



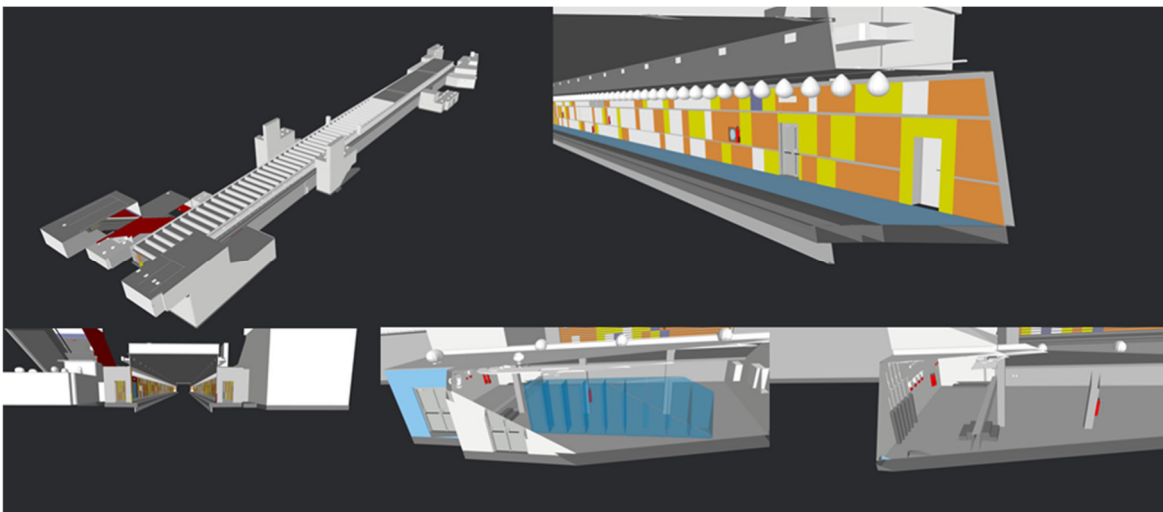
## CLUSTER E - DIGITAL INNOVATIONS FOR RAILWAY INFRASTRUCTURE MANAGEMENT AND MAINTENANCE



### Introduction

This document explores the main innovative technologies for the management and maintenance of railway infrastructure. The topics covered include the use of BIM for station supervision, track condition data fusion, the implementation of blockchain for virtual certification, automatic visual inspection by drones, and decision support systems for station asset management. These solutions aim to enhance the efficiency, safety, and reliability of the railway sector.

### BIM and data-oriented services for station supervision and maintenance



3D view of part of Malaga station BIM model



The project is supported by the Europe's Rail Joint Undertaking and its members.



Using a digital twin to streamline Asset Management is part of the Cluster E objectives within IAM4RAIL project. One approach to fulfil this need involves employing BIM Modelling to facilitate the configuration of the Asset Management System and increase its accuracy. To achieve this goal, the capabilities provided by the BIM files were explored, aiming to maximize the benefits they could offer for station supervision and maintenance.

A BIM Execution Plan was specified to describe the process of producing BIM Models usable for the Asset Management System configuration as well as the automatic extraction of 2D representation of the station from the 3D view.

A tool was designed to analyse the BIM files, automatically identifying missing in files not produced according to the BIM execution Plan. Experiments were conducted to integrate a BIM viewer into the Asset Management System.

For the demonstration purpose, a section of the Malaga station BIM model (supply by ADIF), was used to verify its application and identify necessary modifications to comply with the BIM Execution Plan (BEP). At Innotrans 2024, the intermediate results will be showcased using Virtual Reality to represent the 3D BIM model of Malaga station, including the equipment and related data. The development to interface the BIM model with the station Asset Management System components of the Digital Twin will start in the coming months.

### **Track Condition data fusion in Point Clouds web platform data requirements, architecture and data collection report**

The fusion of track condition data within Point Cloud aims to support the remote track inspection, verification of infrastructure condition, and the preparation of the maintenance and renewal works by remotely verifying the surrounding environment, increasing safety, and reducing "boots-on-track". A web-based software environment has been developed integrating various data streams: track and overhead line condition data; Point clouds; digitalized assets; digitalized view of the railway corridor with the use of orthophotos, digital terrain models and cadastral maps. The architecture of the web-platform has been specified and designed targeting high-vertical and horizontal scalability; high modularity; configurability and personalization; usability and installation-flexibility in both cloud and on-premises environments.

For the demonstration approximately 50 kilometres of high-speed line, supported by Italian Railways (Rete Ferroviaria Italiana), were selected. The high-speed diagnostic train Diamante 2.0 was used to gather track geometry and overhead line condition data, while other airborne and train-borne MERMEC systems were employed to collect mobile surveying data.



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Aerial Surveying outputs sample data: Digital Terrain/Surface Models; Orthophotos



Dedicated MERMEC Vehicle for the digital twin      High-speed Diamante 2.0 diagnostic train

### Blockchain for Virtual Certification Framework

The Virtual Certification Framework (VCF) development is part of the digitization and modernization of the European Rail Joint Undertaking. It aims to improve the efficiency and safety of certification processes through a reliable and secure virtual environment. This aligns with European initiatives to promote innovation and interoperability in the railway sector.

The RFI (Rete Ferroviaria Italiana) certification process currently in use involves three main entities: the entity responsible for project implementation, the entity responsible for infrastructure operation and maintenance, and the entity responsible for technical standards. Each entity has specific tasks that contribute to rail infrastructure compliance and safety.

The VCF aims to create a virtual environment that enables secure and controlled data exchange through the Federated Data Space that is a secure, reliable, and scalable environment where trusted partners can exchange digital resources.



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The VCF uses blockchain technology to track and validate the certification process. Blockchain offers transparency, security and immutability, ensuring that each certification is verifiable and cannot be corrupt.

The comparison between public and private blockchain is central. Public blockchain offers greater transparency and security through a decentralized system, while private blockchain offers greater control and privacy. The choice between the two depends on the specific needs for transparency and control of the certification process.

The designed scenario involves the use of public blockchain to ensure the integrity and transparency of certifications, supported by a Federated Data Space that provides control over the data. This approach aims to create a more secure, efficient, and reliable railway certification system, promoting trust among all the involved stakeholders.



A detail of a switch captured by a drone with high resolution camera from 25 m altitude.

### **Automatic track visual inspection by drones**

This activity contributes to the overall objectives of Cluster E by integrating inspections by unmanned aerial vehicles into the lifecycle of Digital Twins of railway assets. All the work on this subtask is pursued by AZD Praha, the only member of Europe's Rail from Czechia. The company has traditionally focused on Signalling and Control, but since 2016 has



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become an Infrastructure Manager, having purchased and maintaining two regional tracks north of Prague, primarily for test purposes. Concepts developed for modern asset management can thus be immediately tested on these dedicated railways.

The main activities in the use case have been performed by AZD. Starting from an architecture of the system of unmanned visual inspections, hardware and software components have been developed to form an integrated workflow of data acquisition.

The architecture of the system is focused on the Digital Twins of switches and point machines, signals, balises, other trackside equipment and the track itself (e.g. the rails, sleepers and fasteners). The models will integrate available BIM data, real-time measurements from the Signalling and Control Diagnostics, reference visual data from drone surveys, maintenance schedules and records. Data from periodic inspections and event-triggered missions will be processed into marked-up images stored in the Digital Twin.

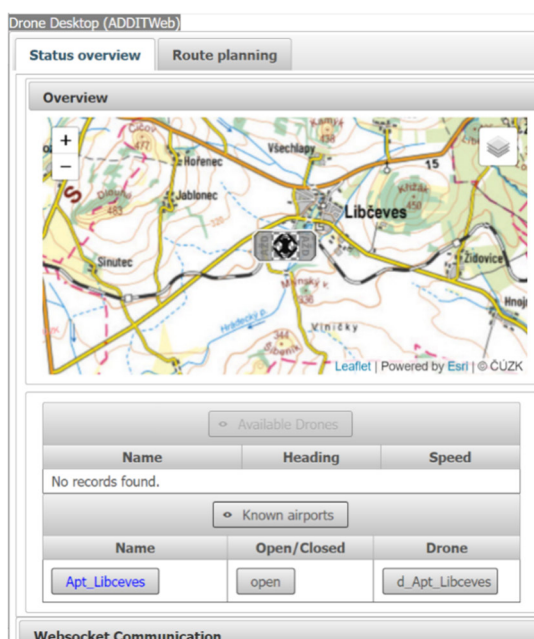
The hardware components of this system include an on-board computer with 5G connectivity, controlling a system of wireless charging, a charging and a docking station used by the drones between missions, and a fleet of industrial drones with payload (cameras and LiDars) best suited to the demands of inspections of track elements. These systems are being assembled and tested for a demonstration deployment next year.



Model of the docking and charging station



On the software side, the team has been working on a module for precise optically guided landing, a web-based dashboard for remote control and monitoring of the drones and docking stations, tools for processing of LiDar data and a database server for storing and retrieval of the Digital Twins of the track components.



Dashboard for drones and airports

In Spring and early Summer of 2024, we conducted the Libčevce station test surveys on the AZD track Čížkovice – Obrnice and established the necessary settings for collecting high quality data. The images taken during these test flights enable the creation of high-resolution photomaps and 3D models of the track and trackside assets. The workflow of preparing and conducting these surveys is now ready. The available software tools to process the collected data has being amended to our needs.

Lively exchange of ideas within the Work Package as well as in the IAM4RAIL community were important for settling on the meaning of Digital Twins within the context of our use cases and for the definition of the Key Performance Indicators.



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## Decision support systems for railway station asset management

This topic focuses on exploiting data centralization from multiple datastreams in order to facilitate decision support systems (DSS) that can help station administrators in their day to day operations on multiple time scales. We are currently working on DSS solutions focusing on:

- Using video monitoring (like CCTV) and station representation to automatically detect trash or mess in order to signal maintenance services.
- Improving maintenance and motion control with appropriate scheduling and necessary predictive models
- Tracking of economical KPIs in real time and providing them to decision makers
- Commercial surface lease support
- Structural health monitoring of station building

All those areas are currently focused by PKP S.A. and cooperating partners for future demonstration including Lodz Kaliska station.

One interesting solution that is currently in development is the integration of BIM models into preparing machine vision methods for trash and dirt detection. Inspired by widespread use of simulations in development of autonomous driving solutions we investigated using automatically generated 3D models of station as a source of data along with scenarios requiring cleaning.



Similar to Autonomous car training – BIM is used to create a virtual station model, where scenarios (i.e. trash) can be tested and simulated CCTV data created

Development of decision support for maintenance and motion control is also underway. It is being analysed two-ways. One solution is based on creation of predictive analysis allowing estimation of necessary maintenance works. Second one is focused on efficient exploitation of available personnel, which focuses not only on time availability and stoppage but also on distances. Solutions based on route planning allow efficient scheduling of maintenance work.



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Name of station		Device type	
Mrozy	Otwock	Piastów	Winda
Nasielsk	Ożarów Mazowiecki	Pilawa	

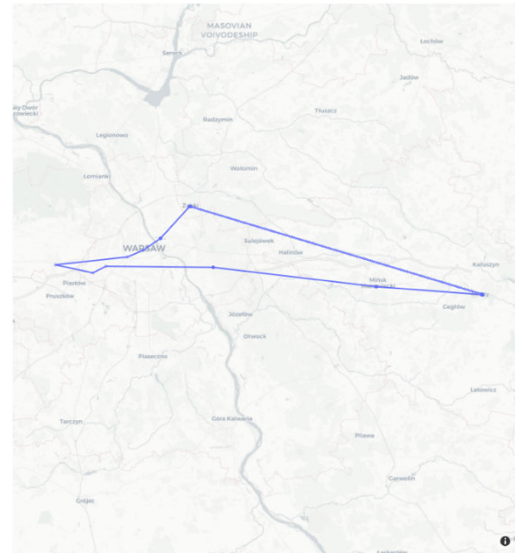
Model	Producer	Service expiration data	Name of station	Producer
Kone MonoSpace	Kone Corporation	9 stycznia 2023	Warszawa Centralna	<input type="checkbox"/> Entrematic
Kone MonoSpace	Kone Corporation	9 stycznia 2023	Warszawa Międzylesie	<input checked="" type="checkbox"/> Kone Corporation
Kone MonoSpace	Kone Corporation	9 stycznia 2023	Warszawa Stadion	<input type="checkbox"/> Otis Elevator
Kone MonoSpace	Kone Corporation	9 stycznia 2023	Warszawa Ursus	<input type="checkbox"/> Stanley Black & Dec...
Kone MonoSpace	Kone Corporation	9 stycznia 2023	Warszawa Włochy	
Kone MonoSpace	Kone Corporation	9 stycznia 2023	Warszawa Zachodnia	
Kone MonoSpace	Kone Corporation	10 stycznia 2024	Warszawa Centralna	
<b>Suma</b>				

Route order according to the traveling salesman algorithm

nr	Miejsce
1.	Mrozy
2.	Miejsk Mazowiecki
3.	Warszawa Międzylesie
4.	Warszawa Włochy
5.	Warszawa Ursus
6.	Ożarów Mazowiecki
7.	Warszawa Zachodnia
8.	Warszawa Centralna
9.	Warszawa Stadion
10.	Ząbki

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Dashboard for maintenance route planning

In April 2024 there was a survey sent to all consortium members as a way to establish common European baseline of data streams, digital twins and related solutions in station and wayside asset management. Questions of the survey consider topics such as:

- Data streams (what data is being collected and how)
- Digital Twin (are they used, or some other similar solutions)
- BIM adoption
- ERP (e.g. SAP, IFS) integration in asset management
- Digital management of assets

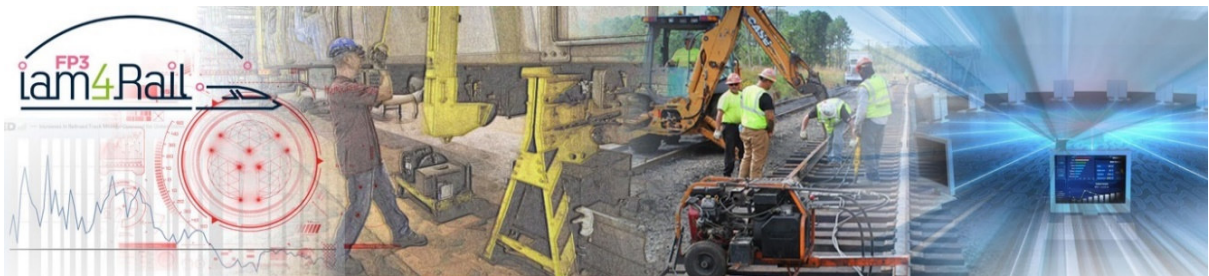
This survey will allow determination of level of integration of such solutions and will shape development of how they can be introduced.



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Founding Members



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