Positioning Approach for Train-Infrastructure Interaction Assets Health Status Monitoring ENC 2020 Virtual Conference, Nov 2020

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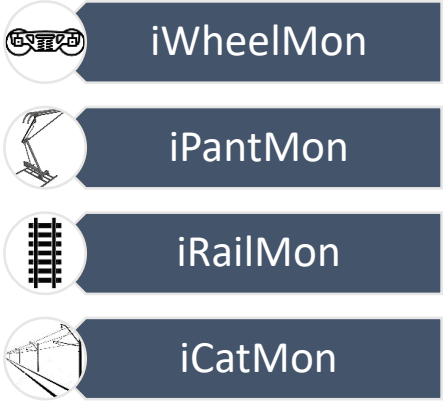
SIA Objectives

SYSTEM FOR VEHICLE-INFRASTRUCTURE INTERACTION ASSETS HEALTH STATUS MONITORING

MAIN GOAL

To develop four ready-to-use new services to provide prognostic information about the health status of the railway's most demanding assets in terms of maintenance costs, at the points of the interaction between the vehicle and the infrastructure (wheelset, pantograph, rail and catenary)



SIA services:

- iWheelMon: Real time information about wheel status and prognostic health status information
- iPantMon: Real time information about the pantograph status and prognostic health status information
- iRailMon: Real time information about the rail status and prognostic health status information
- iCatMon: Real time information about the catenary status and prognostic health status information

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SIA Consortium

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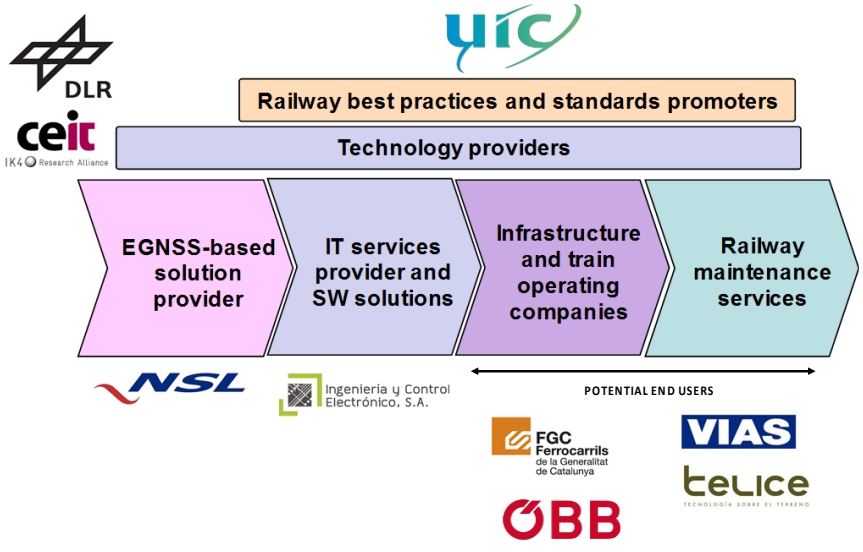

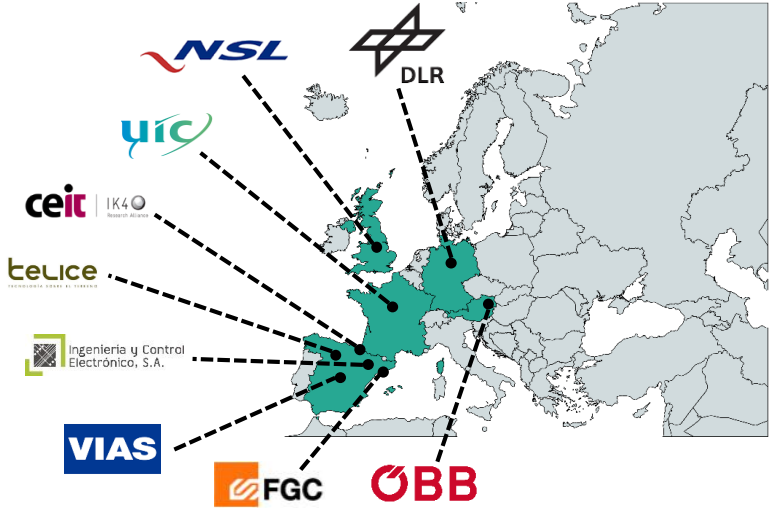

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SIA System Overview

SYSTEM FOR VEHICLE-INFRASTRUCTURE INTERACTION ASSETS HEALTH STATUS MONITORING

Modular architecture with several components

- SIA_POS
  - Position and time information using EGNSS
  - Divided into on-board and back-office solutions
  - Focus of this presentation
- SIA_ABA … to record and analyze axle-box acceleration data
- SIA_PANT … pantograph sensor network
- SIA_DH … data-hub that manages all data
- SIA_VP … visualization platform

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Positioning – SIA_POS

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Position information is essential for the SIA services

- Real-time events localization
- Track-dependent analysis of axle-box or pantograph acceleration data

Position requirements for SIA_POS modules

- On-board – 100 percent availability, 20 m accuracy at 95 percent
- Back-office – 100 percent availability, decimeter accuracy, track-selective

Approaches

- EGNSS, Galileo-driven!
- Precise Point Positioning approach online, hybridization with IMU
- Map-supported Kalman filtering and smoothing in the back-office

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On-board SIA_POS algorithm

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- GNSS + IMU
  -> Poor performance with mass-market IMU
- GNSS + Odometer DR (Dead Reckoning)
  -> Ideal but there is no access to odometer data
- SIA DR approach
  -> Core positioning algorithm: Precise Point Positioning (PPP)
  -> Replacing odometer with along track acceleration

$$speed_H = speed_H^- + a * dt$$

  -> Gyro around z-axis for heading

$$heading = heading^- + gyro_z$$

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EGNSS benefits

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- More satellites in view
  -> Higher GNSS solution availability
  -> Fewer and shorter measurement gaps
    -> Smaller position divergence by DR
    -> Fewer PPP reconvergence

- Galileo has advanced signal structure
  -> Multipath resistance
  -> Improved accuracy

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Experimental GNSS data from Railway

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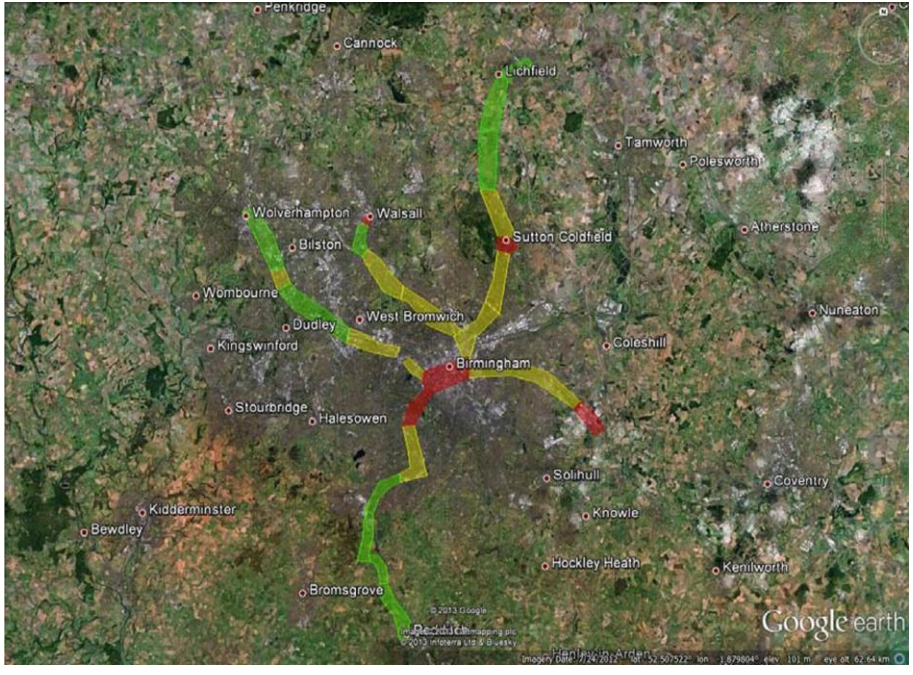

Figure:
open (green), intermediate (yellow) and obstructed (red) areas

Data sets:

- UK Rail Safety and Standards Board (RSSB)
- GNSS data collected in train in 2012

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On-board SIA-POS preliminary results

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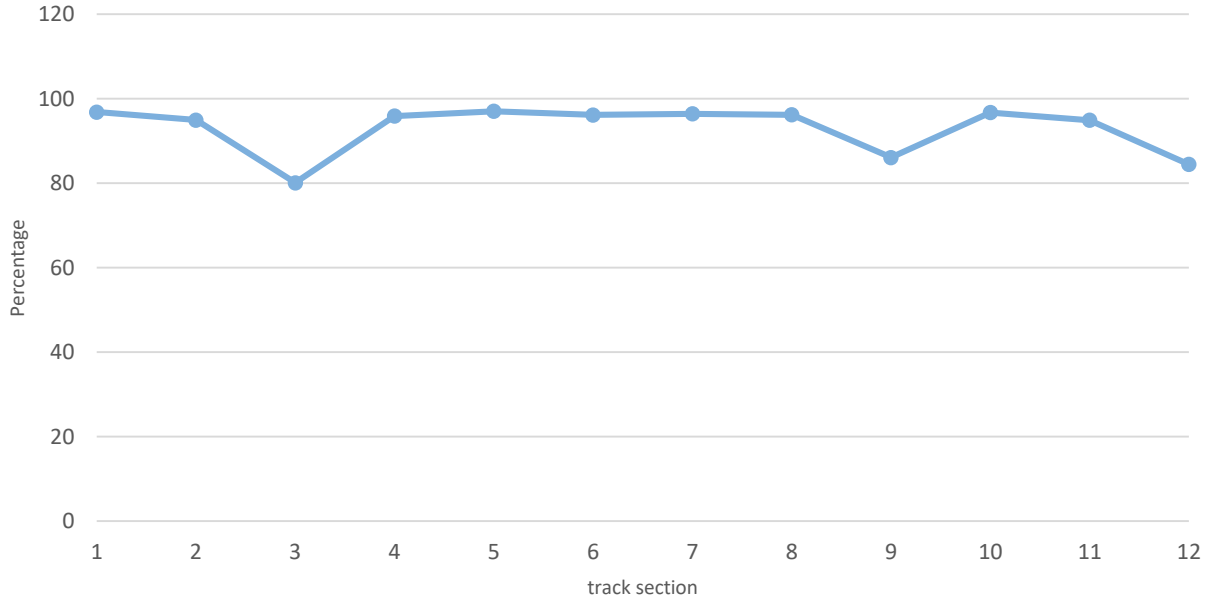

PPP solution availability for different track sections

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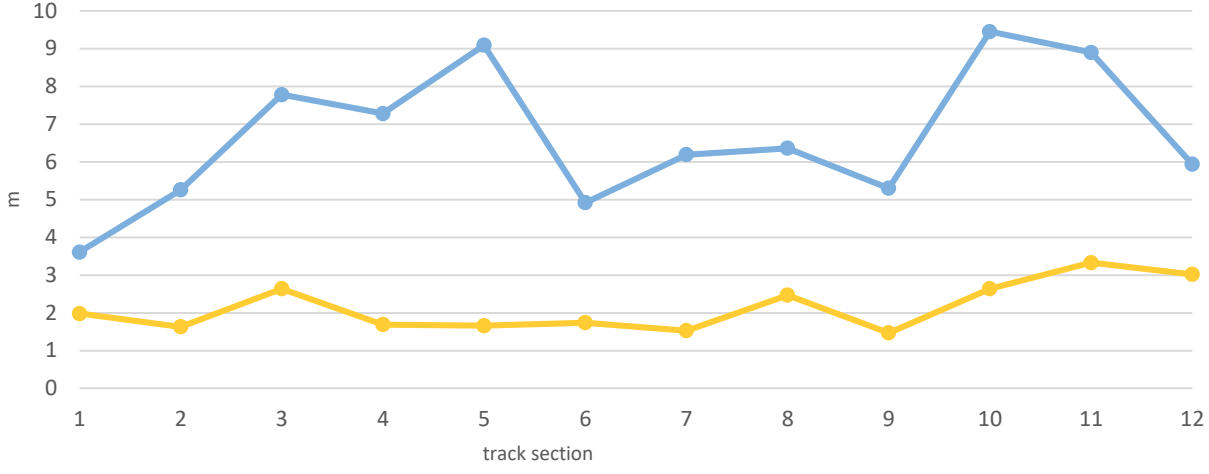

Horizontal 95% postion error for available GNSS solutions,
Blue: Snapshot solution, Orange: PPP solution

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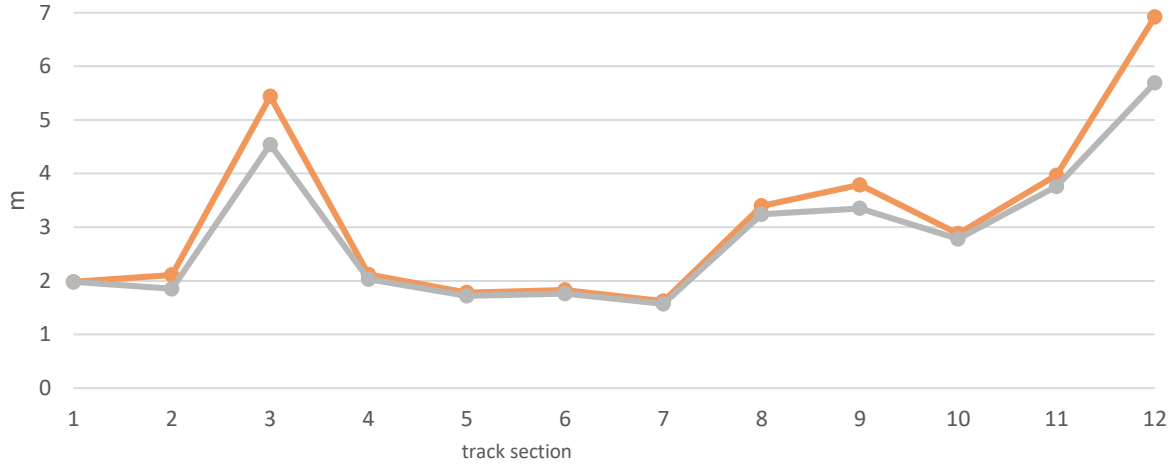

95% horizontal position error,
Orange: PPP solution, Grey: on-board SIA_POS solution

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Back-office positioning algorithm

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- Online positioning results can be improved offline
  - Batch GNSS and IMU data (with varying rates, outages)
  - Context knowledge, path-constrained motion, map data
- Geo-referencing
  - Facilitates the position-dependent analysis of monitoring data (ABA, PANT)
- Methodology
  - Extensive pre-processing
  - Separation of sessions into journeys
  - Path estimation for each journey
  - Path-constrained Kalman filter methods
- Development on test data from a SIA prototype (DLR/ÖBB campaign)

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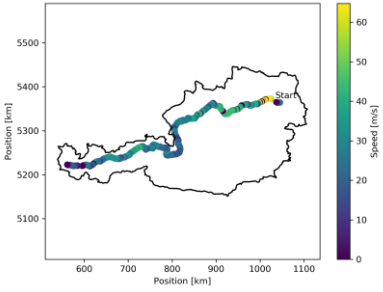
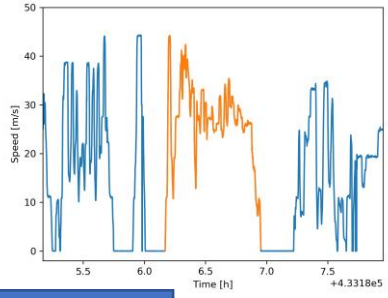




Motion and measurement models

GNSS session, ca. 1Hz

IMU session, ca. 100 Hz

Map data

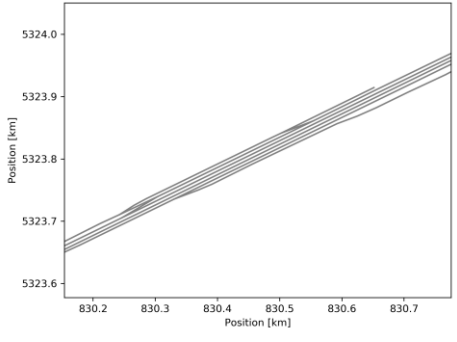
Standstill detection, journey estimation, calibration

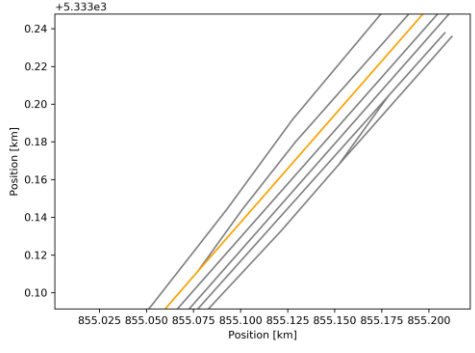
IMU and GNSS, journey data

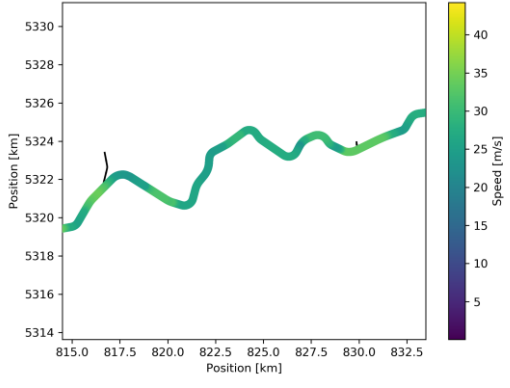
Path estimation

Kalman filter, RTS smoother in path coordinates

On-path position and velocity, const. 100 Hz







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Conclusions and Future Work

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- On-line PPP algorithm tailored for the railway environment
- Simplified GNSS-IMU hybridization approach
- Preliminary results show that the algorithm can deliver the required performance
- Advanced back-office processing chain using map data and Kalman filters shows promising results
- Further data will be collected in joint experiments with the SIA partners FGC and ÖBB

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Follow the SIA project!

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- Twitter feed

  https://twitter.com/SIAGalileo

- Project website with newsletters and deliverables

  https://siaproject.eu/

- 110 minute recording of the SIA mid-term event with further details on all SIA services, including an extensive Q&A session

  https://youtu.be/n854QMTTwDA

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INTERACTION ASSETS HEALTH STATUS MONITORING

Thank you

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