CLUSTER C – ROLLING STOCK ASSET MANAGEMENT: ON-BOARD AND WAYSIDE TECHNOLOGIES

As part of the FP3–IAM4RAIL project, Cluster C plays a key role in transforming the way rolling stock maintenance is managed across Europe. It is focused on developing intelligent technologies that enable real-time monitoring of train conditions, both onboard and from strategically placed trackside systems.

The FP3 initiative aims to deliver integrated European solutions that reach Technology Readiness Level 6 (TRL 6), a stage where systems are demonstrated in real-world environments. Cluster C contributes to this goal by developing and validating technologies that are not only innovative but also ready for deployment.

These advancements are being showcased under Demonstration Objective 2 (DO2), which highlights how monitoring technologies can support informed decision-making and maintenance planning. This includes redirecting trains to workshops for scheduled or rescheduled interventions, using manual processes, and advanced automated inspection systems. The objective is to reach TRL 6 by 2025, ensuring that the solutions are proven in operational settings across Europe, not just theoretical.

DO2 of Cluster C FP3

What does Cluster C include?

Cluster C is structured around three interconnected work packages (WP5, WP6, WP7), each contributing to the development of a comprehensive, intelligent asset management system for rolling stock:

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WP5: Rolling Stock (on-board): Data acquisition and monitoring technologies.

This package focuses on the development of advanced technologies for data acquisition and monitoring of rail vehicles. Its objective is to design, develop, validate, and implement condition-based maintenance (CBM) solutions using machine learning algorithms and digital tools. These solutions are intended to support railway maintainers, owners, and operators in the decision-making process. The objective is to reach a TRL of up to 6.

WP6: Rolling Stock (on-board): Data acquisition, monitoring technologies, asset prognosis and feedback into operational processes.

This work package focuses on the development of technologies for the monitoring of rolling stock assets from the track. The aim is to integrate previous achievements in the railway sector with regard to on-track monitoring and to develop new applied solutions for lines with cross-border and mixed traffic. It aims to create a more complete European railway control point, including the necessary inputs for its basic specifications. The objective is to achieve a TRL of 6/7.

WP7: European Railway Checkpoint for mixed traffic.

This work package performs preparatory actions for demonstrations of the feasibility of proposed technical solutions and preparatory work for fully integrated demonstrators under operational conditions. It also compiles preparatory work in digital environments to achieve intermediate state demonstrators at component/subsystem or system level. The objective is to achieve a TRL of 6.

Discovering Cluster C Use Cases

Cluster C's technologies are being tested in real-world use cases (UCs) across multiple European countries. These pilots are essential to validate the solutions under operational conditions and gather key data for future deployment.

Let's explore the UCs that are revolutionizing rail rolling stock maintenance and efficiency:

UC ID	Title	Leader	Relevant WP/DO
5.1	Bogie Monitoring System (on-board)	ATSA	WP5/WP6/DO2
5.2	Health Monitoring & Analytics of HVAC & Brakes systems	KB	WP5/WP6/DO2
5.3	Health Monitoring & Analytics of HVAC, Sanitary Systems & Brakes	KB	WP5/WP6/DO2
5.4	Health Monitoring & Analytics and ML algorithms development of Traction, HVAC, Doors, Batteries & Brakes	FT	WP5/WP6/DO2
5.5	Health Monitoring & Analytics and ML algorithms development of Traction, HVAC, Doors, Batteries, Brakes & auxiliary system	CAF	WP5/WP6/DO2
6.1	Development of next generation Traction control unit hardware and gate drive communication link	ATSA	WP6/DO2
6.2	Traction Component Health Monitoring & predictive Maintenance	ATSA	WP6/DO2
6.3	Set up of adaptive wireless telecom network between train elements	SNCF	WP6/DO2
6.4	Adhesion estimation for management	PRORAIL	WP6/DO2
6.5	Wayside signalling equipment monitoring system	TALGO	WP6/DO2
6.6	On-board bogie diagnostic solution for fault detection applied to train(s) operating in Germany	SMO	WP6/DO2
6.7	Digital twin for energy	CAF	WP6/DO2
6.8	Smart maintenance scheduling tool	CAF	WP6/DO2

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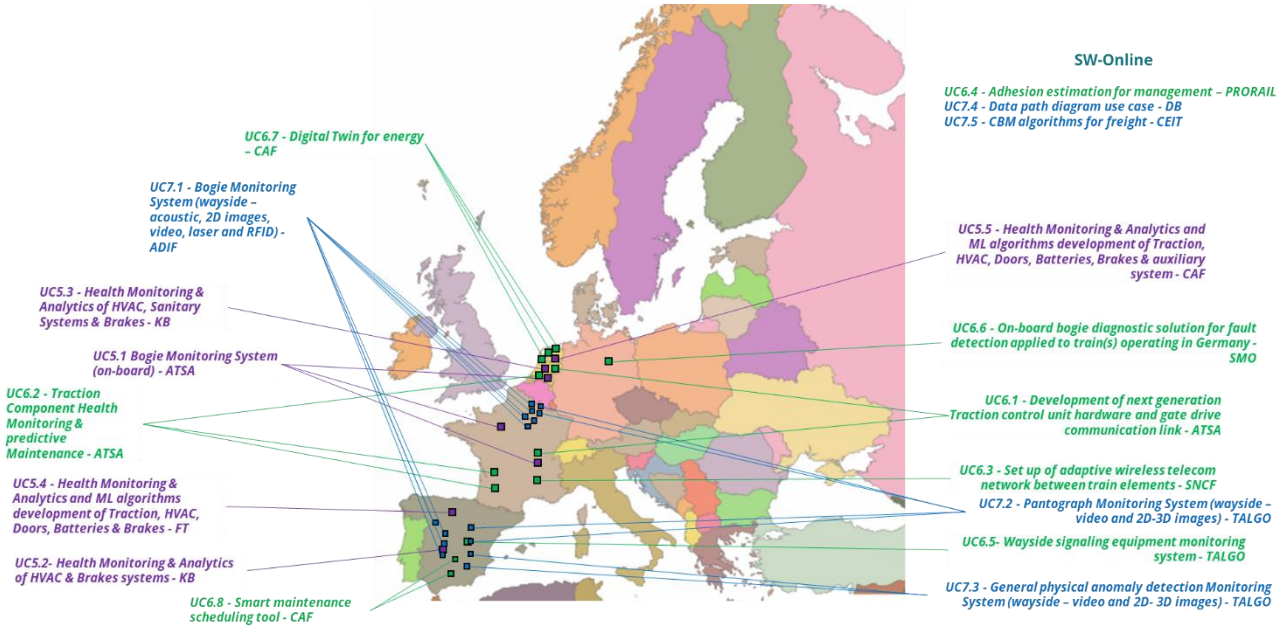
7.1	Bogie Monitoring System (wayside – acoustic, 2D images, video, laser and RFID)	ADIF	WP7/DO2
7.2	Pantograph Monitoring System (wayside – video and 2D-3D images)	TALGO	WP7/DO2
7.3	General physical anomaly detection Monitoring System (wayside – video and 2D- 3D images)	TALGO	WP7/DO2
7.4	Data path diagram use case	DB	WP7/DO2
7.5	CBM algorithms for freight	CEIT	WP7/DO2



UC locations across Europe

The map below represents the location of each UC, showcasing the project's broad international collaboration and impact.

The following table provides a summary of UC5.1 to UC5.5:

UC5.1	UC5.2	UC5.3	UC5.4	UC5.5
France, Netherlands	Spain	Netherlands	Spain	Netherlands
Bogie maintenance is typically scheduled based on fixed time or mileage intervals, which can lead to premature part replacements or unexpected failures. This UC propose an advanced bogie monitoring system to enable condition-based maintenance (CBM), helping to reduce maintenance costs and improve system availability.	The goal of this UC is to develop a sensor kit to retrofit a Spanish high-speed train fleet. One or two vehicles will be equipped with sensors on the HVAC (Heating, Ventilation, and Air Conditioning) and Brake Air Supply systems to collect operational data as part of a proof-of-concept initiative.	The purpose of this UC is to develop a sensor kit to retrofit the SNG (Sprinter New Generation) fleet operated in the Netherlands. One or two vehicles will be equipped with sensors on the HVAC and Brake Air Supply systems to collect operational data as part of a proof-of-concept initiative.	This UC involves deploying sensors and advanced algorithms to monitor key onboard systems such as HVAC, doors, and brake systems in real time to enhance maintenance efficiency and system reliability through continuous condition monitoring and data-driven insights.	This UC aims to leverage sensors and advanced algorithms to monitor critical onboard systems including HVAC, brakes, doors, traction and batteries. By detecting anomalies early, it enables targeted, condition-based maintenance to improve reliability and operational efficiency.

Next, the table outlines use cases UC6.1 to UC6.8:

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UC6.1	UC6.2	UC6.3	UC6.4
France, Netherlands	France, Netherlands	France	Netherlands
This UC is a power test bench which embeds a prototype of the digital communication link between Traction Control Unit and Gate Drive Units. The target is to evaluate the capability of the ability to drive semiconductors for traction purpose at the same time they are being monitored for traction component health management.	Tomorrow's powertrains must make use of predictive maintenance data to reduce possession costs by optimizing the number of maintenance operations, so Intercity Nieuwe Generatie (ICNG) train includes an updated traction software incorporating new software application implementing the technologies developed within the program.	The goal of the UC is to define a multi-purpose resilient adaptative wireless onboard telecom network focusing on the technical and scientific objectives related to the design and evaluation of a safe, secure and resilient solution for train-to-train wireless communications (inter train/consist and inter-carriage).	Estimation for management aims to design methods to estimate/measure the coefficient of friction (COF) in real-time under real operation conditions to determine at certain time window. This will contribute (among other things) to increasing service availability and optimal capacity.
UC6.5	**UC6.6**	**UC6.7**	**UC6.8**
Spain	Germany	Netherlands	Spain
The use of interconnected IT systems in railway transport enhances efficiency and safety but also introduces significant cybersecurity risks. Modern trains are vulnerable to cyber-attacks that could disrupt services or compromise safety. The UC proposes the development of a device for alert mechanisms against cyber-attacks on the train itself, both through internal systems and from train to ground communications.	This UC explores deploying a demonstrator of the SMO on-board bogie diagnostic (BD) solution on a regional train operating in Germany. The objective is to validate the performance of the diagnostic algorithms and assess how the insights generated can be integrated into the maintenance process. This will be done in close collaboration with the train operator and maintenance personnel to evaluate the benefits of CBM.	Energy consumption is a major operational cost for rolling stock. This UC involves developing a digital twin to model and optimise energy use. By combining theoretical models and design data, the digital twin will compare the optimum energy consumption with the real consumption and identify optimal driving strategies. It will give advice on the best driving strategy, and on anomalies related to the energy consumption of different assets.	Transitioning from preventive to condition-based maintenance adds complexity to scheduling due to the dynamic and vast nature of fleet data. This UC presents a dynamic scheduling tool that integrates machine learning insights, maintenance plans and corrective actions. It helps planners optimise task scheduling by recommending maintenance actions based on component health, parts availability and other key factors.

Lastly, the table below summarizes use cases UC7.1 to UC7.5:

UC7.1	UC7.2	UC7.3	UC7.4	UC7.5
Spain, Netherlands	Spain, Netherlands	Spain	Germany	Spain, France
Data capture from wayside technologies (acoustic, visual, laser and RFID). Data may carry information on the health status of different bogie components. This UC has the potential to enhance the monitoring capability of the WP demonstrators (ES and NL), especially for bogie health monitoring.	Based on data collection from Pantograph technology to generate an extensive database that enables to develop algorithms for detecting failures and predicting when maintenance will be required for the rolling stock to perform automated inspection based on automatic monitoring equipment.	Development of different technologies such as image 2D-3D, scan or video recording, installed on wayside to monitor physical anomalies. These technologies allow continuous diagnosis on train elements to determine a status diagnosis in automatic way in real time, providing the maintenance team with a CBM action to consider.	By using the generic safety certification methodology for CBM data paths, requirements from the standards to the specific CBM UCs will be easily transferred, so that IM/RU will save time in preparing the safety certification for the adaption of the maintenance regime.	CBM algorithms for anomalies detection in freight will be developed and focused on wheel flats and axle generators. To simulate different geometries of wheel flats in the different scenarios, varying running conditions (running speed, vehicle load, track irregularities). In this UC axle generators from 1 to 4 on freight wagon of existing fleet will be monitored.

Stay tuned for more updates as we continue to test and validate these innovative solutions across Europe's rail network.

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