



**SYSTEM FOR VEHICLE-INFRASTRUCTURE  
INTERACTION ASSETS HEALTH STATUS MONITORING**

# Newsletter

**April 2020**

## Foreword

The SIA project is now in its final year!

The project started on the 1<sup>st</sup> March 2018 and has a duration of 36 months. This project, led by CEIT, in collaboration with our 9 partners, aims at developing four ready-to-use 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).

We are very happy to present in this issue of the SIA newsletter, our main technical achievements, the benefits of the European Global Navigation Satellite System (EGNSS) that we are finding within the railway environment and the work that is to be completed within the coming year.

**Interested in learning more about the results of the SIA project or exploring synergies with other projects? Please contact:**

Mr. Unai Alvarado, Project Coordinator at CEIT ([ualvarado@ceit.es](mailto:ualvarado@ceit.es)) or

Ms. Christine Hassoun, Dissemination Senior Advisor at UIC (International Union of Railways) ([hassoun@uic.org](mailto:hassoun@uic.org)).

The **SIA website** is updated regularly with all available documents and deliverables. Check out our website at:

**<https://siaproject.eu/>**

## FACTS AND FIGURES

**EU Contribution:**  
€2.9 million

**Duration:**  
36 months

**Project start date:**  
01/03/2018

**Project end date:**  
28/02/2021

**Project coordinator:**  
CEIT

**Partners:**  
9 from 5 countries

**EU H2020 GSA  
Project**

**Grant agreement:**  
n°776402

**Website:**  
**<https://siaproject.eu/>**

*This project has received funding from the European Union's Horizon 2020 research and innovation programme and from the European Global Navigation Satellite Systems Agency under grant agreement #776402*



SYSTEM FOR VEHICLE-INFRASTRUCTURE  
INTERACTION ASSETS HEALTH STATUS MONITORING

## SIA MAIN GOAL

The main objective of SIA is the development of four ready-to-use new services (iWheelMon, iRailMon, iPantMon and iCatMon) 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

## SIA OBJECTIVES

- ↘↘ Development of **low-cost sensor nodes (SIA\_NoS)** for wheel to rail and pantograph to catenary interaction characterisation
- ↘↘ Development of a **data hub (SIA\_DH)** that collects on-board information, provides accurate position and time stamping with high availability, and transmits the information to a trackside visualization platform
- ↘↘ Development of **predictive component degradation models (SIA\_CDM)** that will enable to connect the monitoring information from wheelset, rail, catenary and pantograph with the asset management information system of end-users
- ↘↘ Development of a **visualisation platform (SIA\_VP) with two plug-in software modules specific for the railway** infrastructure (track and catenary) and vehicle maintenance (wheelset and pantograph)

## Technical Achievements



*Early data collection campaign*



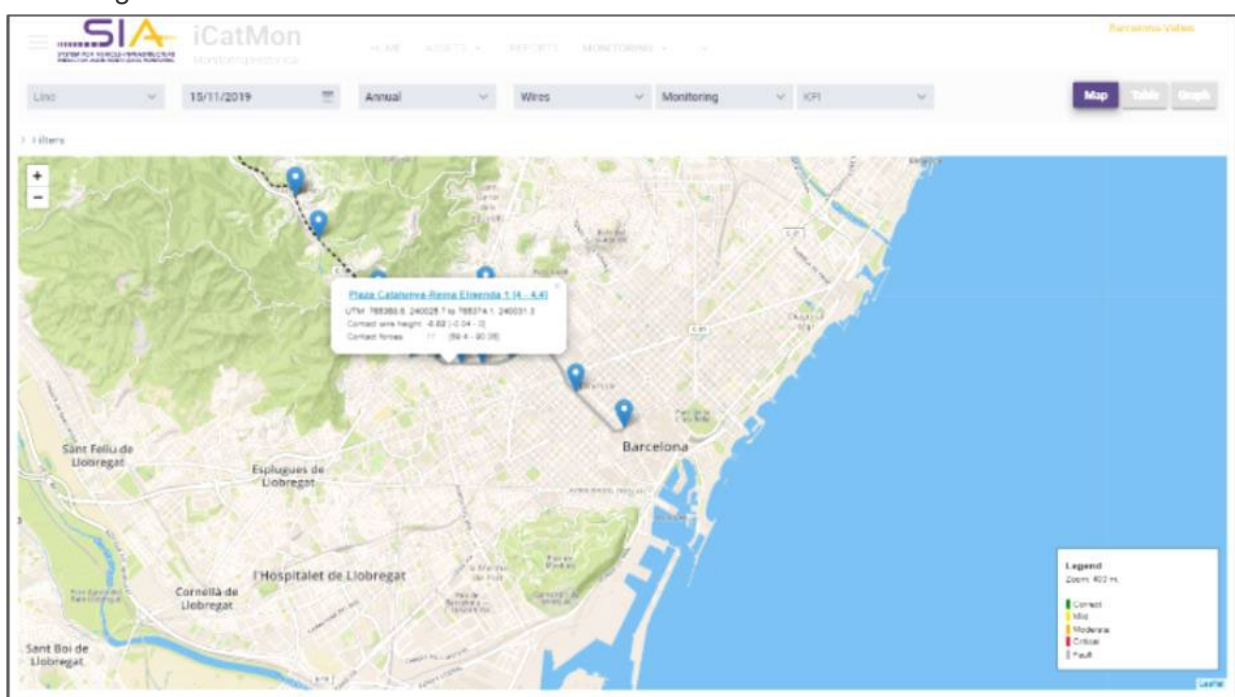
*Onboard equipment prototype*

The SIA project partners have achieved many things through their work and research in 2019. We can now present preliminary prototypes of the on-board equipment, software applications (iCatMon, iPantMon, iWheelMon, iRailMon) and test run data.

In the last year, we have developed a new methodology and some new equipment to assess the interaction between the pantograph and the catenary wire. Among others, this new method, not yet available on the market, will reduce cost in development, installation and maintenance activities and will support decision making in catenary and pantograph maintenance operations.

Moreover, the use of EGNSS to locate failures has been explored in detail. The use of EGNSS is a key advantage in assessing linear assets (i.e. the Rail and Overhead Contact Line) due to the accurate signals & data synchronisation (time & position) that can be provided. In particular, EGNSS allows us to detect small-size failures in infrastructure's components, that require further analysis and work to be done on leverages Machine Learning algorithms.

The SIA partners have also developed a new energy harvesting device. This device will offer new business opportunities, such as the electrification of freight wagons. We have also worked on new approaches to support predictive maintenance through component degradation modeling.



*iCatMon application map view*



# SYSTEM FOR VEHICLE-INFRASTRUCTURE INTERACTION ASSETS HEALTH STATUS MONITORING

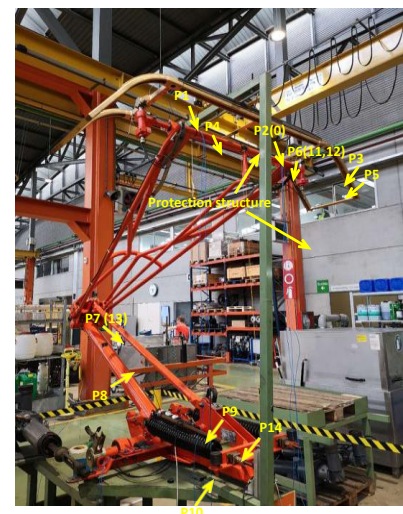


*iCatMon application. OHL KPIs*

In the coming months, the team will complete the development of the second version of the prototypes (featuring railway-certified components), finish the integration of the various subsystems and validate the results in real-life operating environments.



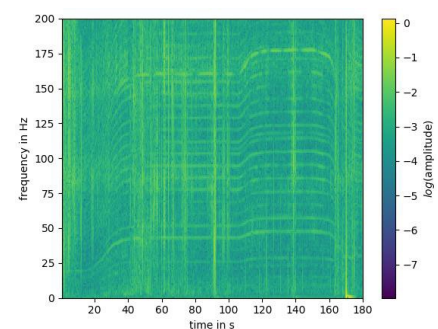
*PCT patent application*



*Pantograph characterisation*



*Rail joint*



*Wheel/Rail interaction feature extraction*







## The Role and Benefits of EGNSS

SIA requires accurate and resilient positioning and time stamping to enable accurate correlations in the onboard sensor information. Using an onboard positioning system is a “costly intrusion” in the TCMS. Hence, in SIA, positioning and time stamping will be done using Global Navigation Satellite Systems (GNSS).

Positioning by GNSS is very challenging in the railway environment. To overcome the challenges, it is essential that we use a multi-constellation multi-frequency approach. Given the advantages of the interoperability of Galileo and GPS, unlike other GNSS systems, the use of Galileo with GPS is the baseline constellation combination for SIA.

In SIA, Precise Point Positioning (PPP) has been selected as the prime positioning technique as no additional infrastructure requirements are needed. Using multiple frequencies in PPP can considerably improve the convergence time by mitigating ionosphere delay. The frequency redundancy provided by Galileo makes it ideal for SIA. Such redundancy also provides resilience against narrow band interference and signal jamming.

In addition, to improve availability and accuracy, Galileo’s advanced modulation techniques make it more robust against signal reflection known as multipath, which is a common GNSS error especially in the railway environment.

In future evolutions of SIA, the Galileo High Accuracy Service (HAS) may provide a suitable source of Secondary surveillance radar (SSR) data and could remove/reduce the reliance on terrestrial communications to access to this data.

European Geostationary Navigation Overlay Service (EGNOS) corrections will not be considered in SIA due to:

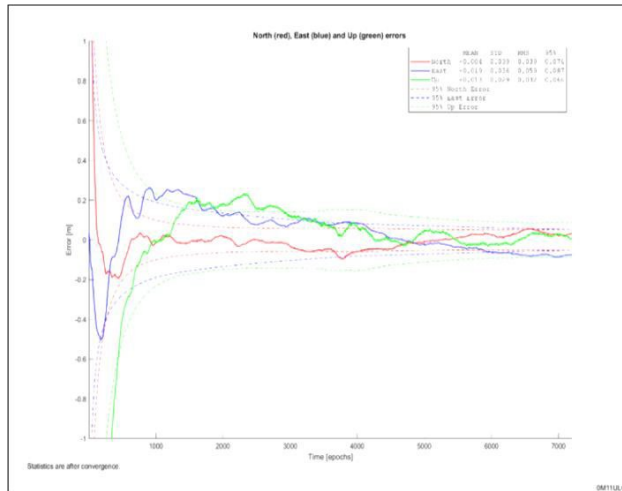
- Limitations in geostationary satellite visibility in the railway network
- Limited added value in a PPP solution

The use of EGNSS will improve the accuracy and availability of the PPP solution used for SIA. To show the impact of EGNSS on the accuracy obtained, PPP solutions in ideal stationary conditions have been compared with the use of for the GPS only and GPS plus Galileo cases. The results show that using Galileo in addition to GPS reduces the convergence time and hence improves accuracy.

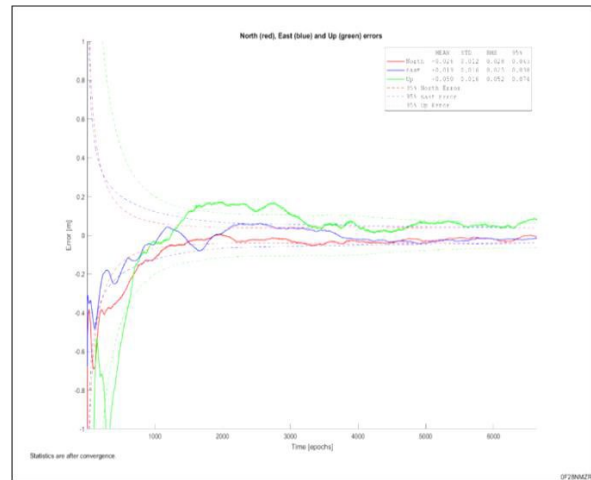
Example: PPP solutions in ideal stationary conditions (GPS only vs multi-frequency GPS + GALILEO)



# SYSTEM FOR VEHICLE-INFRASTRUCTURE INTERACTION ASSETS HEALTH STATUS MONITORING

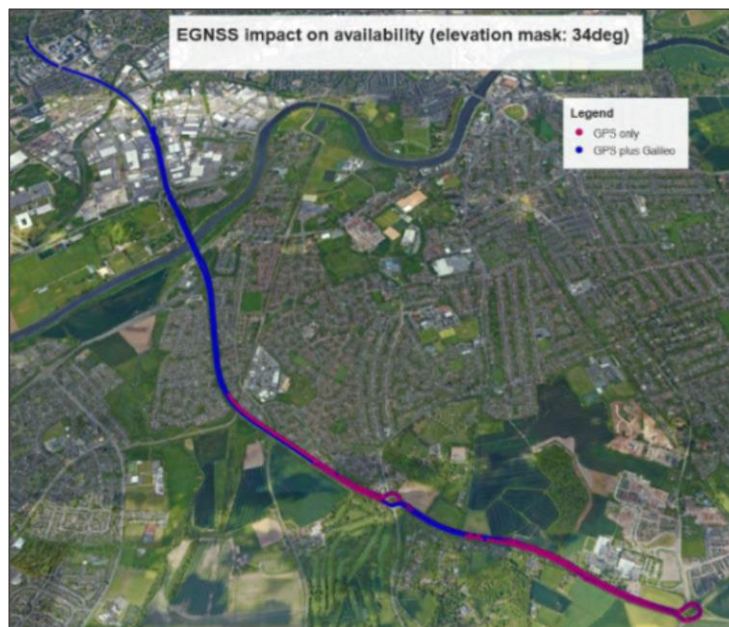


*PPP solution using GPS dual  
frequency measurements*



*PPP solution using GPS plus Galileo  
dual frequency measurements*

To show the positive impact of EGNSS on availability, a road data set recently collected by NSL using an initial version of the SIA positioning unit has been processed in PPP mode at a high elevation mask (34 degrees). At this elevation mask, the availability of the PPP solution has dropped to 49 percent with GPS only. However, using GPS and Galileo, it is shown to be 95%.



*EGNSS impact on availability (elevation mask: 34 degrees)*

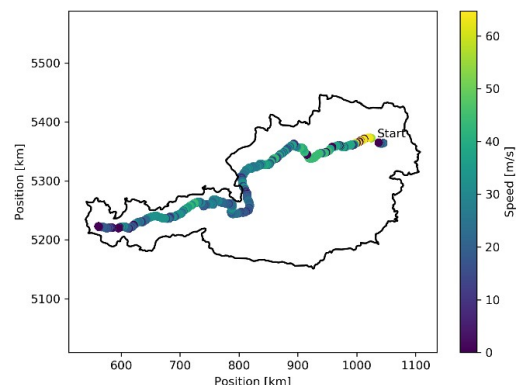


In line with end-user needs, SIA processes and communicates data to the back-office applications in two different ways:

- Online processing (real-time). In this way, only unexpected events (e.g. the detection and location of a given defect) are sent. Given the case, accuracy may be lower but on the other hand, availability and integrity are higher, which is a basic requirement for Condition-Based Maintenance. Real-time events are sent with the identification and location of the critical defects in the infrastructure and on-board key components, which allows for an increase in safety and availability;
- Offline processing (differed time). In this case, raw data is stored and sent in batches to the back-office platform for further big-data analysis. In this scenario, the systems accuracy drastically improves, enabling true predictive maintenance. Big data analysis leverages predictive maintenance, thanks to more reliable feature extraction and KPI analysis about infrastructure critical assets, positively impacting cost, availability and safety. The investigated approaches rely on sensor data fusion methods that can facilitate accurate offline positioning with, e.g., a Galileo receiver, an Inertial Measurement Unit (IMU), and a digital map of the railway network. The strengths of the complementary sensor systems are used to systematically bridge GNSS outages with the IMU and map data, and to correct the position estimates whenever accurate Galileo signal reception is possible. With the advanced processing that can address certain GNSS shortcomings but at the same time exploits Galileo accuracy when possible, the investigated positioning approaches help advance the railway sector and the use of EGNSS.

Another potential benefit brought on by the SIA project is related to future market liberalisation, which could increase infrastructure capacity. However, it may also accelerate its degradation. Infrastructure managers can benefit from continuous (and more accurate) information about the evolution of track degradation caused by rolling stock. This way, the damage caused by the rolling stock can be more accurately derived, and therefore track access charges could be better established.

In the work towards the offline positioning module, several useful software tools are being developed. DLR intends to make these functions available in the form of a python toolbox for rail vehicle positioning. Addressed aspects include the pre-processing of IMU and EGNSS data, IMU calibration, standstill detection based on IMU and GNSS data, the separation of larger data sets into journeys which comprise a single sequence of motion between vehicle start and stop events, and map-supported Kalman filter approaches (including Rauch-Tung-Striebel smoothing) to systematically combine the GNSS and IMU data for each journey.



# SYSTEM FOR VEHICLE-INFRASTRUCTURE INTERACTION ASSETS HEALTH STATUS MONITORING

## CONSORTIUM



*SIA Consortium meeting on 13-14 February  
2020 in DLR premises in Berlin*

## CONTACT

**Project coordinator**  
Mr. Unai Alvarado – CEIT  
ualvarado@ceit.es

**Dissemination**  
Ms. Christine HASSOUN – UIC  
hassoun@uic.org

**SIA PROJECT**



**@SIAGalileo**



**SIA PROJECT**



**[www.siaproject.eu](http://www.siaproject.eu)**