PROJECT RADIUS

Welcome to the future of railway signalling asset monitoring and maintenance using drones

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Railway digitalisation using drones

This project has received funding from the European Union Agency for the Space Programme under the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004192

CONTENTS

CONTEXT

Rail is the backbone of the transport of people and goods. The actual challenge is to develop a smarter and more efficient rail infrastructure. Radius presents a clear improvement in the railway industry by using drones to carry out non-critical maintenance operations. It is simpler, safer, cheaper, more efficient, less polluting, and very scalable.

It is also important to bring this sector into the Digital Era, a process that relies on EU space technology and is based on global navigation satellite systems (GNSS), as explained by the European Union Agency for the Space Programme and Radius financier EUSPA.

Until now, the use of GNSS in the rail sector has been limited to non-safety related applications, such as asset management and passenger services. However this could soon change because GNSS, if complemented by other sensors, meets the stringent safety and integrity requirements of the rail sector.

It could be used in safety-related applications, such as command and control systems. As a result, the capacity of the rail network will increase, reducing operating costs and making the rail sector more efficient and attractive.

In this regards, Radius plays a relevant role because its technology focuses on increasing safety.

Benefits to rail

The EU Space Programme's benefits to rail are extensive.

- It detects displacements, identifies trends and sends alerts in case of risks
- Enables visibility of rail cargo in transit
- Improves availability and accuracy and delivers integrity for safe train localisation
- Reduces the need for physical beacons and helps reduce operational costs

EGNOS and Copernicus

The European Navigation Service (EGNOS) contributes to further improving the accuracy and integrity of train location. Its adoption within the European Rail Traffic Management System (ERTMS) will enable the safe use of GNSS, reducing the industry's dependence on costly track-side infrastructure.

Finally, Copernicus contributes to the overall safety of the rail network by providing infrastructure managers with information on risk exposure in relation to vegetation, landslides, and flooding.

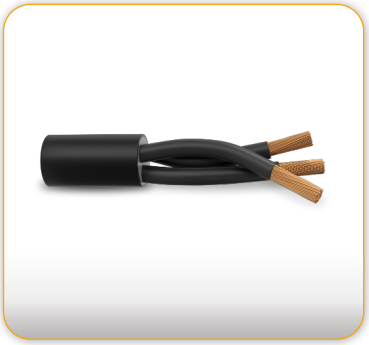
EUSPA and Radius have a common goal of using the benefits of these technologies to improve performance, cost efficiency and enhance safety to strengthen the competitiveness of European railroads.

RAILWAY MAINTENANCE CHALLENGE

There is currently no optimal solution to inspect, monitor and maintain railway signalling assets. The traditional methods have important drawbacks:

Human inspection

Human inspection activities are highly demanding in terms of costs and operational constraints since the tracks being inspected have to be closed or limited. And they impose safety concerns.



Wired solutions

They are very expensive and prone to failures. Cables have to be maintained, increasing the maintenance burden. Limited bandwidth of the solution implies that only a resctricted number of features can be monitored.

Diagnostic trains

They run at lower speed than commercial trains, impacting track capacity. Trains and their monitoring equipment are complex and require high investments and operational costs.

To overcome these limitations, RADIUS proposes to use Unmanned Aerial Systems (UAS) to execute a large part of the inspections and a limited range of maintenance activities like tuning, re-calibration, activation of special functions, etc.

RADIUS BENEFITS

More frequent inspections

Increasing the frequency of inspections means that preventive measures that increase the life span of signalling assets can be used

Cost reduction

The RADIUS system is easier to use, reducing the initial investment as well as the running costs to maintain railway infrastructures

Safety increase

RADIUS will increase the safety of the maintenance operations and also the operational safety of the railways

New business models

The RADIUS concept can be extended to other activities and markets, creating new service provision business models

PROJECT TIMELINE

January 2021
Project start
Kick-off meeting

August 2021
System and architecture specification

April 2022
Initial release of the RADIUS payload components

June 2022
Initial release of the UAS prototype, ready to be tested

September 2022
First version of redesigned UAS-friendly signalling assets and docking station

January 2024
Full RADIUS implementation

July 2024
Successful test and validation of the RADIUS prototype in railway relevant environment

October 2024
Project end

CONSORTIUM

Led by a recognized industry leader in the railway sector, Hitachi Rail STS, the Radius consortium includes Infraestruturas de Portugal, a railway infrastructure manager and several innovative SMEs. The resulting consortium is perfectly suited to conform the Radius solution.

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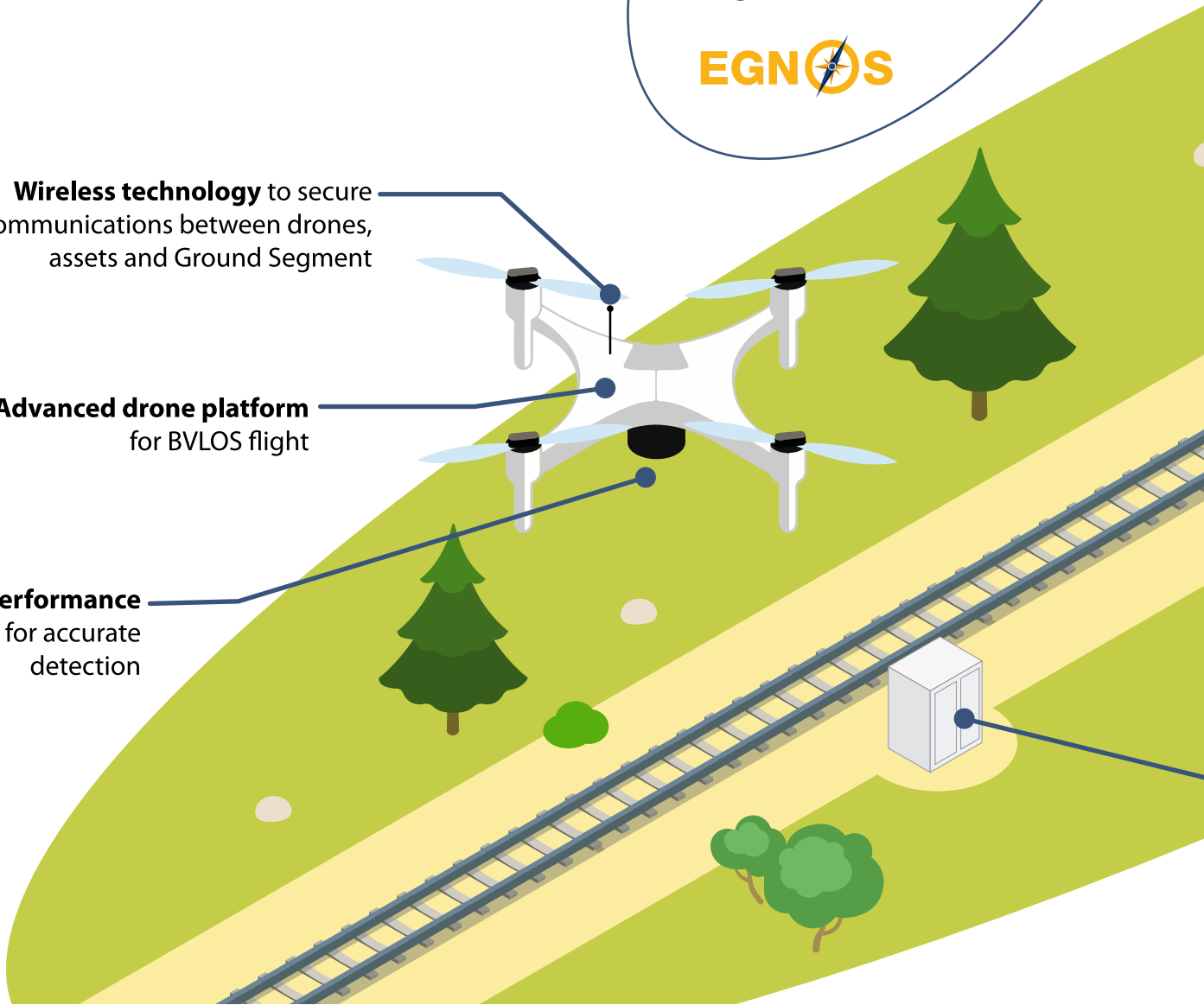
RADIUS CONCEPT

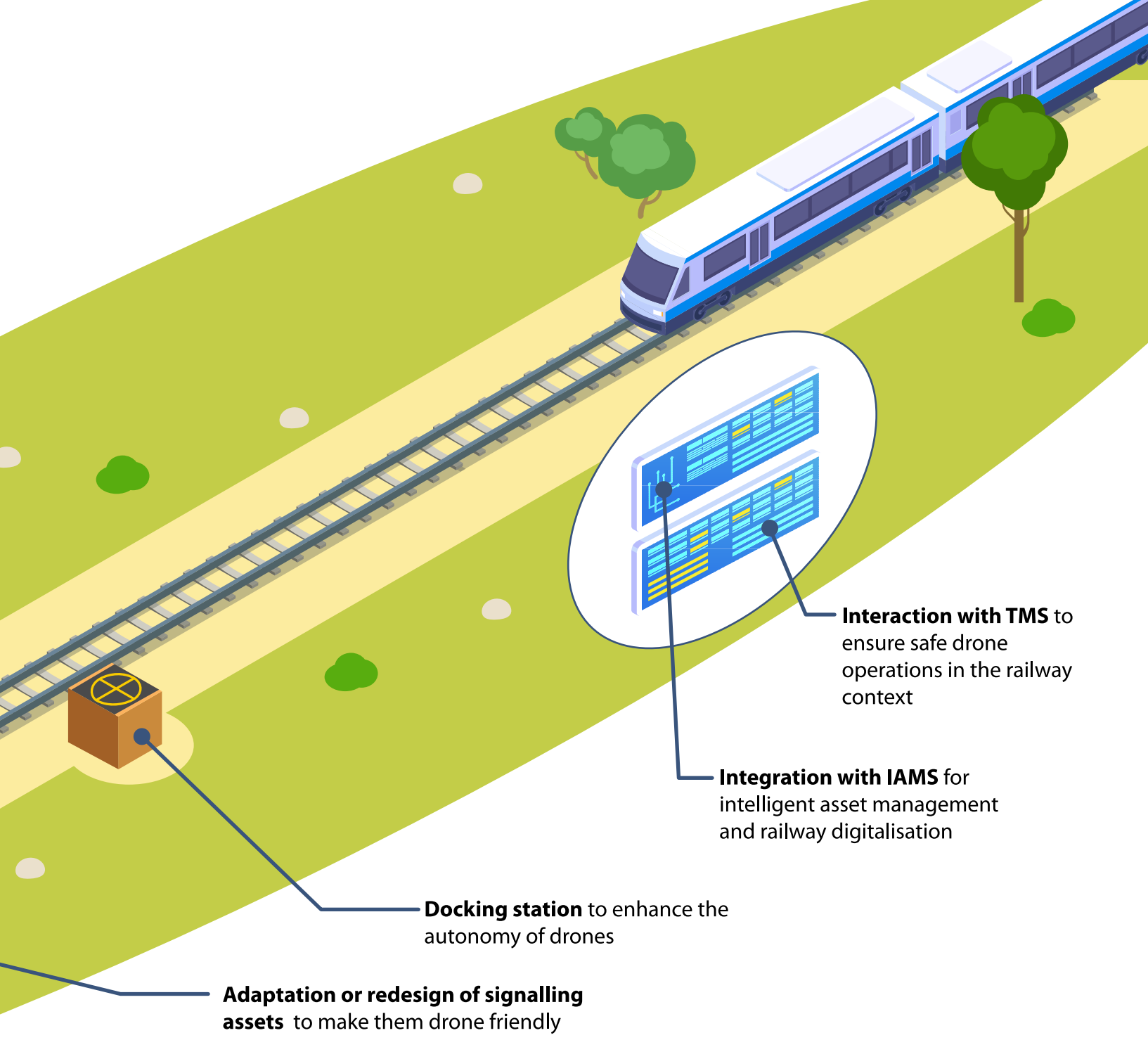
GNSS navigation systems using EGNOS and Galileo to ensure precise and reliable geolocation

Wireless technology to secure communications between drones, assets and Ground Segment

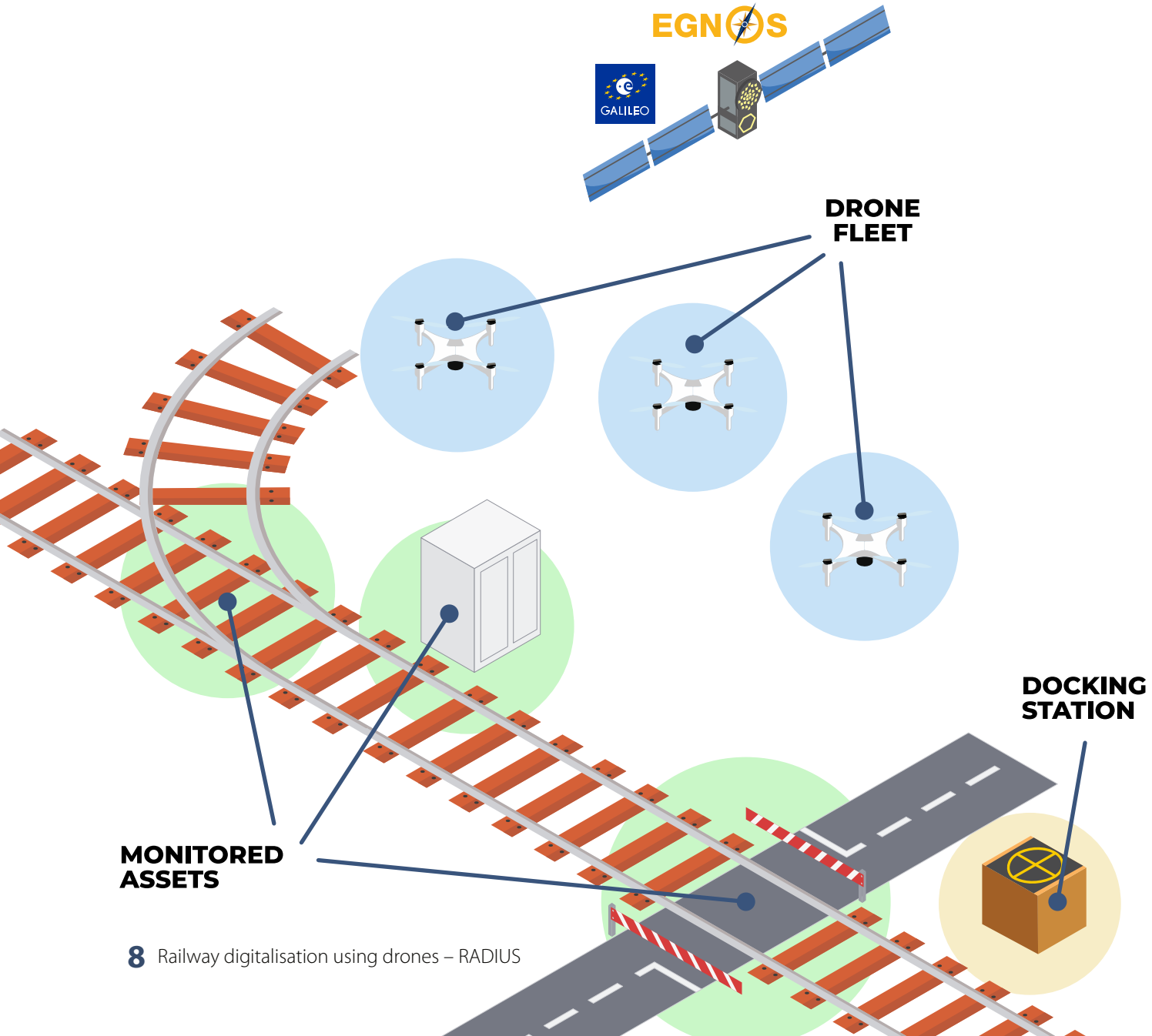
Advanced drone platform for BVLOS flight

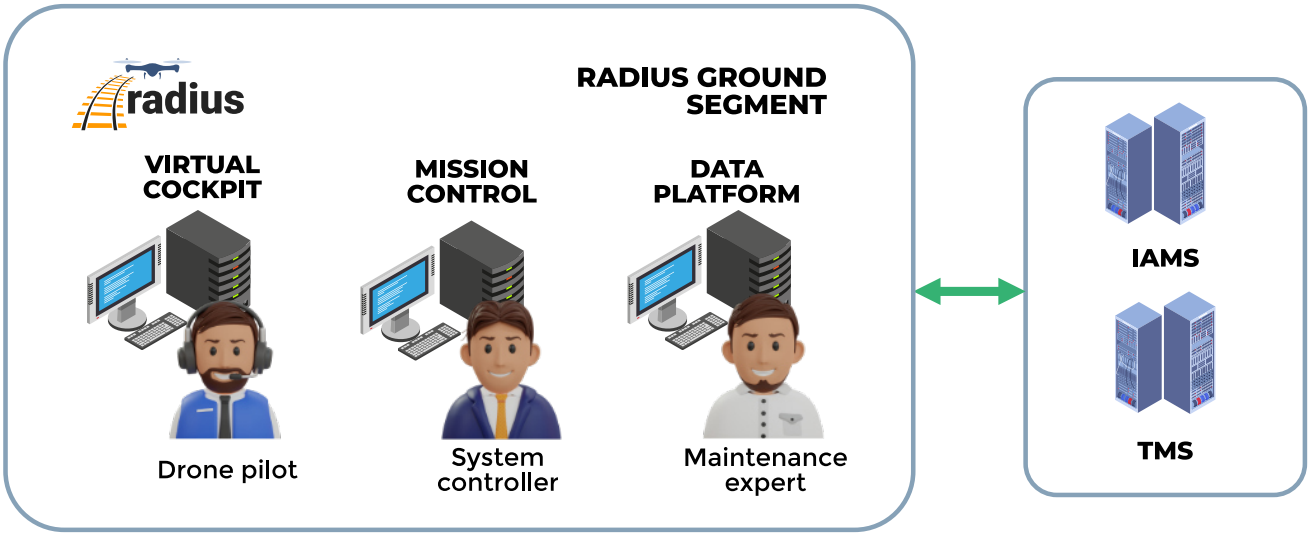
High performance sensors for accurate detection




Interaction with TMS to ensure safe drone operations in the railway context
Integration with IAMS for intelligent asset management and railway digitalisation
Docking station to enhance the autonomy of drones
Adaptation or redesign of signalling assets to make them drone friendly

SYSTEM ARCHITECTURE





The high-level RADIUS system architecture comprises the following main modules and interactions with external systems:

- The **ground segment**, with its key components: virtual cockpit, mission control centre, communication and control, and data management and analytics
- The **interaction with external systems** (TMS and IAMS).
- The **trackside segment** that covers the most relevant signalling assets: switch point, level crossing, cabinets with which the drone will interact with for inspection and monitoring.
- The **drone and its payload** components: sensing devices, contactless interaction with signalling devices, data analytics, communication and control, and EGNSS positioning system.
- The **docking station**.

INTERFACES

Intelligent Asset Management System (IAMS)

The IAMS is an innovative asset management platform that focus on:

- Increase the system reliability and availability.
- Improve the knowledge of the system correlating information coming from different data sources.
- Use predictive capabilities to optimize the working procedures, avoiding system downtimes.
- Reduce operating and maintenance costs.

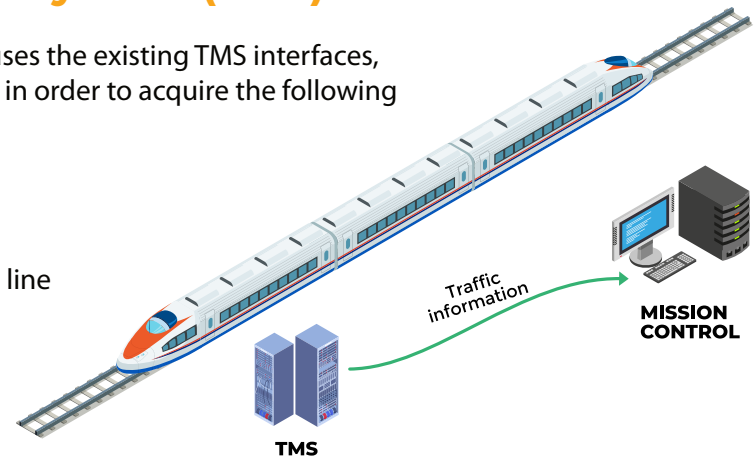
In the context of the RADIUS project, IAMS will be considered as an external system to which the other systems interact to:

- Guarantee a seamless integration of RADIUS into the current railway maintenance operations.
- Optimize the processing power needs in the RADIUS system (both embedded in the drone and in the ground station) by exploiting the off-line processing power of the IAMS.
- Contribute to the railway digitalization process.

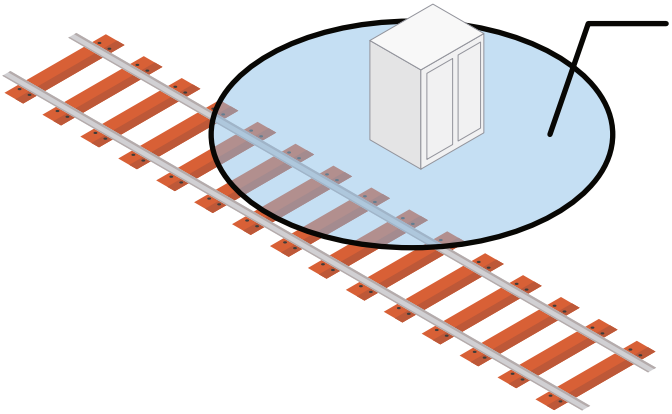
Traffic Management System (TMS)

The Radius Mission Control System uses the existing TMS interfaces, through a unidirectional interaction, in order to acquire the following information:

- Train traffic information
- Track occupancy status
- Train traffic interruption along the line
- Train status information
- Assets operational status

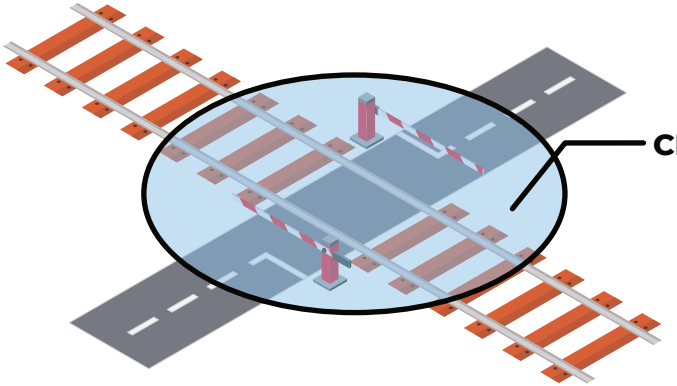


USE CASES



Lineside cabinets are placed on the wayside of the main track, and they play a key role in controlling signalling equipment at trackside.

The use of drones for inspecting lineside cabinets may be carried out by using RGB camera, Infrared camera (NIR) and Thermal camera (LWIR). These sensors can help to detect the correct status of the asset and also to arrange software updates of devices inside the cabinet.

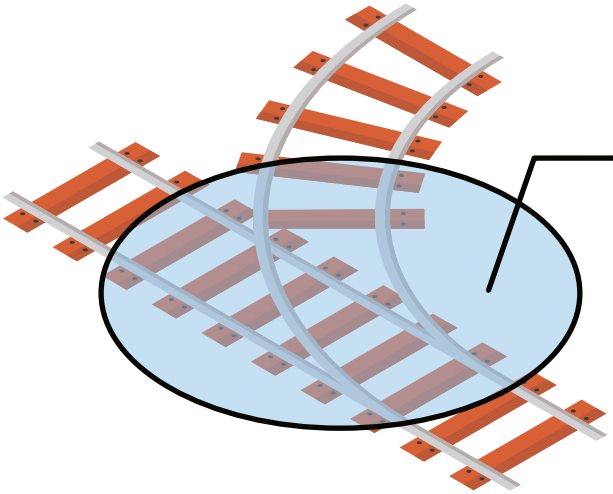


CROSSINGS

A level crossing is an intersection at the same level between a railway track and a road or path. It is the mechanism used to regulate traffic. Radius proposes to carry out detailed monitoring to detect potential failures as early as possible to prevent fatal accidents that still occur every year.

Level crossings have a wide variety of components to regulate traffic, such as road traffic signals, barriers, technical shelter and pavements. It is important that all of them work optimally to avoid collisions between trains and vehicles.

The use of drones for inspecting the level crossing may be carried out by using RGB camera and operators could inspect the asset using the real-time video feed provided by the drone. Visual image recognition can be used as double-edged weapon, providing both a valid tool for diagnostic and maintenance (i.e., monitoring the movements behaviour and time of the barrier, detecting obstacle, etc.), enhancing the availability and the safety of the railway infrastructure.



SWITCHES

A Switch is a device that allows trains to change from one track to another. Their correct operation is vital for rail traffic to function perfectly, thus avoiding incidents such as delays or, in more serious cases, accidents. For this reason, systems that verify its correct operation are key.

At this point, Radius can help improve the way checks are performed. Operators can inspect the asset using the real-time video supplied by the drone, which can provide 3D models of the scene by using technologies such as LIDAR, SFM, etc. Such 3D models can be further used for providing either quantitative or qualitative analysis. Operating time could also be measured using specific algorithms.

Some of the great benefits of using drones for inspecting switches are:

- Simplifying and maximizing the monitoring and maintenance activities by reducing the frequency of the interventions on wayside
- Reducing the impact on Railway system performance and providing a prognostic tool for predicting and diagnosing in advance interventions on a specific component

TESTS AND RESULTS

Radius has conducted several extensive flight campaigns to test and validate the components of the system developed in the technical work packages.

Aviation risk analysis

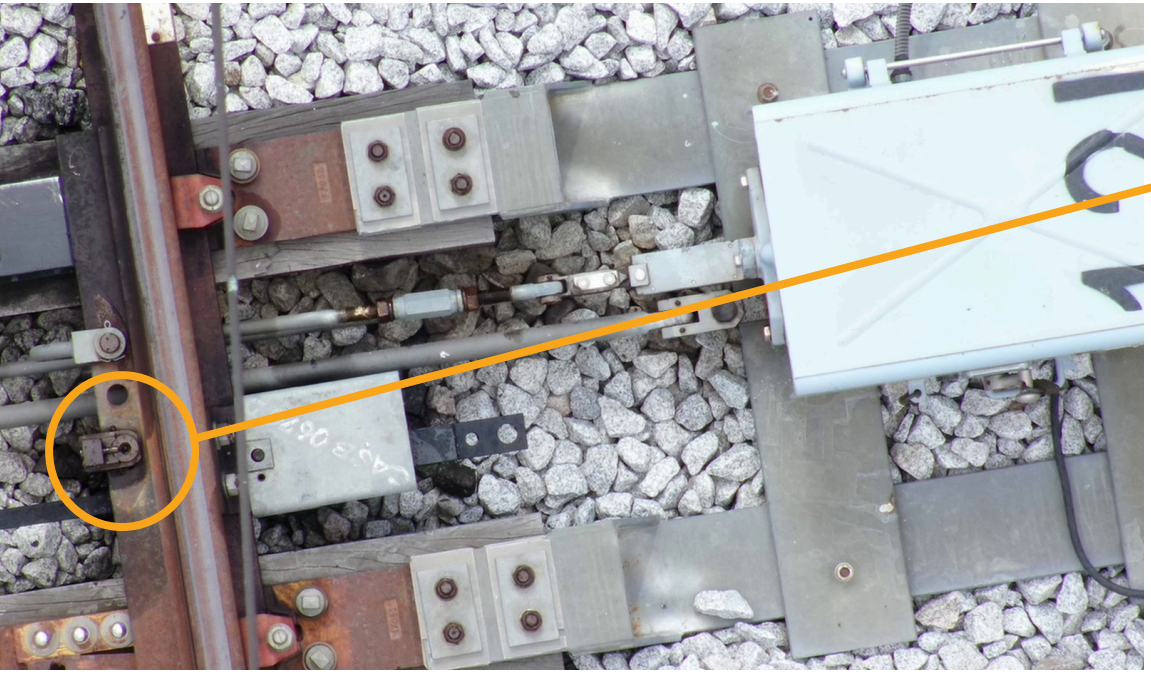
To support the test and validation campaigns, we have performed a Specific Operations Risk Assessment (SORA), identifying the robustness level for each safety risk and the mitigations prescribed by SORA. The assessment includes the risk for third parties on the ground (ground risk) and in the air (air risk).

Initial validation campaign

The initial validation campaign was conducted in a site covering around 12 kms of the Alentejo line from the Casa Branca to the Alcaçovas railway station. This site presents all the characteristics necessary for the RADIUS project and will allow the testing of the BVLOS functionalities of the RADIUS prototype:

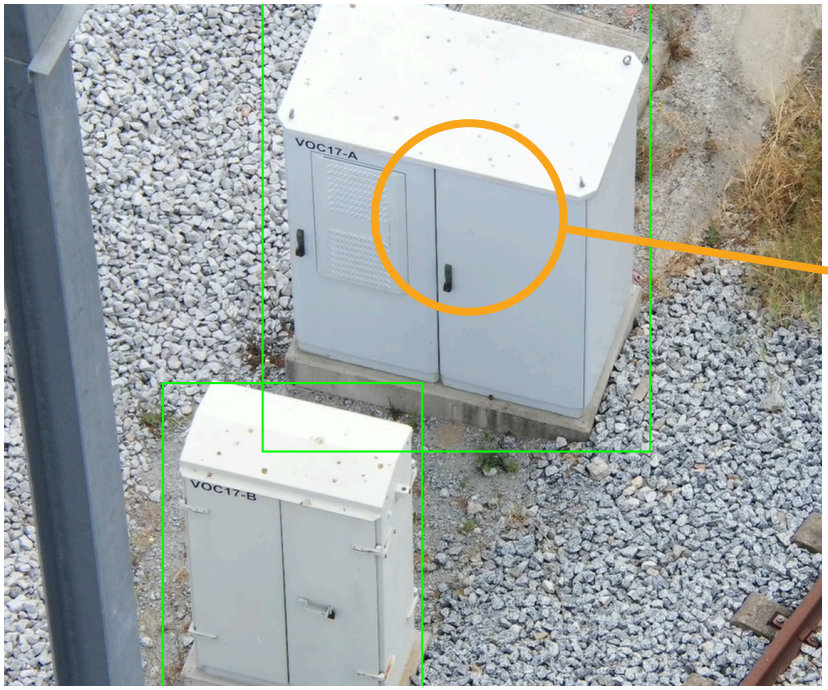
- It is a section of a real railway track allowing tests and validation up to TRL7.
- Train traffic is limited to few slots during the day, offering several traffic-free windows.

In a general view the individual assets can be detected, so the Radius operated drone can stop and zoom on them.



In a zoomed view assets can be analysed to detect possible anomalies

- The section includes both tracks with and without catenary.
- Key assets of RADIUS interest are present, including a level crossing at the Alcaçovas station.
- The section includes typical obstacles to be avoided by a UAS in a railway domain such as a road bridge, a passengers' walkway, light poles, ...
- The area has a very low population density and is free from critical installations (airports, military bases, etc.)



Individual cabinets are identified and isolated for further processeding

Automatic detection of vandalism in the monitored asset

Isolated chronological images of the same asset processed to detect differences

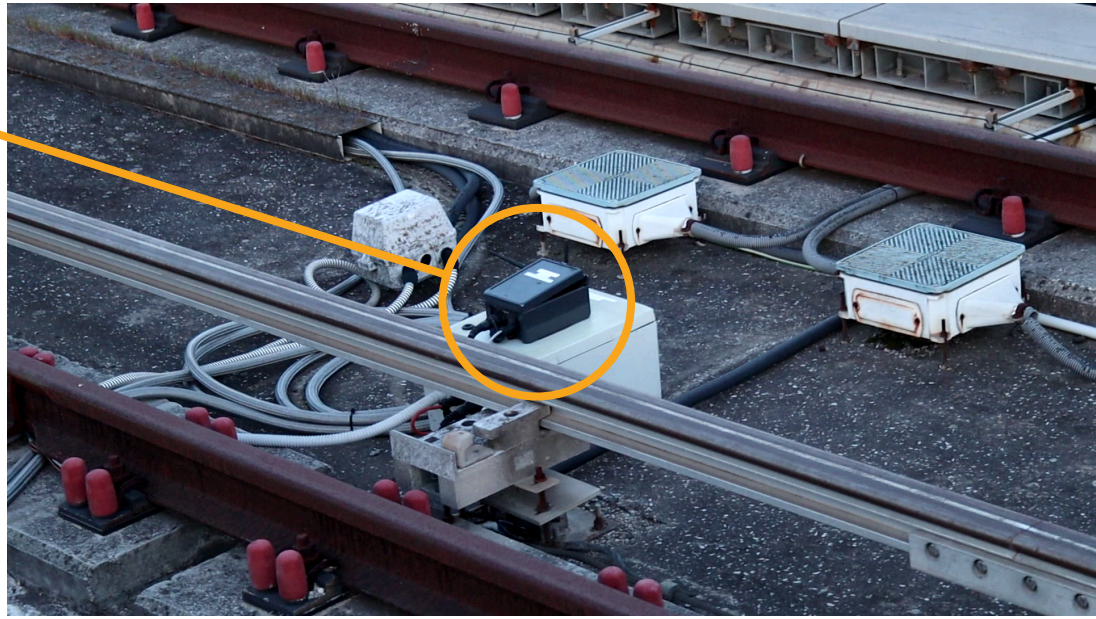
Wireless asset communication

In March 2024, the RADIUS team carried out a series of test flights to validate the remote data acquisition technology that enables the gathering of status and maintenance related data from signaling assets from a flying drone. The demonstration took place at the Naples headquarters of Hitachi Rail, the project coordinator.

The combination of equipment used by RADIUS allows further development of the system to enhance the capture, analysis, and interaction between the drone and the signalling assets in the future, increasing the capabilities of the RADIUS concept.

With this test, RADIUS showed remote acquisition of data is workable in the railway domain, opening the door to extending the concept to other categories of assets and other linear infrastructures.

A simulated signalling asset with a wireless communication device used to test connectivity with a drone hovering over it.



Final demonstration

The final demonstration took place in July 2024, in Ourique Station, in the Alentejan region, in Portugal, which had regular train traffic, allowing the technology to be tested in a real-world scenario. The main objective was to demonstrate all the components of Radius working together.

The demonstration included the final version of the custom developed docking station, a key element of Radius because it allows the drone to take off, land, and charge the drone, thus increasing the range of the solution and making it viable commercially.

The following activities were performed:

- Flights were conducted in VLOS conditions and showed the correct condition and functioning of switches, lineside cabinets, and level crossings.
- Other flights demonstrated how the technology worked in BVLOS. The objective was to demonstrate how a flight would be conducted with the drone out of the pilot line of sight to test the technology in all its aspects.

BUSINESS MODEL

A RADIUS business model has been developed following the Business Model Canvas template. The identified business model is promising, having identified four customers segments (public and private infrastructure managers, railway maintenance service companies, and suppliers of railway maintenance solutions) and the corresponding revenue streams and channels according to the Business Model Canvas approach.

The business model includes the following main conclusions:

- The RADIUS concept is fully viable and exploitable in the railway domain, confirming the strengths identified at the proposal level.
- Two main modes of operation can be considered for RADIUS: survey and condition-based missions.
- RADIUS cannot be exploited for continuous monitoring.
- The most appealing lines for the RADIUS business are the Regional and Community Lines and the Heavy and Conventional Freight Lines, providing an extremely high potential in the EU railway network.
- The number of docking stations required to cover a railway line has an important impact on the total cost of the RADIUS system. Thus, the design of the system should consider choices to minimise the cost of the docking stations, or to increase the UAS operational range to reduce the number of required docking stations.

Key Performance Indicators

Key Performance Indicator	**Target**
Reduction of costs	■ Reduction of 80% of human related costs for preventive maintenance ■ Reduction of 30% of human related costs for corrective maintenance
Increase of health and safety of workers	■ Increase of health and safety of workers by 70% in the long term by reducing their presence in dangerous working areas
Increase of railway reliability and availability	■ Increase of 20% in availability ■ Increase of 5% on reliability

Applications of RADIUS

Application	Comments
Condition monitoring of signalling assets	Images captured by UAS can be used for monitoring of coatings of signalling racks, light intensity of line-side signals, track circuit key parameters, temperature, point machine key parameters, etc.
Identification of vandalism	Detection of vandalism against signalling assets and railway installations close to the tracks.
Detection of malicious and non-malicious radio frequency interference	The UAS can measure signals that are above given thresholds and have the capability of disturbing the signalling communications because of new radio transmissions, degradation of devices that cause emitting outside the usual spectrum, intentional disturbances, etc.
Wireless diagnostic data collection	The UAS can get enough diagnostic data to perform a real-time preliminary analysis aimed at identifying the immediate maintenance actions (e.g., tuning of some key parameters) to restore the operational conditions
Software updates of signalling assets	Signalling assets incur in degraded functionalities because of ageing and wearing of their parts. In most cases, an UAS can fine tune them, optimising their threshold settings or performing firmware updates using wireless technology, considering the security risks inherent to firmware upgrades.
Clearance after human/ mechanical intervention under track possession	UAS can also contribute to increase safety by using the visual sensors to verify that a working site is clear from human and device presence before releasing track possession.

These capabilities go much beyond what is possible to do with the current wired solutions and diagnostic trains and compete favourably with human inspections, at a fraction of the cost and with increased safety.

CONCLUSIONS

Achievements

Radius technology works in the railway environment

The Radius project has succeeded in demonstrating that its technology is technically feasible and allows the use of drones to monitor the correct functioning of critical infrastructures for railway safety. Drones make it possible to carry out more frequent inspections, reduce costs and increase the safety of maintenance operations by avoiding displacing manual work. Moreover, the flights do not interfere with rail traffic.

The docking station makes monitoring of long railway tracks feasible

Radius has developed the docking station, a platform strategically distributed along the tracks that allows drones to land automatically, recharge their batteries and synchronise the information collected during their inspection flights. By extending the range and flight time of the drones, the efficiency of the inspections is improved, reducing costs, and increasing coverage by being able to work in BVLOS, making it a commercially viable solution.

Valuable data acquisition

Radius has proven not only to be technically and commercially feasible, but also that the data obtained during its reconnaissance flights is useful and suitable for assessing and monitoring the state of preservation of the crucial signalling assets. Radius makes it possible to detect efficiently problems or deffects in the monitored assets, ensuring train safety.

Future research

Radius has demonstrated its ability to improve rail safety, but there are still steps to be taken to make it a commercially viable technology.

Improved navigation

Radius currently relies on propietary RTK positioning systems. It would be desirable to remove this dependency. One possible solution would be to use Open-Source solutions based on EGNOS, OSNMA and GALILEO.

Asset management platform

Reconnaissance flights generate a huge amount of data that needs to be processed and archived efficiently so that it can be exploited to the full. Therefore, further steps need to be taken to develop and integrate a specialised and customised asset management system.

From prototype to commercial solution

Radius has managed to reach TRL7 level, but more research would be required to reach TRL9.

The project has conducted successfully validation campaigns in relevant environments, but the next step is to convert this prototype into an economically viable commercial solution on the market.

Other applications

In the rail sector

Radius has demonstrated its viability for monitoring the status of signalling assets, but the technology has the potential to be extended to other categories of assets and other uses cases within the rail sector itself.

In other linear infrastructures

Radius is a project with great potential to be extended to other industries or linear infrastructures, with common characteristics with the railway sector. Many of the technologies developed could be extrapolated to other applications, such as the docking station, wireless communication and the image processing algorithms.

Achievements

Viable technology
Feasible operations
Useful information

Future research

Improved navigation
Asset management platform
Prototype to product

Other applications

Railway domain
Linear infrastructures

Railway digitalisation using drones

To get more information about the project RADIUS, please contact us at:

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