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SIA

SYSTEM FOR VEHICLE-INFRASTRUCTURE
INTERACTION ASSETS HEALTH STATUS MONITORING

CONTENT

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INTERACTION ASSETS HEALTH STATUS MONITORING

Foreword

After 42 months of intensive collaborative work, the EUSPA-funded project SIA, which started in March 2018, has come to an end in August 2021.

Over the last few months, and despite COVID-19 restrictions, we have completed all work and testing activities initially planned and are now conveying the project's final results. This brochure will give our readers a short overview of these activities and results.

For more information on the project, please consult our project website.

Facts & Figures

2.9
million€
EU Contribution

42
months

9
partners

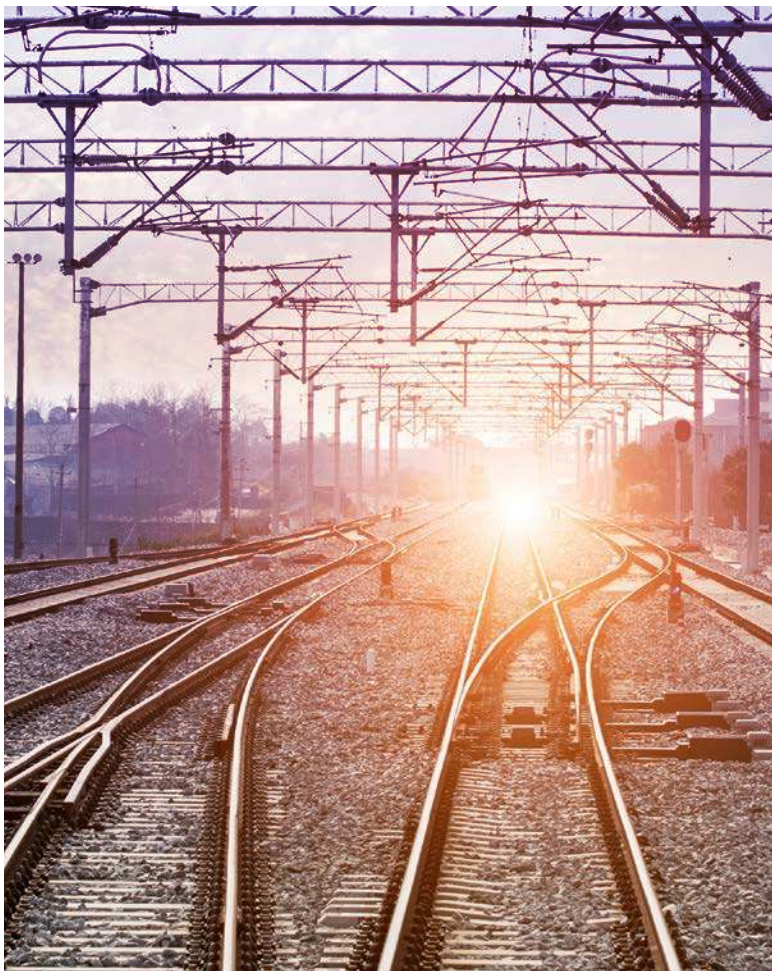
5
countries

Introduction

The main objective of the project was the development of four ready-to-use new services providing prognostic information on the health status of the railway's most demanding assets in terms of maintenance costs (wheel, rail, pantograph and catenary):

- iWheelMon for railway operators will provide real time information about wheel status,
- iPantMon for railway operators will provide real time information about the pantograph status,
- iRailMon for rail infrastructure managers and maintenance subcontractors will provide real time information about the rail status,
- iCatMon for rail infrastructure managers and maintenance subcontractors will provide real time information about the catenary status.

These new services will help to reduce maintenance costs and unscheduled events, as well as derailments associated to the rail-wheel interface. To tackle this challenge, the SIA consortium has brought together multidisciplinary and cross sector partners (E-GNSS technology providers, research centres, IT companies and railway stakeholders) that have co-designed an E-GNSS solution truly adapted to the needs of the rail sector.



Structure of the project

WP1 Project Management

WP2 End user functionality and SIA architecture definition

WP3 EGNOS and Galileo based on-board low-cost receiver and algorithms for railway specific domain

WP4 Integration of sensors, communications and energy supply for on-board sensing nodes

WP5 Component degradation predictive algorithms

WP6 Visualisation environment for railway specific maintenance applications

WP7 Integration with end-user specific application layer

WP8 Test setup development and validation

WP9 Dissemination, communication and result exploitation

List of project deliverables

WP1	**Project Management**	
D1.1	Project Management and Quality Assurance Plan	Public
D1.2	Intellectual Property Rights Controls Agreement	Confidential
WP2	**End user functionality and SIA architecture definition**	
D2.1	End user requirements of SIA and validation plan	Public
D2.2	SIA architecture	Public
WP3	**EGNOS and Galileo based on-board low-cost receiver and algorithms for railway specific domain**	
D3.1	Justification of the selection of the EGNOS and Galileo based receiver HW platform	Confidential
D3.2	Positioning algorithms based on multisensory inputs	Confidential
D3.3	Verification environment for the positioning algorithms	Confidential
WP4	**Integration of sensors, communications and energy supply for on-board sensing nodes**	
D4.1	Wheel to rail and pantograph to catenary sensing nodes	Confidential
D4.2	Wheel to rail and pantograph to catenary power supply systems	Confidential
D4.3	On-board data integration platform and train-track communication hub	Confidential
WP5	**Component degradation predictive algorithms**	
D5.1	Pre-processing algorithms and communication protocols	Confidential
D5.2	Data synchronization in time and position	Confidential
D5.3	Modified xsd and matching RailTopoModel class diagram	Public
D5.4	Linking of physical parameters with component health status	Public
D5.5	Component degradation predictive algorithms	Confidential

WP6	**Visualisation environment for railway specific maintenance applications**	
D6.1	Definition of vehicle maintenance standard views and supporting framework	Public
D6.2	Definition of infrastructure maintenance standard views and supporting framework	Public
WP7	**Integration with end-user specific application layer**	
D7.1	Integration of SIA with end-user information systems	Public
WP8	**Test setup development and validation**	
D8.1	SIA Test setup description	Public
D8.2	Validation of SIA	Public
WP9	**Dissemination, communication and result exploitation**	
D9.1	Dissemination and Communication plan	Public
D9.2	Development and delivery of the exploitation plan	Public
D9.3	Data management plan (DPM)	Public
D9.4	Guidelines for SIA implementation	Public

Public deliverables can be downloaded on the project website at:

siaproject.eu/#deliverables

GMV NSL EGNSS positioning

Objectives

Providing a consistent accurate positioning solution using GNSS for a dynamic train is very challenging, signal masking occurs frequently. This can occur whilst the train passes through tunnels, under bridges, under trees, and through urban obstacles. Signal masking damages both GNSS accuracy and availability however, using more than one GNSS constellation can improve performance due to higher data availability to some extent.

Whilst designing the positioning algorithm for the SIA system for the railway, given the advantages of the accuracy and interoperability of Galileo, the use of Galileo with GPS was identified as the baseline for the positioning system for SIA. It is also noted however that multi-constellation GNSS solutions will not guarantee 100% availability in the railway environment and therefore, augmentation of the GNSS solution with IMU data was also completed..

SIA_POS Test Results

To identify the evolution of the failures in the rail infrastructure, accurate positioning and time stamping that synchronizes measurements from the sensing nodes within the vehicle was deemed essential. These functionalities are provided by the SIA Positioning System (SIA_POS).

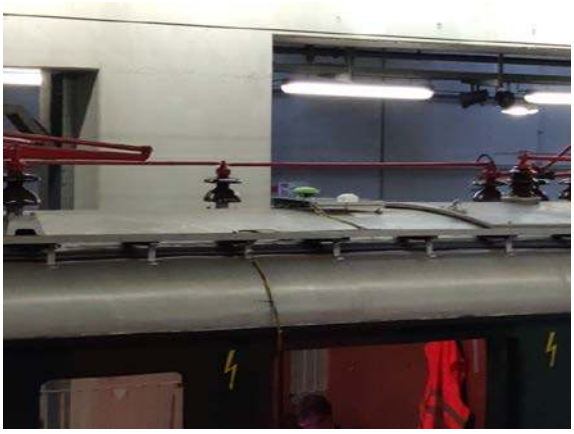
Within the SIA project, GMV NSL's real time SIA_POS system was installed on three locomotives to complete testing and validation activities in three different railway scenarios with our consortium members, OBB, VIAS and FGC. Within the different activities the following routes were taken:

- With OBB, the route used was from Vienna to Linz to the Summerau
- With VIAS, the route used was the high speed line from Madrid to Seville
- With FGC, the route used was the BV railway line from Barcelona to Vallès

OBB Test Campaign (Vienna to Summerau via Linz)

For the OBB testing campaign, the SIA Positioning System was installed in a locomotive that travelled from Vienna to Linz and then from Linz to Summerau. The equipment used within the OBB testing campaign included the SIA Positioning System and the SIA Data Hub. The SIA Positioning system consisted of an EGNSS enabled dual frequency antenna, dual frequency GNSS receiver, Inertial Measurement Unit (IMU), CPU, Battery and a GNSS Inertial Navigation System to provide a reference trajectory.

The images below provide an insight into the setup of the SIA-POS system for the test campaign in the OBB measurement locomotive.



Installation of the antenna on the roof of the locomotive and the SIA_POS unit in the cabin in the OBB testing scenario

The results of the campaign are tabulated below. During the test, 95% of the time an accuracy of 2.05m was observed from the SIA Positioning System. The analysed results show that an average number of 15 satellites were used and that a position solution was available 100% of the time.

Percentage	50%	68%	95%
GPS + Galileo [m]	0.66	0.90	2.05
Mean Number of Satellites	15		
Solution Availability	100%		

As part of our analysis we also analysed the specific improvement provided by Galileo. To see the impact on the positioning solution, the logged real time data was re-processed and analysed using GPS only observations. Using the same reference trajectory, the horizontal error was computed for a GPS only solution, the analysed results show that with GPS alone 95% of the time an accuracy of 2.75m was observed. However while comparing GPS only results with the GPS and Galileo solution, it was shown that the GPS and Galileo solution provided an improvement of 25% for 95% of the test duration.

Percentage	50%	68%	95%
GPS + Galileo [m]	0.66	0.90	2.05
GPS Only [m]	0.77	1.00	2.74
Percentage of Improvement	14.28%	9.99%	25.28%

FGC Test Campaign (Barcelona to Vallès (BV) Railway Line)

The testing activity with FGC provided a very challenging environment for the SIA positioning system. Because the route was mostly underground, the possibility of GNSS signal loss was extremely high. The equipment used within the FGC testing campaign included the SIA Positioning System, SIA Data Hub and SIA Pantograph system. The SIA Positioning system consisted of an EGNSS enabled dual frequency rail certified antenna, dual frequency GNSS receiver, Inertial Measurement Unit (IMU), CPU and Battery.

For the campaign, the position performance statistics have been computed for the whole data set and segmented depending on whether the train was underground. Some of the results have been tabulated below.

Percentage	50%	68%	95%
GPS + Galileo [m]	1.9	3.10	4.36
Mean Number of Satellites	12		
Solution Availability	100%		

The results show that in an open sky scenario, an accuracy of 4.36 m was observed 95% of the time. For the overall accuracy for the FGC scenario it was hard to maintain the accuracy of 20m for the whole duration of the test because the track was mostly underground. In order to obtain better accuracy in underground environment, it is advisable to use a better quality IMU to assist in providing better accuracy.

Like the OBB campaign, as part of our analysis we also analysed the specific improvement provided by Galileo. To see the impact, the logged real time data has been re-processed and analysed using GPS only observations. Using the same reference trajectory, the horizontal error was computed for a GPS only solution (only for an open sky environment with a minimum number of 6 satellites), this analysis is shown below.

The analysed results show that with GPS alone 95% of the time an accuracy of 4.79m was observed. However whilst comparing the GPS only horizontal accuracy with GPS and Galileo position solution, it was shown that the GPS and Galileo solution showed a 9% improvement 95% of the time.

Percentage	50%	68%	95%
GPS + Galileo [m]	1.9	3.10	4.36
GPS Only [m]	1.93	3.80	4.79
Percentage of Improvement	1.5%	18.1%	9.0%

VIAS Test Campaign (Madrid to Seville)

For the VIAS testing campaign, the SIA Positioning System was installed in a construction locomotive that travelled from Madrid to Seville on the high speed line. The equipment used within the VIAS testing campaign included the SIA Positioning and Data Hub systems. The SIA Positioning system consisted of an EGNSS enabled dual frequency rail certified antenna, dual frequency GNSS receiver, Inertial Measurement Unit (IMU), CPU and Battery. Below are a few images from the campaign.

VIAS locomotive and the installation of the E-GNSS enabled antenna on the roof

The results of the campaign are tabulated below which show that 95% of the time an accuracy of 17.9m was observed. The analysed results show that an average number of 15 satellites were used and that a solution was available 100% of the time during the test.

Percentage	50%	68%	95%
GPS + Galileo [m]	0.46	0.58	17.9
Mean Number of Satellites	15		
Solution Availability	100%		

Like the previous campaigns, to see the impact of E-GNSS on the positioning solution, the real time solution was re-processed and analysed using GPS only observations. Using the same reference trajectory, the horizontal error was computed for a GPS only solution, this has been tabulated below. From the results it can be seen that the including Galileo provided a 6% improvement.

Percentage	50%	68%	95%
GPS + Galileo [m]	0.46	0.58	17.9
GPS Only [m]	0.42	0.61	19.0
Percentage of Improvement	-9.5%	4.9%	6.14%

In summary for the three campaigns, the GNSS positioning solution was improved by 9% thanks to the use of Galileo (with 100% availability), although further improvements are required to guarantee a position accuracy of 20m for trains with velocity up to 100 km/h and for underground scenarios.

CEIT
Pantograph-catenary interaction monitoring

Objectives

- To develop a low-cost monitoring system to be installed in the pantograph to monitor the interaction of the pantograph and catenary.
- To develop algorithms that transform the data acquired by the monitoring system into health-related KPIs: OHL geometry (height and stagger) and interaction dynamics (e.g. contact force).
- To integrate the hardware and software in the subsystem in SIA system
- To validate the results in a real scenario (install a prototype in a in service train)

Description

The main goal of the iCatMon and iPantMon applications is to provide health-related information about two important assets of the railway system: the catenary (in particular the overhead line) and the pantograph. As the two systems interact with each other in a dynamic way, the status of one affects the other, and the other way around. For this reason, having low-cost on board systems that monitor (in a non-invasive way) such interaction is very useful to assess the condition of these assets, and eventually to provide prognosis information about how they degrade over time.

In order to develop such a monitoring system, the following approach has been followed in the SIA project:

- **Characterization of pantograph**. First, the static and kinematic performance of the pantograph was assessed using sensors (acceleration, inclination, displacement and force) and measurements in their different constituents: masses, centres of gravity, stiffness, etc. were completed.
- **Pantograph and catenary modelling**. Once the pantograph was assessed, a mathematical model that represents in a very accurate way the behaviour of the pantograph was built. The same applies for the catenary: its static and dynamic conditions were assessed and modelled in order to integrate the two models.
- **Virtual framework**. A virtual framework was built to simulate the dynamic interaction between the pantograph and the catenary. This framework was compliant with the EN50318 standard and allowed us toobtain synthetic data that replicated the real signals that can be obtained by real sensors installed in the pantograph at different locations.
- **Development of algorithms**. With the use of the virtual framework, hundreds of different scenarios were created (e.g. in faulty conditions of the different components of the systems). The signals obtained (e.g. accelerations, forces, etc.) were then used to train machine learning algorithms for the detection of defects and to assess the future evolution of the assets' conditions.
  Algorithms have been developed to monitor the geometry of the overhead line (stagger and height), as well as the dynamic performance of the system (e.g. contact force).

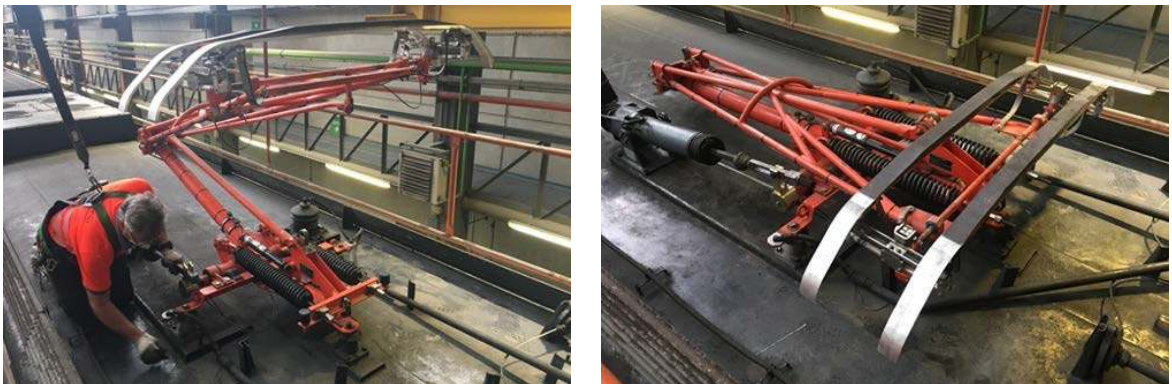
- **Development of prototype**. With the support of the virtual framework, the sensors that are required to generate the signals that lead to health related KPIs were selected, as well as their characteristics and their location in the pantograph. After that, a prototype was built and integrated with the whole SIA system. The prototype is autonomous, as it does not require power supply from the train, and it transmits the information to the data hub wirelessly.
- **Validation**. The prototype has been validated in in service operational conditions on board a FGC train. The validation activity started first by assessing the impact of the system in the performance of the pantograph. Once that the system's non-invasive nature was confirmed, the prototype, and the whole SIA system, was operating and collecting data during commercial service operations for a whole week, with the train traveling across FGC's network in Catalunya (Spain).

The results obtained with this monitoring system are very promising, as they correlate the benchmark KPIs provided by commercial measurement devices.

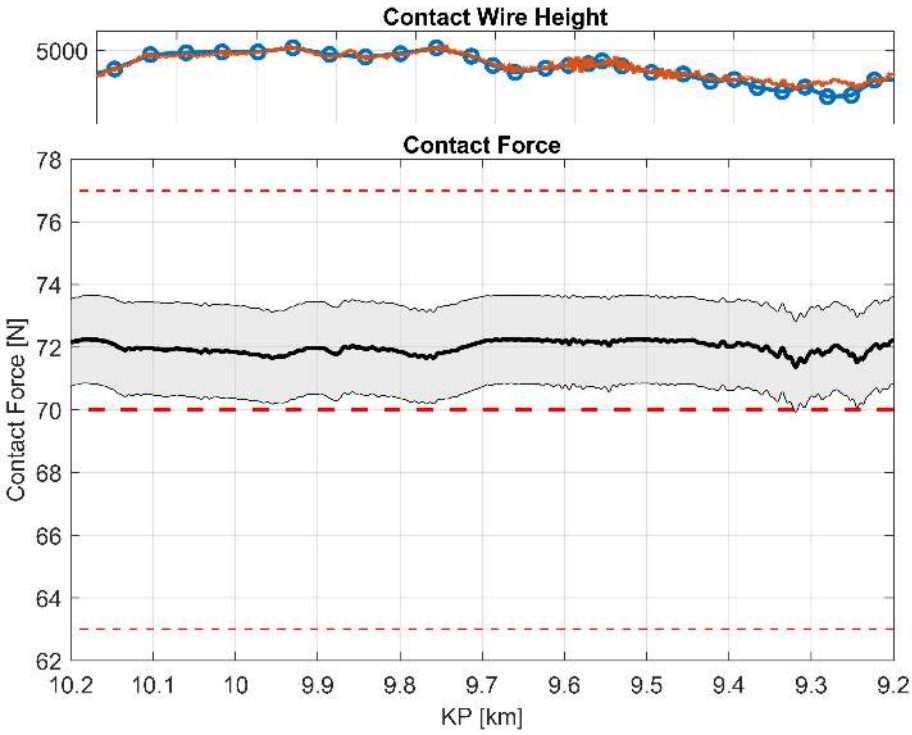
A (very) low-cost system composed by three accelerometers installed in the pantograph is adequate for providing the signals required to generate health condition indicators for the assessment of the catenary and pantograph systems and their interaction.

Ceit's team working in the installation of SIA_PANT

SIA_PANT installed in the pantograph (left). Detail of the main unit on the base plate (right)



Installation of the instrumented pantograph in FGC's train



Contact force (pantograph-catenary interaction)

DLR
Wheel-rail interaction monitoring

Objectives

- Develop sensor systems and processing algorithms for the collection and analysis of geo-referenced axle-box acceleration (ABA) data.
- Install SIA hardware on an ÖBB in-service vehicle to perform several months of pilot operation in the field.
- Derive and compute asset key performance indicators for the condition of wheels and rails on the basis of ABA data collected during the pilot operation.

Description

The interaction between the wheels of a train and the rail surface causes vibrations that can be recorded using on-board sensors. In the SIA project, axle-box acceleration (ABA) sensors placed close to the wheels of a train have been employed to record these vibrations.

The algorithmic analysis of ABA data reveals patterns that can be associated with the condition of the wheels and rails. With this information, the maintenance costs and risks of failure can be reduced.

On-board sensor systems

The Rail to wheel interaction is a data-intensive topic. Therefore, from day one of the SIA project a lot of effort has been put in to working on the sensor systems that live up to the challenging railway environment and the strict railway regulations.

Modular hardware units with two or more ABA sensors attached at each side of a rail vehicle have been designed and built. Railway-certified components were used, including industrial computing hardware and robust analog high-range ABA sensors.

The software for the ABA data collection and processing has been implemented in robot operating system (ROS). The system can operate autonomously over months, in order to collect high-frequency ABA data for the offline analysis.

ABA data analysis

The ABA data can be analyzed both on-board (online) and in the back-office (offline). Positioning information is required for both, to complement detected events in the online data and to perform track-dependent analysis of the ABA data collected in several runs over the same track. Hence, E-GNSS driven positioning is an enabler in SIA.

A range of wheel and rail failure modes have been investigated, including wheel flats and polygonization, as well as rail corrugation. The wheel failures cause periodic responses in the ABA data, which can be recovered using accurate vehicle speed estimates and advanced signal processing methods (ABA cepstrum). Similarly, recurring anomalies in the ABA data that appear at the same positions in the railway network point at track failures. Both wheel and rail key performance indicators have been derived.

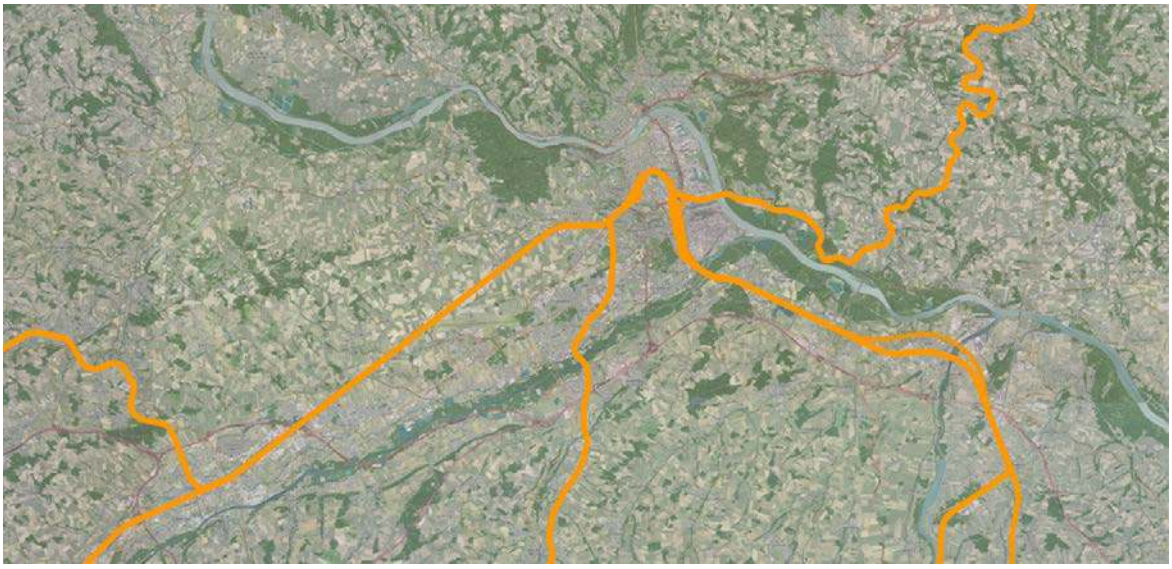
Rail wheel interaction monitoring in action

The first experiment with a SIA prototype was performed on an ÖBB measurement vehicle during a two-week campaign in June 2019. After some Coronavirus-related delays (travelling restrictions and closed workshops) the SIA partners DLR and ÖBB installed SIA hardware for pilot operations on an ÖBB in-service passenger train.

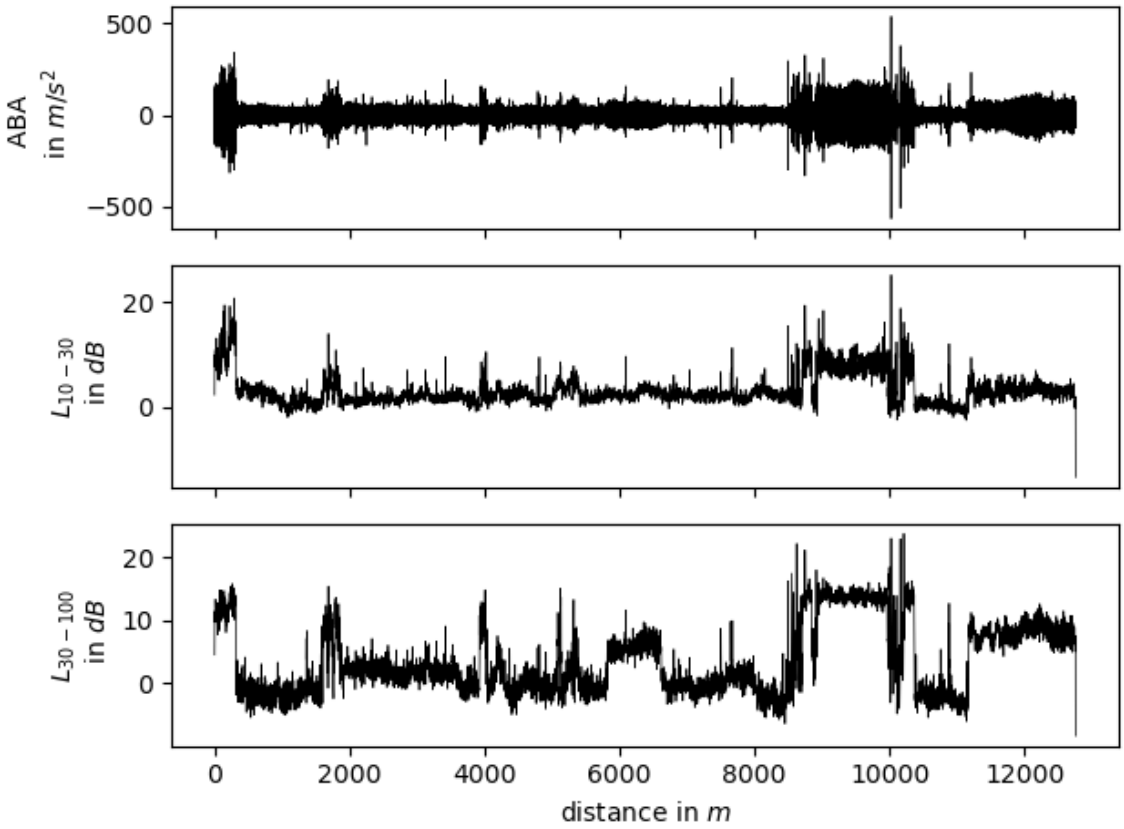
The system has been in operation since November 2020, traversing several routes around Linz and autonomously collecting ABA and E-GNSS data for offline analysis.

SIA hardware for pilot operation (unit, ABA sensor, GNSS antenna on ÖBB vehicle)

The ÖBB in-service passenger train with installation details



Position data from several months pilot operation illustrates the routes visited by the vehicle (aerial image: basemap.at)



ABA data and extracted rail KPI as functions of the along-track distance

Ingecontrol Visualization platform

Objectives

User interfaces (UI) and visualization platforms are paramount to enable end users to exploit data in a system and support successful market uptake. That's why one of the main objectives of the SIA project has been creating and testing a user interface for **railway infrastructure and vehicles maintenance supported by georeferenced data.**

SIA Visualization Platform (SIA VP) has been implemented using an **open-source** software framework after thorough research and trade-offs.

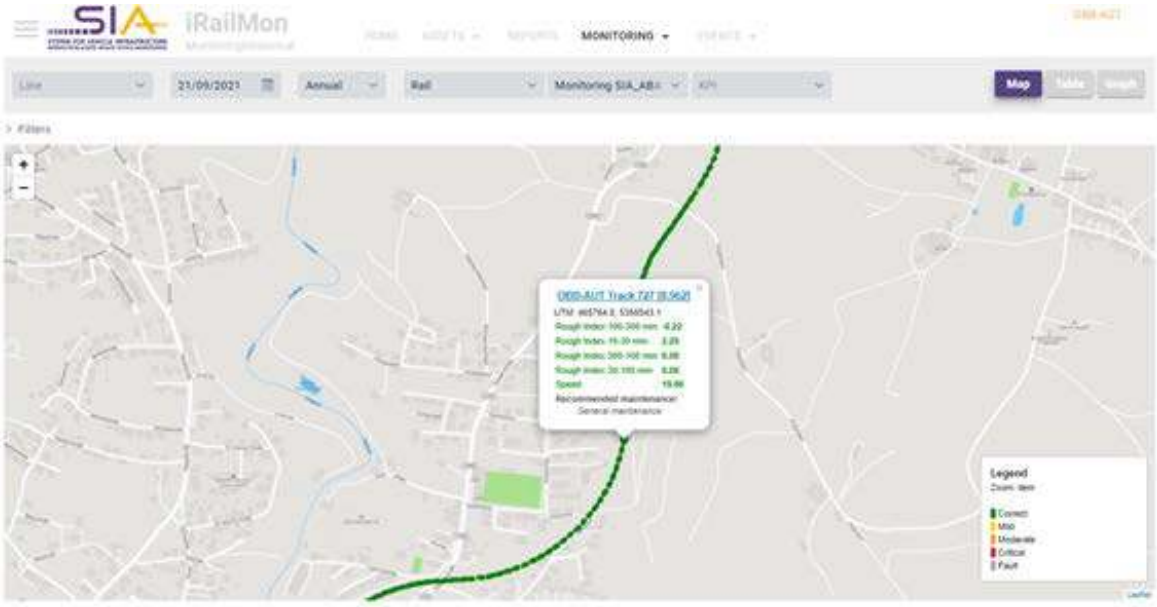
SIA VP is a web-based application with a client-server architecture formed of three layers and four different modules to support each one of the four SIA services: **iRailMon, iWheelMon, iCatMon and iPantMon**. Each of these modules provides the following functionalities to support the corresponding assets, monitoring and maintenance management:

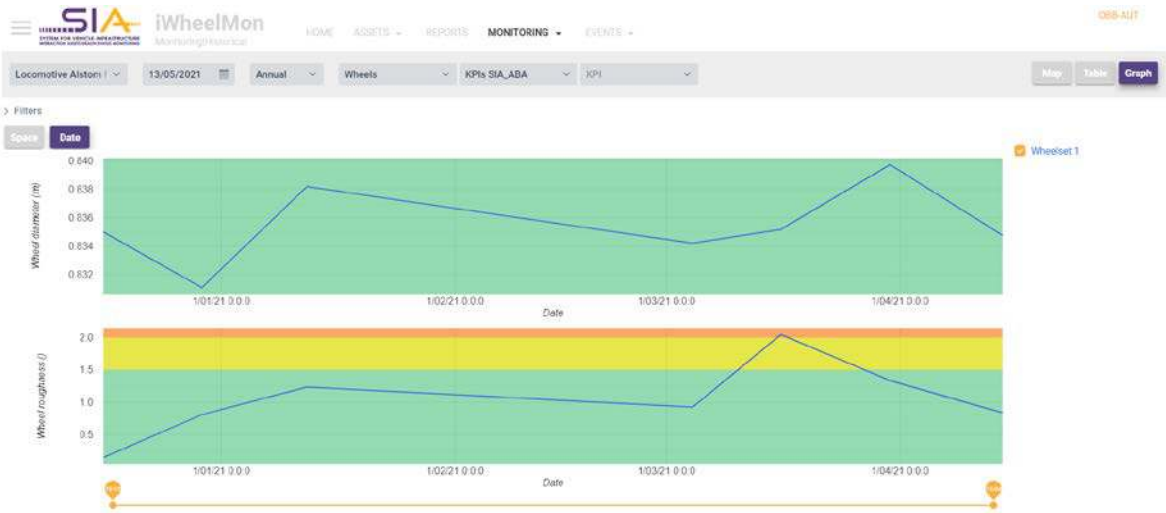
- Manage the list of components and associated KPIs, as well as their limits and thresholds,
- Manage the maintenance list associated to each KPI, and the actions to do based on the KPIs status,
- Display in a GIS (Geographical Information System) map the railway lines in the system,
- Report and visualize the raw auscultation and inspection data,
- Display the current status of the components based on the KPIs,
- Display a prediction of the future status of components based on KPIs,
- Generate alerts reporting the early detection of future failures,
- Display maintenance recommendations based on the assets status.

The development framework selected provides the SIA Visualization Platform with key features such as:

- **Ubiquity:** It can be used from anywhere and on any device with an internet connection, this is very useful for field engineers and operators.
- **Security:** This is mandatory as SIA works within critical infrastructure.
- **Scalability:** SIA manages an ever-growing huge amount of data depending on the size of the network, the monitoring equipment deployed and the volume of historical data collected and future forecasts generated.
- **Rapidity:** The visualization platform has to provide a quick response to user requests independently of the volume of data to be processed.
- **Interoperability** with other third party and legacy applications used by infrastructure managers and train operating companies by means of web services and/or a flexible import/export modules of open formats such as csv, xml and json files.

Thanks to the software development framework selected and following a user centred design methodology, SIA VP has become a powerful GIS solution supported by well-established open-source technologies. SIA VP displays user friendly meaningful information in maps, tables and charts to monitor the present and future status of assets and manage maintenance operations more efficiently in the railway sector.





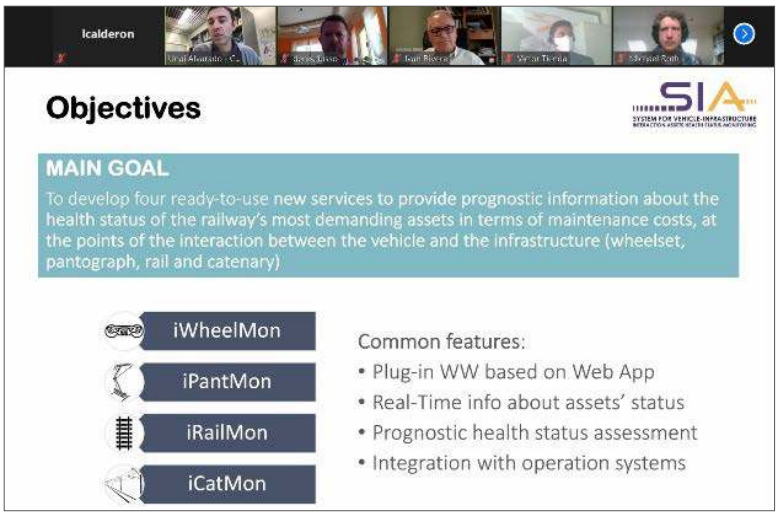
Dissemination

Peer-reviewed papers

The project partners attended several conferences and published a series of papers to present the results achieved during project life. Below a selection of papers published these past 2 years:

- Map Aided Software Enhancement for Autonomous GNSS Complementary Positioning System for Railway – December 2019 – IEEE Transactions on Vehicular Technology (download HERE)
- Hybridized GNSS and IMU Positioning for Train Infrastructure Asset Health Status Monitoring within the SIA-Project – June 2020 – ICL GNSS 2020 (download HERE)
- Positioning for Train-infrastructure Asset Health Status Monitoring within the SIA-project – September 2020 – ION GNSS+ 2020 (download HERE)
- Positioning Approach for Train-Infrastructure Interaction Assets Health – November 2020 – European Navigation Conference (ENC 2020) (download HERE)
- An Unsupervised Machine Learning Approach to Extract Wheel and Track Health Status Indicators from Train-Borne Accelerometer Data – November 2020 – ESREL 2020 PSAM 15 (download HERE)
- Prediction of Rolling Contact Fatigue Behavior in Rails Using Crack Initiation and Growth Models along with Multibody Simulations – January 2021 – Special Issue of Monitoring and Maintenance Systems for Railway Infrastructure (download HERE)
- Train Wheel Condition Monitoring via Cepstral Analysis of Axle Box Accelerations – February 2021 – Special Issue of Monitoring and Maintenance Systems for Railway Infrastructure (download HERE)

SIA Project presented during a webinar organised by the Railway Innovation Hub



On the 21st of May 2021, the Railway Innovation Hub held a webinar to present the project SIA to its members.

The webinar was held partly in Spanish and partly in English.

The two presentations delivered during the webinar can be downloaded below:

- "*Proyecto SIA: Motivación y lecciones aprendidas*". Dr. Unai Alvarado, Centro Tecnológico CEIT
- "*EGNSS Positioning within the SIA Project*", Dr. Michael Roth, German Aerospace Center (DLR)
- The recording of the webinar (first part in Spanish, second part in English) can be found HERE.

SIA Newsletters

The SIA project partners have prepared and published several newsletters to update their followers on the project activities and progress.

These newsletters can be reached at:

#1 2019 Newsletter #1 September 2019

#2 2020 Newsletter #2 April 2020

#3 2021 Newsletter #3 June 2021

SIA held its final event remotely on 15 October 2021

Event highlights:

- Presentation of EUSPA
- Introduction to the project
- Characteristics
- Ambition/Challenges
- Architecture
- Project's results and main achievements
- EGNSS positioning
- Pantograph-catenary interaction monitoring
- Wheel-rail interaction monitoring
- Visualization platform
- Q&A and concluding remarks

The recording of the webinar can be accessed HERE.

The presentation delivered during this event can be downloaded HERE.

SIA held its mid-term event remotely on 9 July 2020

On the 9th of July 2020, **over 70 participants attended the SIA mid-term webinar**; attendees included Infrastructure Managers, EU representatives, industry and academia from all over the world, including Spain, Portugal, France, Belgium, Germany, Italy, Austria, Japan and the United Kingdom.

Event highlights:

- Project overview (CEIT)
- SIA system description (CEIT)
- Positioning system & EGNSS benefits (NSL)
- Wheel-Rail interaction (DLR)
- Pantograph-Catenary interaction (CEIT)
- SIA Visualisation Platform (Ingecontrol)
- Q&A

The recording of the webinar can be accessed HERE.

The consolidated presentation delivered during this event can be downloaded HERE.

List of acronyms

Acronyms	Description
ABA	Axle-Box Acceleration
AC	Alternating Current
ADC	Analog to Digital Converter
AHC	Anti Headcheck
APF	Adjacent Post Fixation
CAT	Corrugation Analysis Trolley
CBM	Condition Based Maintenance
COTS	Commercial of the Shelf
CPU	Central Processing Unit
CW	Contact Wire
CWR	Continuously Welded Rail
DC	Direct Current
DECA	Digital Electronic Control Assembly
DLR	Deutsches Zentrum für Luft- und Raumfahrt (German Aerospace Center)
DOC	Dilution of precision
DOF	Degree of Freedom
DT	Differed time
EGNSS	European Global Navigation Satellite Systems
EIF	External Interface
ETSI	European Telecommunications Standards Institute
FE	Finite Elements
FGC	Ferrocarrils de la Generalitat de Catalunya. Spanish regional train operator
FPGA	Field Programmable Gate Array
FTP	File Transfer Protocol
GIS	Geographic Information System
GLONASS	GLObal Navigation Satellite System
GNSS	Global Navigation Satellite System
GSA	European Global Navigation Satellite Systems Agency
HDD	Hard Disk Drive
HMI	Human Machine Interface
HW	Hardware
iCatMon	Application that provides information about the status of the catenary
ID	Identity / Identification
IEEE	Institute of Electrical and Electronics Engineers
IF	Interface
IIF	Internal interface
IM	Infrastructure Manager

Acronyms	Description
IO	Integrated Operator
IP	Ingress Protection code
iPantMon	Application that provides information about the status of the pantograph
iRailMon	Application that provides information about the status of the rail
IRJ	Insulated Rail Joints
IT	Information Technologies
iWheelMon	Application that provides information about the status of the wheelset
JAVA	A general purpose, high-level, object-oriented, cross-platform programming language developed by Sun Microsystems
KP	Kilometric Point
KPI	Key Performance Indicator
LAN	Local Area Network
LCC	Life Cycle Cost
LED	Light Emitting Device
LiDAR	Light Detection and Ranging, Laser Imaging Detection and Ranging
LPI	Liquid Penetrant Inspection
LTE	Long-Term Evolution
M2M	Machine to Machine
MIMO	Multiple Input Multiple Output
MQTT	Message Queuing Telemetry Transport
MT	Maintainability
NDE	Non-destructive Examination
NWR	Normalized Wear Rate
OBB	Österreichische Bundesbahnen- Austrian Federal Railways, a national train operator
OCL	Overhead Contact Line
OCW	Overhead Contact Wire
OOR	Out of Round
OP	Operability
PCB	Printed Circuit Board
PCIe	Peripheral Component Interconnect (express)
PF	Performance, Post Fixation
PWR	Power
RAMS	Reliability, Availability, Maintainability and Safety
RCF	Rolling Contact Fatigue
REQ	Requirement
RF	Radio Frequency
RMS	Root Mean Square
ROS	Robot Operating System
RT	Real Time

Acronyms	Description
RTOS	Real Time Operative Systems
SATA	Serial AT Attachment
SBE	Electrical Lowering Device
SFTP	Secure File Transfer Protocol
SIA	System for vehicle-infrastructure Interaction Assets health status monitoring
SIA_ABA	SIA subsystem: an onboard device that senses the wheelset-rail interaction
SIA_CDM	Condition Degradation Modeling subsystem
SIA_DH	SIA subsystem: an onboard device that integrates the data coming from onboard sensors (SIA_ABA and SIA_PANT), synchronizes the data with time & position (SIA_POS), stores it and sends it to the visualization platform (SIA_VP)
SIA_DH_COM1	Communications module (with SIA_PANT) of SIA_DH subsystem
SIA_DH_COM2	Communications module (with SIA_ABA) of SIA_DH subsystem
SIA_DH_COM3	Communications module (with SIA_POS) of SIA_DH subsystem
SIA_DH_COM4	Communications module (with SIA_VP) of SIA_DH subsystem
SIA_DH_PS	Power Supply module of SIA_DH subsystem
SIA_DH_PU	Processing Unit module of SIA_DH subsystem
SIA_DH_STO	Storage module of SIA_DH subsystem
SIA_PANT	SIA subsystem: an onboard device that senses the pantograph-catenary interaction
SIA_POS	SIA subsystem: an onboard device that calculates the position of the train to synchronize it with the signals of the sensors
SIA_VP	Visualization platform subsystem
SIA_VP	SIA subsystem: back-office applications that analyze and visualize the data within iCatMon, iPantMon, iWheelMon and iRailMon applications
SMA	SubMiniature version A
SP	Supportability
SPI	Serial Peripheral Interface
SSD	Solid State Drive
STFT	Short-Time Fourier Transform
SW	Software
TBD	To Be Done
TBV	To Be Verified
TOC	Train Operating Company
UDP	User Datagram Protocol
UPN	European standard for U channel
UPS	Uninterruptible Power Supply
USB	Universal Serial Bus
VBOX	SIA_DH_PU module by SINTRONES
WLAN	Wireless Local Area Network
WP	Work Package

Consortium

N°	NAME	SHORT NAME	COUNTRY
1	Asociación Centro Tecnológico Ceit	CEIT	Spain
2	Union Internationale des Chemins de fer	UIC	France
3	Deutsches Zentrum für Luft- und Raumfahrt e.V.	DLR	Germany
4	Ingeniería y Control Electrónico SA	Ingecontrol	Spain
5	Teléfonos Líneas y Centrales SA	TEL	Spain
6	Vías y Construcciones SA	VIAS	Spain
7	ÖBB-Infrastruktur AG	ÖBB	Austria
8	Ferrocarrils de la Generalitat de Catalunya	FGC	Spain
9	GMV NSL	GMV NSL	United Kingdom

SIA

SYSTEM FOR VEHICLE-INFRASTRUCTURE
INTERACTION ASSETS HEALTH STATUS MONITORING

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