# Digitalisation for Infrastructure Managers: the RFI experience

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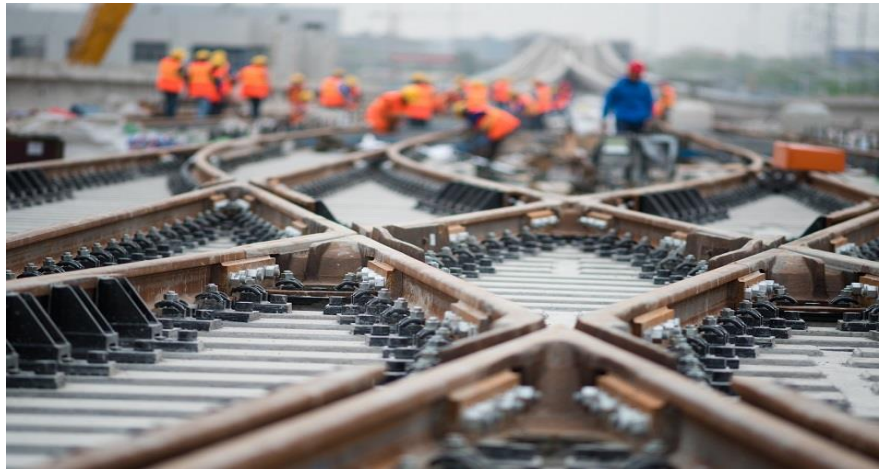
# Digitalisation: the RFI experience

Digitalisation impacts on the **maintenance organisation**, on the operational processes related to **rail traffic management** and also it's important contribution to the development and implementation of **new technological systems.**

The benefits of widespread use of digitalisation and new technologies in general, on one hand are linked to the **increase in efficiency and availability** of railway systems, on the other hand, it **reduces operating costs**, resulting from an optimization of resources and maintenance



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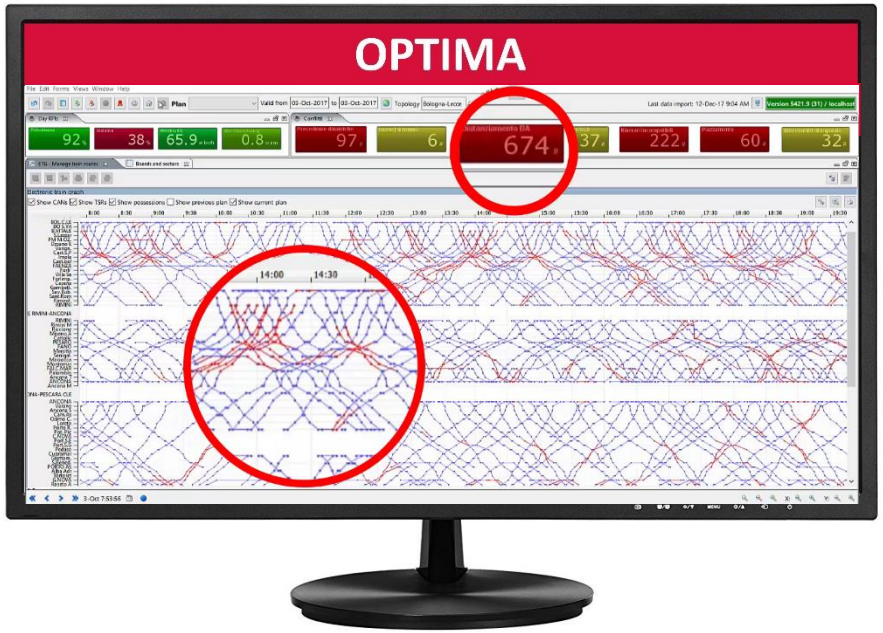
# Digitalisation: the RFI experience

There are many ways to implement digitalisation, first of all, the **massive use of embedded systems** on control and command systems, by increasing the level of automation of the plants, lead both an **increase in levels of signalling reliability and safety** and a constant **reduction in traffic personnel**.

A second way is represented by AI, that through the application of Machine Learning, will support both the **predictive maintenance** process in the immediate future, by analysing huge amounts of data, and also support the **decision-making processes for optimizing rail traffic** even in bad traffic conditions.

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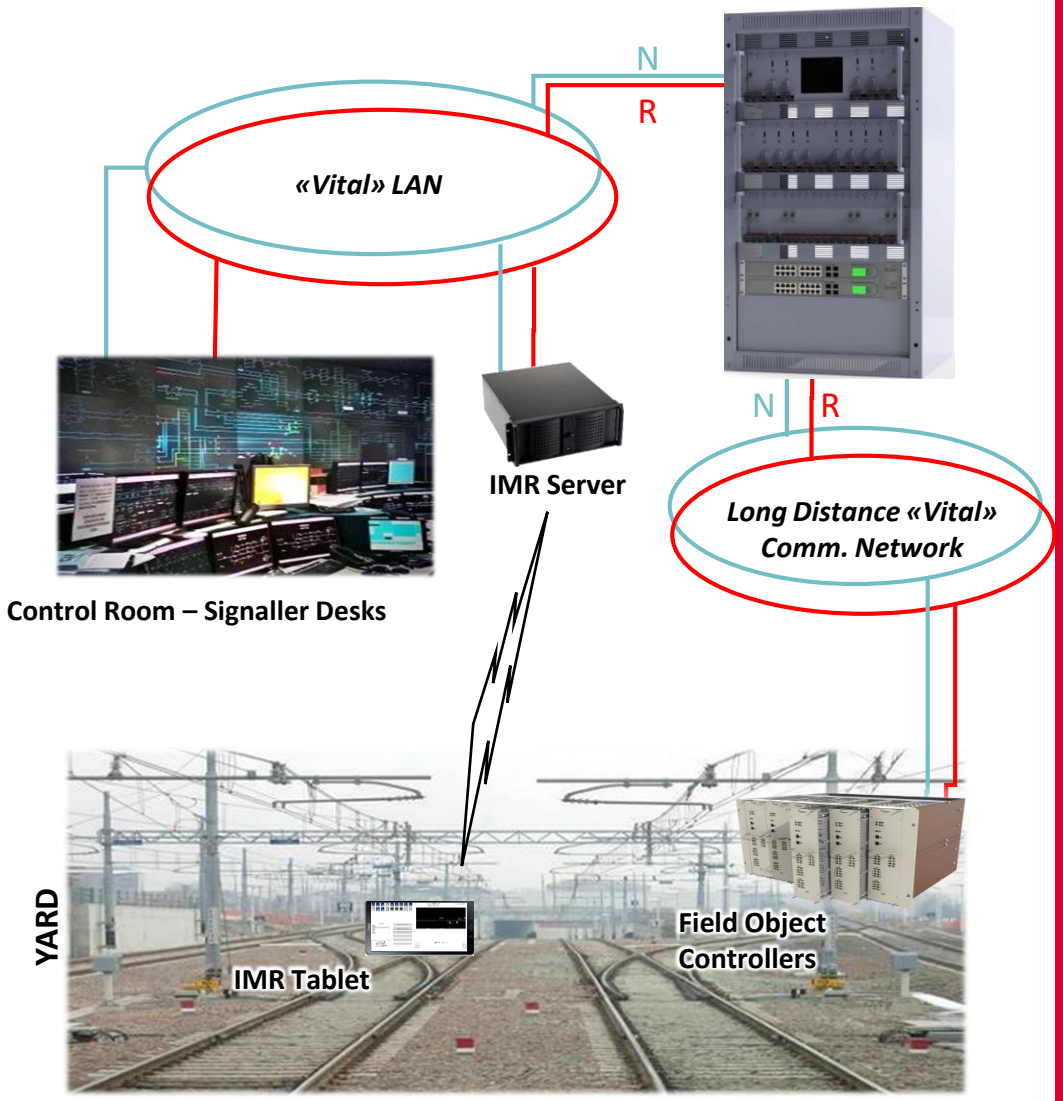
# Embedded system: RFI IXL HW&SW Platform project

- The Project started in 2017 to improve RFI maintenance and logistic support processes by standardization of IXL functions, interfaces, products.
- System architecture and components are designed by engineers of the RFI R&D Department
- The project aims to meet EULYNKS-RCA requirements
- IXL standardization is implemented by standard communication protocols PVS
- Safety Logic Libraries are expressed in standard (and not proprietary) languages in such a way to be imported into commercial sw design environment supporting UML
- High reliability targets throught component redundancy at any level of system architecture

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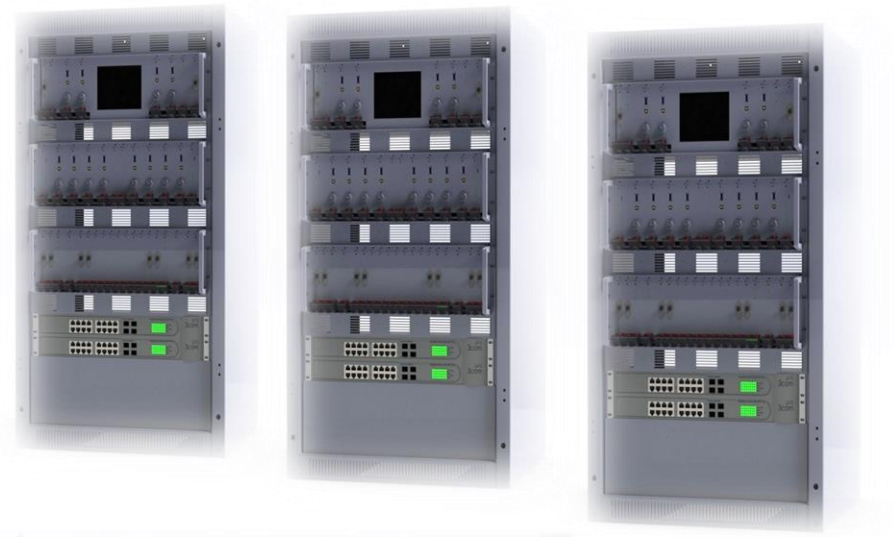
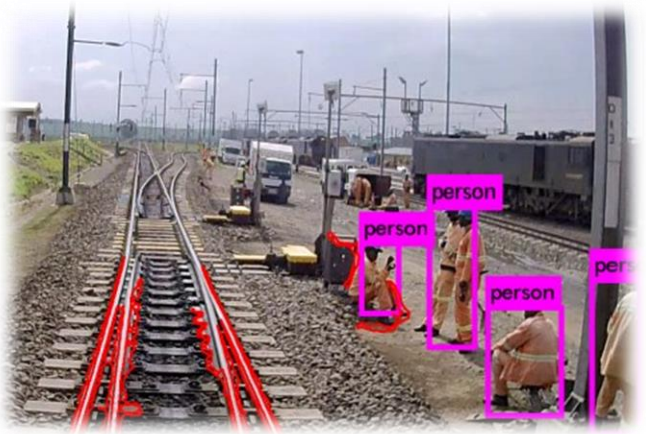
# The challenge of predictive maintenance

Today **predictive maintenance** can be achieved with the massive use of widespread, and until yesterday unimaginable, **computing power** that makes it possible through the use of advanced machine learning applications to discover hidden patterns in data, so far unknown.

This pushes us towards amazing progresses in: **image recognition and robotic vision**, in the understanding of text and speech, using in real time translation tools, and precisely in predictive maintenance.

**But computing power alone is not enough** because the machine learning energy, the machine learning fuel is the data.



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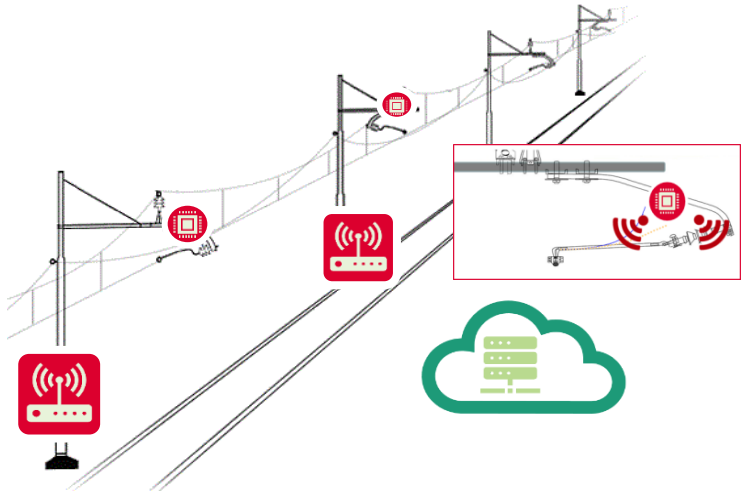
# The challenge of predictive maintenance

Thus, there is a need for a **widespread network of sensors**, capable of recording events like track vibrations, or overhead power supply displacements, and in general all physical variations that takes place on the railway network.




Use of low-cost transducers that can be integrated into the material (**Smart Material**) and sensor nodes with Computational Capacity for Structural Monitoring tasks with self-feeding systems (**Harvesting**)

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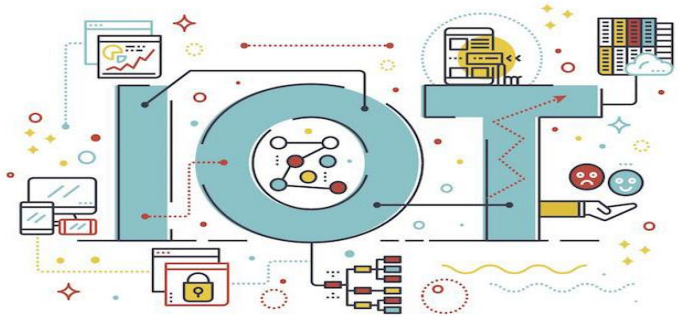
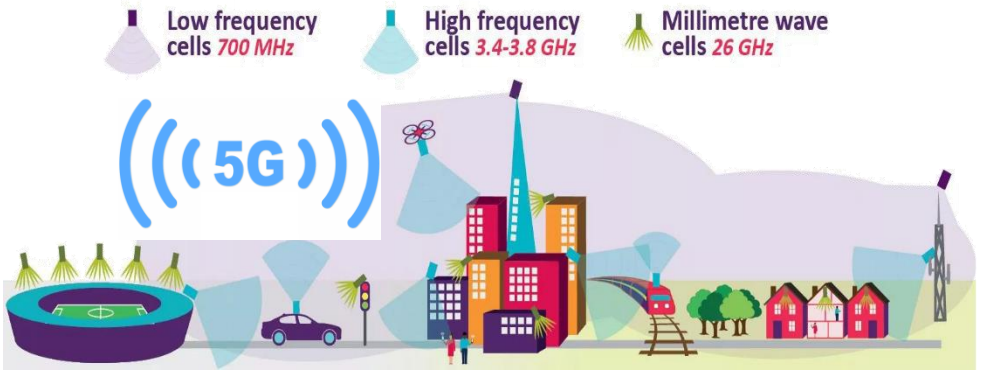
# The challenge of predictive maintenance

Here we are today for the first time having at our disposal the three resources we need. First the **computing power** necessary to develop predictive management models, through the use of AI, second a **new generation of wireless sensors** that can record what is happening on our network both from a mechanical and electronic point of view, and the incredible possibility offered by the **development of 5G network**. That will make available bandwidths that can carry a large amount of data and latency times that will make possible real-time operations.



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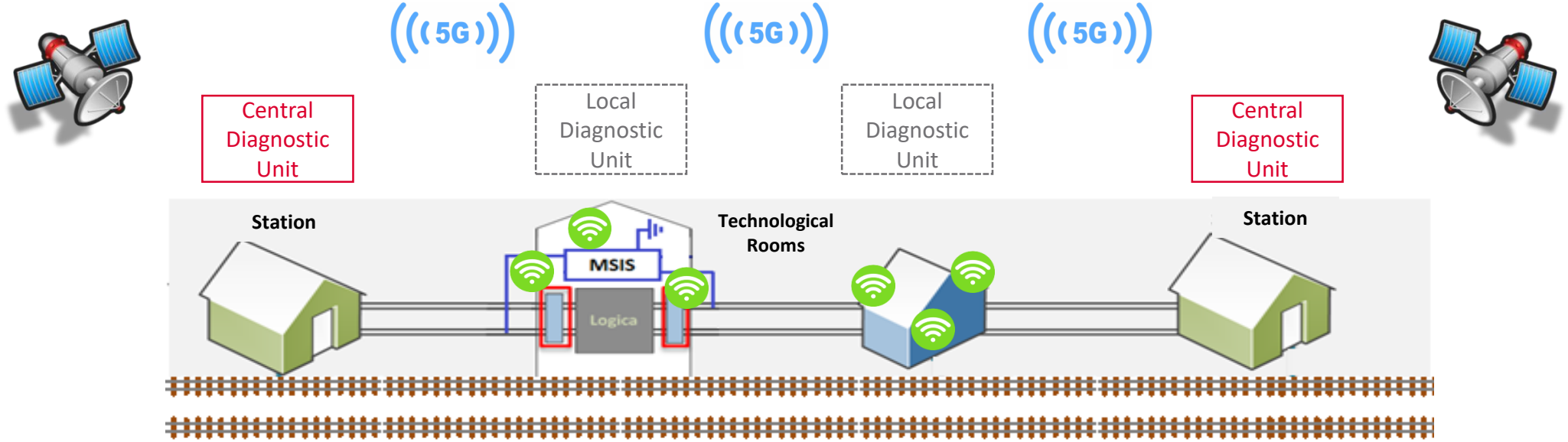
# Predictive maintenance by using 5G and satellite networks

In this context, RFI has launched a research project summarizing these themes and is developing an innovative system **in collaboration with the main national and international players** in terrestrial and satellite telecommunications sector. This system is based on sensors distributed along the railway line and **it can record signals from civil works, from the track, from the power line, from signalling and telecom systems** to transfer to local control rooms using the 5G network with the satellite network used as a backup.

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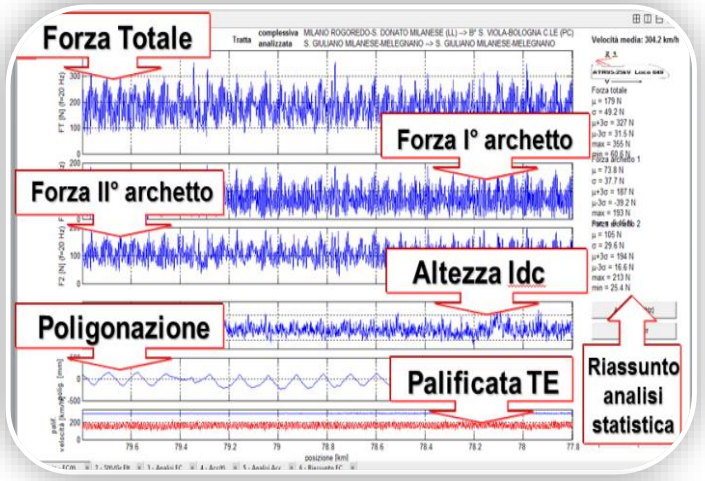
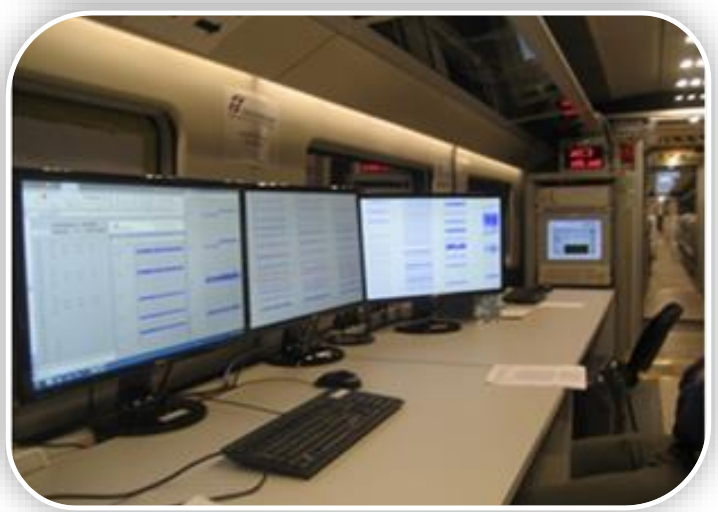
# Predictive maintenance by using 5G and satellite networks

Further monitoring elements will be the measurement systems installed **on board the trains of the RFI diagnostic fleet**, that transmits by 5G in real time the measurements made during the train runs.

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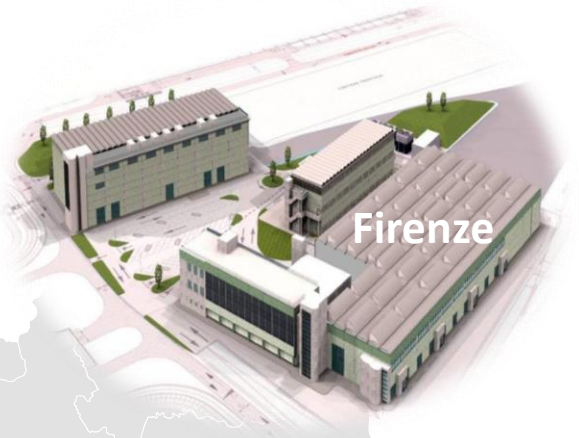
# The Labs: where the Innovation starts

It is very important to have areas available where to do R&D activities. First **the labs where to simulate and reproduce the functional behaviour** of new systems, which is where the innovation starts.

But also where the field tests are carried out is very important, because there we can **check the features and performances of technological demonstrators** tested in the labs.



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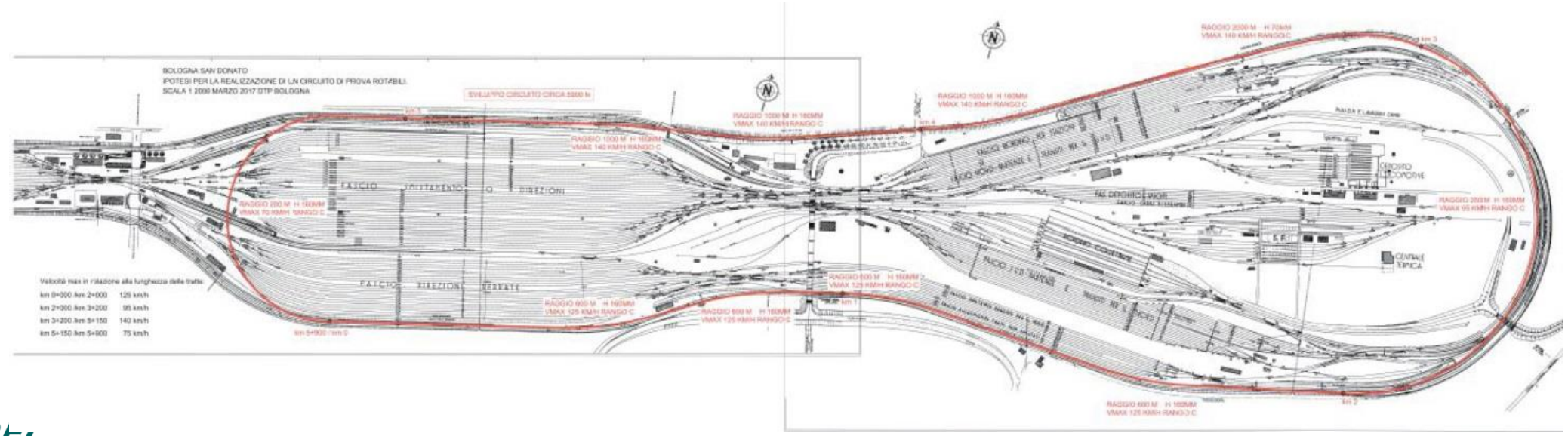
# The Test Circuit: where the dimonstrators can be check

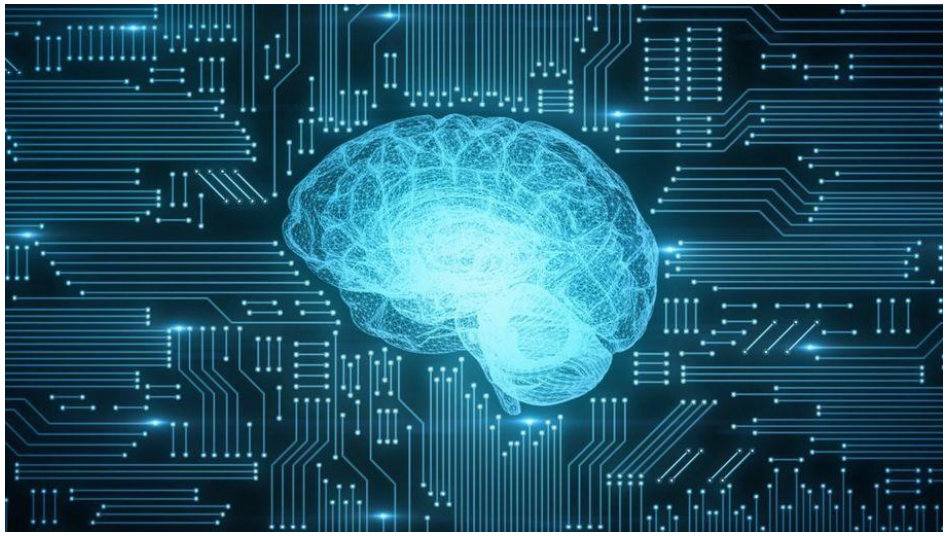
That is why RFI during 2019 puts in service a test circuit in Bologna, where it is possible both to carry out tests for rolling stock and to carry out tests on systems and equipments of the infrastructure.



# AI: new professionals

The **massive use of AI** and machine learning reveals the need for **specialized professional teams** to understand and to analyse real phenomena through data, in order to extract knowledge and thus to generate value.

Specialists who can **define the contours of the problem by choosing the model objective feature**, to capture and to prepare the data, to adopt a machine learning model that is trained to solve the problem and finally to validate test models and to bulk up results.



# AI: new operator skills

**Algorithm developers** will no longer be required to identify the rule-based algorithm of the problem-solving, but they will need to have the ability to interact with machine learning systems.

In addition, we are facing a revolution in **maintenance operators skills**, in the future they will not have strong manual skills or be capable of solving failures. They will need to have a great ability to manage maintenance web oriented tools and why not in a gaming oriented interface.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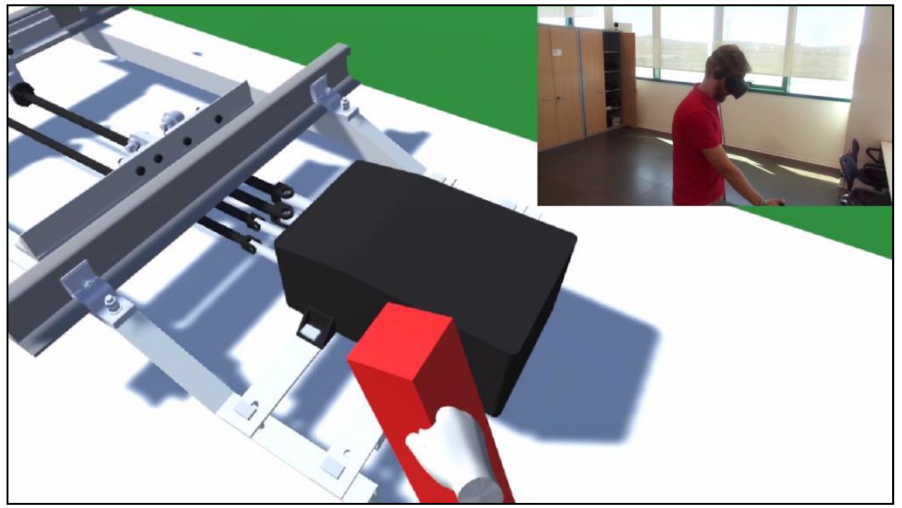
# AI: new staff training

Therefore, staff training will need to go immediately in this direction, to make sure that the staff will be able to properly use **maintenance support systems**, in the coming years, as well as the development of machine learning models predictive maintenance.

This is **the great challenge of the future**, to be ready to develop predictive maintenance systems and to manage them effectively to prevent the large amount of data from burying us all.



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# Universities and Research Institutes network

Innovation and research are not an option but an RFI need, for this reason RFI has been equipped itself with an important internal R&D organisation and **an external competence network including Italian universities and research institutes.**

From last year until today RFI signed specific framework research agreements with 25 universities and research institutes, active nationwide in the main areas of high-tech systems.


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# Universities and Research Institutes agreements

The contracts have enabled research projects ranging from predictive maintenance of wireless sensor-based infrastructure systems, to the use of self-guided rail drones for the control and monitoring of lines, up to the realization of proprietary hardware and software platform for interlocking systems.

To give you an idea of the economic resources used in the last 18 months in this area, more than **16 million euros** have been committed to support a new widespread synergy between academic research and railway world, that is producing extraordinary and unexpected results.

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# RFI R&D main ongoing projects

**RFI Platform**: new HW/SW standard, fully designed, developed and deployed by internal RFI team, applicable for ACC systems within national ERMTS acceleration program and for fail-safe applications;

**Coherent Radar system for railway areas protection**: SIL4 system for the protection of railway areas from landslides and rock fall, in presence of high hydrogeological risk;

**Lightweight Railway Drone for automatic line visit**: automatic guidance system with artificial vision capacity to be used in night construction and working areas to check the freedom of railway lines before the reactivation;

**Monitoring system for rail integrity**: diagnostic system to check rail integrity by means of optical, ultrasonic and accelerometric measurements for an early detection of defects and prompt maintenance activities;

**«Smart Rail» project**: rail monitoring system with optical fibers installed on the rail web to monitor the dynamic behavior of the track and ensure predictive maintenance;

**5G/Satellite for Smart Maintenance**: introduction of 5G technology integrated with satellite communication to ensure monitoring of railway infrastructure in real time;

**Quantum Protocols for safe proof communications:** application of new quantum communication techniques for command and control of safety critical systems with intrinsic protection against potential threats (hackers);

**«Box Drone» project:** management and control system for surveillance drones within critical technological areas (security), fully designed and developed by internal RFI team. Patent application ongoing.

**Technological Simulators for Training**: development of a HW/SW system simulators for training and skills development of RFI staff, through the use of innovative automatic platforms.

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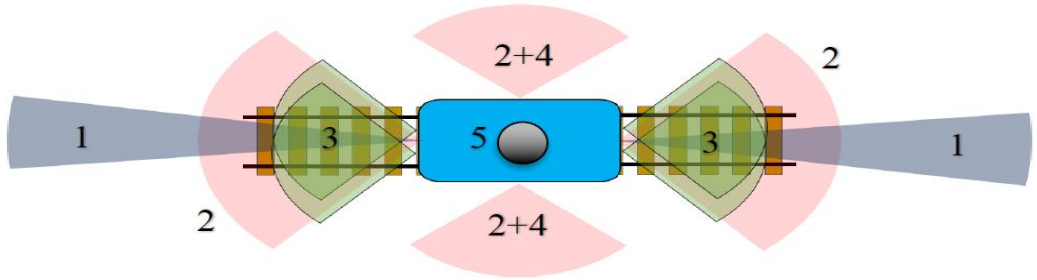
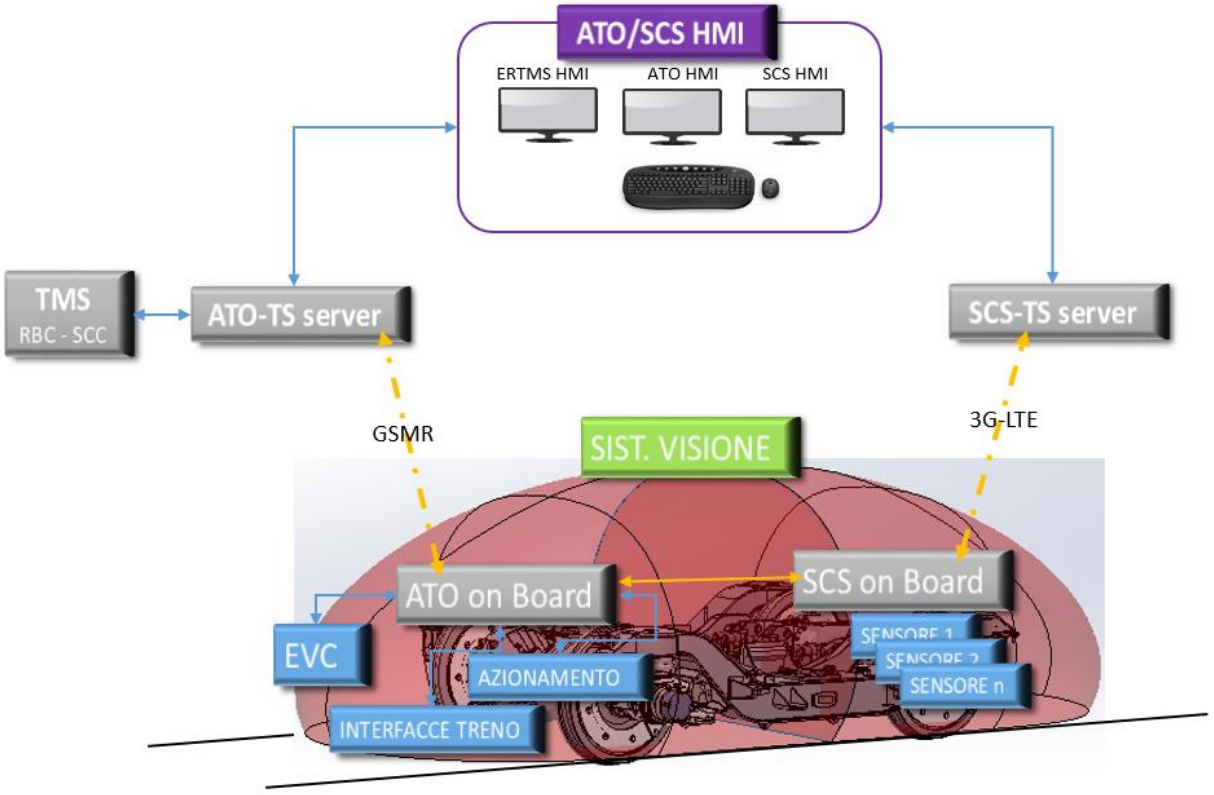
# Unmanned Railway Vehicle

## Railway monitoring , surveillance and maintainance

- The URV will operate on HS railway lines equipped with ETCS level 2
- Two driving modes are provided with the ATO:
  - Autonomous driving
  - Remote driving in charge of a remote operator
- The vehicle is equipped with:
  - Lidar sensor
  - RGB camera
  - IR/NIR/IFR camera

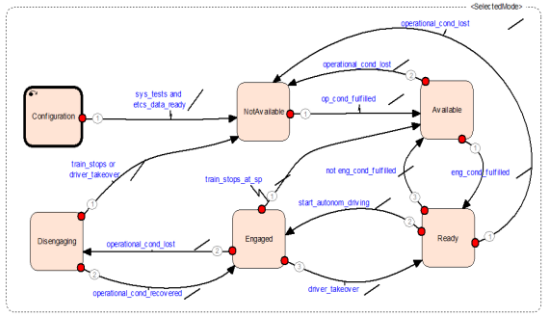


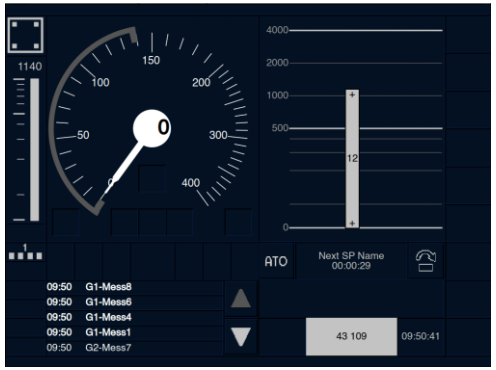



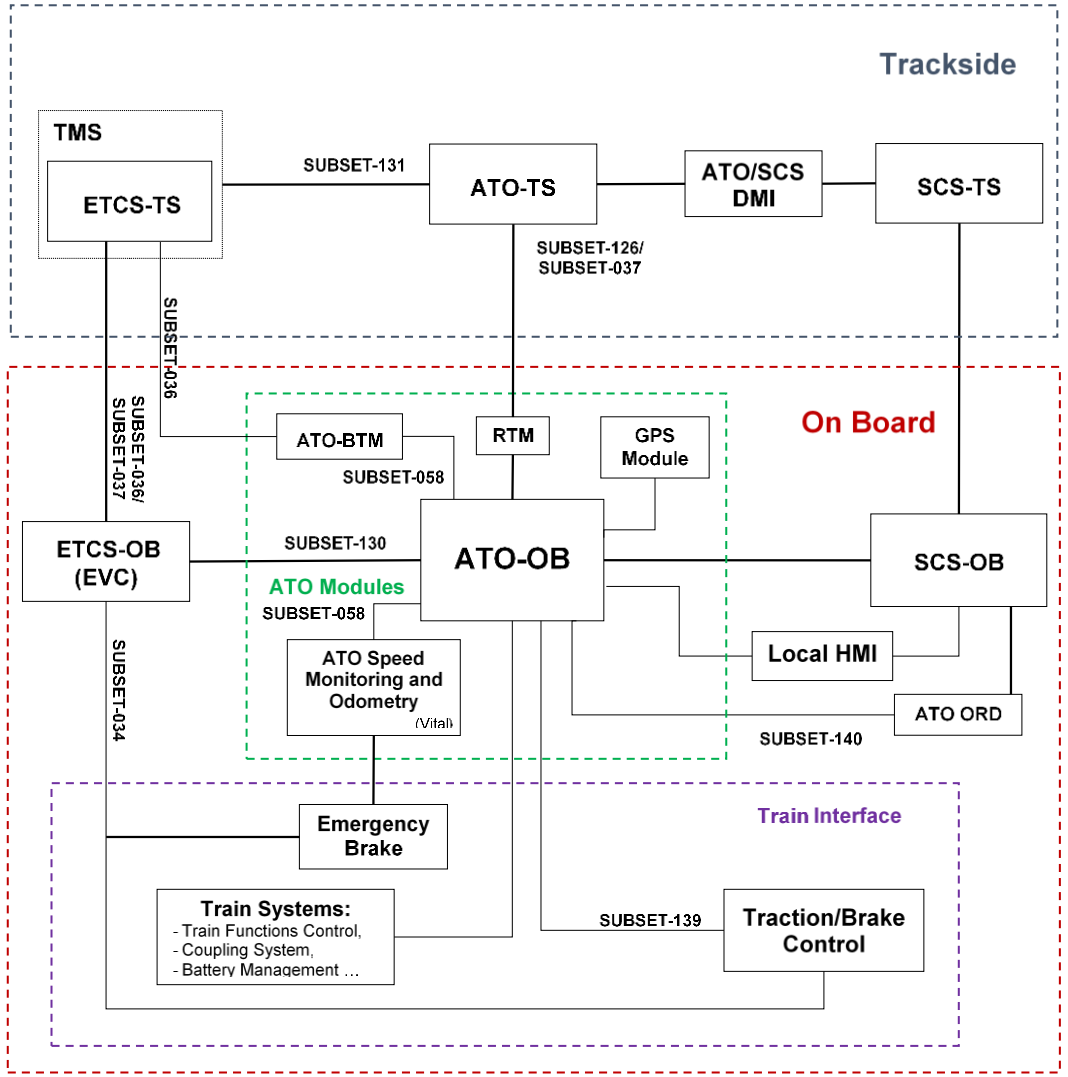
# Autonomous Train Operation

## Railway monitoring , surveillance and maintainance

- The ATO over ETCS for URV is inspired by Shift2Rail specifications
- The proposed ATO supports:
  - Up to Grade of Automation 4
  - Operating scenarios with and without ETCS supervision
- Model-driven design and formal verification tools are currently used for software development and testing
- The first ATO prototype will be tested on the San Donato railway circuit in 2020

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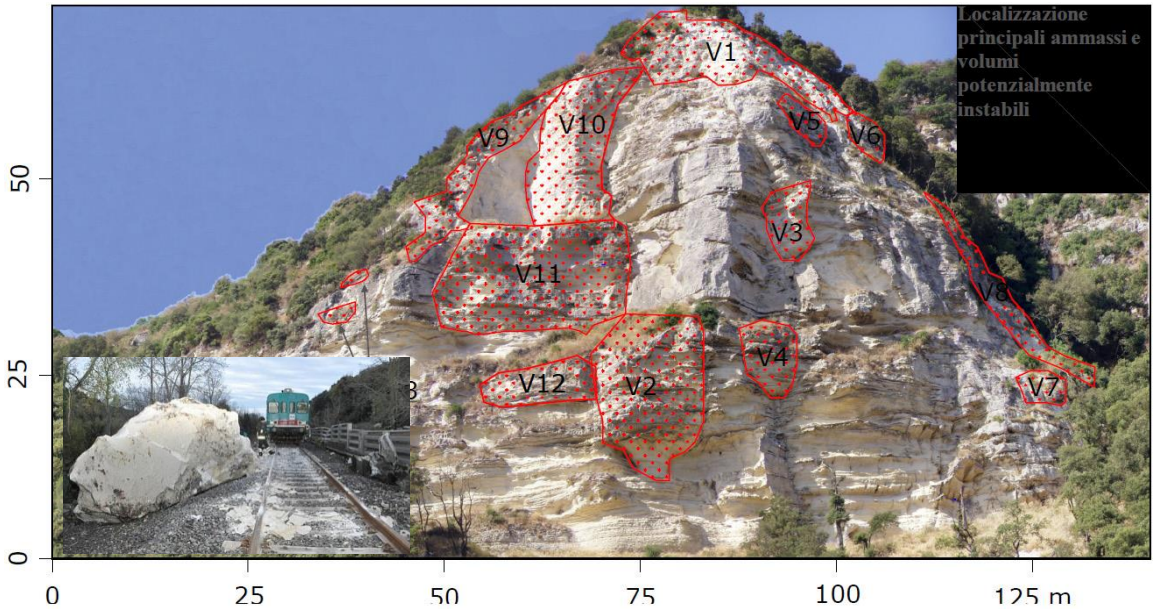
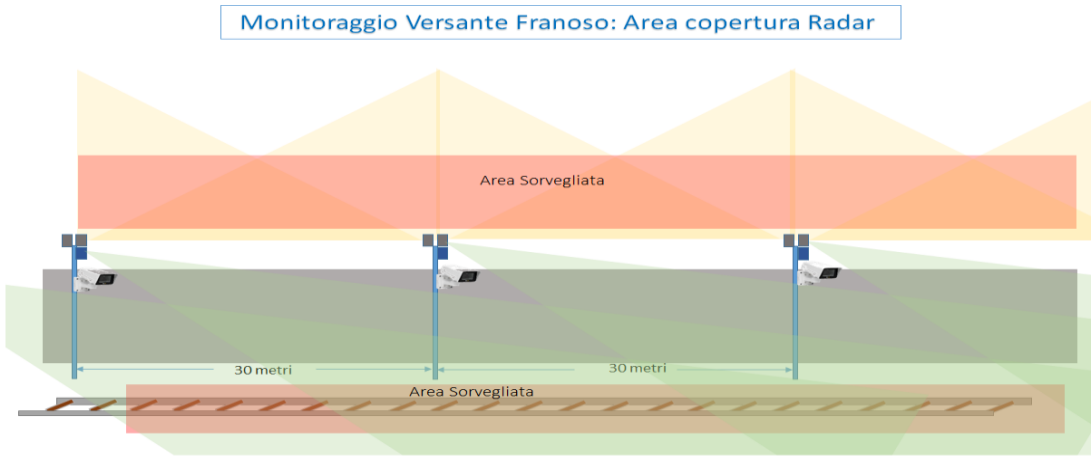
# SIL4 Radar System for Landslide Slope Monitoring




An innovative radar technology can have different application fields.

The research project is focused on the realization of a **“virtual wall”** able to automatically intervene, stopping the train in case of risk due to landslides.

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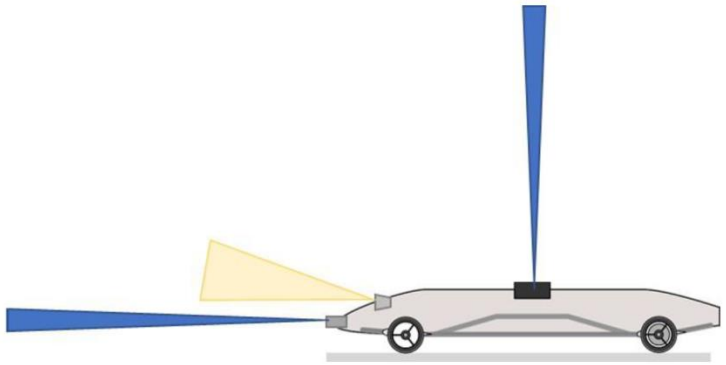
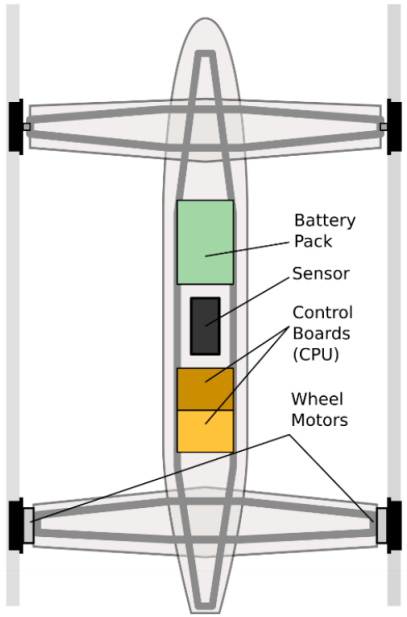
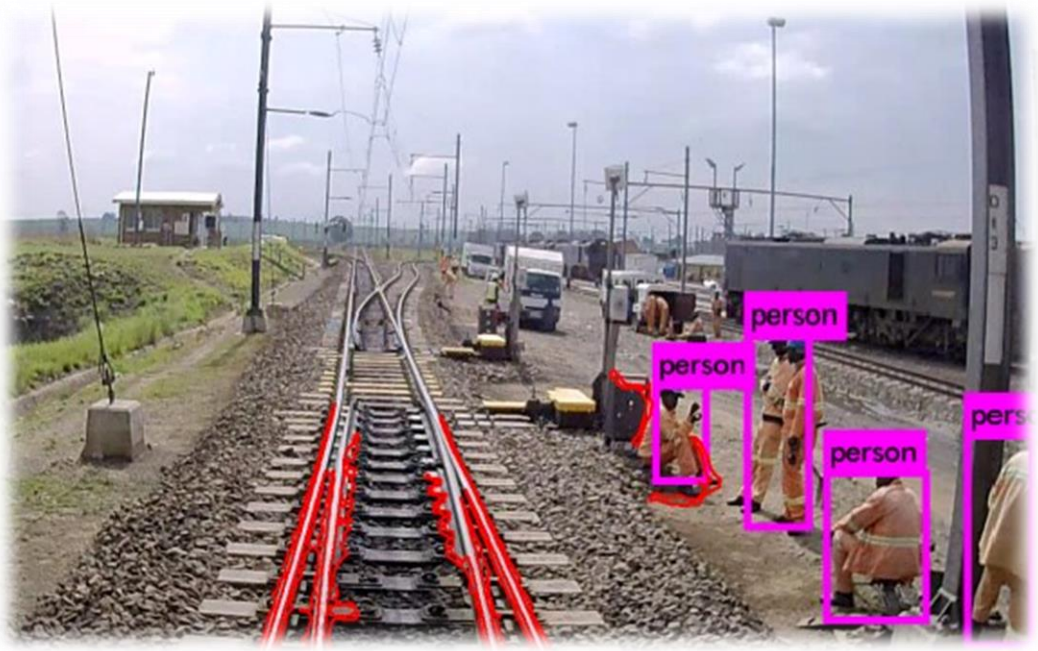
# Autonomous inspection vehicle for railway lines

The research project is aimed at demonstrating the technological feasibility of a drone:

- Programmable autonomous inspection
- Circulating on the track, operating at speeds up to 100 km/h
- Portable, easy to be installed/removed (up to 20 kg)
- Automatical real-time inspection
- Autonomously driven (autonomy of 20 km)
- Anomalies/obstacles detection by means of Laser Scanners and Computer Vision



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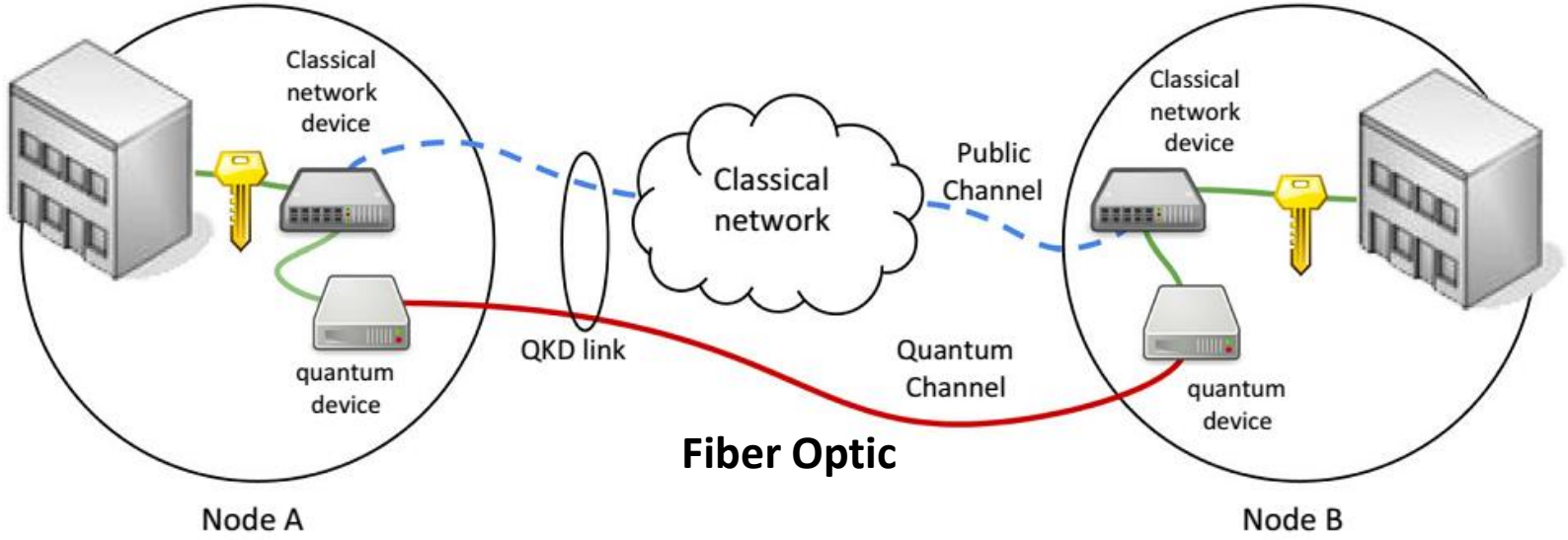
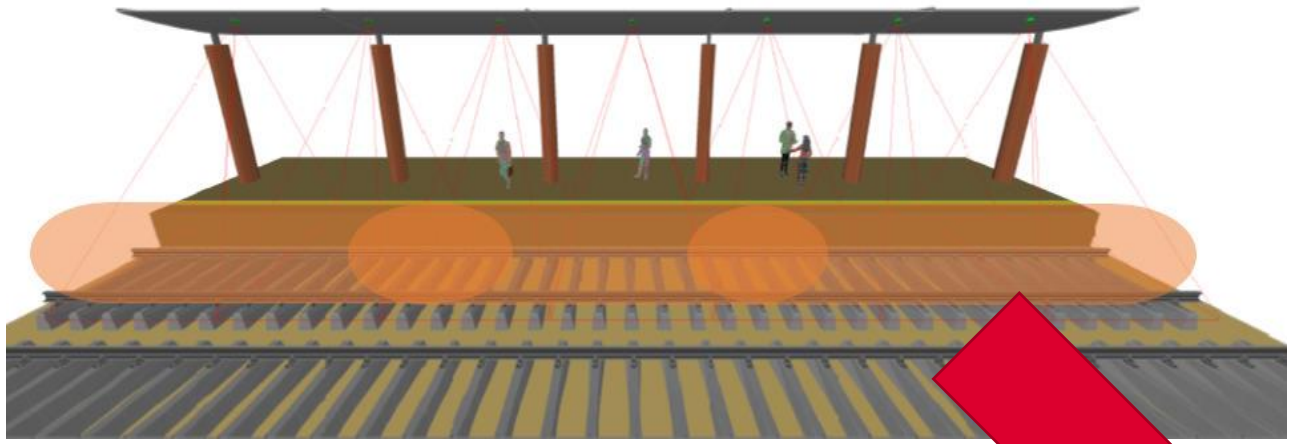
# Quantum Cryptography for Intrinsic Safe Application

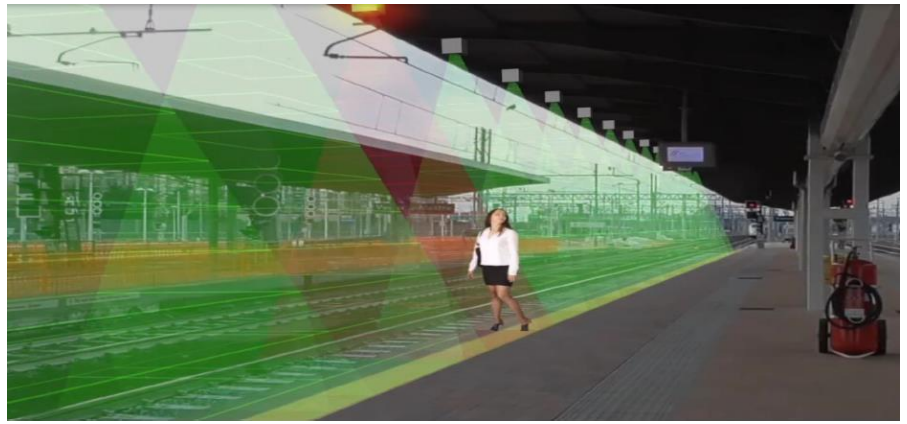
**Quantum Key Distribution (QKD)** overcomes the limitations related to encrypted data communications: enconding and decoding keys are indecipherable and hacking attacks are inherently prevented.
Quantum Cryptography systems concentrate the information of bits in the physical properties of single **photons**, which is the fundamental constituent of light and electromagnetic radiation.
The laws of Quantum Mechanics guarantee that if a photon is intercepted by an attacker on its way between the two parts that are generating the **encoding key**, some of its properties are modified and the attack can therefore be detected. **Security is managed at a physical level**.

**ANY KIND OF COMPUTER ATTACK OR THREAT IS DETECTED**

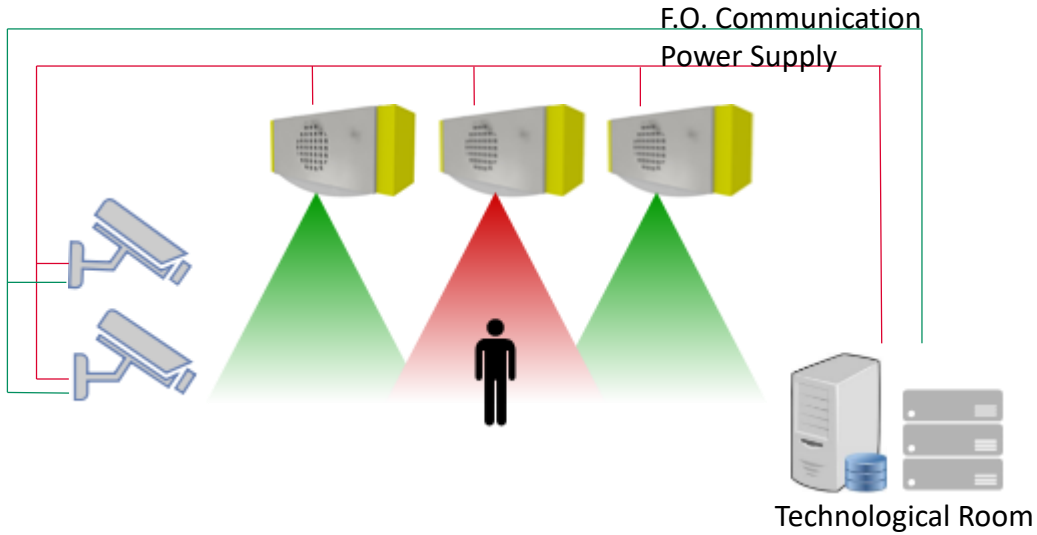


# SIL4 Radar System for Yellow Line at Station Platform





With the innovative intrinsically safe radar technology, a system is set up **to monitor passenger behavior** while waiting for the train, in order to prevent actions such as crossing the track.

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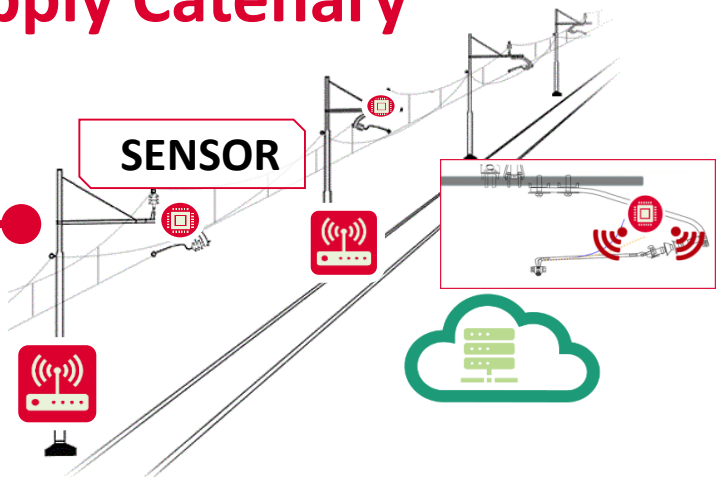
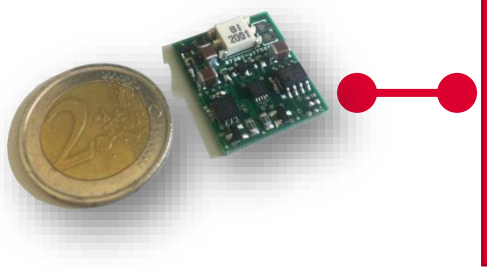
# Embedded Low-Power Diagnostics for Power Supply Catenary

Aimed to the **discriminate the causes of an undue fall of the Railway Catenary**: Real Time monitoring of the infrastructure through sensors and innovative data processing techniques

OBJECT



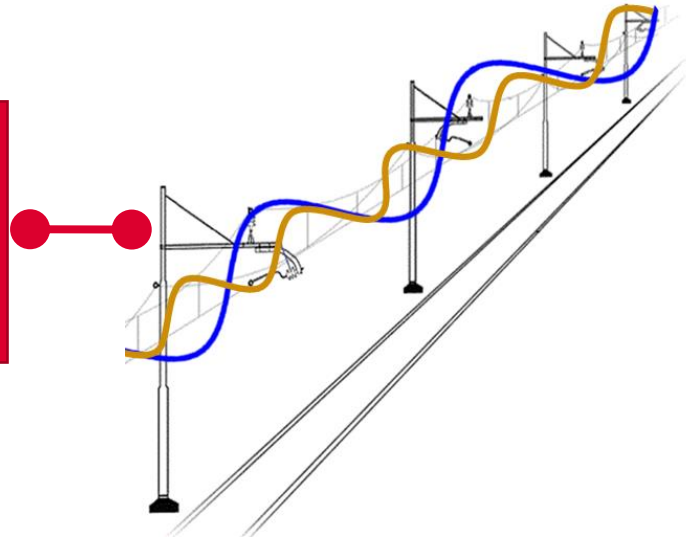



TECHNOLOGY

Use of low-cost transducers that can be integrated into the material (**Smart Material**) and sensor nodes with Computational Capacity for Structural Monitoring tasks compatible with self-feeding systems (**Harvesting**)

As the train approaches, the push that the pantograph exerts on the Railway Catenary lifts the polygon arms **(Up – Lift)** and introduces a second signal, which can be correlated to the **Pantograph - Catenary interaction**

STRATEGY



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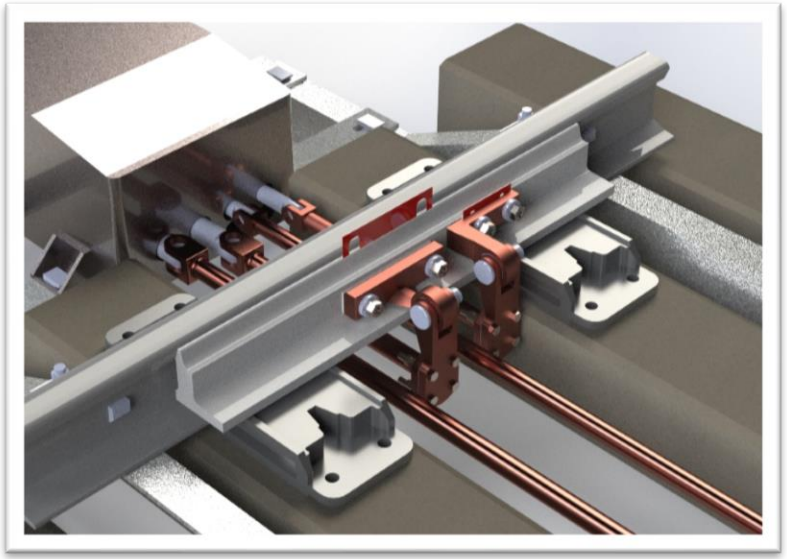
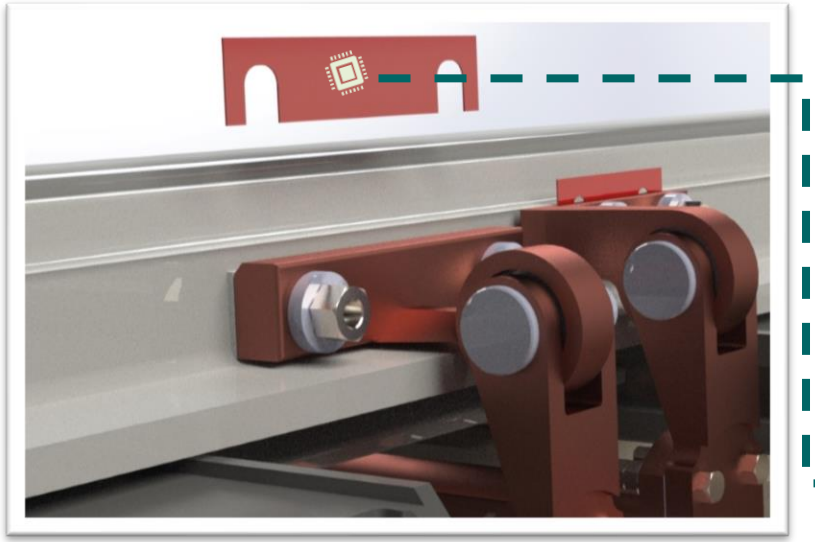
# Embedded Low Power Diagnostic for Switches






- Contactless measurement of rail gauge and all the **safety** distances within the turnout by means of **LVDT** (Linear Variable Displacement Transducer) sensors;
- **Multisensor Analysis Embedded Platform**: miniaturized solution with **6DOF** (Degree Of Freedom) inertial platform for vibration analysis and LVDT data correlation;
- Thermal Effects Compensation on measured parameters.

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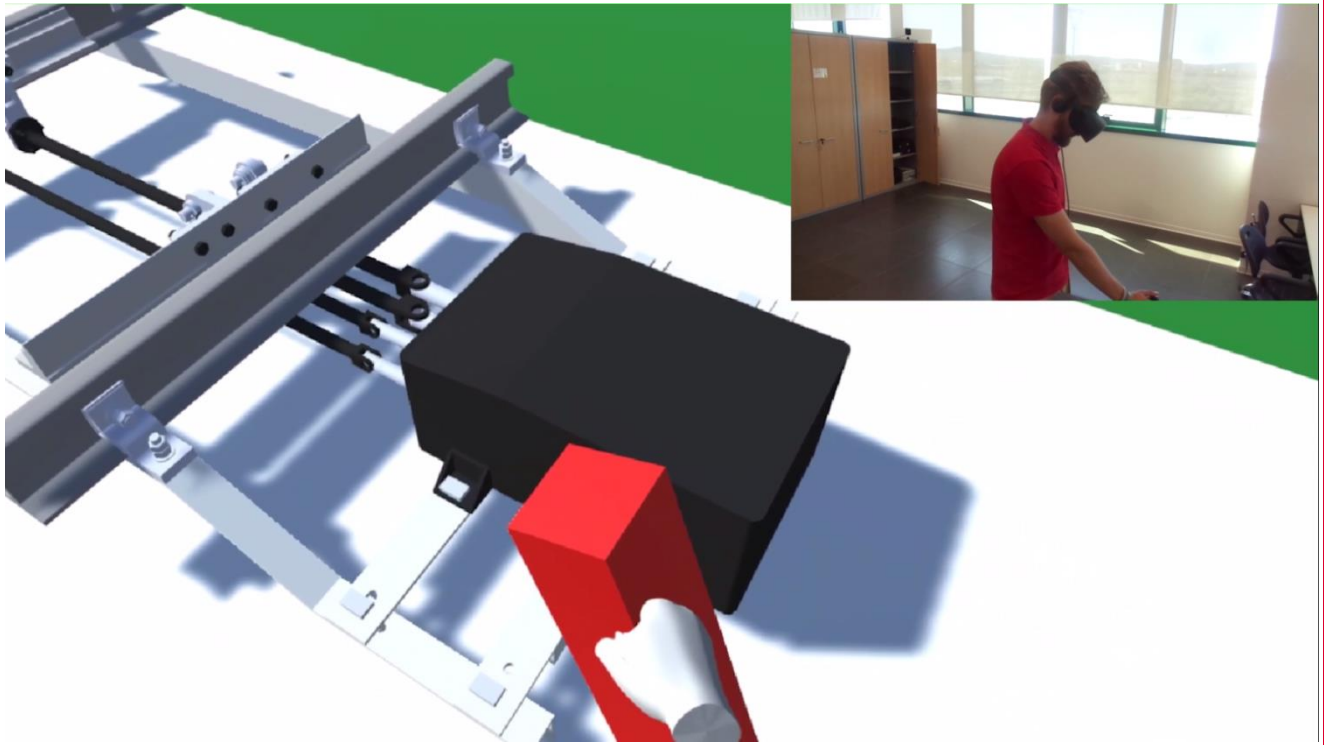
# Virutual and Augmented Reality for maintenance training


The representation of real equipment in a virtual environment is applied in **trainings** of personnel assigned to maintenance operations. The augmented reality will allow to **guide** the operations during the interventions in the field, reducing the possibility of error and the times of intervention.



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# Quantum Protocols for safe proof communications

## Use Case Application

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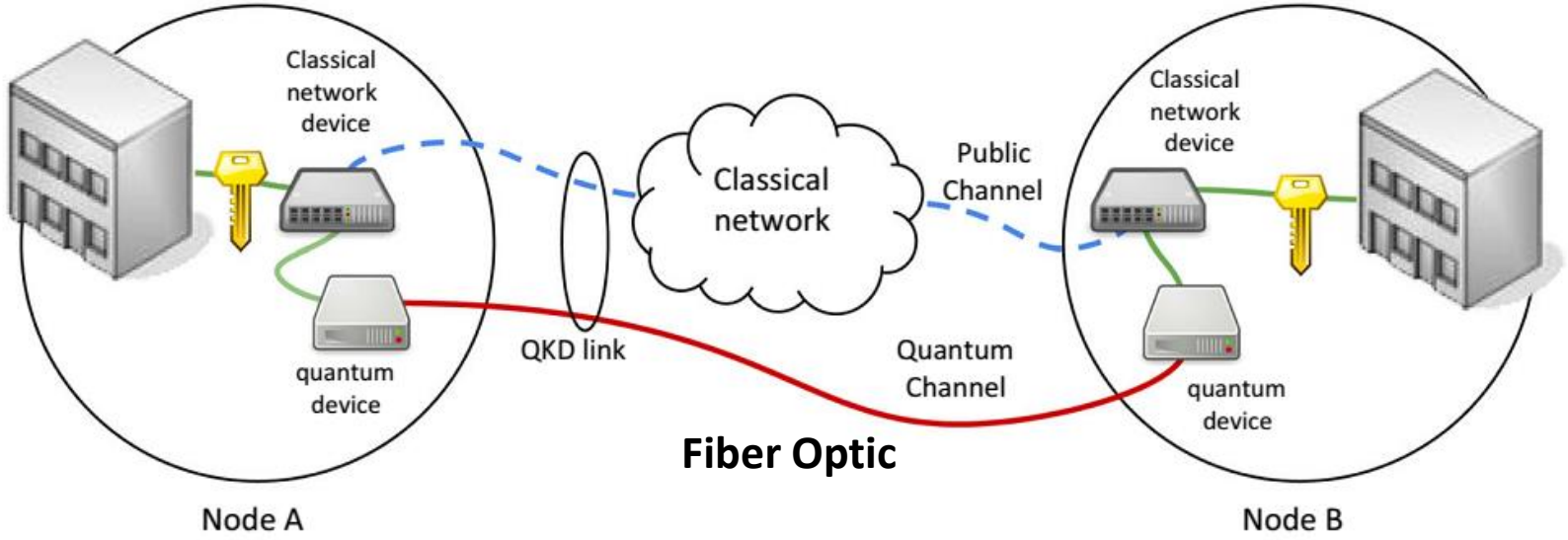
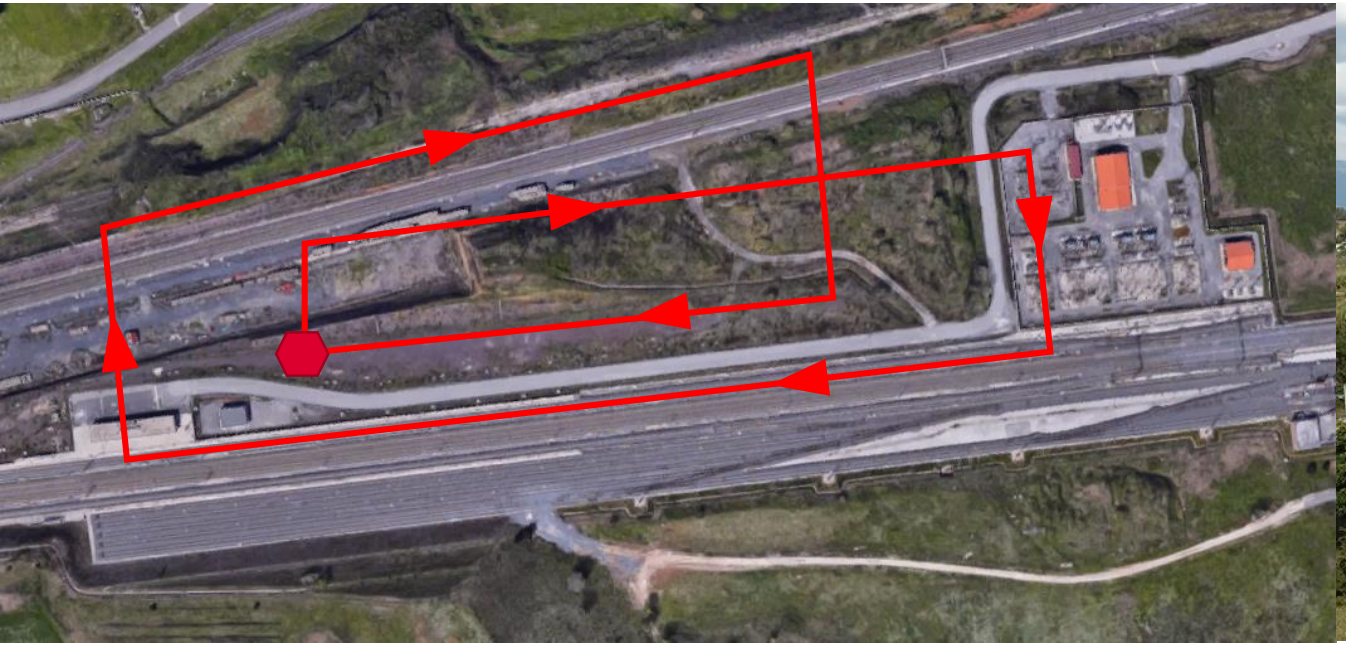


# Drone Box Project

**Automatic platform for drone management** with the scope of monitoring, anomaly detection and mobile video surveillance on railway assets of interest in the security context



## Results and benefits

- Low costs (one order of magnitude lower than competitors)
- HW and SW open architecture (easier to update)
- Modular and transportable according to current legislation
- Proprietary charging system and adaptable to any commercial drone

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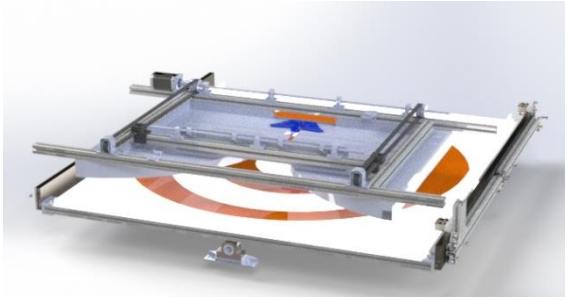
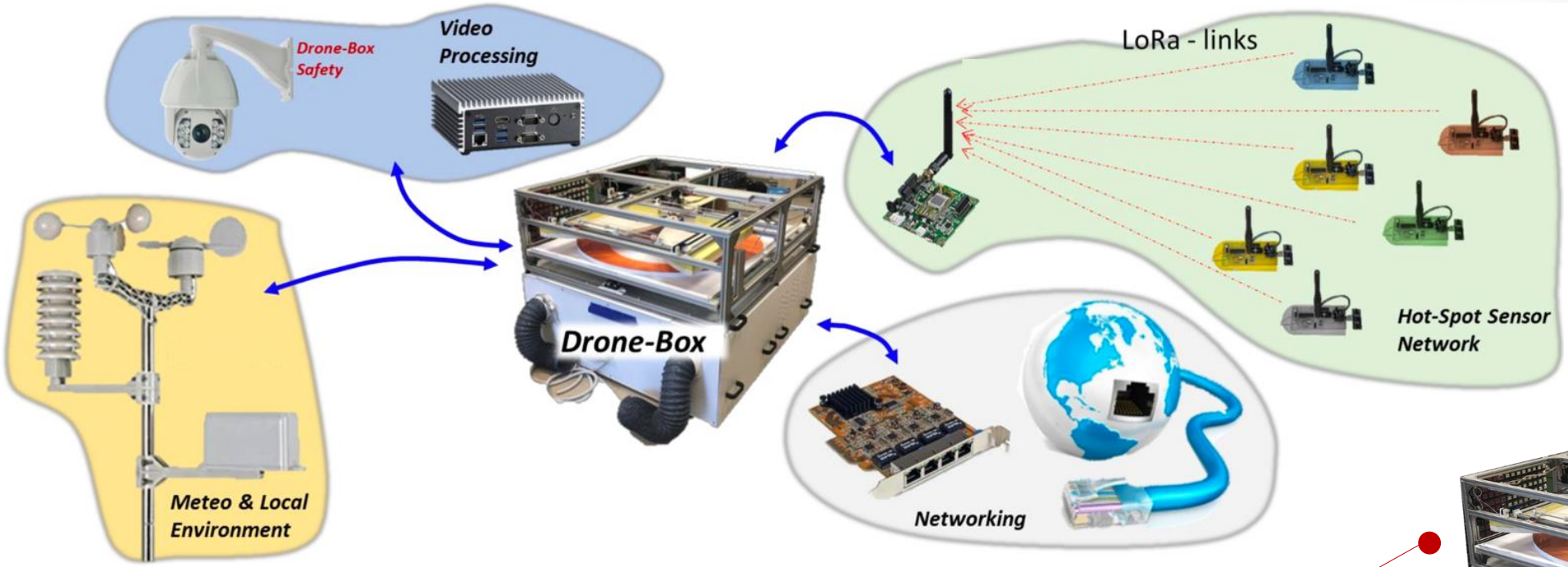
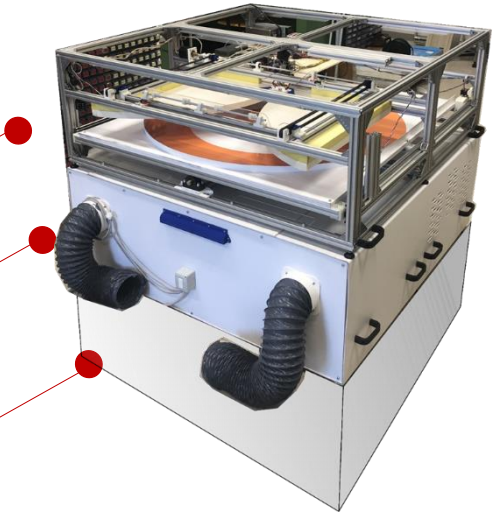
## Mobile video-surveillance on railway assets – Hardware Platform





Hangar Module

Conditioning Module

Hardware Module

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# Thanks for your attention

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