

Id.	KER – Key Exploitable Result	Involved WP
KER 9	Monitoring systems exploiting multi-sensor & multi-vehicle modular architectures, combined with advanced algorithms, physical models and expert knowledge that enable future applications of manned, unmanned, and autonomous inspections.	10, 11
KER 10	Web-based platform for EO and ground visual data fusion.	12, 13
KER 11	Asset management web platform for bridges maintenance based on AI for defect identification from UAV images.	12, 13
KER 12	Asset management platforms for bridges and earthworks addressing several maintenance planning levels.	12, 13
KER 13	Digital platform for Track Condition data, Point Cloud, Simulation outputs and Track Asset Inventory information fusion.	14, 15
KER 14	Digital Platform for Station Asset Management.	14, 15
KER 15	Blockchain application for infrastructure certification	14, 15
KER 16	Determination of improved dynamic amplification factors (DAF) for railway bridges.	16
KER 17	Development and implementation of Additive Manufacturing applications including repair processes in metallic materials, new materials use for spare parts and a related Digital Warehouse.	17
KER 18	Common framework and strategy for the developments of a robotics railway maintenance use-oriented platform.	18
KER 19	Identification and determination of the certification requirements for a safety level assessment for the use of maintenance robots.	18
KER 20	Augmented Reality system architecture and tools.	19
KER 21	Exoskeleton concept design, development and prototype.	19

Table 2: FP3-IAM4Rail project-Preliminary Key Exploitable Results.

4. Individual exploitation plans

This section represents the individual exploitation plans of all organisations involved in the FP3-IAM4Rail project.

4.1. ADMINISTRADOR DE INFRAESTRUCTURAS FERROVIARIAS (ADIF)

4.1.1. Introduction to the exploitation plan

ADIF participates in FP3-IAM4RAIL together with three affiliated entities: RENFE, CEDEX and INECO. ADIF is the railway infrastructure manager in Spain, RENFE is a public Spanish railway undertaking, CEDEX is a research institute and INECO is a public engineering company. When describing ADIF's exploitation plan, it should be understood that its affiliated entities are included.

Some of the objectives that ADIF intends to achieve with FP3-IAM4RAIL are:

- Technological innovation: developing and implementing new technologies to enhance the efficiency and safety of railway operations. This might involve innovations in signalling systems, track maintenance and communication technologies.

- Safety improvements: enhancing safety measures through the development of innovative solutions, such as improved collision avoidance systems and better hazard detection mechanisms.

- Asset management: researching and developing better asset management systems for railway infrastructure, including predictive maintenance technologies to reduce downtime and improve reliability.

- Interoperability: promoting interoperability with other railway networks, both nationally and internationally, to facilitate smoother and more efficient rail transport connections. This way, focusing on findability, accessibility, interoperability and reusability in managing the data collected or generated throughout the FP3-IAM4RAIL project, it will be necessary to ensure its results are open to the research and development communities and external stakeholders.

- Digitalisation: embracing digitalisation and data-driven decision-making using sensors, IoT (Internet of Things) and big data analytics to optimise railway operations and maintenance.

- International collaboration: collaborating with other railway organisations and participating in international R&D initiatives to benefit from shared knowledge and experiences.

- Cost reduction: developing and implementing innovations that help reduce operational and maintenance costs while maintaining or improving the quality of railway services.

The FP3–IAM4RAIL project intends to put into practice the demonstrators and prototypes developed to validate the different objectives described above.

4.1.2. Final products and TRL

As a public entity, ADIF's main goal in its participation in FP3-IAM4RAIL is not to produce a commercial product, but to improve the railway system and to benefit from its improvements to be able to provide a better service for its users. The products developed within FP3-IAM4RAIL, where ADIF and its affiliated entities shall participate, are the following:

Cluster B:

- ADIF participates collecting and providing data from its infrastructure. Proposed assets and operational monitorization, as operation restrictions, signalling and safety regulations, will be the main input, together with TMS, for IAMS data analytics for High Speed, Conventional and Regional lines under different environmental conditions for predictive capabilities. It is related to KER 1, KER 2, KER 8 and KER 9.

Cluster C:

- RENFE, as an affiliated entity of ADIF, participates in the improvement of rolling stock inspection and monitoring technologies by developing and deploying new predictive maintenance strategies based on Machine Learning. Input data will be both on-board and wayside information coming from old and new sensors as traction system information. It is related to KER 3 and KER 4.

- Harmonization and standardization for mixed railway checkpoint, by collecting data from wayside and new sensors, providing different scenarios (mixed, high speed and conventional, freight lines, borders...) for the two different track gauges. It is related to KER 4 and KER 5.

- Algorithm analysis and deployment for freight management at railway checkpoint, to improve preventive and corrective maintenance by using simulation of on-board data and historical data analysis. It is related to KER4 and KER5.

Cluster D:

- ADIF contributes by providing sensors and specific data from the selected infrastructure sections chosen to be the most appropriate for performing the analysis. These sections are a viaduct in the Madrid-Valencia high-speed line and the earthworks in Palencia-A Coruña conventional line. They are related to KER 10, KER 11 and KER 12.

- ADIF is sharing data related to track geometry and S&C inspections to carry out advanced data analysis focusing on the assessment, estimation, and standardization of the impact of infrastructural, conditional, and operational characteristics on track geometry and S&C. This task is related to KER 8.

- At the same time, proofs of concept related to monitoring sleepers, and a feasibility study of the use of a new material, passive magnetic microwire, for the measurement of convergence in tunnels will be developed. These studies are associated with KER 8.

Cluster E:

- To advance KER 13, KER 14 and KER 15, ADIF contributes by helping create the digital twin of one of its stations and sections of track. To achieve this objective and obtain the infrastructure certification, ADIF participates in the BIM analysis of data, with the aim of improving the simulation tools for asset management decision.

Cluster F:

- ADIF provides its high-speed knowledge and expertise to perform analysis and provide data to the AI system, regarding dynamic loads on structures to calculate DAF. It is related to KER 16.

- ADIF contributes by providing information on methods and regulations for welding on rails and track elements (e.g. crossing), as well as information on the base and welding materials (electrodes) used. Rail and crossing section parts are also supplied to be able to carry out laboratory tests of the new techniques that are desired to be developed in this project. It is related to KER17.

- Analysis of a robotic platform, based on the study of the track and switch devices maintenance activities, including the compliance of the required safety level for wayside works. It is related to KER 18 and KER 19.

4.1.3. Demonstrators

As Infrastructure Manager (IM) of Spain, ADIF hosts the demonstrators that take place in the country, participating in most of the activities performed by providing the required infrastructure and data, needed to perform the activities related with the aim not only of achieving the TRL level for each project, but also to obtain the best results to perform the prototypes.

For this reason mentioned above, ADIF will contribute to the following demonstrators and Use Cases:

- Demonstrator 1: Integration between the Intelligent Asset Management System (IAMS) and the Traffic Management System (TMS).
    - UC 3.1: Wayside and Infrastructure IAMS for TMS optimisation (participant).
    - UC 3.2: Wayside monitoring in conventional and high-speed lines for TMS optimisation (participant).

ADIF contributes to the demonstrator by providing specific data assets from the infrastructure and signalling systems, located in Line cercanías C2-Asturias "bifurcación Torrejón de Velasco".

- Demonstrator 2: Asset Management & Rolling Stock.
    - UC 6.8: Smart maintenance scheduling tool (participant).
    - UC 7.4: Railway checkpoints use case (ES) (leader).
    - UC 7.7: Data Analytics for Railway Checkpoints Use Case (participant).
    - UC 7.9: CBM algorithms for freight (participant).

As the leader of UC 7.4., ADIF hosts the project analysis and implementation, providing the required infrastructure and data to achieve the goals. The following locations with different characteristics to perform the demonstrations have been agreed:

- Toledo "La Sagra": standard gauge-passengers.
- Madrid "Atocha": Iberian gauge-passengers.
- Line Madrid-Irún "Beasain": cross-border section/Iberian gauge-mixed traffic.

- Demonstrator 4: Asset Management & Infrastructure. TRL 6.
    - UC 9.1: Sensing railway superstructure system components (leader).
    - UC 9.3: Track Geometry and S&C condition monitoring (participant).
    - UC 10.1: Linking (new) monitoring technologies to asset management issue (participant).
    - UC 10.2: Fusion of (onboard and wayside) monitoring data for an enhanced fault detection and diagnosis (participant).
    - UC 12.2: Bridges and earthworks assets management aided by geotechnics (leader).

ADIF hosts the project analysis and implementation, providing the required infrastructure and data to achieve the goals related to this demonstrator. The following locations with different characteristics to perform the demonstrations have been agreed:

- Bridge: viaduct over Arroyo de las Huertas de Mateo, located in line 040 HSL Bif. Torrejón de Velasco – Valencia Joaquín Sorolla, Spain.
- Earthworks: entrance slope to tunnel 40, CL 800 Palencia-La Coruña, Spain.
- HS Turnouts: high-speed turnout Bif. Torrejón de Velasco – Valencia Joaquín Sorolla, Spain.
- Turnout in Mediterranean Corridor: Passing loop Rifá | Line 600, Vandellós - Tarragona section.
- Tunnel: Feasibility study for tunnel convergence measures with a passive contactless magnetic microwire.

- Demonstrator 5: Asset Management & Digital Twins. TRL 7.
    - UC 15.1: decision support systems for railway station asset management (participant).
    - UC 15.4: BIM model as support to communicate and populate the Station's Asset Management System (participant).

ADIF contributes to the demonstrator by providing its expertise in the different possibilities at railway stations during operation, maintenance and management.

- Demonstrator 6: Design & Manufacturing. TRL 6.
    - UC 16.2: resilient and sustainable lines (participant).
    - UC 17.1: in-situ AM repair machine for rails, switches or crossings (participant).

- UC 17.2: AM repair machine for wheels (participant).
- UC 17.3: in-situ repair of track metallic assets (participant).

ADIF contributes to the demonstrator by providing the infrastructure to perform the maintenance activities for testing new procedures and materials.

- Demonstrator 7: Robotics & Interventions. TRL 6.

  - UC 18.1: Light and Flexible on-track Inspection (participant).

ADIF contributes to the demonstrator by providing the infrastructure data for performing the robotic activities.

4.1.4. Positive impacts

ADIF intends to increase volume of rail traffic in existing lines with improved cost efficiency and lower CO2 emissions from their maintenance and operations. Furthermore, construction time and cost of new assets and lines are reduced, the durability and reliability of their assets increased and their life cycle costs are optimised, while meeting safety requirements. Competitiveness of the European railway industry is strengthened through the obtention of more qualified products, and its application improves the performance (capacity, flexibility and punctuality) of the whole railway system.

Some examples of the positive impacts of ADIF's and affiliated entities contribution to the FP3-IAM4RAIL project include:

- Increasing the efficiency in the unmanned and non-invasive monitoring and inspections technologies in the Spanish network.
- Optimising rolling stock maintenance.
- Reinforcing vehicle/infrastructure control and corresponding parameters by infrastructure managers.
- Increasing capacity in main lines and freight corridors when reducing incidents and slots for transits to workshops/maintenance (especially when connecting large stations/terminals/yards).
- Reducing maintenance cost by providing decision support tools using trains in operation, that is, without using specialised measurement trains.
- Developing solutions for innovative anomaly detection and prediction of track structure components conditions that will allow preventing failures before they occur.
- Increasing the quality and efficiency of maintenance in terms of cost, possession time and sustainability by using predictive maintenance and

optimised maintenance strategies.

- Improvement of civil structural condition monitoring techniques and enhancement of risk management for decision-making processes.
- Increase of the resilience of the infrastructure, preventing incidents such as landslides, floods and other disruptions.
- Extending the lifespan of infrastructure subsystems.
- Lowering the overall maintenance downtimes of track and turnout systems while increasing the availability of the rail lines.
- Life cycle cost of assets will be reduced.

The work will lead towards a comprehensive research data set from operational environment via wayside embedded sensors and research vehicle platforms, for the purpose of this work package, and based on the principles of data modelling, federated data spaces and data governance developed. This data set will enable data analytics research and integration of AI-based decision support tools in operational control centre workflows, but also further exploration and research in predictive analytics acquired by combining the various sources.

Through its involvement in R&D, ADIF has positioned itself as a leader in railway innovation, contributing to the broader industry's advancement and competitiveness.

4.2. ALSTOM TRANSPORT S.A. (ATSA)

4.2.1. Introduction to the exploitation plan

Leading societies to a low carbon future, Alstom develops and markets mobility solutions that provide the sustainable foundations for the future of transportation. Alstom's products portfolio ranges from locomotives, high-speed trains, metros, monorail, trams and e-buses to integrated systems, customised services, infrastructure, signalling and digital mobility solutions.

The output of FP3-IAM4RAIL will be used to reduce the LCC by using the full remaining life of a component and to increase the availability of Rolling Stock due to less in-service failures. To do so, a reliable and cost-efficient way of monitoring assets needs to be established, no matter if it is an on-board or a wayside technology (see Cluster C). Data gathered by Rolling Stock (using existing data sources or data captured by additional equipment) will be used to also reduce the cost of maintenance for track infrastructure and maintain, or further improve, track availability for commercial operation (see Cluster D).

Both the data used for diagnostics of the rolling stock and for the track infrastructure will reduce the maintenance cost for the owner, leading to higher competitiveness.

The Alstom scope is related to KER 3, KER 4, KER 5 and KER 8.

4.2.2. Final products and TRL

The final products expected from Alstom for the FP3-IAM4RAIL program are:

- Reliable and cost-efficient bogie monitoring systems on-board (at TRL6) and wayside - acoustics (at TRL6) to gain information about the health status of the bogie components to enable condition-based and predictive maintenance strategies, to reduce maintenance cost and to achieve high availability of the train system.
- A new set of algorithms to enable traction components health monitoring (at TRL6) for:
  - traction converter semiconductors;
  - traction cooling system heat exchanger;
  - main transformer heat exchanger.
- A new traction hardware system to improve traction component health monitoring capability (at TRL4) by increasing the volume of deep measurements from traction to the ground.
- For track infrastructure monitoring, the final product expected from FP3-IAM4RAIL program is a track infrastructure sensing technology (at TRL6) that is

being further developed to detect various types of track anomalies using different kinds of sensors. Also, a new set of Traction algorithms (at TRL6), which allows us to evaluate and locate track defects even without any additional sensors, will be developed.

4.2.3. Demonstrators

Alstom will contribute to the following Use Cases:

- 5.1 - Bogie Monitoring System (on-board)
- 6.1 - Development of next generation Traction Control Unit Hardware and Gate Drive Communication Link
- 6.2 - Traction component health monitoring & predictive”)
- 6.4 - Adhesion estimation for management
- 7.1 - Bogie Monitoring System (wayside – acoustic)

These use cases are aligned with the following FP demonstrators:

- Demonstrator #2: Asset Management & Rolling Stock
- Demonstrator #4: Asset Management & Infrastructure

4.2.4. Positive impacts

Thanks to these innovations proposed within IAM4RAIL, the Rolling Stock owner will be able to reduce its maintenance costs by only executing maintenance operations when it is necessary (instead of doing it at a fixed time or mileage step). Besides it will also allow the RU to anticipate failures in operation: the direct consequence is a more reliable service seen from the end-customer. This will help the customer to build its train fleet maintenance plan according to condition of the components.

4.3. MER MEC SPA (MERMEC)

4.3.1. Introduction to the exploitation plan

The exploitation plan of MERMEC within FP3-IAM4RAIL is focused on the technologies developed in WP3/4, WP9, WP12/13, WP14/15 and WP19. MERMEC, also representing MER MEC STE, SITAEL and MER MEC ENGINEERING has specific competence in the domain of data acquisition from Trains, Signaling systems and Earth Observation from satellites.

In WP3-4, with the help of FSI, MERMEC gathers ground data pertaining track condition, generating a Track Health Index (THI). The software generated THI will then be passed to the TMS (main theme of WP3-4) and will allow TMS to intervene, optimizing traffic and maintenance of the track. The development of hybrid radar, also communicating with the TMS, will permit a more precise detection of obstacles in presence of level crossings. MER MEC will therefore contribute to KER2. The data gathered in WP3/4 will support WP12/13.

In WP12-13, with the help of FSI, MERMEC aims at designing, developing and implementing a system of control and management for the entire life cycle of civil infrastructure assets (e.g. bridges), railway infrastructure and surrounding territories (vegetation, landslides, floods and other external factors affecting railway infrastructure). In order to move toward a holistic approach to control and management of the railway infrastructure, information from various data sources (satellites, aerial, ground) has to be jointly exploited taking advantages of AI approaches to provide support to the decision-making process of IM operators. MERMEC development activities stemming from WP12/13 will therefore be related the following KERs:

- KER10: Web-based platform for EO and ground visual data fusion.
- KER11: Asset management web platform for bridges maintenance based on AI for defect identification from UAV images.

In WP9, with the help of ADIF, DB and SNCF, MERMEC aims at improving the condition monitoring for both plain track geometry and Switches and Crossings. Regarding track geometry, the target is to use advanced analytics for assessing the propagation of the single track geometry defect and overall standard track quality indexes. Regarding the Switches and Crossings, the approach focuses on the holistic monitoring of the turnout and the specification of the numeric turnout health condition and maintenance index that allows Infrastructure managers to prioritize maintenance works. MERMEC activities stemming from WP9 will therefore be related to the following KERs:

- KER 8: Solutions beyond the state-of-the-art for innovative anomaly detection and prediction of track structure components conditions that will allow preventing failures before they occur.

In WP14/15, with the help of FSI, MERMEC aims at designing, developing and implementing a web platform for accessing all information related to digitalized track assets, explore asset locations inside the point cloud and display track conditions in synchronization. Concurrently, using simulation methods, MERMEC aims to assess the behavior of the Track's substructure based on different operational and track infrastructure conditions. MERMEC activities stemming from WP9 will therefore be related to the following KERs:

- KER 13: Digital platform for Track Condition data, Point Cloud, Simulation outputs and Track Asset Inventory information fusion.

In WP 19, MERMEC is involved with design specification and test of both VR and exoskeleton, leveraging on the experience gathered in previous projects such as STREAM. In this respect MERMEC contributes to KER 20 and KER21.

4.3.2. Final products and TRL

Three main products will derive from the involvement of MERMEC across the various WPs. In WP 3/4, the hybrid radar will reach TRL 5, with the product being tested in a mock up environment with all the prominent features of a level crossing setting.

The works in WP12-13 will result in 2 main products:

- A Railway Monitoring Platform, integrating different data sources (satellite, drones, in-situ) to provide actionable insight on the whole railway network condition and its surrounding. The platform will represent a one-stop-shop for information related to hydrogeological risks, vegetation growth and third parties interference, and will provide support to the decision-making process of IM operators involved in railway maintenance.
- A Bridge Management Platform, integrating image acquisition, processing and classification service for the automatic detection of defects and for the estimation of the residual lifetime of the civil infrastructures. The platform will become a new tool to support decisions pertaining bridge maintenance.

Both 2 web platforms will reach TRL 6/7 by the end of this programme.

The works in WP14-15 will result in 1 main product reaching TRL 6/7 by the end of this programme:

- A Railway monitoring platform integrating digitalised assets with Track condition data, Point cloud information and Simulation outputs. The platform will provide a unique environment that will increase and support further the digitalisation of the assets and support of proper decision making as well as work scheduling.

4.3.3. Demonstrators

The functionalities of KER 10 developed within WP12/13 will be showcased on a target area corresponding to a section of the High Speed line connecting Milano with Torino. In particular the section between Milano and Greggio will be used to demonstrate the capability to identify critical areas based on predefined criteria. Within the same area, a few bridges with different characteristics will be selected to showcase the functionalities of KER 11 for bridge defect identification.

The same section of high-speed line connection Milano to Torino will be used to showcase the functionalities of KER 13 developed within WP14/15.

4.3.4. Positive impacts

The activity performed by MERMEC within WP12 and 13 will have a positive impact at consolidating and improving its market position in railway asset monitoring, thanks to the addition of information derived from less conventional data sources such as satellites and drones. In particular, these activities will support MERMEC and its affiliated entities in reinforcing and expanding their satellite Earth Observation related business, demonstrating the value that EO data can bring to the railway sector. The platforms developed will be able to integrate with MERMEC proprietary diagnostic platform to create a one-stop-shop solution for railway track and infrastructure monitoring.

The activity performed by MERMEC within WP9 will have a positive impact at finding the balance between planning maintenance and renewal activities. Infrastructure Managers will be able to re-assess the prioritisation of the works in the medium and long-term supporting their decision-making process with objective data.

The activity performed by MERMEC within WP14 and 15 will have a positive impact at understanding how the substructure of the track behaves under different loading conditions and speeds, and correlating these outputs with real track conditions inside a digital point cloud environment.

4.4. AZD PRAHA SRO (AZD)

4.4.1. Introduction to the exploitation plan

AZD is focused within the FP3-IAM4RAIL project only on 2 R&I areas – will be described below – so the activities are rather limited from the point of view of the number of topics dealt with in the project. But the intention is to gradually develop and exploit the results of both the collaborative and individual activities to the extent that allows final users, mainly IMs, of AZD's products and services to reduce their LCC and, besides that, to highly improve the quality and availability of their own services in the field of asset management and maintenance. Novel flexible and cost-efficient methods of monitoring assets, enabling also to share the asset status data with interconnected Traffic Management Systems, will be proposed, specified and demonstrated.
The AZD scope is related to KER 1 and KER 2 within WP3/4 and to KER 13 within WP14/15.

4.4.2. Final products and TRL

In WP3/4 AZD will contribute to the development of specifications of data models, formats and protocols defining the interface and data transfer between IAMS and TMS. Then, building on these specifications will implement a model and also a limited scale demonstrator at TRL 5/6. The data link between those systems will enable automatic transfer of track availability status and maintenance period prediction and completion which will allow the TMS to adapt real-time traffic, generate TSRs and allow to free relevant tracks from traffic in order to secure necessary maintenance of the track. The AZD demonstrator will both connect own IAM system and TMS and, besides that, will provide data to the HSTS demonstrator to prove interoperability of data, protocols and interfaces.
We expect that the attainable TRL is going to be limited to TRL 5/6 at this stage, mainly by the TMS side of the interface, as the range of scenarios that can be tested at the AZD-owned and operated regional track and via remote or offline connection to the partner's TMS (in Italy) is restricted. However, close cooperation with the WP partners will enable further validation and demonstration of the developed product in a relevant environment in the following years beyond FP3-IAM4RAIL. So, in the following project in FA3, we expect to achieve at least TRL7 thanks to implementation of more use cases and scenarios.

In WP14/15, AZD develops a comprehensive solution for the automation of unmanned aerial monitoring of railway infrastructure, including the mission preparation, pre-flight checks, mission execution and post-flight data processing phases. This solution will include hardware and software components developed around a prototype of an unmanned aerial vehicle, cameras and lidars. AZD will initiate development of standards

concerning operation of unmanned aerial vehicles over rail tracks, either in the scope of TSI or other suitable industry standards or best practices.
More to the point of WP14/15, the visual and 3D data about railway infrastructure generated through UAVs will be integrated into digital models of railway assets via newly developed protocols and interfaces. This action will lead to a TRL 6 demonstrator within the timespan of FP3-IAM4RAIL.
In the following project in FA3 we expect to achieve at least TRL7.

4.4.3. Demonstrators

The AZD demonstrator #1 at the TRL 5/6 in WP4 will both connect own IAM system and TMS and, besides that, will provide data to the HSTS demonstrator to prove interoperability of data, protocols and interfaces.
The AZD demonstrator #2 at TRL 6 in WP15 will include a comprehensive package of hardware, software and operational procedures, approved by the national Civil Aviation Authority, to enable remote surveillance of signalling and other RI assets by unmanned aerial vehicles. The generated visual and 3D data will be integrated into Digital Twin models of the infrastructure.

4.4.4. Positive impacts

Any Infrastructure Manager, thanks to the above mentioned innovations developed within FP3-IAM4RAIL, will be able:

1. To reduce its maintenance costs by substantial decrease in the number of necessary track inspection personnel and by decreasing a frequency of inspection trips and useless device replacements thanks to executing maintenance operations when it is necessary (instead of doing it at a fixed time or mileage step).
2. To predict/anticipate failures in operation, followed by the suitable planned maintenance, which will result in preventing unexpected track shut downs or switching to degraded mode of the traffic operation. Hence the direct improvement over the current situation is a more reliable service experienced by the end-customer.
3. To automatically reroute the current traffic in real-time by its TMS in order to minimize train delays both for passenger trains and freight trains and to provide passengers and clients relevant and early information on rerouting and changes in time-tables.
4. To gather visual information with less staff, greater flexibility, higher replicability and less post-processing labour, which will streamline planning of maintenance and repair works and improve decision making during emergencies, reducing costs and delays to railway traffic operators and end users.

4.5. Construcciones y Auxiliar de Ferrocarriles, S.A. (CAF)

4.5.1. Introduction to the exploitation plan

The exploitation plan aims at maximizing the impact and reach of the developed solutions.
Construcciones y Auxiliar de Ferrocarriles, better known by the acronym CAF, is a Spanish company based in Beasáin that manufactures trains and railway material for the tramway, metropolitan railroad, metro, subway, suburban, commuter, long distance and high speed networks.
The achieved demonstrators will be used to reduce life cycle costs for partners and customers. It will also provide valuable insights into how to improve functionality and provide improved product experiences.

CAF is focusing on WP5, WP6, developing new models and AI algorithms to support the shift from actual maintenance strategies to predictive maintenance. For that, CAF will be using the onboard monitoring and digital data transmission architecture and capabilities, already built in past years.

CAF is focusing on WP7, developing wayside systems to automate inspection of train components such as pantographs, wheels, bogies, and unit bodies.

Id.	KER – Key Exploitable Result	Involved WP
KER 3	On-board monitoring and inspection technologies for rolling stock (e.g., additional sensors or using the signal coming from traction system).	5, 6
KER 4	Predictive algorithms or ML based analysis for on-board monitoring data capable of supporting the railway maintainers, owners, and operators of the asset management decision-making process.	5, 6, 7
KER 5	European Railway Checkpoint for mixed traffic for different operational conditions and climate-types.	7

Table 3: CAF Key Exploitable Results

4.5.2. Final products and TRL

CAF is focusing on the following product capabilities:

- Development of analytical models to support Conditioned Based Maintenance of railway units, based on data collected from the units themselves.
- Development of analytical models to develop a digital twin of energy

consumption in railway units.
- Development of analytical models to develop Smart Maintenance Scheduling, based on the outputs of condition-based maintenance models.
- Development and installation of wayside equipment to collect measurements of wheel parameters, and to take images of the pantographs, bogies and boxes of the inspected units.
- Development of machine learning models to support automatic image inspection, and to detect failures in certain systems such as pantographs, wheels, bogies and boxes.

These products shall reach a TRL 6-7 by the end of the project, enabling further development into serial products in subsequent projects.

4.5.3. Demonstrators

CAF is involved in the following use cases:

- Health Monitoring & Analytics and ML algorithms development of HVAC, Doors, & Brakes (ES)
- Health Monitoring & Analytics and ML algorithms development of HVAC, Sanitary Systems & Brakes, Traction & auxiliary system (NL)
- Adhesion estimation for management
- Digital twin for energy
- Smart maintenance scheduling tool

These use cases are contained with the following FP demonstrator:

- Demonstrator #2: Asset Management & Rolling Stock

Demonstrations will take place in Spain and in the Netherlands.

4.5.4. Positive impacts

The aim of the use cases is to reduce maintenance costs and improve availability of the fleets. By monitoring the actual status of systems, maintenance activities can be more efficiently planned and prepared, and status indications can reduce the duration of required tasks. More exact information about the systems can also allow for improved lifetime utilisation and a reduced need of material and spare parts.

Over time, collected data can enable better prediction and prevention of failures, and reduce the amount of in-service failures, which are a major cost driver for the rail operators.

4.6. ASOCIACIÓN CENTRO TECNOLÓGICO CEIT (CEIT)

4.6.1. Introduction to the exploitation plan

CEIT is a private non-profit research centre, whose mission is to contribute to improving the competitiveness of the business community, through applied research projects that generate advanced solutions based on scientific and technological excellence. Likewise, CEIT pretends to contribute to the training of young researchers who will lead the necessary changes to bring companies to the first level of international competitiveness.

CEIT plans to exploit the results of FP3-IAM4RAIL as follows:

- **Know-how for new projects**. The know-how gained in the project will be further exploited in new R+D project projects and consultancy services, at regional, national and European level.
- **Publications**. Disseminating the results of the projects with publications in JCR Journals and International Conferences it in the DNA of CEIT. During the project (and after its conclusion) CEIT will contribute with international scientific publications and keynote presentations in relation with the results of FP3-IAM4RAIL.
- **Development of new products and technology transfer**. CEIT does not develop/commercialize new products as such, but 'technology assets' that may turn into future products. In this sense, CEIT has created two spin-off companies that are dedicated to the railway sector: MainRail and InspectRail. The technology assets developed in this project will be transferred (licensed) and exploited by these companies.

4.6.2. Final products and TRL

As said before, CEIT does not develop/commercialize new products as such, but 'technology assets' that may turn into future products exploited by other companies. In this project, CEIT plans to contribute to the following technology assets:

- Algorithms for the condition assessment of freight wagons, to contribute to the digitalisation of the freight sector.
- Infrastructure inspection & monitoring systems and technologies, in view of their integration of an autonomous inspection vehicle for railway infrastructure.
- In-situ Additive Manufacturing repair machine for rails, switches and crossings.
- Robotics, Exoeskeleton and Augmented Reality technologies for worker's support in railway operations.

4.6.3. Demonstrators

CEIT will contribute to the demonstration activities of the following use cases:

- UC7.9: CBM algorithms for freight
- UC11.1: Linking (new) monitoring technologies to asset management issues
- UC11.2: Fusion of (onboard and wayside) monitoring data for an enhanced fault detection and diagnosis
- UC17.1: In-situ AM repair machine for rails, switches and crossings
- UC17.2: AM repair machine for wheels
- UC18.2: Automated installation of ERTMS balises and axle counters
- UC19.1: Upper-body exoskeleton for worker's support in railway industry
- UC19.2: Augmented Reality tools to help and guide railway workers in maintenance operations

These use cases are aligned with the following FP demonstrators:

- Demonstrator #2: Asset Management & Rolling Stock
- Demonstrator #4: Asset Management & Infrastructure
- Demonstrator #6: Design and Manufacturing
- Demonstrator #7: Robotics & Interventions

4.6.4. Positive impacts

- Scientific impact, with the creation of new knowledge and its diffusion in scientific papers in International Journals and Conferences.
- Societal impact, by training young researchers that will be transferred to the industry to lead innovation activities.
- Impact in maintenance operations and support to rail workers, by means of better inspection & monitoring technologies and tools that facilitate interventions, also contributing to safer operations and cost effectiveness.

4.7. DEUTSCHE BAHN AG (DB)

DB has been working on two research topics within FP3-IAM4Rail: *The maintenance of tracks* and the *maintenance of rolling stock*, including *3D-printing* of parts.
The maintenance of tracks shall be improved twofold: By developing and testing a wireless measuring system suitable for standard trains to monitor the track position, and by prescriptive maintenance of switches, crossings, and tracks. The wireless measuring system will reduce costs and is more flexible to use in comparison to the cable-based measuring system. Milestones of the project are the construction and test of the laboratory-prototype (scheduled for March 2024) and a second testing phase on the vehicle (June 2024). The pilot-phase shall begin in March 2025.

Building on results of the Shift2Rail-projects IN2SMART and IN2SMART-2, methods for a prescriptive maintenance including the prognosis as well as planning the optimized service of tracks and switches will be developed. Methods for the data collection, preparation, analysis, and forecasting will be further refined. Milestones are an automatic detection of anomalies on the route from Rotterdam to Geneve starting in December 2023. A new database shall be established in June 2024.

To enhance the *maintenance of rolling stock*, a Datapath for Condition Based Maintenance as well as AI-methods for a Smart Visual Inspection of passenger and freight trains are being developed. The Datapath is improving the data driven maintenance by accelerating CBM-methods while also preventing errors and reducing risks in the maintenance-process. An EU-report shall be finished by July 2024.
Five different AI-based rails service robots, which are being researched and developed in the project, are to form the basis for uniform Visual Inspection solutions in Europe. For this purpose, a uniform proof of equal safety must be created. Milestones in the project are the technical approval of inspection hardware (January 2024) and the proof of equal safety (December 2025).
Additionally, the project Additive4Rail investigates 3D-printing manufacturing technologies and materials to meet railway-specific requirements. The materials shall be used for the braking systems and the train's interior. Milestones such as the development and testing of the material for the breaking-system shall be reached in December 2024.

We are looking forward to disseminating our project's results at multiple expos and events, such as the InnoTrans 2024 & 2026 and the Railway Forum 2025. Additionally, scientific papers will be published.

4.8. DEUTSCHES ZENTRUM FUR LUFT – UND RAUMFAHRT EV (DLR)

4.8.1. Introduction to the exploitation plan

DLR is contributing to KER 9 by scientific progress in respect to sensor data analysis (with focus on supervised and unsupervised anomaly detection) for the detection of failures and faults as well as the development of traceable diagnostic and prognostic models for asset management. Focus is laid on holistic condition monitoring, diagnostics and prognostics based on human-in-the-loop machine learning including wayside and train-borne embedded sensors as well as all kind of relevant additional information such as environmental conditions, loading, and maintenance records. The scientific results as provided mainly by scientific publications (journals and conferences). Additionally, open source and open data publications of prototype implementations in python and accompanying benchmark/test data sets are planned, if applicable and agreed by involved project partners.

The scientific results of the project will be further developed and enhanced within follow-up projects. It is planned to transfer the methodological progress obtained within the project in the areas of anomaly detection, interpretable diagnostic models as well as prognostics to other domains (e. g. road infrastructure), use cases and assets. The exploitation of the project results is furthermore realized by the utilization of the demonstrated show cases as references for the acquisition of new third-party funded projects together with industrial and academic partners. Open-source publications of prototype implementations play a key role in this respect to exploit the results obtained within FP3-IAM4RAIL in a wider and broader context and with diverse European partners. The published articles as well as the conference and fair presentations of the project results obtained in cooperation with well-known ERJU members are of highest value to expand the reputation of DLR as an internationally acknowledged application-oriented research institution.

4.8.2. Final products and TRL

As a public funded research institution DLR is not developing products in the commercial sense. DLR research is focused on the TRL range 3 to 6, higher TRL are addressed in cooperation with industry partners by the industry partners. Main “products” from DLR point of view are scientific publications in international journals, presentations on scientific conferences as well as open source and open data publications.

DLR plans to present recent project results on, at least, one international scientific conference per year. Relevant conferences considered for the submission of abstracts within FP3-IAM4RAIL are amongst others:

- Transport Research Arena (TRA)
- World Congress on Railway Research (WCRR)
- European Safety and Reliability Conference (ESREL)
- Condition Monitoring and Diagnostic Engineering Management (COMADEM)
- European Conference of the Prognostics and Health Management (PHM) Society (ePHM)
- International Conference on Intelligent Transportation Systems (IEEE-ITSC)

In general, the announcements of international scientific conferences in the field of research are continuously monitored for relevance. Next to conference presentations the dissemination of project results within journals is planned.

Relevant journals considered for the submission of manuscripts are:

- Sensors (ISSN 1424-8220)
- Applied Sciences (ISSN 2076-3417)
- Proceedings of the Institution of Mechanical Engineers, Part F: Journal of Rail and Rapid Transit (ISSN 0954-4097)
- Proceedings of the Institution of Mechanical Engineers, Part O: Journal of Risk and Reliability (ISSN 1748-006X)
- Signal und Draht (ISSN 0037-4997)
- Eisenbahningenieur (ISSN 0013-2810)

Furthermore, project results are published in form of prototype implementations of algorithms in python as part of DLR open source toolboxes, if applicable and agreed by involved project partners. Additional to the scientific publications project results will be disseminated in context of the InnoTrans fairs during the project duration by presentations on the DLR booth.

4.8.3. Demonstrators

DLR operates own sensor systems in operational environment (TRL 5-6) to gather data for data science R&D. DLR is utilizing on-board and wayside measurement data gathered in a German industrial railway network (shunting operations). This setup is available for demonstrations and gathered data is utilized within FP3-IAM4RAIL. Furthermore, DLR contributes to the integrated demonstrator of WP10 and WP11 (see deliverable D10.2) in the use cases described in deliverable D10.1 by prototype implementations of algorithms and machine learning approaches for embedded train-borne and wayside condition monitoring as well as holistic diagnostics and prognostics. Focus is laid on the WP10/WP11 pilot site in the Netherlands (see D10.1).

4.8.4. Positive impacts

The research of DLR provides positive impacts in respect to operations, maintenance, safety and cost-effectiveness by progressing the automation of inspection, condition monitoring, asset management and maintenance activities. As a result of automated condition monitoring with embedded sensors less manual inspection work in and at the track is increasing the availability for train operation by reducing track possessions and increasing safety by reducing the presence of persons in and at the track. Both is increasing furthermore cost-effectiveness. Embedded condition monitoring and decision support tools enhance furthermore the asset management and maintenance preparation to further increase cost effectiveness, availability and reliability.

4.9. CENTRO DE ESTUDIO DE MATERIALES Y CONTROL DE OBRA SA (CEMOSA)

4.9.1. Introduction to the exploitation plan

The exploitation plan of CEMOSA within FP3-IAM4RAIL is focused on the technologies developed in WP12 and WP13, focused on civil engineering asset management, which is the main area of action of CEMOSA as a company. More specifically, the developments of CEMOSA are related to Key Exploitable Result KER 12: *Asset management platforms for bridges and earthworks addressing several maintenance planning levels*. This KER will be divided into several sub-KERs, which will constitute new products in the portfolio of CEMOSA:

1. **KER 12.1.** Bridge degradation algorithms for pot bearings using Machine Learning techniques.
2. **KER 12.2.** Bridge degradation algorithms using Operational Modal Analysis and Machine Learning techniques.
3. **KER 12.3.** Earthworks analysis algorithms using data fusion from IoT (Internet of Things) and static data information.
4. **KER 12.4.** Bridge asset management platform (integrating KER 12.1 and 12.2).
5. **KER 12.5.** Earthwork asset management platform (integrating KER 12.3).

This deliverable provides a first analysis of the exploitation plan for these KERs, which will be reviewed in the upcoming deliverables.

4.9.2. Final products and TRL

To achieve the objectives in the previous sub-section, CEMOSA has a strong background in both the civil engineering and data science field. This is summarized in the following table (Table 3):

Current capabilities	Current TRL	Final Products	Final TRL
Machine Learning capabilities applied to infrastructure	TRL 4	Bridge degradation algorithms for pot bearings using Machine Learning techniques	TRL 7
Operational Modal Analysis algorithms using Frequency Domain Decomposition (FDD)	TRL 4	Bridge degradation algorithms using Operational Modal Analysis and Machine Learning techniques	TRL 7
Machine Learning capabilities applied to earthworks. Expertise in earthworks monitoring	TRL 3	Earthworks analysis algorithms using data fusion from IoT (Internet of Things) and static data information	TRL 7

Current capabilities	Current TRL	Final Products	Final TRL
Platform prototypes using the SAP environment and SAP HANA DB	TRL 3	Bridge asset management platform (integrating KER 12.1 and 12.2)	TRL 7
	TRL 3	Earthwork asset management platform (integrating KER 12.3)	TRL 7

Table 4: CEMOSA Key Exploitable Results.

4.9.3. Demonstrators

The KERs of CEMOSA will be tested in two different demonstrators within WP12 and WP13, as presented below:

1. **Bridge asset management:** Viaduct over Arroyo de las Huertas de Mateo, located on line 040 HSL Madrid - Levante, Spain.
    a. **KER 12.1.** Bridge degradation algorithms for pot bearings using Machine Learning techniques.
    b. **KER 12.2.** Bridge degradation algorithms using Operational Modal Analysis and Machine Learning techniques.
    c. **KER 12.4.** Bridge asset management platform (integrating KER 12.1 and 12.2).
2. **Earthworks asset management:** Entrance slope to tunnel 40, CL 800 Palencia-La Coruña, Spain.
    a. **KER 12.3.** Earthworks analysis algorithms using data fusion from IoT (Internet of Things) and static data information..
    b. **KER 12.5.** Earthwork asset management platform (integrating KER 12.3).

4.9.4. Positive impacts

The objective of CEMOSA in FP3-IAM4RAIL is to gradually expand its capabilities on IT technologies for maintenance management in the area of transport infrastructures. The new developments from IAM4RAIL will enable previous capabilities to reach TRL 7, in collaboration with relevant infrastructure managers, contractors and industrial partners. The studies planned by CEMOSA in Europe's Rail and in this project will have a direct impact in CEMOSA's exploitation activities, mainly supporting four business areas:

a. **Maintenance engineering**, by improving the services on monitoring, infrastructure analytics, assistance to maintenance planning and supporting decision-making on maintenance, refurbishment, renewal and rehabilitation investments.
b. **Reliability engineering**, by exploiting the various methodologies at the operational and tactical planning levels that will be developed in FP3-IAM4RAIL.
c. **Design engineering**, by providing railway design projects with improved estimated maintenance costs as well as the life cycle costs of the involved assets.
d. **Development and demonstration** of platform tools for the support in decision-making processes of transport infrastructures.

4.10. COMSA SAU (COMSA)

4.10.1. Introduction to the exploitation plan

The exploitation plan of COMSA is focused on the technologies developed in WP12 focused on civil engineering asset management, because of the strong involvement of COMSA in railways infrastructure maintenance. More specifically, the developments of COMSA are related to Key Exploitable Result KER 12: *Asset management platforms for bridges and earthworks addressing several maintenance planning levels*.

4.10.2. Final products and TRL

COMSA will contribute to the achievement of the final products and final TRL of our industrial partners.

4.10.3. Demonstrators

The KERs of COMSA will be tested in the following demonstrator within WP12 as presented below:

Bridge asset management: Viaduct over Arroyo de las Huertas de Mateo, located on line 040 HSL Madrid - Levante, Spain.

a. **KER 12.1.** Bridge degradation algorithms for pot bearings using Machine Learning techniques.
b. **KER 12.2.** Bridge degradation algorithms using Operational Modal Analysis and Machine Learning techniques.
c. **KER 12.4.** Bridge asset management platform (integrating KER 12.1 and 12.2).

4.10.4. Positive impacts

The objective of COMSA in IAM4RAIL is to gradually expand its capabilities on railways infrastructure maintenance management The new developments from FP3-IAM4RAIL will enable previous capabilities to reach TRL 7, in collaboration with relevant infrastructure managers, contractors and industrial partners.

The studies planned by COMSA in Europe's Rail and in this project will have a direct impact in COMSA's exploitation activities, mainly supporting four business areas:

a. **Maintenance engineering**, by improving the services on monitoring, infrastructure analytics, assistance to maintenance planning and supporting decision-making on maintenance, refurbishment, renewal and rehabilitation investments.
b. **Reliability engineering**, by exploiting the various methodologies at the operational and tactical planning levels that will be developed in FP3-IAM4RAIL.
c. **Design engineering**, by providing railway design projects with improved estimated maintenance costs as well as the life cycle costs of the involved assets.
d. **Development and demonstration** of platform tools for the support in decision-making processes of transport infrastructures.

4.11. ENCLAVAMIENTOS Y SEÑALIZACIÓN FERROVIARIA ENYSE SA (ENYSE)

4.11.1. Introduction to the exploitation plan

ENYSE is in a process of expansion and growth in which the development and updating of its railway solutions is one of the main objectives. To achieve this, the development of an Integrated Asset Management System (IAMS) is essential. Therefore, taking advantage of the great synergies between the ENYSE objectives and the FP3 project of the ERJU initiative objectives, it has been decided to participate mainly in WP3-WP4 of FP3-IAM4RAIL, which provides ENYSE with the opportunity to carry out the development of the IAMS System. In addition, ENYSE will contribute with its experience and its signalling products to the standardization of this type of systems.
The main objectives of ENYSE's exploitation plan in FP3-IAM4RAIL are:

- **Technological Innovation**: development and implementation, applying innovative techniques and tools, to achieve an Asset Management System (IAMS) that has a great impact on railway systems and is at the forefront of technology.
- **Increase Availability**: anticipate possible asset failures by carrying out preventive and predictive maintenance, reducing the risk of asset unavailability.
- **Interoperability**: promote the standardization of an Asset Management System (IAMS) that allows interoperability between different railway networks and technologies, both nationally and internationally. This will allow having for much more competitive products, interconnections between different railway networks and the reuse of equipment.
- **International Collaboration**: collaborate with other railway organizations to benefit from shared knowledge and experiences. In addition, ENYSE also considers this initiative as a great opportunity to increase its international visibility.
- **Cost Reduction**: All technical objectives also converge into an objective of reducing installation, operation and maintenance costs of railway facilities.

The developments of ENYSE are related to Key Exploitable Result KER 1 and KER 2. The KER 1will be divided into several sub-KERs, therefore, remaining as follows:

- **KER 1**: *Platform data acquisition from signalling equipment and sensors, data collection and storage and data analysis for Operation & Maintenance and TMS needs:*
  - **KER 1.1**: Data acquisition, collection and storage platform from signalling equipment, sensors, and other analysis elements.
  - **KER 1.2**: Data analysis for use by Operations, Maintenance and TMS needs.
- **KER 2**: *Decision Support System (DSS) methods and algorithms solution for Data Analytics, TMS and Operation & Maintenance link.*

This deliverable provides a first analysis of the exploitation plan for these KERs, which will be reviewed in the upcoming deliverables.

4.11.2. Final products and TRL

To fulfil the objectives of the exploitation plan, ENYSE is going to provide its ENYBAS product (Level Crossing barrier drive) with a diagnostic system that allows monitoring parameters that may influence the prediction of a possible equipment failure.

In addition, ENYSE is going to incorporate into its ENYMaTT product (Maintenance Management System) a new functionality that allows analysing and correlating the data collected from assets, using algorithms, to predict possible failures. Moreover, communication with the Operation platform and the TMS will also be implemented.
In Table 5 you can see the correlation between KERs and products, and the TRL at the end of the project:

KERs	Sub. KERs	Products	Final TRL
KER 1	KER 1.1	ENYBAS (Level Crossing barrier drive)	TRL 6
	KER 1.2		TRL 6
KER 2	-	ENYMaTT (Maintenance Management System)	TRL 6

Table 5: ENYSE Key Exploitable Results.

4.11.3 Demonstrators

The KERs of ENYSE will be tested in a joint demonstrator with other members of the IAM4RAIL project through a specific use case. This joint demonstrator will have several specific use cases with different locations, dividing these locations between Spain and Italy. ENYSE will install its equipment on a conventional railway traffic line belonging to the Spanish infrastructure manager (ADIF).

4.11.4 Positive impacts

ENYSE, with its participation in the FP3-IAM4RAIL project, will expand its portfolio of solutions for railway systems, providing new alternatives to its clients. In addition, it will allow ENYSE to enter new international markets in which it does not yet have a presence, as well as increase its presence in those in which it is already present.
These innovative solutions will have a great impact on society:

- **Competitiveness:** Increased competitiveness between suppliers due to the trend of standardization of systems, which involves into improved solutions and optimization of costs for clients.

- **Operational**: Reduction of incidents in railway traffic caused by failures in field assets.
- **Energy:** The optimization of railway traffic will reduce energy consumption, contributing to a more sustainable and environmentally friendly railway network.
- **Economic:** All the impacts described above converge in economic savings due to:
    - Cost reduction due to competitiveness between suppliers.
    - Increase in the number of passengers due to improve confidence in rail transport (punctuality in travel). As well as the reduction of economic compensation for operational delays.
    - Reduction in energy costs due to reduced consumption.

The impact on society will be increasing, since the economic reduction will allow reinvestment in new projects that will once again have a great impact, entering a loop of continuous improvement.

4.12. FUNDACIÓN TEKNIKER (TEKNIKER)

4.12.1. Introduction to the exploitation plan

TEKNIKER is a technological center legally constituted as a private not-for-profit Foundation that aims at the development and transfer of technology to improve the competitiveness of industry. TEKNIKER not only provides companies with technological support, but is also involved in generating new business initiatives, which are usually technological and, often, "spin offs" of the center itself. Some examples related to the project are Atten2, an industrial sensor manufacturer recently participated by the largest Spanish utility company (Iberdrola).

TEKNIKER will try to exploit results in the following way:

- **Know-how for new projects**: The knowledge acquired in the project will be further leveraged in new research and development projects and consultancy services at regional, national, and European levels.
- **Publications**: Disseminating the project results through publications in JCR Journals and international conferences is an integral part of TEKNIKER's mission. Throughout the project and after its completion, TEKNIKER will contribute through international scientific publications and keynote presentations related to the outcomes of FP3-IAM4RAIL.
- **Development of new products and technology transfer**: TEKNIKER does not directly create or market new products; instead, it focuses on developing "technology assets" that have the potential to evolve into future products. In this regard, TEKNIER has ATTEN2, a spin-off that works in sensor manufacturing . The technology assets developed in this project will be transferred (licensed) and utilized by these companies.

TEKNIKER will be involved in KER 3 and 4:

- On-board monitoring and inspection technologies for rolling stock (e.g., additional sensors or using the signal coming from traction system).
- Predictive algorithms or ML based analysis for on-board monitoring data capable of supporting the railway maintainers, owners, and operators of the asset management decision-making process.

4.12.2. Final products and TRL

As mentioned earlier, TEKNIKER does not create or market new products directly. Instead, it focuses on developing "technology assets" that have the potential to evolve into future products that can be utilized by other companies. In this project, main objective of TEKNIKER is the development of health monitoring techniques for bogies and drive components. The main idea is to work in rotating machinery where oil systems are involved, so our experience in condition monitoring could be transferred to trains. Actual condition monitoring systems uses one type of principles for failure monitoring.

Our main objective is to merge various sensors and technologies to predict failures in bogies.

Current capabilities are TRL4 and the idea is to achieve a TRL7.

4.12.3. Demonstrators

TEKNIKER is working in WP5 and WP6 in predictive maintenance activities.
Oil sensors will be installed in Alstom and Talgo test benches and data will be used to develop new algorithms. This algorithm could be used in train demonstrators where same sensors will be installed.

UC 5.1 Bogie Monitoring System (on-board) (participant)

These use cases are aligned with the following FP demonstrators:

- Demonstrator #2: Asset Management & Rolling Stock

4.12.4. Positive impacts

Enhanced inspection and monitoring technologies and tools have a positive impact on maintenance operations and provide better support to rail workers. They not only facilitate interventions but also contribute to safer operations and increased cost-effectiveness. Failures will be reduced and maintenance optimized with predictive maintenance.

And as research centre, there will be also scientific impact, with new knowledge and its diffusion.

4.13. FAIVELEY TRANSPORT SAS (FT)

4.13.1. Introduction to the exploitation plan

The goal of the exploitation plan is to fully utilize the developed solutions to have the greatest possible impact and reach. Faiveley Transport, a globally renowned provider of rail systems, intends to use the demonstrated solutions improve the LCC (life cycle costs) for its partners. Furthermore, this effort will yield valuable insights into ways to enhance functionality and improve the overall product experience. Faiveley Transport's specific focus lies in the development of on-board monitoring and digital solutions for railway systems within WP5 and WP6.

To achieve these goals, Faiveley Transport SAS is bringing knowledge from railways system perspective and involving its affiliated entities Faiveley Transport Tours, Faiveley Transport NSF, Faiveley Transport Leipzig to achieve the following goals:

- Improved asset management: Focus is on conducting research and development for railway asset management systems, leveraging predictive maintenance technologies and artificial intelligence. The aim is to minimize downtime caused by failures, enhance reliability, and optimize rail traffic management.
- Enhance decision making: Integrate digitalization with data-driven decision-making by employing big data analytics to enhance the optimization of railway maintenance.
- Lower the cost of railway operation and maintenance: Create and integrate advanced maintenance solutions to effectively lower operational and maintenance expenses.
- Share knowledge with other partners: Collaborate with other project partners and railway organizations to exchange experiences and knowledge. In addition to that, participate in research and development events to publish the obtained results as part of this project.

4.13.2. Final products and TRL

Faiveley Transport is a member of Cluster C, focusing on developing the following capabilities:

- Collecting data from various Faiveley Transport systems, including doors, brakes, and HVACs. Processing and extracting insights from this data to develop Condition-Based Maintenance (CBM) algorithms for the monitored systems.
- Facilitating data exchange with partners to provide extracted data from the systems and receive predictions for upcoming maintenance actions.

The project aims to achieve a Technology Readiness Level (TRL) of 6 by its completion.

4.13.3. Demonstrators

Faiveley Transport is involved in the following use case:

- Health Monitoring & Analytics an ML algorithms development of HVAC, Doors, & Brakes (ES, CAF Fleet)

This use case will be demonstrated as part of the Demonstrator Do2: Asset Management & Rolling Stock.

4.13.4. Positive impacts

The primary focus of result exploitation is to enhance competitiveness by integrating innovations from diverse fields of knowledge. Within the span of its topics, Faiveley Transport foresees the following positive impacts:

- The adoption of CBM and predictive maintenance, advanced techniques, and asset management tools not only enhances maintenance practices and safety but also reduces costs associated with unplanned downtime and prolongs the lifespan of assets.
- Improving train performance and reduce downtime will result in decreased energy consumption in rail operations. This allows trains to operate more efficiently, leading to lower energy consumption and contributing to a greener and more sustainable rail network.
- Utilizing a CBM and predictive maintenance approaches reduces overall maintenance costs by optimizing resource allocation and ensuring timely interventions. As a result, this leads to cost savings for rail operators. This will improve the attractivity of rail travel over other travelling modes.

4.14. FERROVIE DELLO STATO ITALIANE SPA (FS)

4.14.1. Introduction to the exploitation plan

FS participates in FP3-IAM4RAIL together with three affiliated entities: RFI, ITALFERR and TRENITALIA. FS is a public Italian railway holding, RFI is the railway infrastructure manager in Italy, Trenitalia is the Italian railway undertaking (train operator), and ITALFERR is an engineering railway company. When describing FS's exploitation plan, its affiliated entities are included.

Some of the objectives that FS intends to achieve with FP3-IAM4RAIL are:

- Development and implementation of new technologies: promotion of technological innovation in both the maintenance techniques of rolling stock and railway infrastructure (including civil works) to improve the efficiency and safety of railway circulation.
- Intelligent asset management: research and development of asset management systems for railway infrastructures, which exploit and implement predictive maintenance technologies, by artificial intelligence, to reduce downtime due to failure and improve reliability and rail traffic management.
- Digitalisation: combine digitalisation with data-driven decision-making using data detection sensors, IoT (Internet of Things) and big data analytics to optimise railway traffic and maintenance.
- Knowledge sharing with project partners: Exchange and sharing of experiences and knowledge with other project partners and railway organisations, participating in international research and development events.
- Reducing costs without reducing the quality of the railway service: develop and implement innovative maintenance technologies for rolling stock and railway infrastructure that help reduce operational and maintenance costs while maintaining or improving the quality of the railway service.

The prototypes and demonstrators developed in the FP3–IAM4RAIL project aim to achieve the technological and maintenance objectives described above.

4.14.2. Final products and TRL

FS participates in the FP3-IAM4RAIL project as a public entity with the aim of improving the railway system and contributing to the development of innovative technological systems for infrastructure and rolling stock maintenance to guarantee the best service to its users. The products developed under FP3-IAM4RAIL, in which FS and its affiliated entities will participate, are the following:

Cluster B:

RFI (affiliated of FS) is mainly involved in the WP3 and WP4 with the development of IAMS (Integrated Asset Management System) for wayside and infrastructure assets.

RFI participates collecting and providing data from different generation of on-board and wayside signalling equipment (including but not limited to track circuits, S&C, balises, signals etc.), diagnostic data of civil infrastructure assets (focusing mainly on several kind of bridges) and data coming from diagnostic vehicles (e.g., Track Geometry, Lidar, Accelerometers, etc.). This data, via a specific communication interface, is stored and transmitted to a remote data platform. Integrated Asset Management System (IAMS) aims to provide advanced data collection, processing, analysis and integration with traffic management systems (TMS). The final TRL expected at the end of the project is 6.

RFI also intends to contribute to the development of an obstacle detection system to be applied on railway level crossings based on the fusion of two different technologies: Lidar and Radar. The final TRL expected at the end of the project is 5

All the initiatives are related to KER 1 and KER 2.

Cluster D:

RFI (affiliated of FS) is mainly involved in WP12 and WP13 with the development of "Multiscale monitoring of civil assets" System for the control and management of the entire life cycle of civil infrastructure assets (e.g. bridges), railway infrastructures and the surrounding territory (vegetation, landslides, floods and other external factors affecting the railway infrastructure). This system integrates the use of surveys and data carried out by Unmanned Aerial Vehicle (drones), satellite technology and various sensors.

RFI contributes by providing specific data (previous infrastructures' surveys, and new acquisitions by the means and sensors made available by the project partners) from the selected infrastructure sections chosen to be the most appropriate for performing the analysis and the related maintenance regulations. These sections belong to Torino – Novara High Speed Line.

They are related to KER 10, KER 11 and KER 12.

The final TRL expected at the end of the project is 6/7.

Cluster E:

ITALFERR (affiliated of FS) is developing a Blockchain application to manage the certifications of the railway infrastructure. The Blockchain application is envisioned as the core element of a Virtual Certification Framework based on Digital Twin that collects actors and actions for the purpose of the railway infrastructure asset certifications issue and management. The application is the KER 15 and it is being developed in WP14-15 with target TRL 6.

Current best practices in place employ centralized database, paper-based processes, rely for most part on manual data processing and do not exploit the advantages of Digital Twin. The blockchain solution and the Virtual Certification Framework based on Digital

Twin aim to alleviate some short coming of the traditional approach, especially in the context of the relations with the validation bodies.

Cluster F:

Trenitalia is involved within the WP18 aimed at introducing novel robotic solutions for monitoring, inspection and intervention in the railway asset (from the infrastructural as well as rolling stock point of view). Precisely, the main goal of the WP18 is defining the fundamentals for a robotic ecosystem where robotic solutions compliant with the scope of WP18 could be coexistent thanks to a proper choice of a common middleware, a level of modularity as high as possible, and also, last but not least, a right compliance with safety Norms thanks to a safety assessment.

RFI is involved within the WP19 aimed to develop a new and smart assistive tool to support workers in their daily railway maintenance tasks. More specifically, Exoskeleton and Augmented Reality systems to improve skills and human safety. They are related to the KER 20 and KER 21.

4.14.3. Demonstrators

For WP3-WP4, in order to develop a IAMS platform for wayside assets, RFI makes its railway infrastructure available, both by hosting the demonstrator in railway node of Quadrivio Turro in north Italy (Lombardia), and by providing infrastructural maintenance and wayside data (on Novara-Milano HS Line). The final objective is to have a centralized interface for collecting and managing data from various subsystems involved in monitoring.

The aim of this demonstrator, through development of algorithms and models for asset status prediction and anomaly detection, through automatic data collection from different wayside and infrastructure systems (stored on the IAMS platform) is to evaluate the asset status prediction (in First Phase, to implement, if necessary, eventual improvements to the system in second Phase - Complete IAMS Platform Implementation). In the Second Phase of the project RFI will provide all useful information to create a user interface and the implementation of defined functionalities, according to Internal and national Roles.

Also, the development of an obstacle detection system to be applied on railway level crossings, multisensor system based on the fusion of two different technologies: Lidar and Radar, will be developed and tested in a near-real environment, at the laboratories of the project partner.

Demonstration will be aligned with:

- FP1/TT: Conceptual Data Model specification developed in FP1 and data sample coming from the current here above-described use case.
- FP1: Definition of specific requirements for data exchange protocols and format to implement the TMS-IAMS channel.

For WP12-WP13, in order to develop a "Multiscale monitoring of civil assets" Platform, RFI makes its railway infrastructure available, both by hosting the demonstrator in the railway area which includes the Quadrivio Turro in northern Italy (Lombardia) and extends up to Piemonte, in correspondence with high-speed line Milan-Novara, and providing infrastructure data (ground data from diagnostic vehicles, UAVs data for bridge asset monitoring of several structural typologies; climate data, mainly measures of temperature and rainfall...) to integrate and manage all data coming from the various subsystems to monitor.
In particular, the demonstrator for bridge monitoring must achieve the objective of automating the identification of structural defects present on civil infrastructure by Machine Learning models for data analysis, creation and testing of models (typically Neural Networks) to automatically identify defects, their intensity and extent (according to the Bridge Management System in use at RFI). Application of techniques and models for estimating the residual life of civil infrastructure and Predictive Maintenance, exploiting the data obtained from the acquired material.

The Blockchain application for the railway infrastructure certification (KER 15) will be demonstrated by staging an instance of the Virtual Certification framework integrating the demonstrative initiatives of WP14-15 partners. The demonstrator will be developed in task 15.4.2 and will purse the demonstration objective DO5. "To demonstrate Digital Twins for the optimization of processes, maintenance planning". The demonstrator will contribute to the overarching integrated demonstrator #5: "Asset Management & Digital Twins" and #6: "Design and Manufacturing"

Within the WP18, Trenitalia is the leader of task 18.4 concerned with management and development of the operative tasks of all the use cases (from grant Agreement, task 18.4 – "Use cases related tasks"). In addition, Trenitalia is directly involved in two use cases out of six as follows:

- A disinfection robot aimed at sanitizing the rolling stock as well as the small stations (from Grant Agreement, subtask 18.4.3).
- The SW developments of the ARGO robot, a modular mobile platform equipped with embedded sensors and based on mutual cooperation between robotics and AI techniques, mostly machine learning (from Grant Agreement, subtask 18.4.4).

In both cases, Trenitalia is available to host experimental campaigns during the Project in maintenance depots sited in Rome and Florence, according to what has been declared in past documents.
For WP19 in order to validate the technology developed makes its railway sperimental situ (Circuito Sperimentale Bologna San Donato) available, both by hosting the demonstrator and providing the infrastructural maintenance and wayside data needed. RFI is an active participant within all the development of the technology starting from the collection and analysis of needs from operators, as support from infrastructure

manager during the design of technologies, to the validation of them.

4.14.4. Positive impacts

The expected impact of an asset management system integrated with existing systems, (IAMS platform) is represented by an important technological evolution, providing improvements in data collection, which occurs automatically from the various subsystems, providing important and substantial insights into asset performance. Furthermore, the system uses algorithms and models for resource status prediction and anomaly detection, enabling proactive maintenance and reducing downtime, optimizing rail traffic planning and resource use.

While the expected impact of an obstacle detection system to be applied on railway level crossings (based on the fusion of two different technologies: Lidar and Radar) is the innovative combination of technologies offers greater reliability in terms of obstacle detection and subsequent communication to the TMS.

In fact, the system would allow the monitoring of singular points of the infrastructure where railway and car/pedestrian traffic intersect, increasing the safety of the system (circulation, employees, users), reducing slowdown requirements and the related management costs.

The expected impact of the development and implementation of a "Multiscale monitoring of civil assets " system for the control and management of the entire life cycle of civil infrastructure assets (e.g. bridges), railway infrastructures and the surrounding territory (vegetation, landslides, floods and other external factors affecting the railway infrastructure) is to integrate and optimize all the information coming from various data sources and from different technologies in order to provide support to the operator in maintenance and decisions, making the processing of the acquired data more usable for those who involved in the maintenance activities of the railway infrastructure, currently managed separately and not integrated, also reducing response times to a minimum and obtaining results in the emergency phase.

In particular, "bridge monitoring" platform could be a valid support for the decisions phases with the aim of automating part of the analysis activities carried out manually to date.

The expected impacts of the Blockchain solution for the railway infrastructure certification are aligned with the Technical Objective (TO) 6 "To enable advanced and holistic design and certification of assets" to contribute to the pursuing of the socio-economic objectives SEO4 "Increase the number of assets managed and monitored by Digital Twins in 25% to increase digitisation in the railway sector", SEO6 "Time reduction (from design to manufacturing) in 20%" and SEO7 "Cost reduction of new designs up to 20%". The expected direct impacts are:

- improved overall cost and time to deliver the system;
- improved accountability;

- improved cost and time to investigate late non-conformities and resolve litigations.

As part of a Digital Twin-based Virtual Certification Framework:

- improved confidence for asset conformity and safety.

Within the WP18, Trenitalia is positive about thinking achievable the following KPIs, according to what declared in the Grant Agreement:

- Increased accuracy of inspections of 25% with respect to conventional interventions.
- Reproducibility of inspections of 25% with respect to conventional interventions.
- Cost reduction of the interventions by at least 10%.

The positive impacts of the WP19 are in maintenance operations and support to rail workers, by:

- training old and young operators;
- optimize inspection & monitoring technologies and tools that facilitate interventions;
- contributing to safer operations and cost effectiveness.

4.15. HITACHI RAIL STS SPA (STS)

4.15.1. Introduction to the exploitation plan

Hitachi Rail STS is mainly involved in the WP3 and WP4 with the development of IAMS (Integrated Asset Management System) for wayside assets, represents the opportunity to improve innovative asset management solutions started in Shift2rail projects, resulting in a relevant increase of efficiency and attractiveness in the market.
Within FP3-IAM4RAIL, STS will improve the platform capabilities for data collection, processing and correlation. One of the main objectives is to interact with the TMS, sharing analytics results and prediction to improve the management of train operation. One example of such interaction might be that IAMS suggests to the TMS to set an alternative route inside a train station for the scheduling of heavy freight trains in order to reduce the stress on old or anomalous switches and limit the possibility of failures. In doing so, FP3-IAM4RAIL will also build upon the work done on the CDM (Canonical Data Model) in previous S2R projects and provide contribution for its enhancement.
Within the project Wayside and Infrastructure Monitoring Systems will provide a remote and centralized interface to each subsystem involved, automatically collecting reports, functional parameters, logs, alarms and other diagnostic data, and storing them on the dedicated data platform. The collected data is then processed, cleaned and stored in a database in order to provide easy access to the maintainer, enable correlation of different sources and serve as a starting point for the development of data analytics procedures.
The information that are derived from the collected data, that will range from statistics about some key operative indicators, prediction on assets status and of possible anomalies, will be exploited mainly to improve the maintenance activities to be performed and to optimize the scheduling of traffic. This will create therefore a link both with the Decision Support System and with the Traffic Management System.

4.15.2. Final products and TRL

Integrated Asset Management System (IAMS) aims to provide advanced data collection, processing, analytics, and integration with Traffic Management Systems (TMS).
Railways often rely on traditional, manual methods for asset management, resulting in limited data collection and analysis capabilities. Maintenance activities are typically scheduled based on predefined intervals rather than real-time data.
IAMS represents a significant advancement over traditional methods, providing improvement in data collection, making automatic data collection from various subsystems, providing insights into asset performance.
Moreover, the system utilizes algorithms and models for asset status prediction and anomaly detection, enabling proactive maintenance and reducing downtime.
The final product will result in a IAMS platform integrated with the existing systems that

will enhance the sharing of analytics results and predictions with Traffic Management Systems to optimize train scheduling, route planning, and asset usage.
This platform will be designed with a multipurpose approach so that could be used on other contest also.
The final expected TRL at the end of the project is 6.

4.15.3. Demonstrators

IAMS platform capabilities will be developed and demonstrated in Wayside and Infrastructure Monitoring System focused on the regional railway node of Quadrivio Turro in north Italy. This system's objective is to provide a centralized interface for collecting and managing data from various subsystems involved in monitoring. The demonstrators will include:

- Preliminary Analytics Design: General architecture and validation process will be established for the analytics component of the system. This will include development of algorithms and models for asset status prediction and anomaly detection.
- Data Collection Implementation: Automatic data collection will be implemented from different wayside and infrastructure systems. This data will be stored on the IAMS platform, creating a repository for further analysis. Data from signalling assets at "Quadrivio Turro" and diagnostic information from the Novara-Milano line will be included.
- Evaluation of Initial Results: Initial results obtained from the analytics component, specifically focusing on asset status predictions will be evaluated. Feedbacks and insights will be gathered during this phase to make improvements to the system.
- Complete IAMS Platform Implementation: The project will move towards a full-fledged IAMS platform with a user interface and the implementation of defined functionalities. IAMS platform will serve as the central hub for data storage, processing, and access. Validation of the platform's results will be conducted by actively involving users from the industry who will provide feedback and reports.

Demonstration will be aligned with:

- FP1/TT: Conceptual Data Model specification developed in FP1 and data sample coming from the current here above described use case.
- FP1: Definition of specific requirements for data exchange protocols and format to implement the TMS-IAMS channel.

4.15.4. Positive impacts

The main scope of result exploitation will be to improve the Competitiveness on the market and this will be fulfilled by developing and demonstrate this IAMS platform. Therefore Hitachi will increase its competitiveness on international market, not only

specifically railways but e.g. metros, having a better profile in terms of added values to its hand key transport systems.
More in details improvements are expected throughout the following aspects list.

- **Operational:** Outcome of the project in terms of IAMS for wayside monitoring will enhance operational efficiency by providing data-driven insights for better scheduling, route optimization, and traffic management. This leads to smoother operations, reduced delays, and improved service reliability.
- **Maintenance:** The use of predictive analytics and asset management tools improves maintenance practices. Predicting asset status and anomalies allows for proactive maintenance, reducing unplanned downtime and extending asset lifespan.
- **Cost Effectiveness:** The data-driven approach lowers overall maintenance costs through optimized resource allocation and timely interventions. This results in cost savings for rail operators and, potentially, reduced ticket prices for passengers.
- **Energy Efficiency:** By optimizing train scheduling and traffic management, energy consumption in rail operations will be reduced. Efficient routes and better coordination mean trains can operate with lower energy consumption, contributing to a more sustainable and eco-friendly rail network.
- **Customer Experience:** Passengers benefit from more reliable and punctual services, enhancing their overall experience and increasing the attractiveness of rail travel as a mode of transportation.

4.16. INDRA SISTEMAS SA (INDRA)

4.16.1. Introduction to the exploitation plan

INDRA participates in FP3-IAM4RAIL as a technological solutions supplier with proven experience in providing solutions within the railways domain and experience in R&D projects and initiatives as Shift2Rail and ECSEL.

Some of the objectives that INDRA intends to achieve with FP3-IAM4RAIL are:

- Technological innovation: Promotion and development of technological innovation to enhance the efficiency and safety of railway operations and maintenance .

- Asset management: Researching and developing better asset management systems for railway infrastructure, including predictive maintenance technologies to reduce downtime and improve reliability.

- Interoperability: Promoting interoperability between systems, using open standards for operation and data sharing.

- Digitalisation: Digitalisation and data-driven decision-making based on detection sensors, IoT (Internet of Things) and data analytics to optimise railway operations and maintenance.

- Cost reduction: Developing and implementing innovations that help reduce operational and maintenance costs while maintaining or improving the quality of railway services.

The FP3–IAM4RAIL project intends to put into practice the demonstrators and prototypes developed to validate the different objectives described above.

4.16.2. Final products and TRL

Cluster B:

- INDRA participates in the enrichment of Integrated Asset Management System (IAMS) aims to provide advanced data collection, processing, analytics, and integration with Traffic Management Systems (TMS). INDRA will participate Collecting data from signalling assets in High speed lines with the goal of achieving TRL6.

It is related to KER 1, KER 2, KER 8.

Cluster C:

- INDRA participates in WP7 focusing in the improvement of rolling stock inspection and monitoring by developing and deploying new predictive maintenance strategies based on Machine Learning applied to images recognition and processing and data fusion.
- Input data will be wayside information coming from Standardized Railway Checkpoints. The development of will focus on covering several use cases identified during the development of the project, related to the improvement of predictive maintenance leading to reducing operation time and costs. The checkpoint implemented will aim to a TRL 6. It is related to KER 3 and KER 5.

Cluster D:

INDRA participates In WP9 the development of Smart Sleeper for infrastructure monitoring. The sleeper is designed to include energy harvesting capabilities, along with multi-sensor data recording and processing (temperature, flood detections, loading conditions or vibrations), and effective tools for the automatic assessment of its conditions and decision-making. The smart sleeper implemented will aim to a TRL 8.

4.16.3. Demonstrators

INDRA will participate in several demonstrators, developed in different relevant locations in Netherlands and Spain. Those demonstrators are directly related to the use cases identified in the scope of the project.

Regarding the Cluster C, INDRA will participate in the following demonstrator:

- Demonstrator 2: Asset Management & Rolling Stock. Within which the Use Cases covered will include:
  - UC 7.4: Railway checkpoints use case (ES) (participant).
  - UC 7.7: Data Analytics for Railway Checkpoints Use Case (leader).

As the leader of UC 7.7, INDRA will contribute to the standardization of data analytics models and the infrastructure for the management of such data.
Besides, regarding the participation in UC 7.4, INDRA will contribute to the definition of required technologies, needed to cover the functionalities required to meet the WP7 goals.

- Demonstrator 4: Asset Management & Infrastructure. TRL 6.
  - UC 9.1: Sensing railway superstructure system components (leader).
  - UC 9.3: Track Geometry and S&C condition monitoring (participant).
  - UC 10.1: Linking (new) monitoring technologies to asset management issue (participant).

INDRA intends to participate in the following locations:
Deploying sensors in order to monitor turnouts and analyse the collected data for maintenance purposes.

  - HS Turnouts: high-speed turnout Bif. Torrejón de Velasco – Valencia Joaquín Sorolla, Spain.

- Demonstrator 4: Asset Management & Infrastructure. TRL 6.

  - UC 9.1: Sensing railway superstructure system components (leader).
  - UC 10.1: Linking (new) monitoring technologies to asset management issue (participant).

INDRA will participate by deploying it´s smart sleeper in some of the agreed locations (not defined yet):

  - Bridge: viaduct over Arroyo de las Huertas de Mateo, located in line 040 HSL Bif. Torrejón de Velasco – Valencia Joaquín Sorolla, Spain.
  - Earthworks: entrance slope to tunnel 40, CL 800 Palencia-La Coruña, Spain.
  - HS Turnouts: high-speed turnout Bif. Torrejón de Velasco – Valencia Joaquín Sorolla, Spain.
  - Turnout in Mediterranean Corridor: Passing loop Rifá | Line 600, Vandellós - Tarragona section.
  - Tunnel: Feasibility study for tunnel convergence measures with a passive contactless magnetic microwire.

4.16.4. Positive impacts

Technology when implemented will have positive effect on Operational and Maintenance fields. Cost effectiveness will improve and transparency and decision making, without reducing quality and safety.
Main goals of INDRA will be:

- Automatization of current manual processes, such as assets and defects identification.
- Distributed monitoring of the infrastructure.
- Digitalization of the information and standardization.
- Reduction of downtimes in maintenance workshops.
- Improvement of predictive maintenance, thanks to the recording of different data in relevant locations.
- Digitalization of the information and standardization.

Achieving this goals will INDRA participation will have a specific impact in the following aspects:

- **Operational**: Wayside monitoring will enhance operational efficiency by providing data-driven insights for better scheduling, route optimization, and traffic management.

- **Maintenance**: The use of predictive analytics for anomaly detection and prediction of track structure components conditions that will allow preventing failures by real time monitoring of systems status, maintenance activities can be more efficiently planned and prepared, optimizing resource allocation and timely interventions resulting in cost savings.

4.17. PATENTES TALGO SL (TALGO)

4.17.1. Introduction to the exploitation plan

TALGO is committed to deliver innovations related with assets management an increase the life span of rolling stock components.
Our experience is based on a self-created model in which constant improvement is guaranteed through a virtuous cycle, which encourages feedback from specific experiences to develop new engineering solutions.
This model also allows us to follow the technological lifecycle of a specific product as well as become specialists in maintenance and replacement of all kinds of rolling stock through:

- Technological innovation
- Maximum availability and reliability
- Quality and safety guarantee
- New maintenance solutions
- Product LCC optimisation

E-Maintenance and Reliability Centered Maintenance (RCM) aim is to optimize the comprehensive maintenance of trains and to extend the lifecycle of a specific product.

4.17.2. Final products and TRL

No final products are going to be delivered.

4.17.3. Demonstrators

As described in the GA, High level TRL:

- Railway checkpoint for wayside train HMS, TALVI.
- On-board system for HMS, T-Smart.
- Repair metallic assets, wheel application.

4.17.4. Positive impacts

The main scope of result exploitation will be to improve the competitiveness on the maintenance service market bringing innovation from different fields of knowledge. The use of predictive maintenance, advance techniques and asset management tools improves maintenance practices and safety and reduce cost from unplanned downtime and extending asset lifespan.
Also, these activities are aligned with the improvement of sustainability on the railway system.

4.18. NORWEGIAN RAILWAY DIRECTORATE (NRD)

4.18.1. Introduction to the exploitation plan

This exploitation plan summarizes NRD's and its affiliates strategy and action for exploiting project results. The plan establishes the basis for protecting intellectual property and exploitation activities. The protection strategy will rely on scientific publishing of results within international conference proceedings and scientific journals. Results will be exploited through further maturation in future projects in Europe's Rail while continually adapted by the Norwegian national infrastructure owner Bane NOR. The Norwegian Railway Directorate is currently establishing a national network focused on the innovations in the field of railway maintenance. This network is inspired by the topics covered in the project FP3-IAM4RAIL. The project will thus use this network for efficient dissemination to all national railway sector and research actors.

The project results will contribute to KERs 7, 12 and 18 through the development of the methodologies and technologies accordingly listed in Subsection 4.18.2.

4.18.2. Final products and TRL

The final products targeted in this project are:

1. Improved methodology compared to state-of-the-art for estimating remaining service life of critical elements in steel bridges due to fatigue at increased accuracy (TRL6). Currently, the modeling methodology used by Bane NOR has high uncertainty and thus large safety factors leading to conservative estimates of remaining service life.
2. Improved methodology compared to state-of-the-art for detecting specific damages in concrete bridges based on sensor data (TRL6). Currently, Bane NOR does not have a standardized monitoring system that is scalable for the amount of bridges found in Norway.
3. Sensor system for mapping tunnels interior with inbuilt navigation functionality (TRL6). Currently, Bane NOR does not have such technology with necessary mapping accuracy or functionality required by the use-case.

4.18.3. Demonstrators

The results will contribute to Demonstrators #3 and #7 by providing more accurate information about current and future states of the infrastructure, which are important aspects for developing decision support for optimizing lifecycle cost. Important contribution is recommendations for instrumentation and data analysis for infrastructure monitoring that can be adopted by the national infrastructure owner Bane NOR. The results of the demonstrators will be exploited through continued development for maturing of the methodologies and develop the methodologies into technologies and products beyond the FP3-IAM4RAIL project. Target is to continue the developments through subsequent Europe's Rail projects.

4.18.4. Positive impacts

Enhanced methodologies for infrastructure inspection and monitoring by increased accuracy in prognosis and earlier detection of faults will:

- Reduce risk of accidents with possible fatal consequences.
- Increase availability due to better planned maintenance activities.
- Reduce maintenance and repair costs.
- Provide more accurate information increasing efficiency in renewal programs.

The research will improve the national competency within railway infrastructure monitoring, which is important to develop scalable tools and technologies needed to address the problem of aging railway infrastructure.

4.19. KNORR-BREMSE SYSTEME FUR SCHIENENFAHRZEUGE GMBH (KB)

4.19.1. Introduction to the exploitation plan

The exploitation plan aims at maximizing the impact and reach of the developed solutions. Knorr-Bremse is a worldwide active rail components and systems provider, and the achieved demonstrators will be used to reduce life cycle costs for partners and customers. It will also provide valuable insights into how to improve functionality and provide improved product experiences.
Knorr-Bremse is focusing on WP5 and WP6 developing on board monitoring and digital data transmission capabilities supporting the following KER:

Id.	KER – Key Exploitable Result
KER 3	On-board monitoring and inspection technologies for rolling stock (e.g., additional sensors or using the signal coming from traction system).
KER 4	Predictive algorithms or ML based analysis for on-board monitoring data capable of supporting the railway maintainers, owners, and operators of the asset management decision-making process.

Table 6: KB Key Exploitable Results.

4.19.2. Final products and TRL

Knorr-Bremse is focusing on the following product capabilities:

- Implementation of digital value chain for several KB subsystems covering data collection (for example through new sensor equipment), data pre-processing & transmission, data preparation and analysis. The aim is to enable CBM of the covered systems and components.
- Cloud to cloud connectivity with partners to exchange data and actionable information.

These products shall reach a TRL 6 by the end of the project, enabling further development into serial products in subsequent projects.

4.19.3. Demonstrators

KB is involved in the following use cases:

- Health Monitoring & Analytics of HVAC & Brake systems (ES, Talgo fleet)
- Health Monitoring & Analytics and ML algorithms development of HVAC, Sanitary Systems & Brakes, Traction & auxiliary system (NL)

These use cases are contained with the following FP demonstrator:

- Demonstrator #2: Asset Management & Rolling Stock

Demonstrations will take place in Spain and in the Netherlands.

4.19.4. Positive impacts

The aim of the use cases is to reduce maintenance costs and improve availability of the fleets. By monitoring the actual status of systems, maintenance activities can be more efficiently planned and prepared, and status indications can reduce the duration of required tasks. More exact information about the systems can also allow for improved lifetime utilisation and a reduced need of material and spare parts.

Over time, collected data can enable better prediction and prevention of failures, and reduce the amount of in-service failures, which are a major cost driver for the rail operators.

4.20. ÖBB-TECHNISCHE SERVICES-GMBH (ÖBB TS)

4.20.1. Introduction to the exploitation plan

ÖBB TS, as ECM or "Entity in Charge of Maintenance", is the company responsible for the maintenance of ÖBB's rolling stock (passenger coaches, EMUs, locomotives, freight waggons etc.) covering all necessary functions, processes, and roles from ECM1 to ECM4. As such, we can provide a "customer view" on the one hand, as well as specific domain knowledge on the other hand to the consortium. In regards of FP3 - IAM4Rail ÖBB TS aims to exploit the results for the improvement of **maintenance methods** for rolling stock, hence:

- Obtaining new ways for **wayside asset status data collection and maintenance related train inspection**.
- **3D-printing** of rolling stock specific **spare parts**. In order to use these novel manufacturing technologies and materials for maintenance purposes, railway-specific requirements need to be met.

4.20.2. Final products and TRL

ÖBB TS's R&D activities will therefore cover:

- Definition and development of condition monitoring use cases from a maintenance prospect as well as the necessary sub-system development of the cameras, sensors to be used on the demonstrators in the later stage for condition monitoring of passenger and freight trains.
- Optimised preventive, condition-based, prescriptive or corrective maintenance strategies for the assemblies and components defined in the use cases.
- Development of additive manufacturing repair techniques and metallic materials for infrastructure and rolling stock assets.
- Selection of suitable and feasible manufacturing processes for each use case.
- Market research and qualification of polymers and compounds for spare parts.
- Development of a digital warehouse for the supply of spare parts.
- Any testing will be done under real conditions.

4.20.3. Demonstrators

WP7:

- Main focus of OEBB TS will be the activities covered in Task 7.2 for the research & development of the technologies for wayside use cases such as:
    - UC7.1.: Bogie monitoring (using video and imaging technologies)
    - UC7.2.: Pantograph monitoring (using video and imaging technologies)
    - UC7.3.: General physical anomaly detection (using video and imaging technologies)
- If applicable, assistance in other related topics (Tasks 7.1, 7.3, UC7.8, HERD etc.)

- The large scale system integration, testing and application of the technology developed by 7.2 shall be covered by the demonstrators (TRL6) in Task 7.3.

WP17:

- Task 17.3.: Market research for and qualification of flame-retardant polymers and elastomers for spare parts.
- Task 17.4.: Digital warehouse and methods for systematic analysis and identification of spare parts.

4.20.4. Positive impacts

- Introduction of new capabilities and competences in vehicle maintenance.
- Through the resulting data driven approach, the condition monitoring system shall demonstrate that it can increase the quantity and quality of available information (regarding the train condition) for the workshop employees as well as reduce costs, preventing errors and reducing risks in the maintenance-process.
- Additive Manufacturing and batch production capabilities, increasing availability of polymer and metallic components.
- Digital warehouse to improve the supply chain for maintenance.

4.21. POLSKIE KOLEJE PANSTWOWE SPOLKA ACKYJNA (PKP)

4.21.1. Introduction to the exploitation plan

PKP has been working on one primary topic within FP3-IAM4Rail: Decision support systems for railway station asset management. Asset management will be improved by:

- Data centralization by Data Lake;
- Tracking of economic indicators;
- Support in asset related business processes;
- maintaining cleanliness at train stations;
- Improving asset maintenance by predictive models;
- Integration of structural health monitoring.

KER 14 will be achieved directly by introduction proposed solution.
This will be also integrated with other partners solutions. Milestones of the project are the construction and test of the laboratory-prototype (scheduled for November 2024). The pilot-phase shall begin in early 2025.

4.21.2. Final products and TRL

The final product will be a distributed decision support system (DSS), working on multiple levels of organization. The system will integrate Data Lake, DSS logic, business logic and dashboarding solutions. Desired TRL is 6. At the moment no such solutions are being widely used. Current TRL regarding such technologies is between 2 and 3.

4.21.3. Demonstrators

PKP together with their partners in WP14 and WP15 will create a distributed demonstrator parts of which will be in Malaga Maria Zambrano Station and parts in Łódź Kaliska Station. Depending on which component of the DSS is more relevant for the location.

4.21.4. Positive impacts

The asset management of stations will benefit in multiple aspects. The most important one would be a data centralization mechanism that comes from the introduction of the Data Lake solution to the asset management process. Process will be streamlined by formal identification of asset management data streams and their integration maps. Moreover proposed solution will increase the maintenance coverage of multiple assets, with a special focus on accessibility related ones. Finally, the response time regarding cleanliness incidents will be reduced thanks to provided solutions.
Additional positive impact will be project result dissemination. We are looking forward to disseminating our project’s results at multiple conferences and events, such as the MMAR and the IECON. Additionally, scientific papers will be published.

4.22. PRORAIL BV (PR)

4.22.1. Introduction to the exploitation plan

PR participates in FP3-IAM4RAIL with TUDelft as an affiliated entity. PR is the Dutch railway infrastructure manager and works with the Section of Railway Engineering of TUDelft in various research and development projects.

Innovation is necessary for the growth of the Dutch rail network. One of the goals of PR in ERJU is to modernize railway infrastructure technology while thinking along and developing them with European partners from the railway industry. State-of-the-art leading-edge asset management technologies for infrastructure and rolling stock allow for minimized life-cycle costs and extended life cycles while meeting requirements on the railway system's sustainability, safety, reliability, availability, and capacity.

We expect collaboration with partners in FP3-IAM4RAIL, which are key players in the railway industry, and to increase interoperability and accelerate breakthroughs so we can improve our sustainability and societal targets, such as making an affordable rail public transport system possible. By participating in FP3-IAM4RAIL, we expect The Netherlands to present itself as a testing ground for European rail innovations.

4.22.2. Final products and TRL

PR in FP3–IAM4RAIL project is working on the in-field deployment of new technologies and developing new experimental methods as part of demonstrators and prototypes.

Cluster C:

- PR and TUDelft will contribute to developing anomaly detection and component health evaluation algorithms in traction systems, focusing on Coefficient of Friction estimation. The current developments are at TRL3-TRL4, with a target TRL4-TRL5 at the end of the project. Key exploitable results: KER3 and KER4.

Cluster D:

- PR and TUDelft will contribute to the use of laser Doppler vibrometer (LDV) and axle box acceleration (ABA) measurements for the estimation of transfer functions of the railway track (inputs are from ABA and outputs from LDV). The ABA technology has a TRL7 and the LDV technology a TRL4. Their combined use has not been tested before, and we have a target TRL3 at the end of the project. Key exploitable results: KER2 and KER8.
- PR and TUDelft will contribute to using axle box acceleration (ABA) measurements and track geometry measurements to obtain estimations of the embankment stability. The ABA technology currently has a TRL7, while track

geometry is a common practice TRL9. The application of both for the analysis of embankment has not been done in the past, and we aim for a TRL3 at the end of the project. Key exploitable result: KER12.

4.22.3. Demonstrators

PR participates in the following demonstrators:

- Demonstrator 2: Asset Management & Rolling Stock
    - UC 6.4 Adhesion estimation for management

- Demonstrator 4: Asset Management & Infrastructure
    - UC9.4 Infrastructure monitoring solutions
    - UC9.5 Prescriptive maintenance solutions
    - UC 12.4 The Netherlands-Norway Use Case: bridge and embankment monitoring

4.22.4. Positive impacts

FA3-IAM4RAIL offers PR a unique opportunity to work with influential partners on monitoring technologies, decision-making, detection, and automated understanding of the railway system oriented at high TRL levels. With the demonstrators, we expect to test the latest technologies in the Dutch railway network and to participate in other EU demonstrators with an impact on the Netherlands. Opportunities to work with the latest technologies will allow their fast implementation in the Dutch network.

By increasing TRL levels of our technologies, we will make the design of decision-making support possible based on onboard and wayside inspection of infrastructure and rolling stock, including non-contact optical laser-based monitoring, dynamic-based monitoring, adhesion management (tribo-sensors), embankment stability estimators, etc.
Working together in Europe will facilitate our transition to digitalization. One goal – One language for Digital Twins, ATO, Cross-border operations, better ways to connect interfaces, train/infrastructure, homologation, and normative.

4.23. NS REIZIGERS BV (NSR)

4.23.1. Introduction to the exploitation plan

NSR is pleased that, together with ProRail, it can contribute to the developments and innovation within the FP3-IAM4Rail programme. Main goal for NSR is to be able to take a big step in (further) developing predictive maintenance through this innovation approach.

By collaborating with key players in the railway industry and sharing advanced asset management technologies, we aim to minimise life-cycle costs and extend the life of our rolling stock. Our participation in FP3-IAM4RAIL not only enables us to accelerate breakthroughs and increase interoperability, but also positions the Netherlands as a testing ground for European railway innovations.

4.23.2. Final products and TRL

Within Cluster C, NSR is working with CAF and others to develop advanced camera inspection technologies for railcars through so-called way-side portals. The aim is to detect and evaluate defects in railcars early, improving maintenance needs and reducing costs.

We are working with Knorr-Bremse and others to expand the sensorics on the rolling stock to come up with better analyses by combining them with existing data, which in turn will provide data for better maintenance planning and greater rolling stock lifetime. The TRL is largely determined by how we will use the data. Right now, we often use it that 1-dimensionally. By combining the already existing data and new sensor data to be obtained (analysis), we expect to move from TRL 5 to 7 in the course of this trajectory.

We are currently installing innovative high-definition cameras capable of effectively inspecting train sets from various angles. Using advanced image analysis algorithms, the cameras can identify any problems quickly and accurately, focusing on the safety and efficiency of train services. Currently, these developments are at TRL3-TRL4, aiming for TRL6-TRL7 by the end of the project, after which major exploitable results such as KER 3 and KER 4 will follow.

Id.	KER – Key Exploitable Result	Involved WP
KER 3	On-board monitoring and inspection technologies for rolling stock (e.g., additional sensors or using the signal coming from traction system).	5, 6
KER 4	Predictive algorithms or ML based analysis for on-board monitoring data capable of supporting the railway	5, 6, 7

	maintainers, owners, and operators of the asset management decision-making process.	
KER 5	European Railway Checkpoint for mixed traffic for different operational conditions and climate-types.	7

Table 7: NS Key Exploitable Results.

We believe these developments in camera inspection technologies and new sensors will lead to significant improvements in the safety, reliability and efficiency of our train industry. As NSR, we therefore remain committed to innovation in the rail industry and are proud to contribute to this project.

4.23.3. Demonstrators

As a Dutch carrier, we are host for several demonstrators in our country and are in the lead for WP6.2 (Demonstration and validation of Rolling Stock (on-board) inspection and monitoring systems), and within WP7 (Design & Deployment strategy for Railway Checkpoint and other Demonstrators) for subtask 7.3.2, which is the actual demonstrator.

We support the activities, which partners require from us and are necessary to properly implement the demonstrators.

4.23.4. Positive impacts

NSR sees in participating in FP3-IAM4RAIL an opportunity to work with influential partners to develop and test the latest monitoring technologies. By focusing on decision making, detection and automated understanding of the equipment, we aim to develop innovative solutions that will make the maintenance of our equipment even more sustainable, efficient and safe.

Using the latest technologies gives us the opportunity to quickly implement new innovations in our network and contribute to raising TRL levels. With the aim of designing decision support based on inspection of infrastructure and rolling stock on board and along the rails. This will involve investigating whether optical and laser-based monitoring, dynamic monitoring, etc. will also be used in collaboration with our partners within ERJU.
Our cooperation within Europe will ease our transition to digitalisation and help us speak one language for Digital Twins, ATO, cross-border operations, and so on. Achieving these goals is essential for the future of our railway industry. As NSR, we eagerly look forward to seizing this opportunity and generating positive impact for the Dutch railway network.

4.24. SIEMENS MOBILITY GMBH (SMO)

4.24.1. Introduction to the exploitation plan

The exploitation of the results of project FP3-IAM4RAIL aims to maximize the utilization of the developed asset management solutions in the railway industry. It involves identifying target users, promoting system advantages, and implementing marketing strategies.

4.24.2. Final products and TRL

The results of the project FP3-IAM4RAIL will be used for existing product lines and tools in Siemens' established cloud based IoT platform **"Railigent X"**. This paves the way for various enablers in the company's own service offering and in practice, but also for the creation and usage of commercial products that can be implemented by third parties.

4.24.3. Demonstrators

A detailed report will be published to demonstrate exemplarily how a digitalized exchange of asset management information can be realized across organizational boundaries.

The report will outline a specification for a basic digitized data exchange process between entities in charge of maintenance (ECM) (see also Deliverable D6.2 "Data standards & information sharing across supply chain")

4.24.4. Positive impacts

Positive impacts of the exploitation plan for the results of the project FP3-IAM4RAIL are the enhancement of security measures, a streamlined access control, cost savings as well as scalability for holistic and integrated asset management enablers among various corporations and institutions. Additionally, it accommodates future growth and provides a competitive advantage for the rail industry with better service delivery and customer satisfaction.

4.25. SOCIETE NATIONALE SNCF (SNCF)

SNCF works on different parts in the project with several expectations of exploitation. In WP6, the main interest is in building a secure in-train telecommunication network using virtualization to separate production, safety, and service networks. The final product in the project is a first full scale prototype Multi-purpose on-board telecom network, corresponding to an improve from TRL 4 to TRL 7. Deploying this new wireless network will facilitate maintenance, increase its resilience and compatibility with further technologies, and unlock new possibilities such as train modularity.

In WP8, SNCF will focus on building tools for analytics rendering and visualization of spatial-temporal data. These tools are necessary for developing use cases such as dynamic maintenance and root cause identification. The proposed solution starts from TRL 3 (including a new representation of an asset's trajectory) and is expected to reach TRL 6. These developments will significantly improve operational conditions and reduce cost of a rolling stock or infrastructure failure.

Several contributions in WP9, 12, 13, 16 aim at improving the infrastructure monitoring since its knowledge has been identified as one the main lack for further maintenance improvement. Among necessary improvements in data collection using appropriate sensors such as lidar, infra-red or accelerometers, one main KER for SNCF is the development of a pre-standard in the use of Distributed Acoustic Sensors (DAS). The standard framework is the key to build a flexible and interoperable ecosystem allowing to easily develop new applications based on this technology, thus increasing its cost effectiveness. An evolution from TRL 4 to 6 is expected to some of the proposed applications based on these pre-standards.

In WP17, SNCF aims at widening the use of additive manufacturing for spare part manufacturing and repairing. The main KER is a range of qualified combination of existing materials for elastomers that is compliant with fire-smoke standards. That list of fire-retardant polymers will allow quicker deployment of new applications in additive manufacturing for railway use, thus reducing the downtime of assets to be repaired or enabling new interior design. To illustrate these applications, several parts are expected to be built, demonstrating an evolution in TRL from 5 to 7.

In WP17, SNCF aims at widening the use of additive manufacturing for spare part manufacturing and repairing. The main KER is a larger range of printable elastomers and polymers following the flame-retardant railway standard and at railway costs. That material list will allow quicker deployment of new applications in additive manufacturing for railway use especially large interior parts in polymer, thus reducing the downtime of assets to be repaired or enabling new interior design. To illustrate these applications, several parts are expected to be built, demonstrating an evolution in TRL from 4 to 6.

Finally, SNCF leads the WP18 linked with KER 18 and 19 dealing with short and mid-term objectives. The short-term work is focused on railway practical use cases. SNCF plans to use intermediate outputs from the development of the multifunctional inspection robot prototype to feed a project to develop a mixed rail-road vehicle (FLEXY), even if the TRL level targeted is 6 to 7. Are also examined opportunities for extending this robot to cover other uses (vegetation control, mechanical track stiffness).

For the mid-term, WP18 is developing a framework. This framework is a fundamental element of the SNCF strategy, and we are ardent supporters of it. It's the framework that enables us to develop modular robots. We expect to be direct users of tools from that framework and promote them to the techno-providers we need to attract to our ecosystem. The maturity of the tools developed will evolve between 5 and 7.

4.26. STRUKTON RAIL NEDERLAND BV (SRNL)

4.26.1. Introduction to the exploitation plan

Strukton Rail Nederland is a pioneer in rail technology, specializing in rail infrastructure and mobility systems. Our central mission is to excel in the construction, maintenance, and renewal of railway infrastructure, spanning tracks, signalling systems, power supply, and catenary systems. Talking about daily maintenance, at our core, we embody the spirit of the credo: "Discover it, Guard it: Pre-empt Breakdowns!"—a testament to our steadfast dedication to proactively enhance maintenance operations, vigilantly monitor and inspect vital infrastructure, and elevate the availability, maintainability, reliability, and safety of railway systems.

Affiliated with the broader rail activities of the Strukton Group across Europe, including the Netherlands, Belgium, Italy, Sweden, and Denmark, Strukton Rail Nederland represents a workforce of approximately 1700 professionals. Evolving beyond conventional rail contracting, Strukton Rail has grown into a comprehensive solutions and service provider. Drawing from our extensive experience in railway maintenance, we have pioneered tools and techniques to bolster maintenance efforts. Strukton Rail now acts as a system integrator and supplier of products and services crucial for sustaining rail infrastructure. Our approach incorporates railway measurement, inspection, and data management, transforming the execution of interventions. Notably, we have introduced visual inspections of switches, tracks, and catenary systems, reducing the reliance on foot patrols, and optimising inspection processes.
At the core of our Research & Innovation portfolio, aligned with Flagship Area 3, lie three primary objectives: the development and enhancement of (1) maintenance execution and operation through cutting-edge mechanised maintenance equipment, robotics, and wearable technology for efficient support of workers; (2) extension of affordable measurement, inspection, and monitoring systems; and (3) the creation of sophisticated data analysis, decision support systems, and intelligent data management capabilities. Strukton Rail is dedicated to revolutionising the rail industry by embracing innovation and pushing boundaries to usher in a new era of railway systems.

4.26.2. Final products and TRL

General idea is that development will lead to viable solutions. Viable in the sense that the solutions are practical, solve real life issues and can be implemented. Viable also in the sense that there is a commercial benefit, either by using the solution incorporated in the overall maintenance services or as a separated product. Results from FP3-IAM4RAIL are the basis for further work in follow-up projects: either as the basis for new ideas and developments or, in case of continuation of the work from this project, leading to a demonstrator with higher TRL levels or integrated with other developments. This will also include alignment with existing products and tools. This will free the way for use of the tools in either the own service offering and practice, but also to create commercial products available for implementation by third parties.

The fundamental concept is that progress and innovation will pave the way for practical, real-world solutions. These solutions should address tangible problems and be readily applicable. Furthermore, their viability extends to being commercially advantageous—whether by integrating the solutions into comprehensive maintenance services or marketing them as standalone products. The outcomes derived from Iam4Rail serve as the foundational groundwork for subsequent endeavours. They can either spark novel concepts and advancements or, if this project's efforts continue, culminate in a demonstrator featuring higher Technology Readiness Levels (TRLs) or integration with other advancements. This process will also entail harmonisation with existing products and tools, enabling seamless incorporation into our service offerings and, potentially, the creation of commercialized products accessible for implementation by external entities. In more detail:

- WP10/11: Strukton's involvement in KER 9 involves creating distinct applications by harnessing data gathered from both wayside and on-board solutions, such as vision systems, RF-microwave, inertia sensors, lidar, and others. These applications will utilize various technologies and align with the prototype platform's overarching architecture to address challenges pertaining to rail infrastructure. These challenges encompass areas are, as an example, identifying cracks and surface damages, monitoring vegetation around rail infrastructure, and visualising underground infrastructure. The motivation for the chosen applications is driven by the necessities of day-to-day rail operations, and they will seamlessly integrate into the operational processes, ensuring a high TRL demonstration. Besides being used with the daily operation, solutions can also be brought to the market as a service.
- WP17: Strukton's involvement in KER 17 entails defining specifications for the on-site utilization of additive manufacturing techniques, facilitating testing in practical operational settings, and actively aiding the development of an operational and economically feasible machine tailored for in-situ application of additive manufacturing techniques in rail head repairs. The envisioned machine could be developed by third parties with expertise in developing, producing, and successfully bringing rail machines to the market. Other option is that consortium partners coordinate and build a commercially viable product.
- WP18: Strukton's contribution to KER 18 involves advancing the foundational principles of a robot platform tailored to our specific use case. This use case centers around a specialised robot that optimizes end-effector functionality to automate the precise positioning and upkeep of track-associated objects. The goal is to streamline and accelerate the manual process of installing crucial items like balises (and potentially axle counters and stop marker boards) along the track. This robot is being developed in close collaboration with our client (ProRail) as well as a third-party with expertise in constructing rail-specific machines and

effectively commercialising them. Furthermore, the envisioned outcome is intended to be deployed in ERTMS implementation projects.

- WP19: Strukton's involvement in KER 20 and KER 21 centers on augmented reality and exoskeleton technology. In the realm of augmented reality, Strukton will experiment with and refine applications relevant to the rail industry. This will encompass training applications, notably safety training, and real-time assistance. The outcomes will be integrated into our own operations and shared across the broader industry. Concerning exoskeletons, Strukton will contribute to the development of rail-specific exoskeletons by establishing requirements and assessing testing outcomes. Concurrently, we will explore potential collaborations with third-party entities for the adoption of rail-specific exoskeletons as commercial products.

4.26.3. Demonstrators

Strukton will contribute to the demonstration activities of the following use cases:

- *UC11.1*: Linking (new) monitoring technologies to asset management issues
- *UC11.2*: Fusion of (onboard and wayside) monitoring data for an enhanced fault detection and diagnosis
- *UC17.1*: In-situ AM repair machine for rails, switches, and crossings
- *UC18.2*: Automated installation of ERTMS balises, and, possibly, axle counters
- *UC19.1*: Upper-body exoskeleton for worker's support in railway industry
- *UC19.2*: Augmented Reality tools to help and guide railway workers in maintenance operations.

These use cases are aligned with the following FP demonstrators:

- *Demonstrator #4*: Asset Management & Infrastructure
- *Demonstrator #6*: Design and Manufacturing
- *Demonstrator #7*: Robotics & Interventions

4.26.4. Positive impacts

Our advancements have substantial influence, notably within the realms of Operations, Maintenance, Safety, and Cost-effectiveness. The impact rests in the heightened reliability of the infrastructure, ensuring smoother operations and minimizing disruptions. This translates to a significant reduction in intervention costs, culminating in an overall decrease in expenses and ultimately enhancing cost-effectiveness across rail infrastructure.

Delving into the domain of maintenance interventions, the enhancements brought about by our developments are meaningful: the improvement lies in operational efficiency, where interventions become more precise, streamlined, and effective. This optimisation leads to minimised downtimes and increased asset uptime, resulting in an efficient maintenance process. It can be seen as an example to how technology-driven solutions can bring tangible benefits to day-to-day operations, ensuring that the rail systems operate at their optimum potential.

Not to be understated is the prioritisation of worker safety and health. The innovative tools and supportive technologies we contribute to are designed with this core principle in mind. By incorporating safety features and ergonomic designs, we aim to mitigate risks and enhance the well-being of the workforce. A safer working environment is not only an ethical imperative but also an essential factor in ensuring a productive and motivated workforce.

Lastly, our approach to innovation extends beyond mere novelty. We are resolutely committed to facilitating the seamless deployment of these innovations, ensuring they become an integral part of everyday operations. Innovation, for us, is not confined to a theoretical realm—it's about practical implementation and visible impact. This mindset propels us to bridge the gap between conceptualisation and realisation, making innovation an enduring and transformative force within the rail industry. We can make this true by using our own operation as a testbed and example.

4.27. GTS DEUTSCHLAND GMBH (GTSD)

4.27.1. Introduction to the exploitation plan

Countries, cities and transport operators rely on Thales' Ground Transportation solutions to meet new mobility needs. We use the power of digital technologies to offer innovative and cybersecured solutions in signalling, train control, supervision, communications, and revenue collection. Using our expertise, we help our customers build safe, affordable, accessible, and sustainable mobility, benefiting today's passengers and future generations. No matter how challenging the project, we are by your side, building a future we can all trust.

Addressing the Railway transport new mobility needs:

- Increase Capacity
- Meet New Standards & Technologies
- Improve Operations & Reduce Life Cycle Costs
- Reduce Energy Consumption to Meet Environmental Needs
- Leverage Digital Solutions & New Business Models Support
- New End-to-End Travellers' Behaviours

4.27.2. Final products and TRL

GTSD, together with its affiliated entities, GTSF and TTE, and, aligned with its strategy, will focus on FP3-IAM4RAIL on the design, development and validation (TRL6/7) of:

- Intelligent Asset Management System for wayside assets (CLUSTER B). This includes securely collecting, storing, and analysing data from wayside assets and sharing information with the Traffic Management System (TMS) capable of supporting the railway operators and infrastructure managers in maintaining smooth and uninterrupted operations. The work is the continuation on the work performed in previous Shift2rail projects.
- Decision support functions for Long term asset management and Life Cycle Cost (LCC) optimization (CLUSTER D) related to maintenance activities and as part of the Asset Management System.
- Digital Twin use cases to pave the way for assets virtual testing and certification and the exploitation of BIM and Digital Twin technologies for the asset management of a station. (CLUSTER E).

4.27.3 Demonstrators

Demonstrator #1: Asset Management and TMS (WP3, WP4)

Main Objective Main objective is to design the generic architecture and to implement field installations for the setup of an Intelligent Asset Management System (IAMS) in WP3 paving the way for the development of analytics at Asset Management level and the integration with the TMS in WP4.

Technical Objectives include information sharing between IAMS and TMS (TO1), inspection system (TO2), prescriptive analysis for decision support (TO4) and preparation of work in view of future demonstrators (TO8). The capabilities which have been addressed include the information sharing across the supply chain and TMS, unmanned and non-invasive monitoring and inspections and advanced and holistic asset decisions. The Demonstrator #1 links to **technical enables 1, 2 and 4**:

- **Enabler 1:** Scalable information platform to integrate and exchange information across the IAMS (Integrated Asset Management System) and TMS o Data exchange (secure harmonised interfaces, methods, and processes) o edge computing solutions coupled with secure communication networks.
- - **Enabler 2:** Asset diagnostic and inspection systems, including AI solutions and ML algorithms to analyse and combine information provided by different inspection systems.
- **Enabler 4:** New methodologies and technologies to leverage advanced and holistic asset decisions o Operational and IoT data to enable cooperative diagnostic between assets o AI-based hybrid decision support based on predictive and prescriptive data analytics.

Demonstrator #3: Long Term Asset Management in the scope of WP 8

Main objective is to develop decision support applications for asset management and Life Cycle Cost (LCC) optimization (DO3).

Technical objectives include:

- TO1: information sharing between IAMS and TMS,
- TO4: life cycle assessment and methodologies for decision support, and
- TO8: preparation work in view of future demonstrators.

The Demonstrator link to the technical Enabler 4: long term asset management:

o Data analytics for maintenance optimization and long-term planning

Demonstrator #5: Asset Management & Digital Twins WP14/15

Main objective of this demonstrator is to develop Digital Twins to support the design, maintenance, upgrade, and renewal of railway assets (DO5). Technical objectives are:

- TO5: Digital Twins integrated with BIM,
- TO6: Automated certification techniques (including virtual certification),
- TO8: Preparation work in view of future demonstrators.

This addresses the capabilities such as **Advanced and holistic asset decisions** and links to **Enabler 5:** Digital Twins integrated with BIM to improve reliability, safety, efficiency, and effectiveness of asset management.

In WP14 & 15, we are in charge to develop methods to implement BIM for Asset management and use digital twin to leverage supervision and maintenance operation and reduce the CAPEX & OPEX of a station management in collaboration with ADIF, FS and PKP. We will proceed to implementation and the demonstration of DT & BIM in a DT by using data from ADIF (Malaga Station), with the objective to reach TRL6.

Demonstrator #6: Design and Manufacturing WP 14/15

The Objective of this demonstrator is to showcase the usage of eco-friendly design, production and reparation of resilient assets including Additive Manufacturing (DO6). It covers technical objectives such as:

- TO6: new concepts for design,
- TO8: preparation work in view of future demonstrators.

Capabilities addressed: Advanced and holistic design and certification of assets.
Links to **Enabler 6**: advanced and holistic design and certification of assets.

Id.	KER – Key Exploitable Result	Involved WP
KER 1	Platform data acquisition from signalling equipment and sensors, data collection and storage and data analysis for Operation & Maintenance and TMS needs.	3, 4, 8
KER 2	Decision Support System (DSS) methods and algorithms solution for Data Analytics, TMS and Operation & Maintenance link.	3, 4, 8
KER 7	Decision support for maintenance optimization and management of dynamic maintenance programs within maintenance concept.	8
KER 13	Digital platform for Track Condition data, Point Cloud, Simulation outputs and Track Asset Inventory information fusion.	14, 15
KER 14	Digital Platform for Station Asset Management.	14, 15

Table 8: GTSD Key Exploitable Results.

4.27.4 Positive impacts

Thales master the technologies that set the benchmark and prepare the future.
Our technology is created to support customers with system evolution, allowing for upgrades and enhancements to make the most out of the technology and their investment.
Asset Management is at the heart of built to last supporting the movement of greenfield and brownfield projects to the next mobility demands thanks to our latest digital technology and enabling high-performance, flexibility, faster and easier deployment, minimal disruptions and lower life cycle cost.
Asset Management protects the whole system with our best in class, end-to-end

cybersecurity products and continuously ensure safety, availability and resilience.
Today, **Infrastructure Managers, Operators and Maintainers** make use **of various solutions** existing in the market, including Thales' ones, to support them in performing their mission of managing their assets life cycle cost in the most efficient and sustainable way.
This variety of solutions represents a real pain for them as they suffer from having to use multiple tools from multiple suppliers for different types of assets as well as different purposes and visuals, not always addressing their specific needs.
This is not only increasing the mission complexity due to the lack of one unified and integrated UI, and lack of interoperability and integration between the systems, but also impacting the operational **performance**, and increasing **costs** and **risks** for the complete rail infrastructure **lifecycle**.

Thales' system helps our customers run their mission and operations at best and supports them in managing their **resources** according to their operational **priorities** so that they can meet increasing requirements with respect to **performance** and **cost**.

The use of BIM will be an opportunity for us to have a standard and more competitive solution to implement asset management system, while the Digital Twin demonstrator will be the opportunity to test new way of monitoring asset management (3D representation) and the base for Data driven services and maintenance improvement.

As for a broader scope GTSD intends to exploit the final products with actions such as utilizing the project results in further research activities as part of the next ERJU waves of calls and through the dissemination activities as detailed in the Dissemination Plan.

4.28 TRAFIKVERKET- TRV (TRV)

4.28.1 Introduction to the exploitation plan

Trafikverket is an Infrastructure Manager with a very high interest in effective asset management. Trafikverket follows all demonstrators in FP3-IAM4RAIL with the ambition to evaluate the feasibility for exploitation. The developed methods, models, methodologies and frameworks in this project are all subjects for integration into the decision framework at Trafikverket, if proven, to improve robustness, increase the capacity and improve the efficiency and effectiveness. Several research findings will be demonstrated on Trafikverket's assets directly and future exploitation will therefore, to some extent, be prepared.

4.28.2 Final products and TRL

Research activities will reach up to TRL6/7 in current project and can be further developed for implementation in daily operation.

4.28.3 Demonstrators

There is a need to further increase axle loads and speeds on existing railway bridges. As current values for dynamic amplification factor are believed to be over-conservative, the understanding of DAF for railway bridges with focus on freight trains will be improved in the project. Previous studies have also shown that current criteria for design of new bridges for high-speed tracks are likely over-conservative or potentially physically inaccurate. As there are limited knowledge of ballast behaviour under dynamic loading, the project aims to improve understanding under varying amplitude and frequency. Within the project a conceptual model with virtual trains on a selected line will be demonstrated. The use of dark fibre and eddy current measurements will be demonstrated for monitoring selected features. Technology development and demonstrators performed during the project are stand-alone activities not dependent on other demonstrators, yet to be aligned for later inclusion.

4.28.4 Positive impacts

Technology when implemented will have positive effect on Operational and Maintenance fields with Safety preserved. Cost effectiveness will improve and transparency of made decisions will enhance. Existing bridges to be able to be upgraded to higher allowable axle loads without strengthening or replacement – and new bridges to be designed more cost-efficient. Recommendations for dynamic modelling of ballasted bridge decks and proposal for new regulations for design of new bridges for high-speed track.

4.29 VOESTALPINE RAILWAY SYSTEM GMBH (vaRS)

4.29.1 Introduction to the exploitation plan

Voestalpine Railway Systems is global market leader for railway infrastructure system solutions. As the global track technology company and full-range supplier, we offer our customers throughout the world fully integrated railway solutions for all types of rail traffic. We help our customers creating maximum benefit from our premium product and service portfolio for rails, turnouts, signalling and monitoring applications – this is the driving force behind all our activities. Our infrastructure portfolio springs from a constant focus on dynamic innovation and target-oriented research & development.

With approximately 7,000 employees, we are committed to making an important contribution to the mobility of people and the transport systems all over the world. We have contributed decisively to the development of digital railway systems by deploying modern signalling and monitoring technologies to increase existing capacity and safety as well as lower the costs.
Worldwide fully integrated solutions from a single source – PERFORMANCE ON TRACK®
Advanced materials and geometries combined with state-of-the-art production systems guarantee the highest quality and performance of rails and turnouts. Fully integrated and tailored drive, locking and detection applications optimize the interface between track and signalling components. Intelligent monitoring and diagnostic equipment provide relevant data to improve maintenance activities. They allow for modern asset management of both fixed infrastructure and rolling stock.
Infrastructure managers need integrated solutions, which consider the specific network requirements. Consequently, our market approach is no longer defined by individual company limits but by strategic business fields: Mixed traffic, urban traffic (commuter/metro/tram), high speed traffic and freight traffic (heavy haul/industry) traffic. For each area, we are in a position to provide a complete system offer combining the portfolios of rails, turnouts, signalling and track solutions - customized and future-oriented solutions from a single source. As the first and worldwide leading system house for rail track, we add the most relevant value for railway infrastructure providers: We ensure the highest availability with the lowest life cycle costs, we provide PERFORMANCE ON TRACK®.

In the course of this project, we aim to develop groundbreaking "first-of-a-kind" Sustainable Track Systems Solutions (STSS), which contains several demonstrators.

4.29.2 Final products and TRL

Voestalpine Railway Systems is going to develop as much final products with high TRL levels due to the customers' needs. Therefore, voestalpine Railway Systems can provide on the one hand side really theoretical approaches like FEM simulations as well as practical ones like final assembled turnouts.

4.29.3 Demonstrators

Monitoring System for High Speed (WP10/11) – TRL7

In the railway infrastructure safety is the most essential factor. Especially in the most demanding fields like high-speed traffic there is no margin for error. To ensure highest safety the expertise of design validation of Fatigue strength of rails and attached components under dynamic loads in reality will provide the core input for developing the optimized monitoring system. Furthermore, the validation process will include multi body simulation and finite element modelling.

Special focus of condition monitoring will be laid on rail fracture, crossing transition geometry, resilient fastening system / bedding and signalling components.

Monitoring System for Mixed Traffic (WP10/11) – TRL7

Track and turnout inspection, as it is carried out today, is a very cost- and personal intensive process requiring a noteworthy number of temporary track closures. A maintenance and inspection system that drives out (for example in the maintenance window on subways) and carries out inspections and maintenance if necessary. Data is automatically saved in a historized asset database and prepared for the analysis process. The new system should be able to make a comparison of measuring processes (manual, automated, working-process), costs effects, diagnostic ability – learning from each other. Exchange of information and definition/investigation of “best-use-cases” for given boundary conditions.

Smart and Digital Asset Management Demonstrator (WP10/11) – TRL7

Inspection and maintenance of turnouts, drives, locking and monitoring devices, as well as of the control & command technology are very expensive and time-consuming.

The targets of the development are the implementation of an asset database for turnouts.

With this application one should be able to store, process and retrieve vital asset information and data in one environment. Furthermore, it is necessary to retrieve all necessary maintenance and manage it efficiently.

This will help to reduce time for maintenance on-site, increase safety during maintenance, reduce paperwork and reduce costs.

Green Turnout WP16 – TRL6/7

Railway transportation is the most environmentally friendly form of transportation. Besides the huge technological advantages of railways, there are still some essential side processes that heavily rely on conventional energy technologies. For example, in cold weather situation it must always be ensured that all movable parts of a turnout are

moving freely, and that any kind of operational functionality is guaranteed. This is conventionally done via turnout heating that consume up to 5 MWh per year and turnout or up to 2.250 kg CO2 per turnout and year. In addition, conventional rail and concrete sleeper production have a high CO2 footprint which can be significantly reduced by changing to new production processes.
For that voestalpine Railway Systems is improving the production processes as well as reducing the CO2 emission during operation.

Innovative Sleeper and innovative Fastening System WP16 – TRL4
The total lifespan of infrastructure subsystems (turnouts, e.g.) can be limited by one single component.
Regarding turnouts, the limited lifetime of ballast beds can be crucial and related maintenance processes are additional major cost drivers for railway infrastructure companies and reduce the availability. Furthermore, the settlement processes occurring with conventional turnout systems are very unequal in regards of their special distribution which makes turnouts especially prone to need maintenance in form of tamping or a change of their ballast bed before the estimated product lifetime has ended. Especially system critical railway infrastructure in congested areas around highly populated cities would profit enormously if a newly developed system would improve these weak points of currently used standard products. As a result, overall maintenance downtimes of track and turnout systems could be lowered significantly, and the availability of the rail lines would increase at the same time. As a result, Life Cycle Costs would be reduced.
The objective is to develop concrete sleepers which have an optimised bearing area in order to distribute loadings from the rolling stock most equally in comparison to standard solutions. Also, settlement processes shall be minimised. Settlement processes occurring in turnouts shall be distributed much more homogeneous over the whole turnout than with standard solutions to preserve the initial installation levels for as long as possible. The new sleeper concept is meant be used for tracks as well as for turnouts and should require no or very little tamping operations through its entire product lifetime, which is longer for the entire turnout as well.
Additionally, turnouts will feature novel fastening point concepts which provide an overall attractive system for the customer.

Squat resistant rails WP16 – TRL7
In our highly trafficked networks, a good planning schedule for maintenance action is crucial and an important factor to keep the availability of the whole system high.
Within the various Rail defects, there is especially one defect type that causes problems. The so-called Squat. This operational defect is a sub-surface crack under the running band with a V-shaped surface appearance that is detected in late stages of development. The repair of squat defects causes higher efforts in workloads compared to other defects.

Developing new steel grades for railway operation will contribute significantly to eliminate the problem of squats.

AM repair welding Demonstrator WP17 – TRL4

Railway turnouts represent key assets of any railway infrastructure and have to fulfil highest demands regarding any kind of requirement.

Crossings are one of the most essential components of turnouts and although standardized to a high degree in regards of their manufacturing process, they are one-of-a-kind assets once they are in track.

This, as any crossing reacts to local boundary conditions leading to slight geometrical changes in an early of stage of the service life (superstructure, traffic and operation).

Additive Manufacturing Technology (AMT) Crossings enable a completely novel era of railway crossing technology and avoid compromises in production and deterioration processes during the running-in phase. The crossing is the required tailor-made asset already from the time of installation and produced via Batch-Size-1-Manufacturing, both representing a revolution in railway technology.

Development of AMT crossings that feature an ideal distribution of specific metal alloys according to the specific position in the complex internal structure of a crossing to meet local stress situations and individual material resistance requirements (wear, fatigue, plastic deformation). Furthermore, they offer a tailor-made geometry to perfectly match the exact traffic and infrastructure based demands the customer needs for the specific turnout.

Welding process automation Demonstrator WP18 – TRL4

The crossing is one of the most important but also one of the most wear-prone components within a turnout. This results in increased maintenance requirements which also have high quality requirements.

Elevating the repair quality to industrial standards as well as integration of the automated repair-welding process will significantly contribute to improved performance of crossings in track. Furthermore, this process will be embedded in a novel robot that executes all the working steps (scanning, grinding, cutting, welding) within the crossing-repair process automatically. These approaches are suitable to reduce execution time and to increase working quality significantly. Therefore, track availability increases considerably and the service life of the frog and consequently of the entire turnout can be extended.

In this project the focus will lie on the development of the basics for an automatized repair-welding process into the entire turnout-maintenance-procedure (measuring, service, manual/machined maintenance, …) as an essential contribution to optimize temporary track closures (combination of tasks within a temporary track closure and planning of subsequent temporary track closures)

To optimize and speed-up of the crossing repair process, 3d-geometry scans of the grinded defect surface will be used for path generation of the welding robot. The welding process itself will be improved by monitoring the intermediate layer temperature and overriding the weld path.

4.29.4 Positive impacts

Voestalpine Railway System is going to reduce the CO2 emissions during most of the lifecycle elements of turnouts, rails, sleepers, etc.

Another important point is to increase the availability and reduce the maintenance times.