UIC HIGHSPEED Morocco 2023

HIGH-SPEED RAIL : THE RIGHT SPEED FOR OUR PLANET

Under the High Patronage of his Majesty King Mohammed VI

Session5.5 Room Fez 1
Superstructure / Maintenance and renewal

Moderator : Ms. Sylvie Humbert
Chief Marketing and International Distribution Officer, SNCF Voyageurs, France

ONCF UIC

Session 5.5
Superstructure / Maintenance and renewal
Speaker Lists;

1

Ms.Emilia FREYDIER

France

2

Mr.Kenichi Kogayo

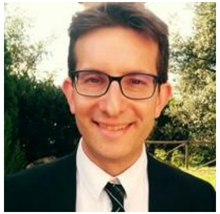
Japan

3

Mr.Ramy Shaltout

United Kingdom

4



Mr.Mirko Ermini

Italy

5

Mr.Asghar Bahramali

Iran

6

Mr.Franco Iacobini

Italy

11TH WORLD CONGRESS OF HIGH-SPEED RAIL

Marrakech, 7-10 MARCH 2023

Digital Twins : the first industrialized technological brick for the maintainer, manager & asset manager

FREYDIER Emilia
Avatar projet manager - SNCF RESEAU, France
Session5-5.5 Superstructure / Maintenance and renewal- **8 March @ 4:15 pm - 6:00 pm**

SNCF RÉSEAU

28,000 KM
of lines in operation
including 2,700 km of high speed lines

2.837 billion €
devoted to renewing tracks

15,000
trains every day

745 km
of tracks renewed every year

3,000
stations and halts

GARE SNCF

250,000 tonnes
of goods transported every day

5 million
passengers every day

2.252 billion €
invested in development projects for the national network

97.7%
of rails originating in our workshops in France were recycled

38.4 M€
of purchases from the social economy

44 customers
including railway companies for passengers, freight and transport operators on the French railway network (intermodal transport, ports)

6.6 billion €
in sales

20,000
train paths delivered every day

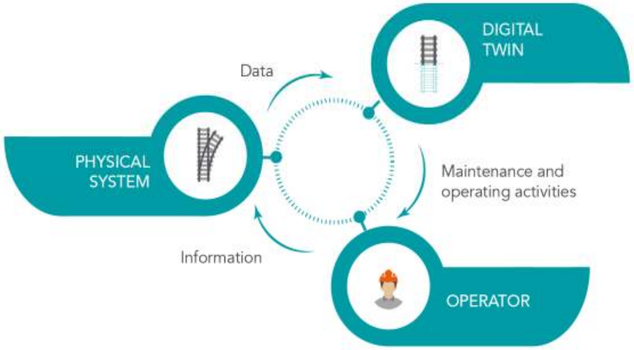
SNCF RÉSEAU

A DIGITAL TWIN

- Setting the requirements to make a digital twin of railway system for operation and maintenance sectors.

DEFINITION OF THE DIGITAL TWIN

A digital twin is a digital replica of a **physical system** that connects with railway infrastructure and working practices. Its input comes from the reference databases and sensors fitted in the infrastructure that serve to **keep this data up-to-date** in real **time** throughout the **system** lifecycle.



Interaction between physical system, digital twin and operator.
aims to a global cyber physical system (CPS)

Railway system digital twin

- MAIN STEPS AND OBJECTIVES

2022

DELIVERY OF THE FIRST DIGITAL TWIN SERVICES

2023

ROADS MAP AND ECONOMICAL MODEL FINALIZED

2025

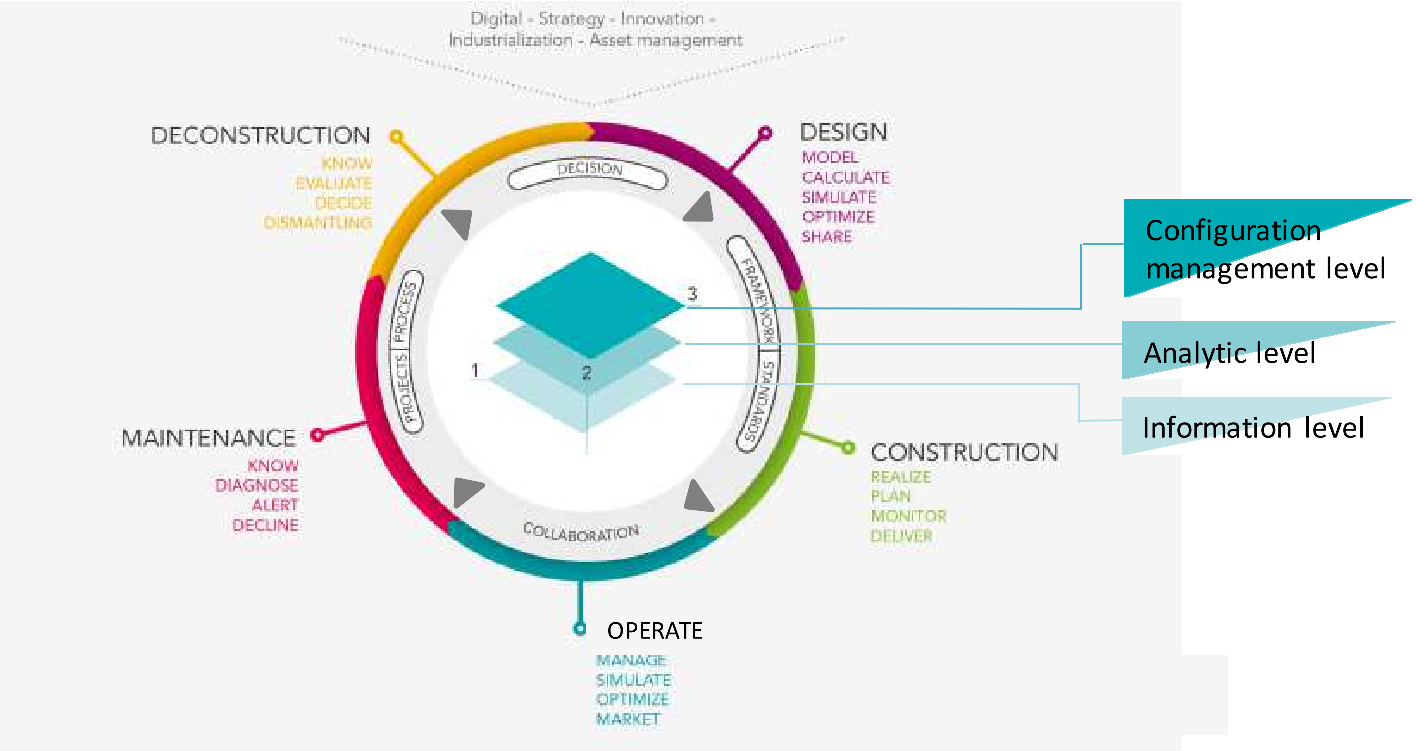
SNCF RESEAU STRATEGIC DECISONS ARE BASED ON THE DIGITAL TWIN

2030

THE DIGITAL TWIN IS THE KEYSTONE OF THE DIGITALIZATION OF THE COMPANY

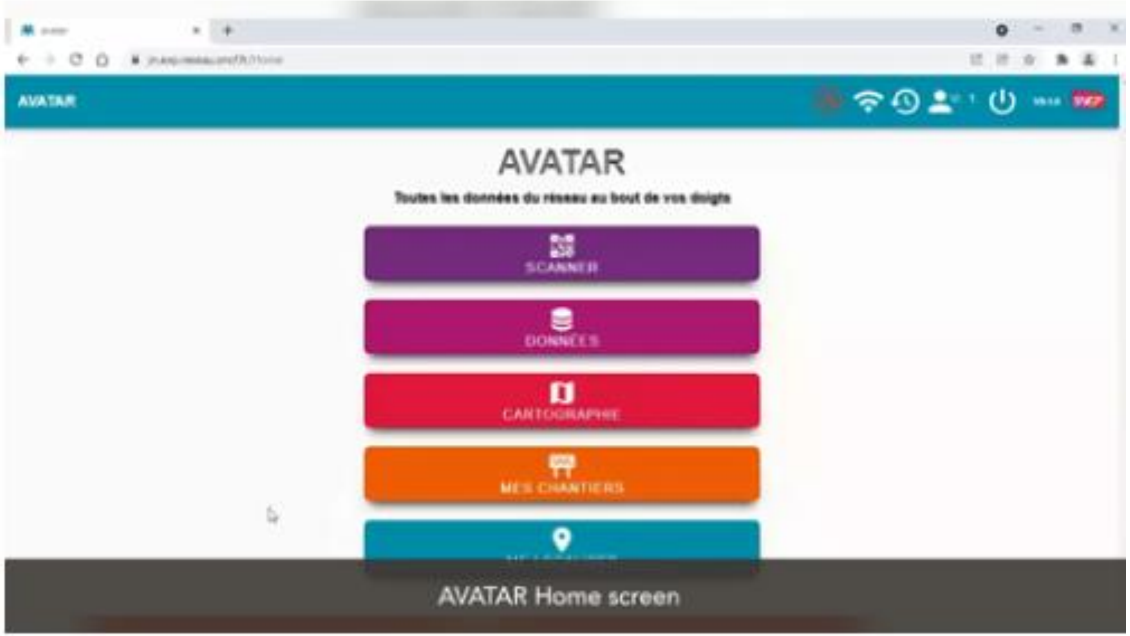
About the architecture

- Architecture of infrastructure network's system digital twin, Making a skeleton of this digital twin and a data model.



A CONCRETE EXAMPLE OF a service

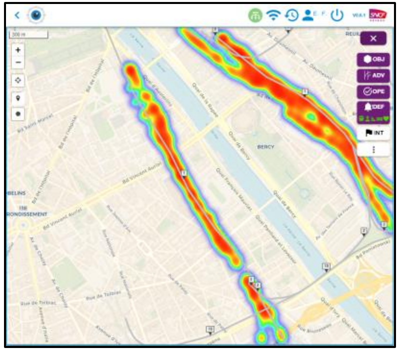
- The first industrialized technological brick for the maintainer, manager & asset manager



We are moving from **dozens of siloed business applications** and databases to a **simple, relevant and powerful** tool that teams will buy into (without specific training).

A data agGregator

- A database connector allowing



NB : the red areas are presented for illustration purposes

Simplified access to rail object data in the field and in the office

1. **OPTIMISE MAINTENANCE INTERVENTIONS** > ENABLE AGENTS IN THE FIELD TO IDENTIFY ANOMALIES TO BE CORRECTED, IN ADDITION TO PRIORITY ACTIONS
2. **FIND A PLAN B, IN THE PLANNED AREA** > DO NOT LOSE A SITE, DUE TO RISKS (RESOURCES, WEATHER, ...)
3. **SIMPLIFY COMMUNICATION BETWEEN THE FIELD AND THE OFFICE**
4. **SIMPLIFY LINK TOWARDS AMORTIZATION OF DEFECTS** > ACCELERATE THE PROCESS

The Digital Twin is accessible with concrete applications that respond to real difficulties in the field

Next step

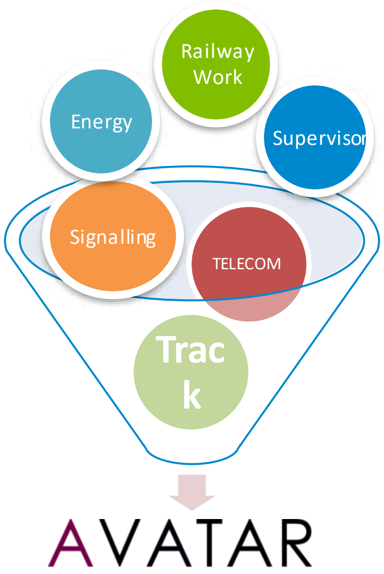
- Deployment and new use cases

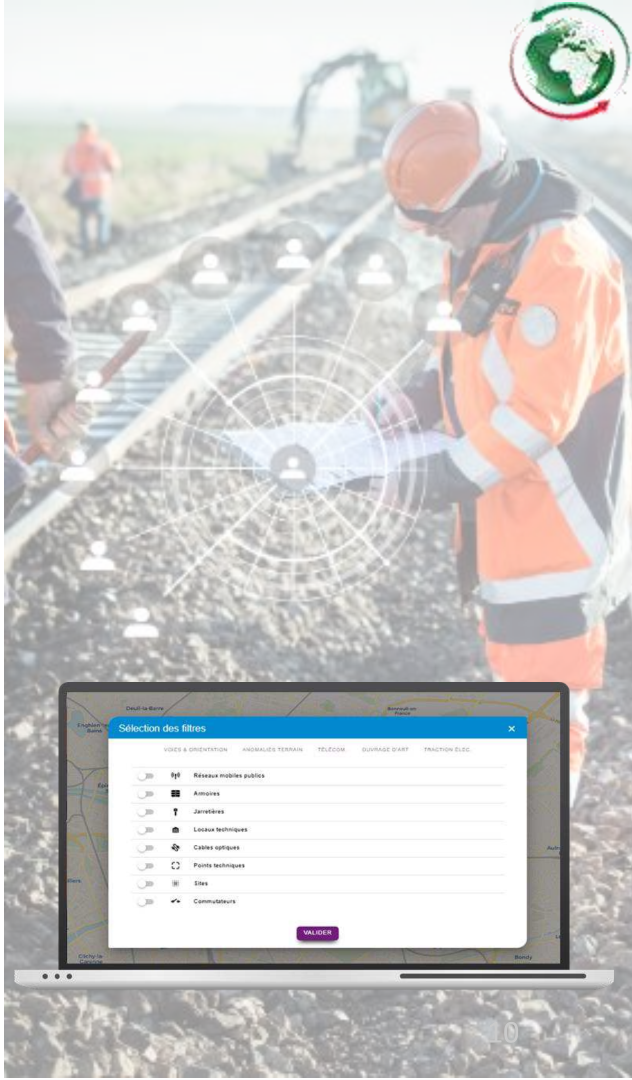
TRAC
K

Built in 1 year, with key user.

Avatar provides several key services (without functional or business rules) for the maintainer.

It is customisable (depending on the business) but also adaptable to any rail network



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11TH WORLD CONGRESS OF HIGH-SPEED RAIL

Marrakech, 7-10 MARCH 2023

Optimizing JR-East Shinkansen track maintenance

Kenichi, Kogayo
Chief, East Japan Railway Company, Japan
Session5-5.5 Superstructure / Maintenance and renewal

ONCF UIC

Business Structure of JR-East

Operating ALL CATEGORIES OF RAILWAY

Metropolitan

High Speed

Regional

Network: 7,401 km

No. of Passengers: 13 Million /day (As of April 1, 2022)

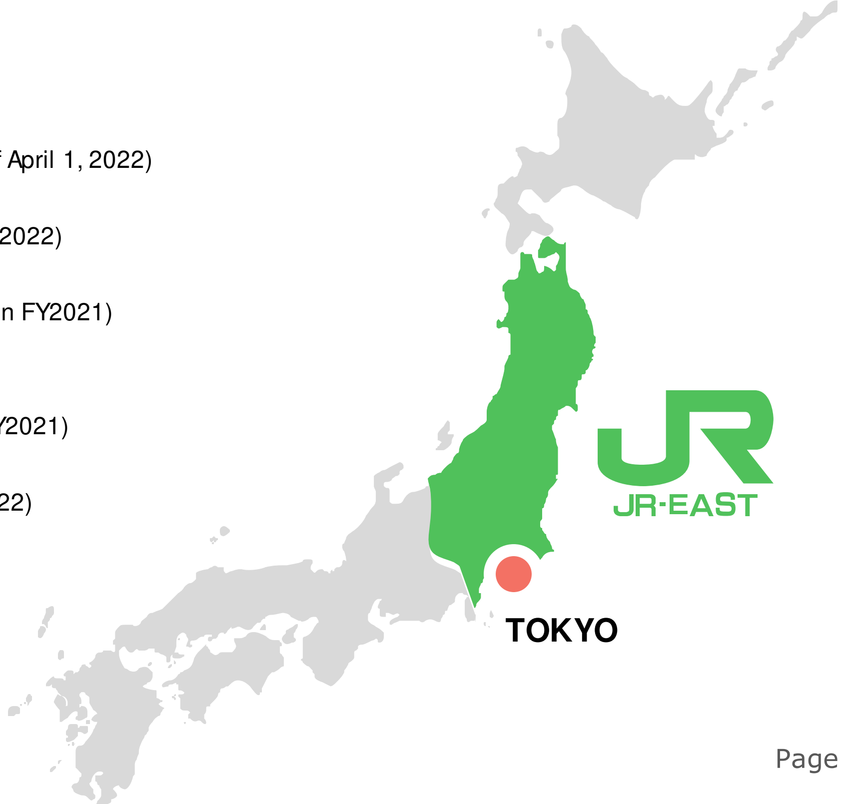
No. of Trains: 12,017 /day (as of March 12, 2022)

Annual Operating Revenue: $11 billion (in FY2021)
(no subsidies from the government)

Net Annual Income: △$763 million (in FY2021)

No. of Employees: 48,042 (as of April 1, 2022)

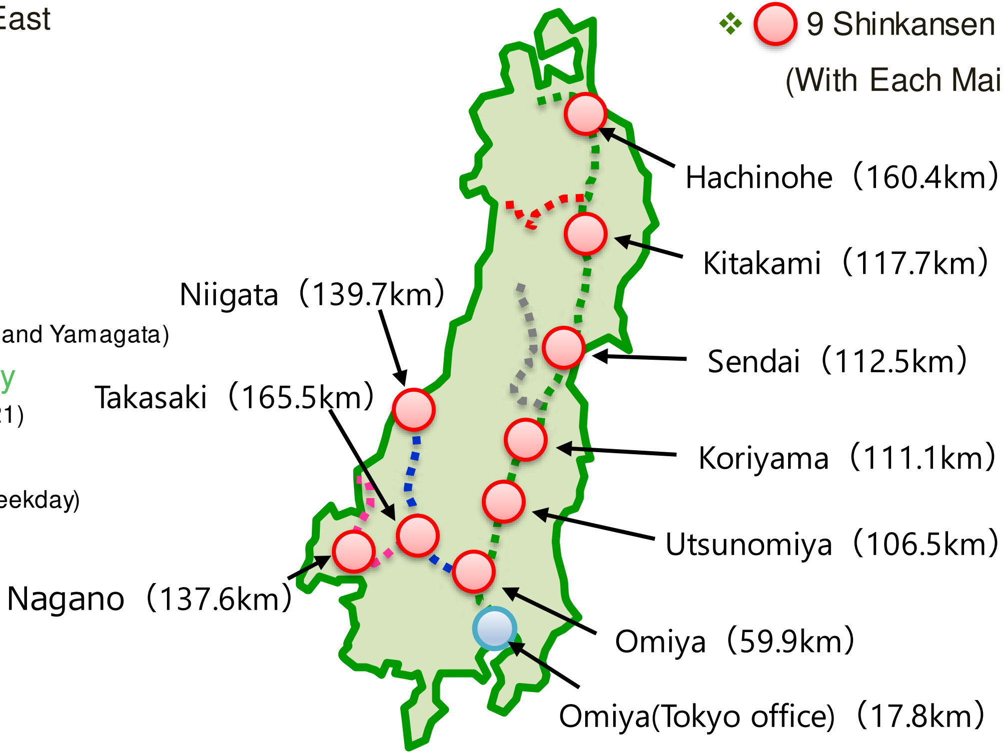
*Calculated by 1 $ = 130 JPY



Features of JR-East Shinkansen

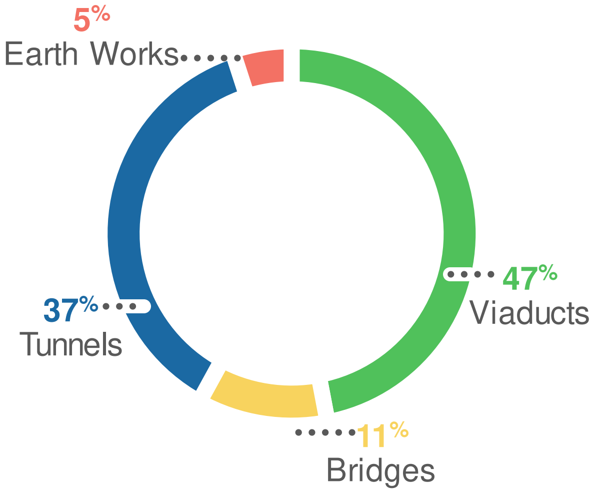
- Shinkansen Lines of JR East
  - Tohoku
  - Joetsu
  - Hokuriku
  - Akita
  - Yamagata
- Network 1,470 km
  (includes Akita and Yamagata)
- Passengers 148,000 / day
  (in FY2021)
- Trains: 324/day
  (Number of trains per Weekday)

- 9 Shinkansen Track Maintenance Centers
  (With Each Maintenance Route Length)



Structure of Shinkansen Infrastructure

❖ Breakdown of Shinkansen infrastructure



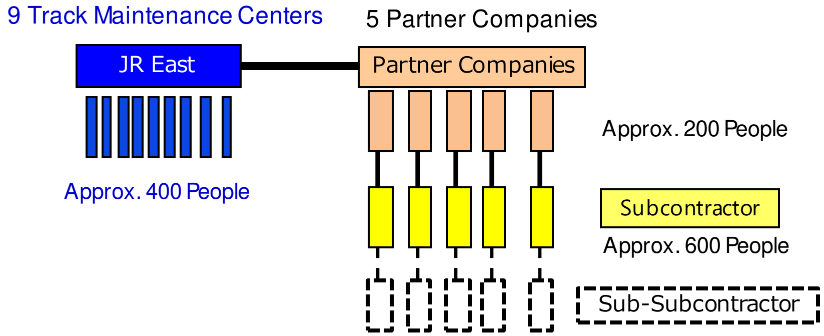
❖ Structure Types of Shinkansen Tracks

Ballast	Slab	Anti-Vibration
		
166.6km(7.4%)	1959.4km(87.4%)	114.8km(5.1%)

Efficient Track Maintenance

❖ Our challenges

- ✓ Labor force will gradually decrease in 20 years
- ✓ Require mechanization
- ✓ Improvements especially in ballast and rails replacement



Rail Grinding vehicles

Multiple tie tampers

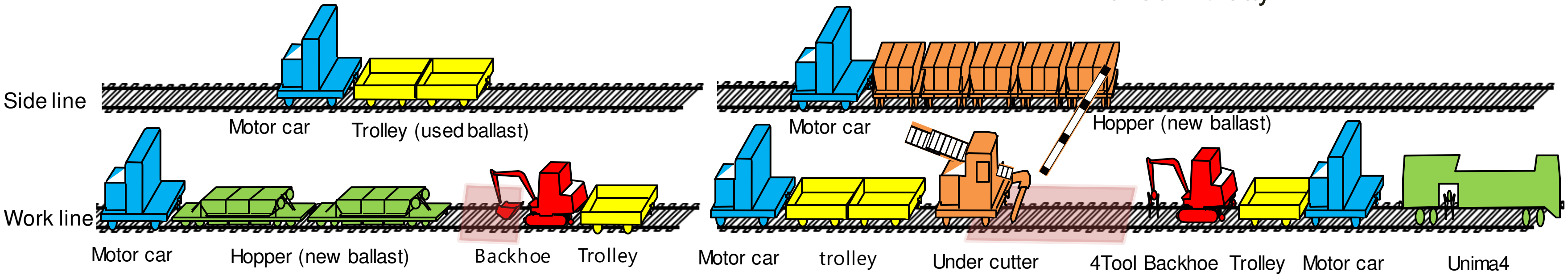
Dealing with the challenges: ①Ballast replacement

❖ Conventional method

using a backhoe: 5~10 m / day

❖ New ballast excavator in 2016

20~30 m / day



Dealing with the challenges: ①Ballast replacement

❖ Increase the running speed after work

Conventional method

ballast replacement

↓ ← Next day 160km/h ← 320km/h

Next night, spot surfacing

↓ ← Day after day 320km/h

Revised work method in 2022

ballast replacement + excitation

↓ ← Next day 210km/h

Next night, spot surfacing

↓ ← Day after day 320km/h

Unima 4

dynamic track stabilizer

Dealing with the challenges: ②Rails replacement

❖ Large-scale rail replacement project

40 years passed

✓ Rail replacement criteria

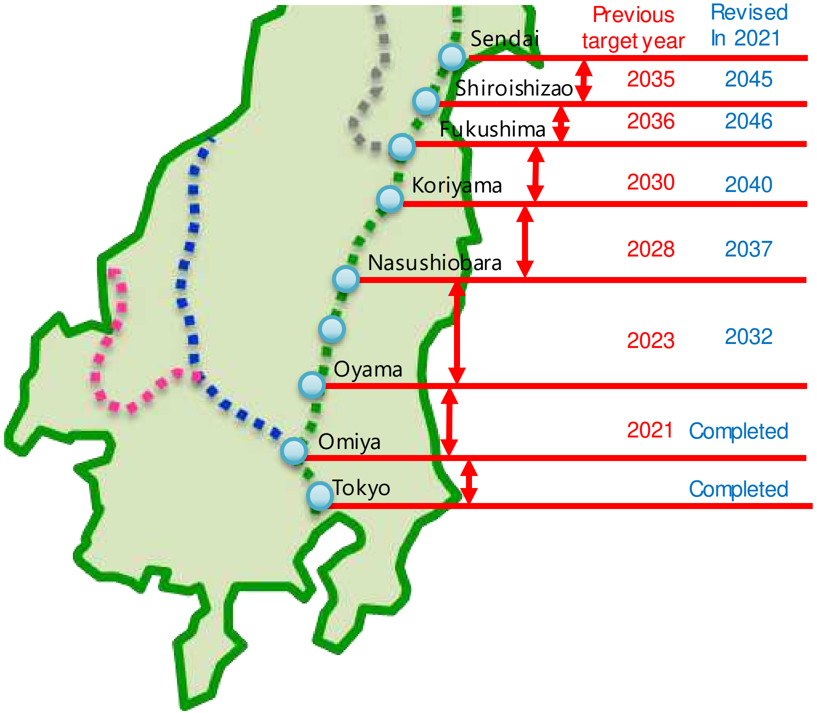
Based on accumulated passing tonnage: **800 million** ton

→Reaching rail replacement by 2021 (Omiya – Oyama)

Revised in 2021

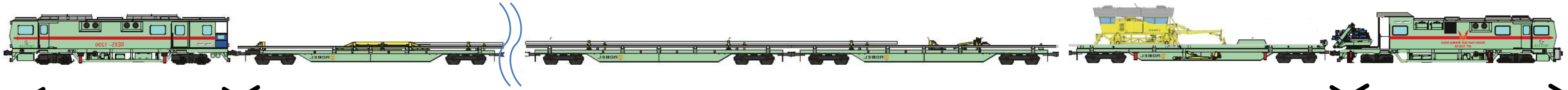
Accumulated passing tonnage: ***1 billion*** ton

❖ Rail replacement Plan in 2017



Dealing with the challenges: ②Rails replacement

- New Shinkansen Rail Exchange System (REXS)



20m — 190m(19m×10cars) — 20m

Rail Delivery, Welding, and Rail Exchange **just by REXS!!**

Dealing with the challenges: ②Rails replacement

❖ New Shinkansen Rail Exchange System (REXS)

Conventional method

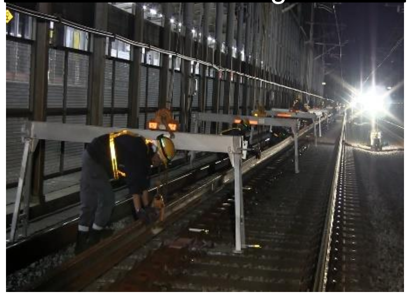
Rail Delivery

75m × 10

Weld

40min / 1 GP

Rail Exchange



Lots of workers

REXS

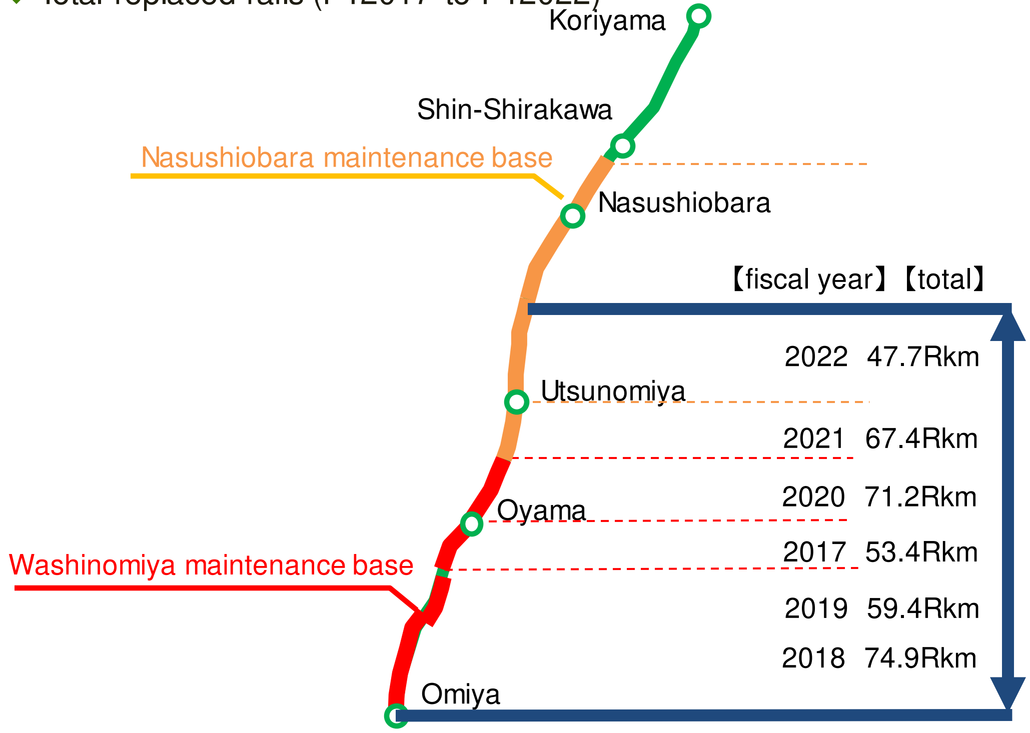
150m × 20

6min / 1 Flash-butt welding

Mechanized

Dealing with the challenges: ②Rails replacement

❖ Total replaced rails (FY2017 to FY2022)



・2017～2022 374Rkm
Omiya ~Utsunomiya / Nasushiobara

<u>Total annual rail replacement length by each Maintenance Center</u>

<u>2.7Rkm</u>

Introduction of REXS

<u>74.9Rkm</u>

About 30 times!

*Rkm is the unit used for the total distance of rail replacement per kilometer for direction to both north and south.
i.e. If all 4 rails are replaced in 1 kilometer: 4Rkm

THANK YOU

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Marrakech, 7-10 MARCH 2023

SMART AUTONOMOUS RAIL MONITORING SYSTEMS FOR DIGITALIZED RAILWAYS

Ramy, Shaltout
School of Energy, Construction and Environment,Coventry University, UK.
Session5-5.5 Superstructure / Maintenance and renewal

ONCF UIC

Contents

Digital transformation of Railway Condition Monitoring

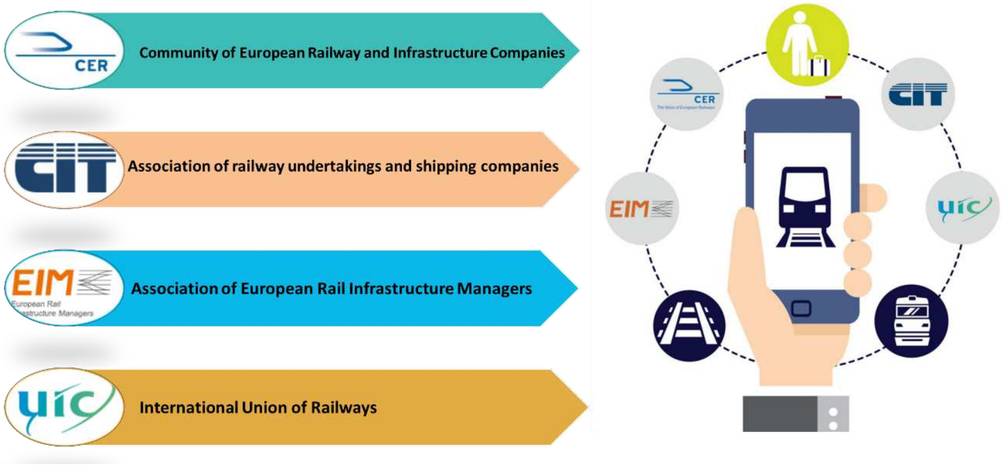
- Globally, the level of investment in information and communication technologies (ICT) has exceeded USD 4.1T in 2021. The digital transformation is established on four main pillars

Four key pillars of the digital transformation

Digital transformation of Railway Condition Monitoring

The roadmap defines the key areas of digital technologies deployment in the railway sector. Those main areas of interest include:

- Developing a connected, safe, and efficient railway services by providing reliable connectivity;
- Offering improved and added value for rail customers by enhancing the railway customer experience in all sectors of the railway provided services;
- Utilization of the collected data for boosting the rail competitiveness.



Roadmap for railway digitalization, adopted*

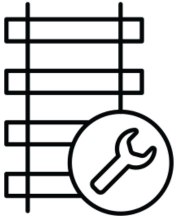
*CER, CIT, EIM, UIC (2016). A Roadmap for Digital Railways, http://www.cer.be/sites/default/files/publication/A%20Roadmap%20for%20Digital%20 Railways.pdf (Accessed on 10.01.2018).

Condition monitoring of railway systems

Applications

- **To identify failure (diagnosis)**
  - No signal
  - Over temperature
- **To identify impending failure (prognosis)**
  - Downtime
  - Accident prevention
  - Consequential damage
- **To know why failure occurs**
  - Pull the part under investigation from service
  - Analyse the incipient failure
  - Change what you're doing

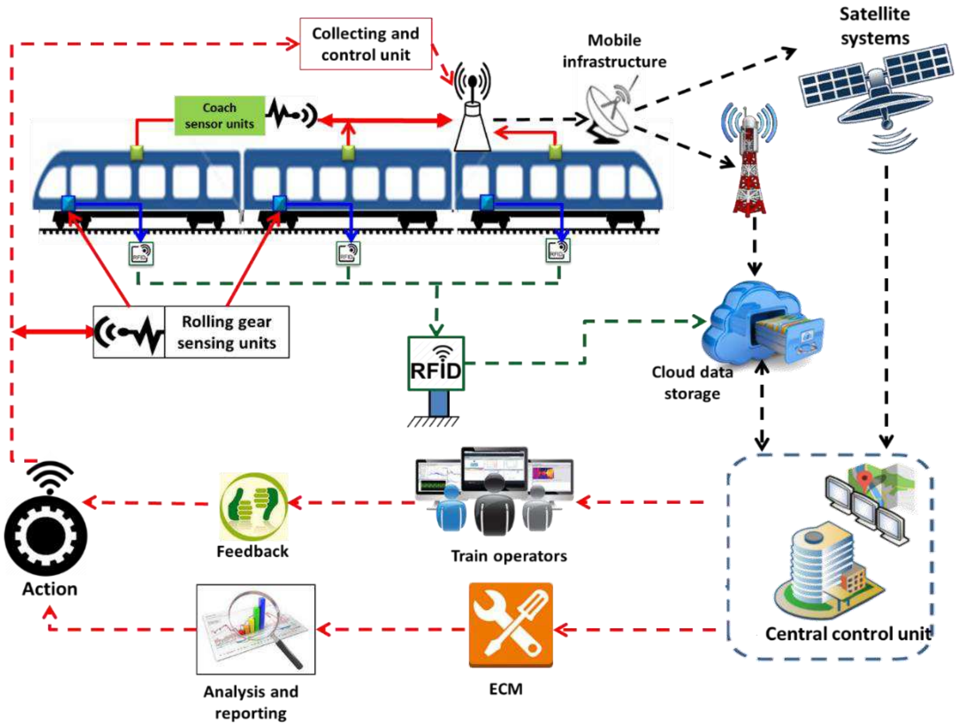
Source



Condition monitoring of railway systems

Challenges

- Sensing systems
- Tracking and tracing
- Networking and data communication
- Power sources and energy harvesting
- Real time condition monitoring



Schematic diagram of Conceptual design of real time condition monitoring of railway systems

DIGIT Rail-EGY

High-speed Rail in Egypt

High-speed lines planned in Egypt

LINE	MAXIMUM SPEED (km/h)	YEAR	DISTANCE (KILOMETRES)
Cairo - Alexandria	320	2024	210
Cairo - Aswan	320	2024	700
El Alamein - Ain Sokhna	250	2025	460
El Alamein - Marsa Matrouh	250	2025	200
			Total km = 1,570

High-speed lines with long-term planning in Egypt

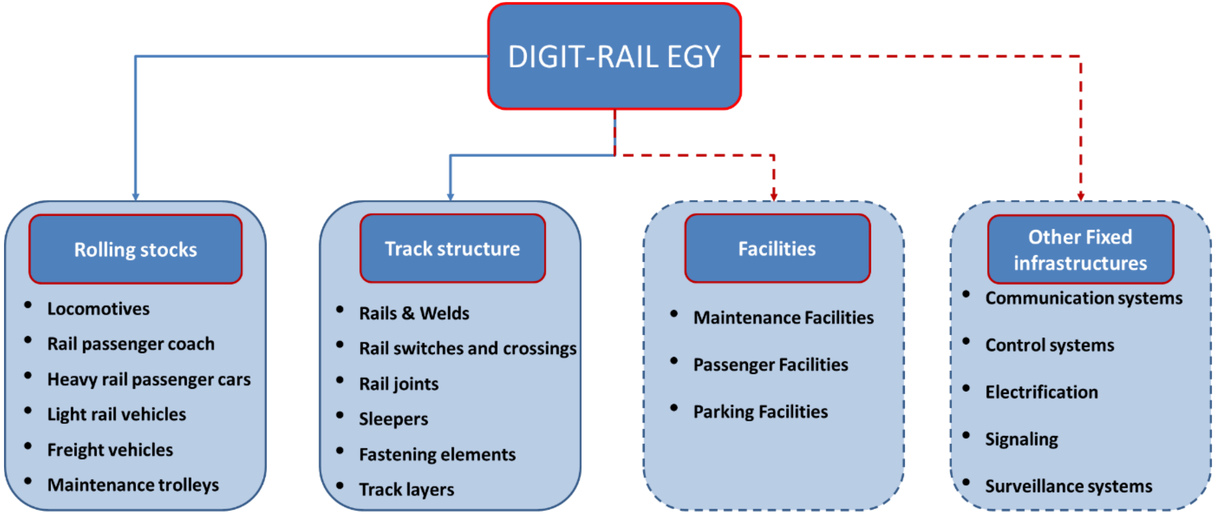
LINE	MAXIMUM SPEED (km/h)	YEAR	DISTANCE (KILOMETRES)
Ain Sokhna - Hurghada	250	2030	320
Hurghada - Luxor	250	-	285
6th October City - Luxor	250	-	640
Luxor - Aswan	250	-	210
Safaga - Barnis	250	-	350
			Total km = 1,805

Source: compiled by authors based on International Union of Railways, 2021

DIGIT Rail-EGY

Objectives

- Establishment of a digital platform for condition monitoring of railway systems in Egypt as part of the national strategic plan for the digital transformation.
- Development of an accessible data centers for parties interested in the provided service
- Development of an integrated system for condition monitoring system for monitoring of key parameters for critical types of freight, passenger vehicles as well as rail infrastructure

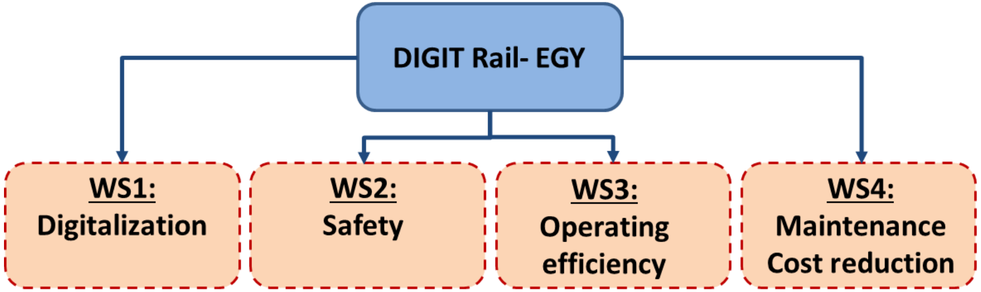


DIGIT-RAIL EGY Frame of work

DIGIT Rail-EGY

DIGIT Rail-EGY concept

The proposed approach of the work plan of DIGIT-Rail project is described in the below section. The project concept that will be implemented in three main steps:



- **First step:** Determination of all market driver, benchmarking and definition of specification and requirements needed for the project evolution.

- **Second step:** Development of innovative solutions and for the digital transition of condition monitoring of railway systems, and Concept demonstrated by pilot testing.

- **Third step:** Testing the innovative solution in real environment and fine tune the required outputs from the project's produced innovations.

Smart autonomous railway condition monitoring systems

Sensing systems

Challenge: autonomous self-powered sensor system for passenger/freight vehicles for the real time vehicle condition monitoring as well as observing key parameters for passenger comfort and safety

Connection type
- *Wired sensor*
- *Wireless*

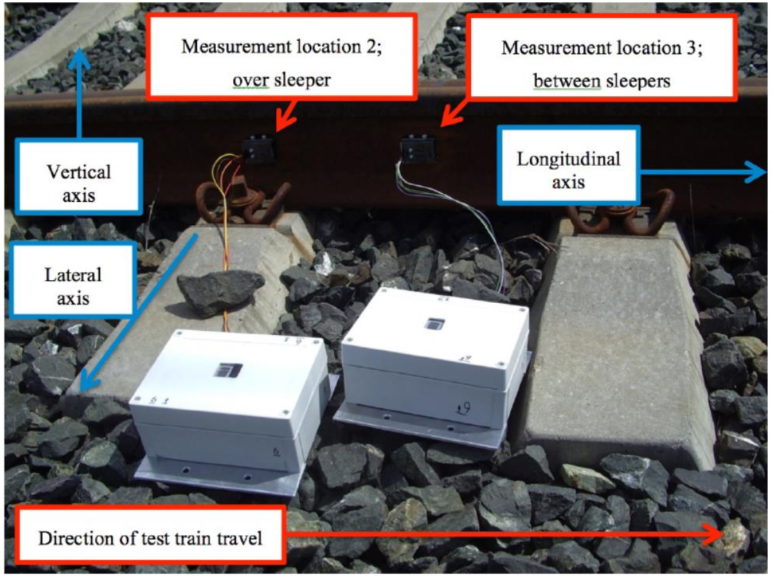
Location
- *Onboard*
- *Wayside*

Powering
- *Powered*
- *Autonomous/self powered*

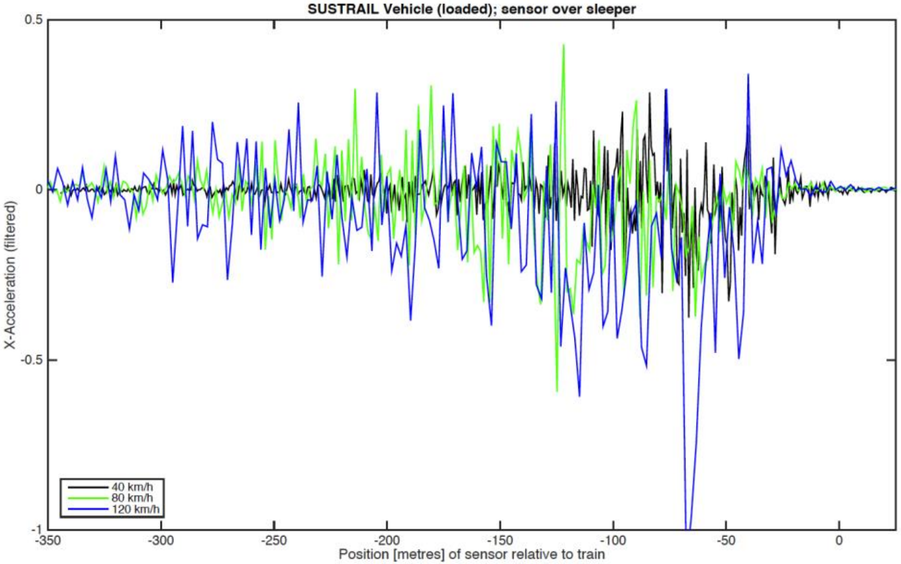
Functionality Principle
- *Electro-magnetic*
- *optical*
- *Ultrasonic, etc.*

Requirements
- cost-effective,
- reliable and environmentally friendly

Smart autonomous railway condition monitoring systems



Fitting of sensors to the side of the rail web on a straight section of track on the main test



Accelerometer measurements from portable sensor system on rail web, mounted over sleeper, at three speeds

THANK YOU

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2021 COVENTRY UK CITY OF CULTURE

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Integrated communication network of satellite and 5G for railway infrastructure diagnostic and predictive maintenance (alias DINoS5G)

Mirko, Ermini
Innovative Research Leader, Rete Ferroviaria Italiana, Italy
Session5-5.5 Superstructure / Maintenance and renewal

RAIL INFRASTRUCTURE IN ITALY

Rail Infastructure in Italy	
Railway Network	24.564 km tracks (1.467 km high speed)
Stations	2.220
Works of art	~8.000 bridges/overpasses ; ~1.700 tunnels
Goods Plant	207
Lines with Train Control System	100%
Electrified Lines	72%

MAINTENANCE ... A “SMART” APPROACH

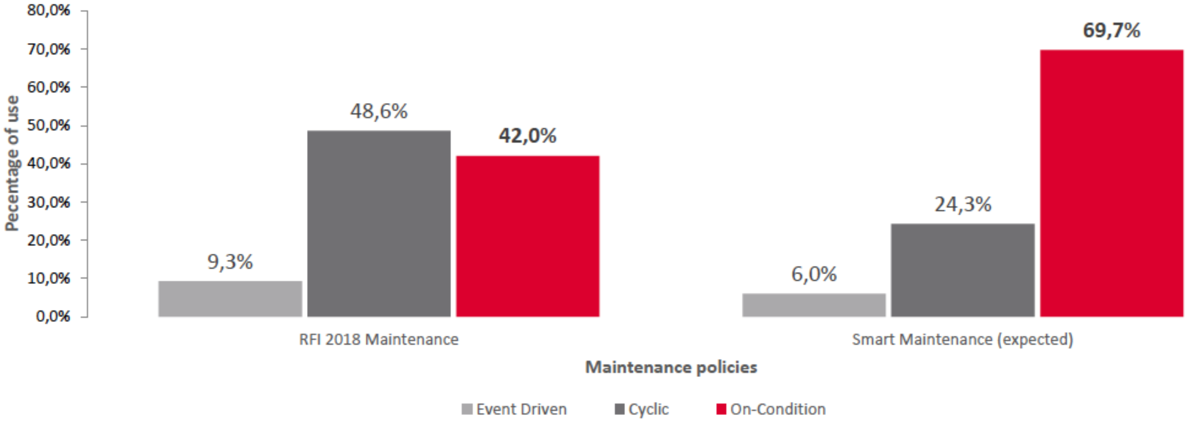
- The strategic needs of railway infrastructure management are:
  - increase in data collected in terms of number, type and geographical density;
  - exploitation of over-the-air communication resources with customizable performance on different use cases
  - sovereignty over the data collected
- The high-speed network, as a "primary" network, will see a rapid extension of the new 5G communication system and is already covered by satellite services: this will be an enabling factor for the diffusion of a platform for the predictive maintenance of the high-speed network, based on IoT concepts applied to the railway environment.

PROBLEM ADDRESSED ... THE DINoS5G PROJECT

- Several hundreds to thousands of diagnostic units (**LDU**s, Local Data Units) need to dynamically transfer data collected from rail and environment sensors to a limited number of central data units (**CDU**s, Central Data Units)
- CDUs are in charge of processing data, perform business intelligence with them, and provide ”predictive” maintenance instead of just “failure-event-triggered” interventions.
- The current communication legacy available to LDUs and CDUs may not meet very much needed requirements like **massive data transfer**, **minimum latency** and **availability** of underlying resources, especially in the areas covered by a high speed.

EVOLUTION OF MAINTENANCE APPROACH... LONG-TERM OBJECTIVES

- A "Smart Maintenance approach": capability to optimize the maintenance scheduling activities, shifting resources from cyclic to on-condition maintenance.
- More information-aware maintenance: greater quantity of data collected by a greater number of railway components, wider spectrum of collected parameters
- Increasing the effectiveness of maintenance operations to increase the level of service in terms of overall rail traffic regularity.



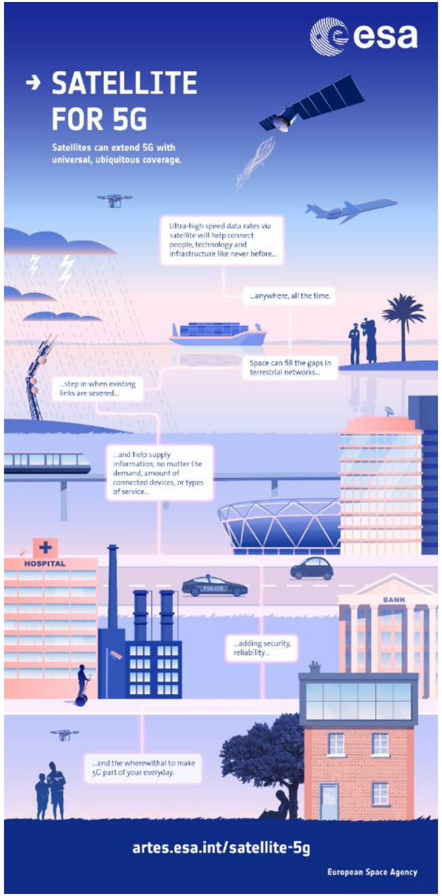
DINoS5G PROJECT

The "DINoS5G" project (Diagnostic Integrated Networks of Satellite and 5G) is a research project to develop an end-to-end solution based on integration of a High Throughput Satellite (HTS) system and a 5G terrestrial infrastructure.
The aim is to provide a flexible, efficient and reliable communication platform to the endpoints of a “smart” predictive maintenance application for the railway infrastructure.

The project realized a **trial site in Bologna San Donato** to verify the capability of 5G and satellite technologies to collect diagnostic data from both wayside and onboard diagnostic systems of the Italian railway network.

PROJECT ORGANIZATION

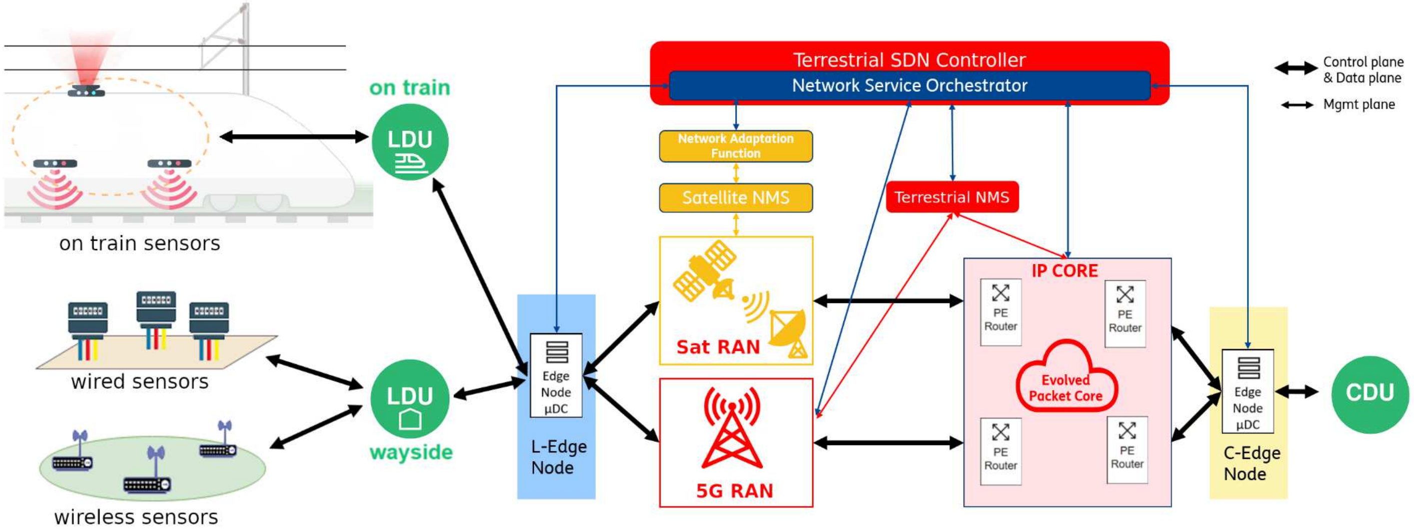
- The project kicked-off from the initiative of RFI and Fondazione "Ugo Bordoni".
- It is funded by ESA (European Space Agency) through its program "*ARTES 4.0 Program Line Competitiveness & Growth*", aimed at combining the usage of 5G and satellite communication technologies for land applications.
- The project is led by RFI in the role of Prime Contractor, with the participation of some of the Italian excellences in the industrial and research sectors.



OVERALL ARCHITECTURE

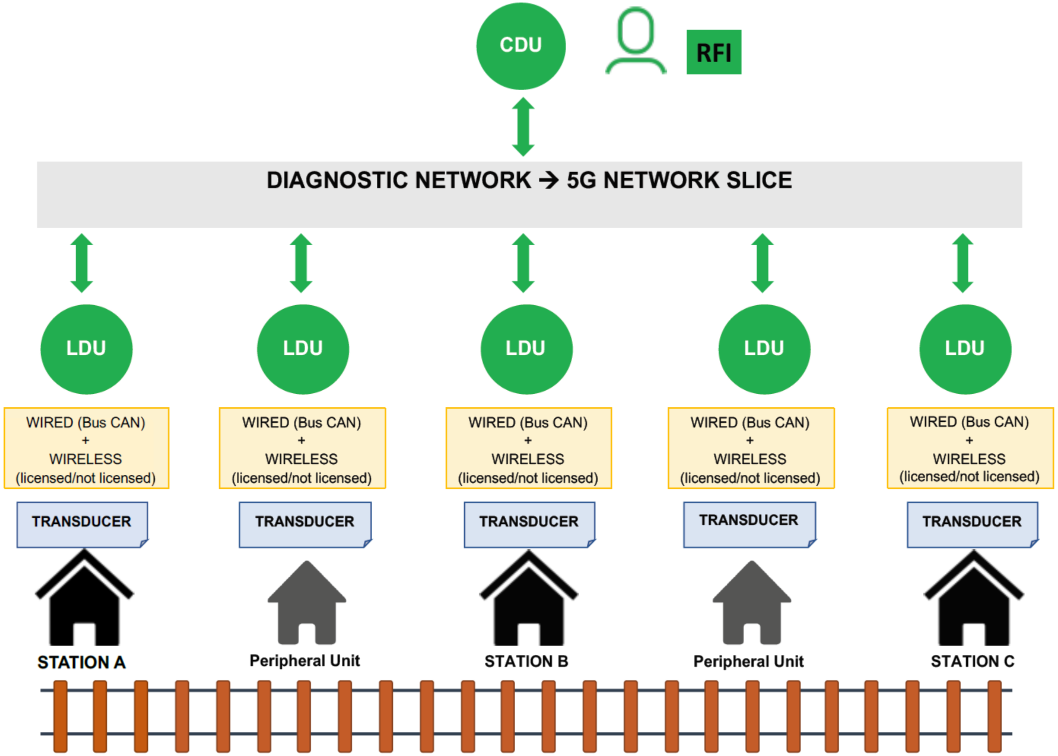
The **5G/Sat network** is dynamically configured through orchestration and virtualization functions, seamlessly integrating the terrestrial 5G access network, the satellite access network and the 5G core network.

Edge Nodes realize the interconnection of different classes of application nodes, based on the use of the best path, in a way that is transparent to the nodes themselves whilst dynamically decided by priority information expressed by the nodes.

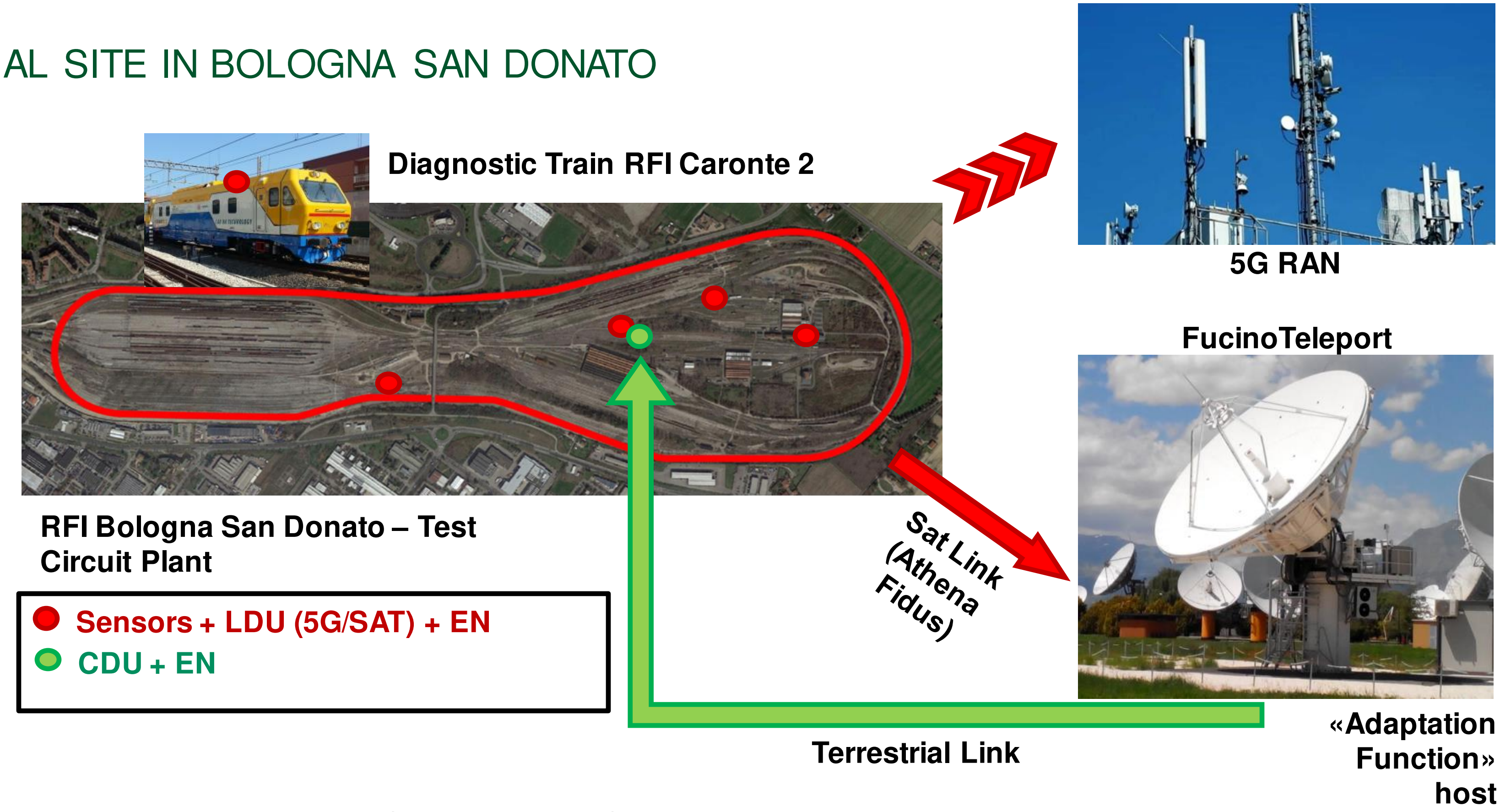


DIAGNOSTIC NETWORK EVOLUTION

- Collecting a much **larger number of parameters** to be monitored.
- **Real-time monitoring**, thanks to low latency time of the 5G network, thus enabling so far unexplored cross-correlation between monitored parameters
- **Collecting raw data** in case of detailed monitoring for deep analysis of anomalies
- It will be possible to apply advanced algorithms of **data analysis**, in order to achieve a broader and deeper capacity of monitoring for complex scenarios which can be influenced by a multiplicity of parameters



TRIAL SITE IN BOLOGNA SAN DONATO

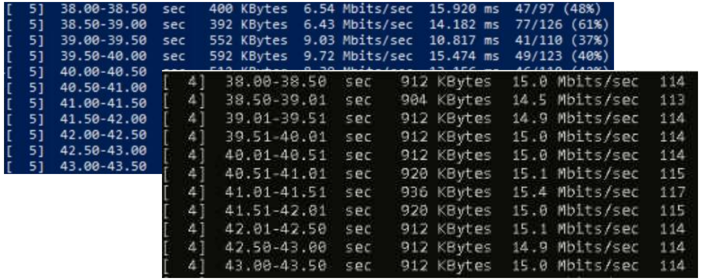


TRIAL EXECUTION

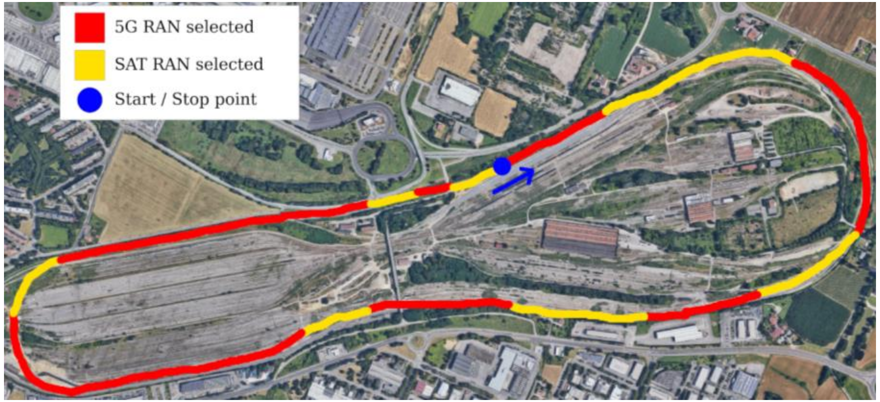
- Example of test with the aim of exercising steering policy
- Caronte 2 train running on San Donato Test Circuit (6 Km)
- Train speed: 70 - 90Kmh
- Edge Node steering policy: coverage hole detection
- Coverage holes detected during run

The outcome of DINoS5G solution is expected to pave the way to flexible communication infrastructure serving innovative railway predictive maintenance services.

LDU



CDU



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11TH WORLD CONGRESS OF HIGH-SPEED RAIL

Marrakech, 7-10 MARCH 2023

An Ultra Low Power analog IoT node for high speed bridge health monitoring

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Session5-5.5 Superstructure / Maintenance and renewal

ONCF UIC

Initiatives

The impact of high speed on HSR bridges:

- Vertical deflection
- Line rotation
- Acceleration
- Natural frequency vibration

$$A_{rv} \infty V^2$$

- At speeds of higher than 200km/h the risk of resonance vibration is high (specially at short span bridges)

Ballast Destabilization

Necessities and Background

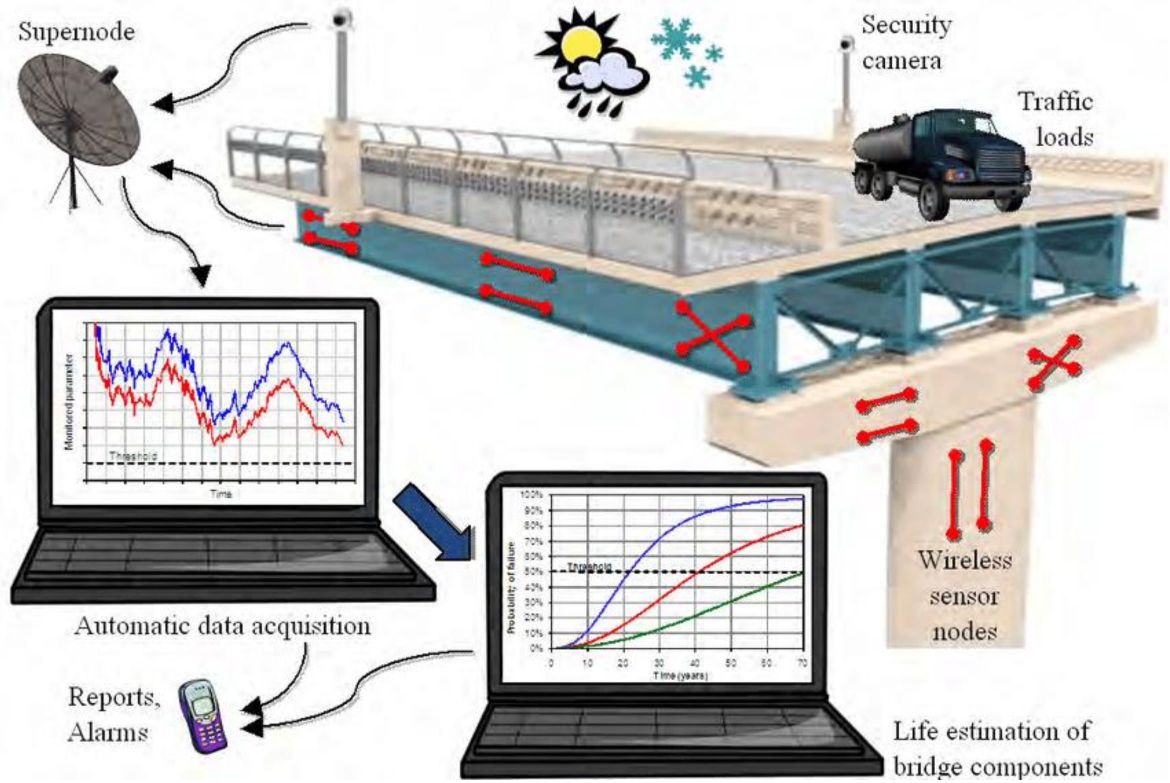
Rigorous inspections would be necessary

- To improve the passenger safety
- To enhance the passenger comfort
- To extend the life of the bridges

Traditional inspections

- Expensive
- Time consuming
- Labour-strenuous

IoT- Bridge health monitoring



Improving performance prediction of corroding concrete bridges with field monitoring- Cusson, D. Daigle, L. Lounis, Z. July 2010.

IoT for outdoor applications

Power constraint

- Limited or no access to the main supply source
  - Electronic circuitry
    - To be powered by a supply source
      - Local batteries
      - Self-supplied

Low available area

Exposed to harsh environmental condition

- Abrupt temperature change
- Humidity variation
- Cosmetic electromagnetic radiation, ...

Low power/area design strategy

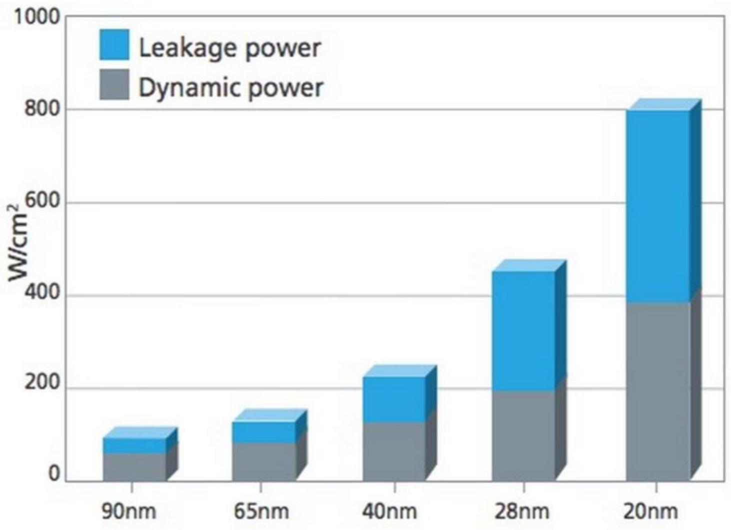
CMOS-only devices

Low device count configurations

Miniaturization

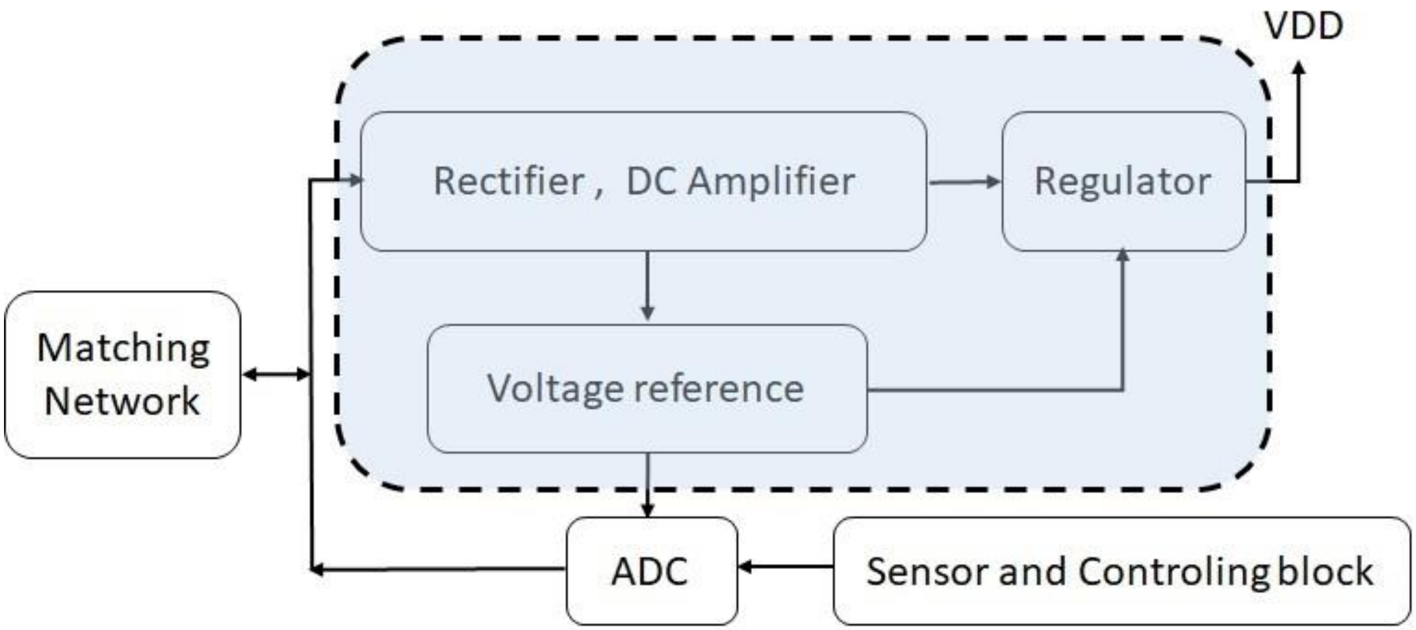
Sub-threshold region of operation

Avoiding resistors



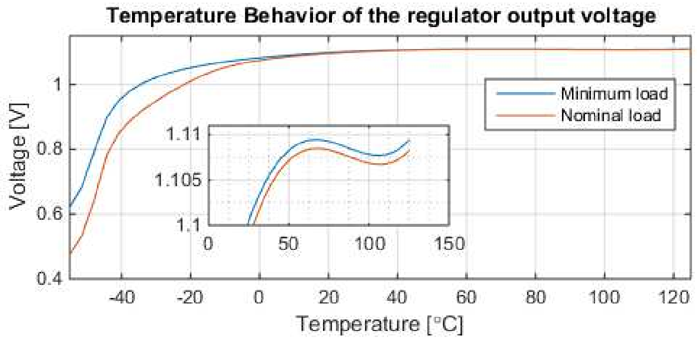
C. Singh and R. Tangirala, "As Nodes Advance, So Must Power Analysis", Semiconductor Engineering, June 2014

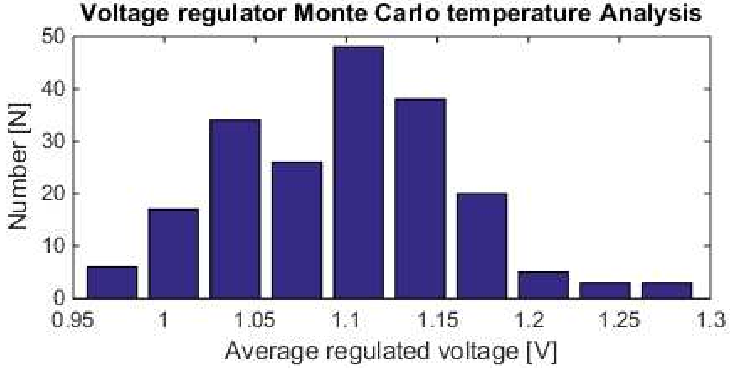
Proposed platform

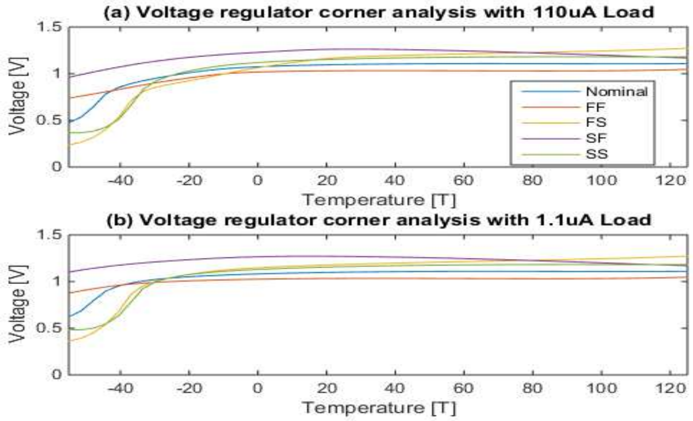


Temperature performance results

$TC_{reg} = 91\ PPM/$°C in 25°C to 125°C
Corner Analysis= $-6.4\% + 14.6\%$
at the nominal load
Corner Analysis= $-5.5\% + 15.4\%$
at the minimum load



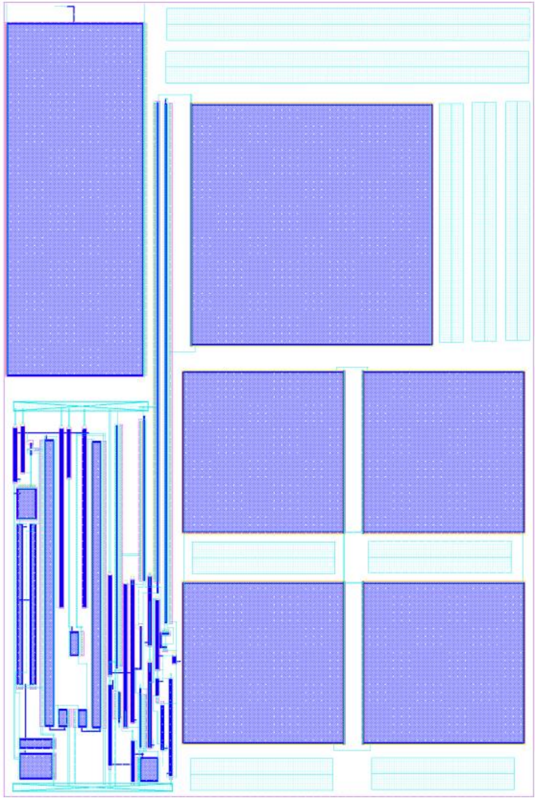




Layout

The area of the layout of the whole regulator including the voltage reference and the load $(10pF)$ and the Miller $(18pF)$ capacitors:

$$0.0067mm^2 = 100.5\mu m * 66.44mm^2$$



Comparing results

	This work	[76]	[77]	[78]	[86]	[79]	[64]	[80]
Year	2020	2019	2017	2019	2019	2018	2017	2018
Technology	40 (nm)	65 (nm)	180(nm)	180 (nm)	180 (nm)	350 (nm)	22FDX	180 (nm)
Pass Transistor	pMOS	pMOS	Push-Pull	pMOS	pMOS	pMOS	nMOS	Push-Pull
Active Area (mm^2)	0.0067	0.04	0.022	---	0.094	---	0.02	0.24
Quiescent Current (μA)	0.8	4.9	3.4	70	1.9	37.7	200	1.8
Maximum I_L (mA)	1	105	±100	50	100	50	15	±80
Drop-Out Voltage (mV)	200	50	200	200	200	500	440	200
Input Voltage (V)	1.3-2	0.5-1	1.2-2.5	2.2-4	1.2	3.3	1.35-2	1.2
Regulated Voltage (V)	1.1	0.45-0.95	1	2.2	1	2.8	0.77-0.91	1
Efficiency (%)	98	95	83.3	91.5	83.3	85	67	83.3
Phase Margin	58°	---	35°-85°	81°	61.1°	57°	45°	104°
C_L embedded (pF)	10	0	10	0-100 Off Chip	---	10	30	100
C_{Total} embedded (pF)	28	42	12.5	4	18	35	30	100
Transient voltage (mV)	190	88	220	290	54	---	63	227
PSRR (dB)	-28.5@915MHz	---	-49@1Hz-20@10kHz	---	---	-45@100kHz	-35@10MHz	-30@10Hz
FOM(pF*V* μA)	4.5	10.3	8.5	56	2.5	660	2640	36

Conclusion

Parameter	Desired Value	Realized value
Platform power consumption	≤ 1µW	≈1µW
Active area	≤ 0.01mm^2	≤0.007mm^2
Temperature range	-55°C≤ T ≤ 125°C	25°C≤ T ≤ 125°C
Temperature coefficient	≤ 100PPM/°C	91PPM/°C
Regulated load power	≥ 120µW	121µW-Nominal
Regulation efficiency	≥ 95%	98%

THANK YOU

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Under the High Patronage of his Majesty King Mohammed VI

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DRONE4RAIL, HARMONIZED METHODOLOGY FOR DRONE/UAV USE FOR BRIDGE INSPECTIONS

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Session5-5.5. Superstructure/Maintenance and Renewal

ONCF UIC

DRONE4RAIL PROJECT: OVERVIEW

Infrastructure Managers from all over Europe have participated in the *UIC-project "DRONE4RAIL - Harmonized methodology for drone / UAV use for bridge inspections"*, to research the *use of drone technology* (UAS – Unmanned Aerial Systems) to inspect *railway bridges* and to *standardize regulations*.

The project consists of *three Work Packages* (WP)

NETWORK RAIL	United Kingdom
DB	Germany
ADIF	Spain
IP	Portugal
RFI	Italy
BANENOR	Norway
INFRABEL	Belgium
ÖBB	Austria
SBB	Switzerland
SNCF	France
PRORAIL	Netherlands

WP1 *State of the Art*

WP2 *Experimental studies*

WP3 *Guideline Definition*

WORK PACKAGE 1: STATE OF THE ART

The main aim is to identify the *State of the Art* of drone usage and its application for the bridge inspections. A review on the use of drones has been carried out focusing on those aspects that can be applied in the field of *structural inspection in the railway environment*.

Two *questionnaires* have been drawn up and sent to all the *D4R members* and to several *drone industries* focusing on the following topics:

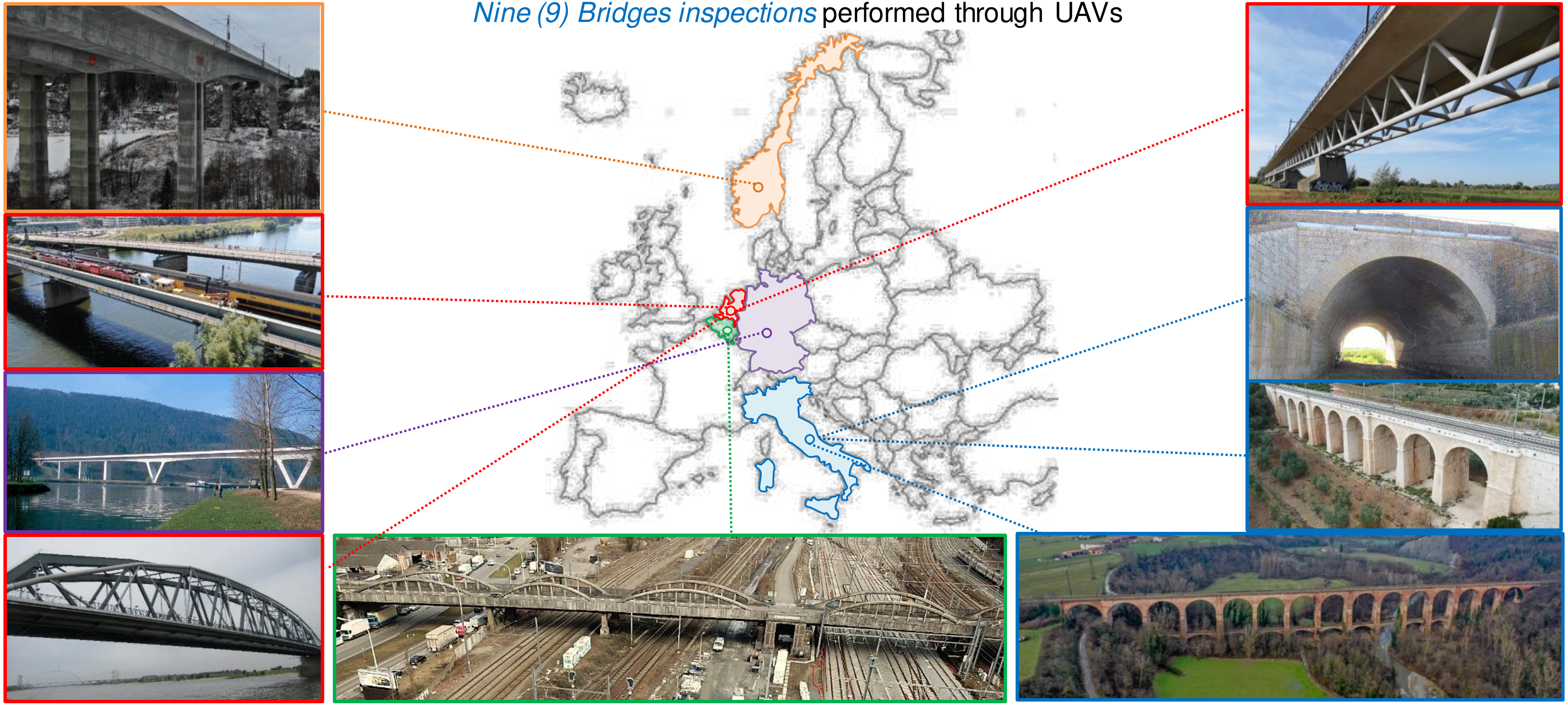
- General Data of use of drones
- Hardware
- Software and Post Processing
- Field Activities
- Legal Environment
- Future Developments

PARTICIPANTS TO QUESTIONNAIRES

- 10 Infrastructure Managers
- 9 Drone Industry companies

WORK PACKAGE 2: EXPERIMENTAL STUDIES

Nine (9) Bridges inspections performed through UAVs



WORK PACKAGE 2: EXPERIMENTAL STUDIES

Validation of the results and comparison with general inspections have been carried out in some cases.

Different drone typologies have been used to perform inspections.

DRONE ACTIVITY FEATURES

Drone inspections are characterized by 2 main phases:

FIELD ACTIVITIES

based on flights and data acquisition

POST PROCESSING PHASE

based on acquired data elaboration, defects detection and definitions of models and reports.

WORK PACKAGE 2: EXPERIMENTAL STUDIES - FIELD ACTIVITIES

The *field activities* consist of *direct inspection* through UAV flights and *defects recording*.
Moreover, *GPS detailed surveys* are necessary to set and analyse the acquired data during the post-processing phase.

A *preliminary survey* has to be carry out in order to identify the main *critical issues* that could occur during the field inspection activities avoiding loss of time, if any.

ASPECTS TO BE ANALYSED DURING THE PRELIMINARY SURVEY

Presence of *vegetation* on the structure

Definition of necessary *equipment*

Different conditions from *standard scenarios* identified by national guidelines

Accessibility conditions (such as land morphology and private accesses)

Identification of *environment conditions* that could limit flight activities (e.g. strong wind).

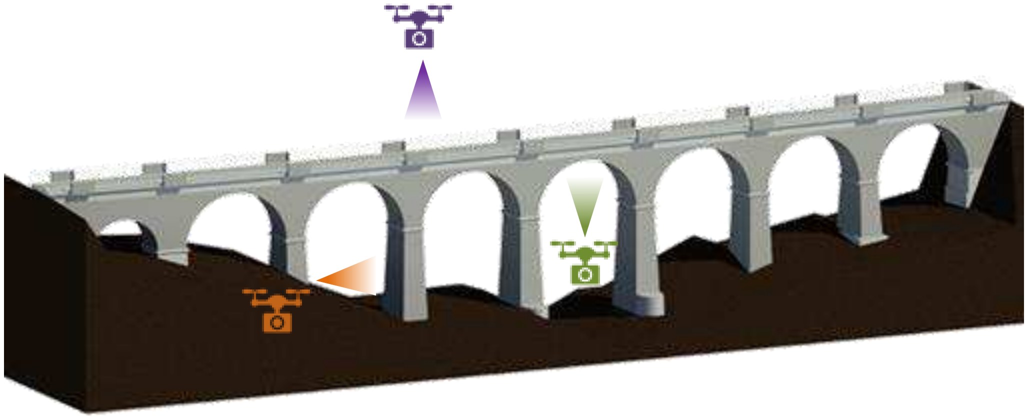
WORK PACKAGE 2: EXPERIMENTAL STUDIES - FIELD ACTIVITIES

RECOMMENDED FLIGHTS

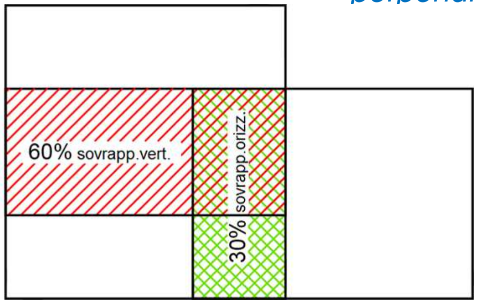
2 flights
under each vault/deck of the bridge

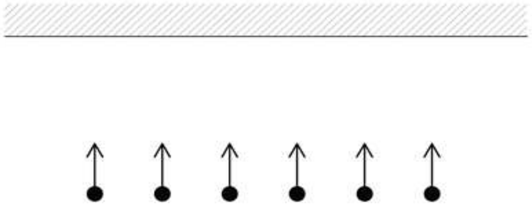
1 flight
for each front of every bridge span

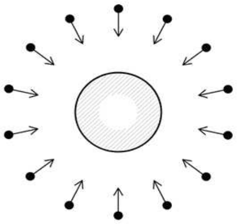
1 flight
over the railway line under train operation suspension



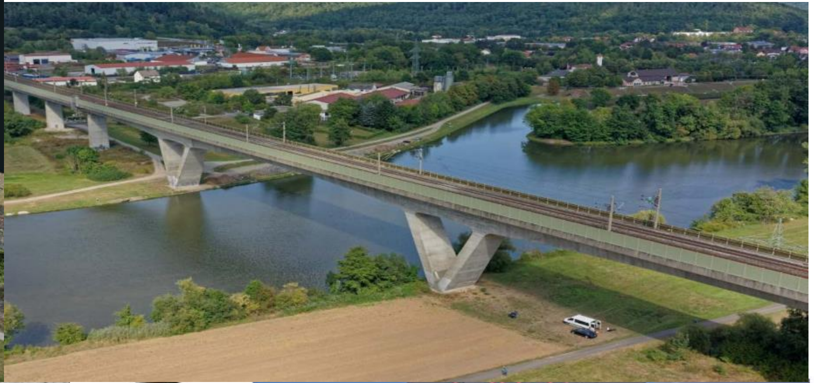
The acquired images have to respect at least *60% of vertical overlap* and *30% of horizontal overlap* and must be taken in *perpendicular direction to flat surfaces* and in *radial direction to curved ones*.

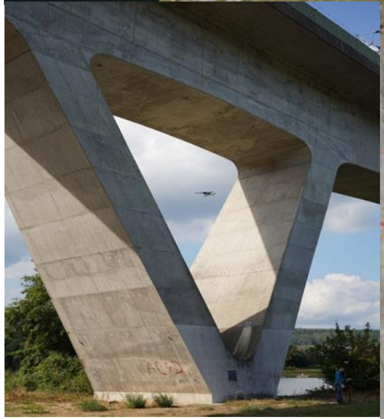


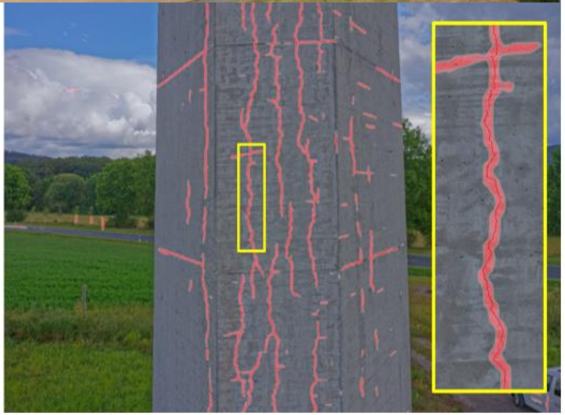




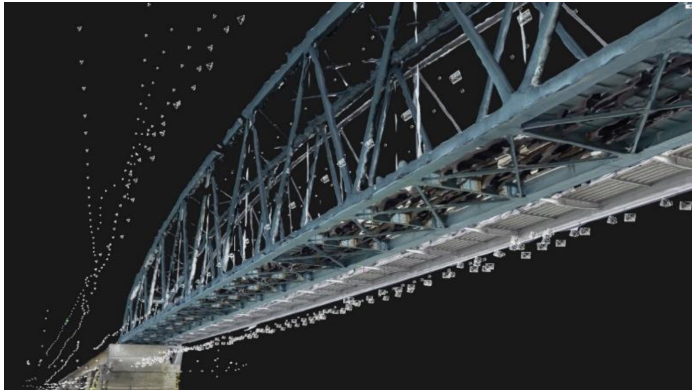
WORK PACKAGE 2: EXPERIMENTAL STUDIES – POST PROCESSING PHASE







WORK PACKAGE 2: EXPERIMENTAL STUDIES – SORA ANALYSIS



Specific Operations Risk Assessment (SORA) analysis has been carry out by an external consultant analysing one of the inspected bridges during the Drone4Rail project.

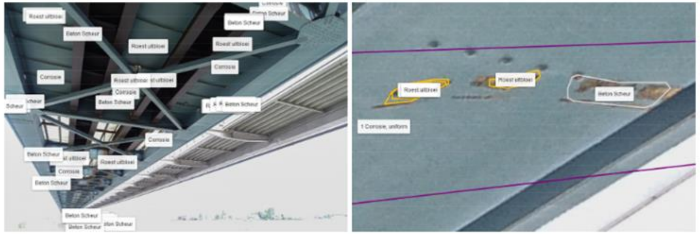
The *Specific Assurance and Integrity Level* (SAIL) has been defined.

This parameter consolidates the ground and air risk analyses and represents the level of confidence that the UAS operation will remain under control.

SAIL = II

AirHub

INTERNATIONAL UNION OF RAILWAYS



WORK PACKAGE 3: GUIDELINE DEFINITION

BENEFITS

- Drone inspections are an added value as *support to the inspector* especially for big bridges and hard-to-reach areas of the structure.
- These make it possible *to highly reduce the field operation time* and *the impact on the train operation*.
- The performed inspections showed that *most of the defect typologies could be recognized* for all bridges typologies recording the extent, intensity and the position.
- *3D bridge measurable models* with high resolution could be obtained through the application of this technology.

LIMITATIONS

- Some *defects require in-depth investigation* such as defects that need a *mechanical control* and defects on structures that are difficult to inspect because of their *geometrical characteristics.*
- The drone flight is affected by the *battery capacity* and *weather conditions*.
- The *light conditions*, the presence of *covers over bearings* and dark paint over the structure could obstacle the drone-inspections.

WORK PACKAGE 3: GUIDELINE DEFINITION

FUTURE DEVELOPMENTS

- The gained experiences make it possible to identify aspects to be improved: *development of AI* (Artificial Intelligence) *technologies*, the on-board sensors and payload, some *drone characteristics* and the *application of drone technology in hazardous areas*.
- The drone application could be improved through the interaction of output coming from the post-processing elaborations with the *“digital twin” created by BIM*.

THANK YOU

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