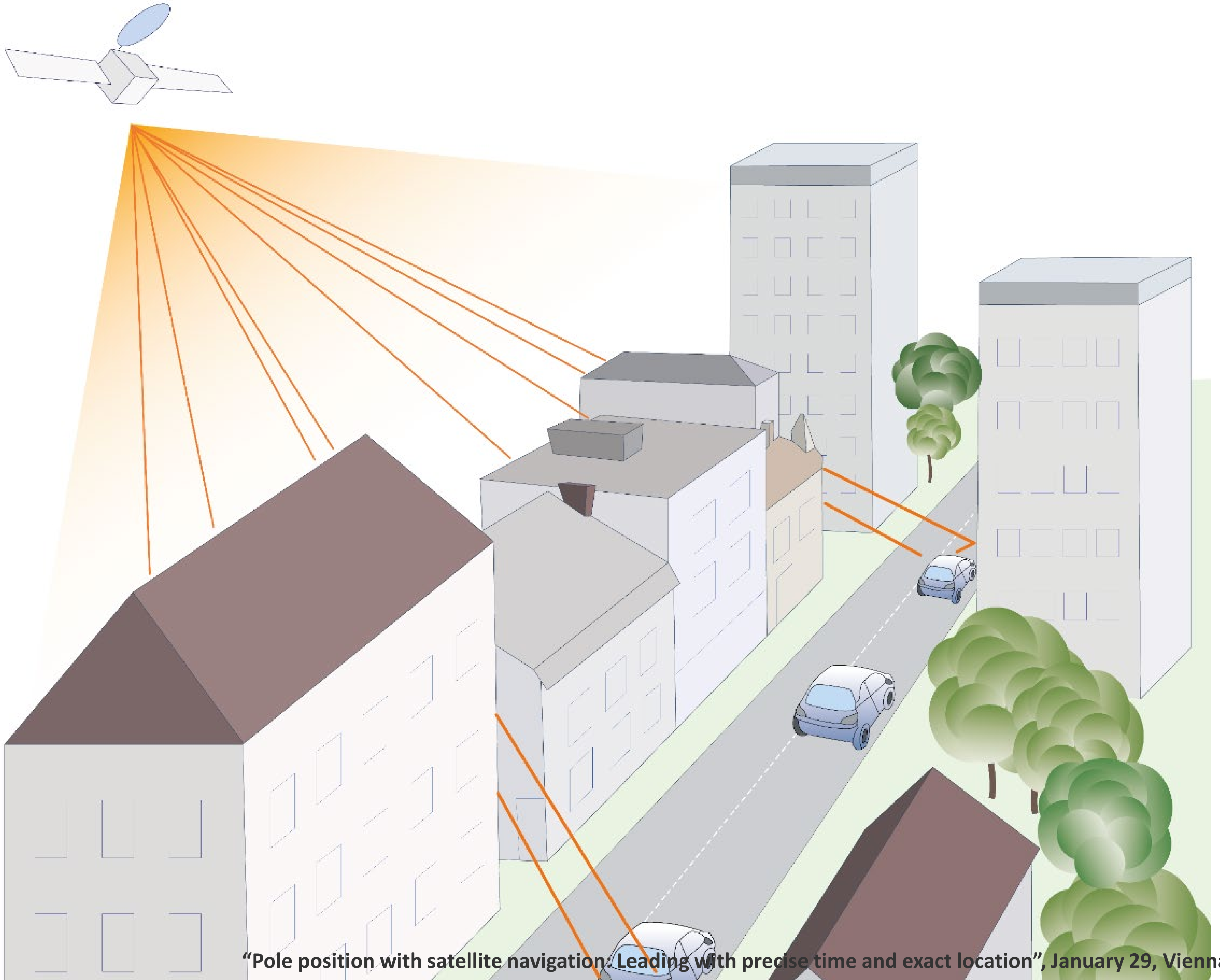

JOANNEUM RESEARCH DIGITAL

Virtual Vehicle Digital twins and PNT

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JOANNEUM RESEARCH DIGITAL

Contents

Introduction and Motivation

- In automotive applications often digital twins are used for simulations
- Typically the accuracy of digital twins is crucial for their use and applications
- Geometric digital twins often are established via laserscanners or cameras
- The accuracy of the trajectory of the measurement system is crucial
  - typically GNSS/IMU-based trajectory measurements are used
  - alternatively SLAM-based trajectories may be considered
- Comparisons of GNSS/IMU- and SLAM-based trajectories allow a more detailed insight into achievable accuracies

Digital Twins in Automotive Applications with Importance of precise PNT

- Simulations and tests in vehicle design and prototyping
  - Common performance assessment (e.g. ADAS, etc.)
  - Energy efficiency and sustainability analysis
  - Customization and configuration Management
- Predictive maintenance and diagnostics
  - Personalized customer service
- Autonomous vehicle validation

Recording a Set of Digital Twins for Test and Analysis Purposes

- Recording of test data
  - Laserscanner (airborne – ALS, mobile – MLS, backpack - BLS)
  - JOANNEUM RESEARCH (JR) holds und uses the following systems:

VIAmetris MS 96

Riegl VZ400i

Riegl VMX-2HA

Riegl RiCopter VUX-SYS

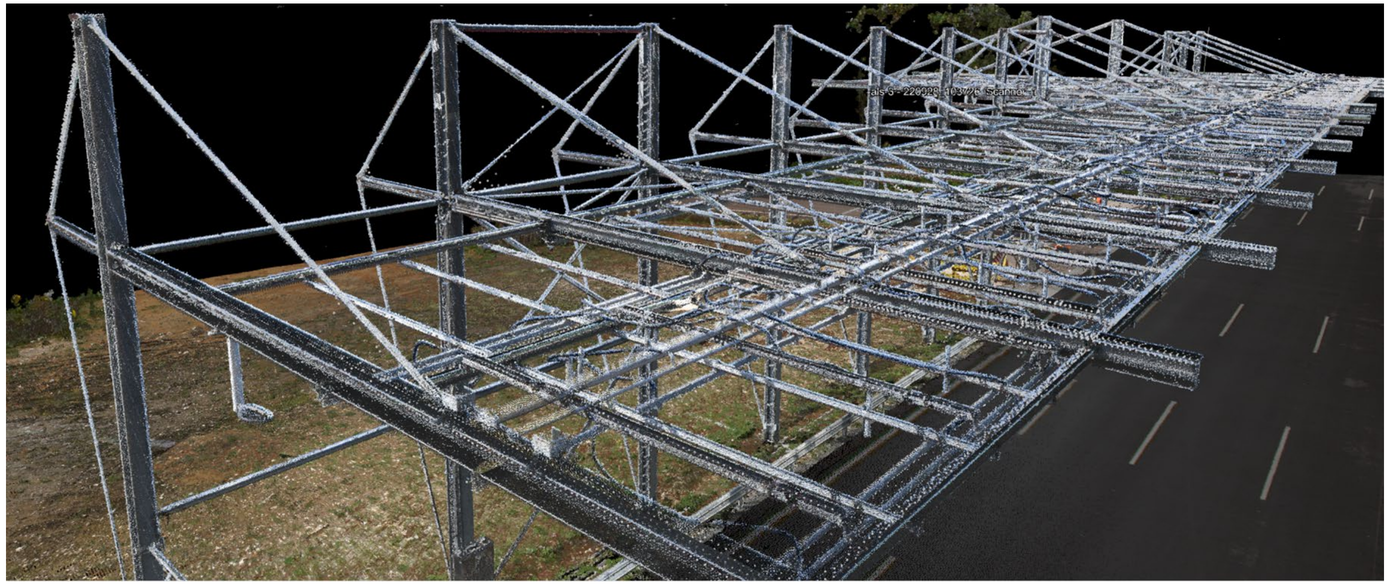
Collecting Point Cloud Data with the Viametris Backpack System

- The Viametris Backpack System can easily be transported and employed even on a scooter
- It records full pointcloud data plus GNSS/IMU data
- Viametris provides a software package including a SLAM algorithm for analysing the pointcloud data
- Thus a comparative set of two different trajectories (GNSS/IMU- and SLAM-based) may be generated, based on a commercial product representing maybe quite a few personyears

Recording a Digital Twin of an Automotive Proving Ground

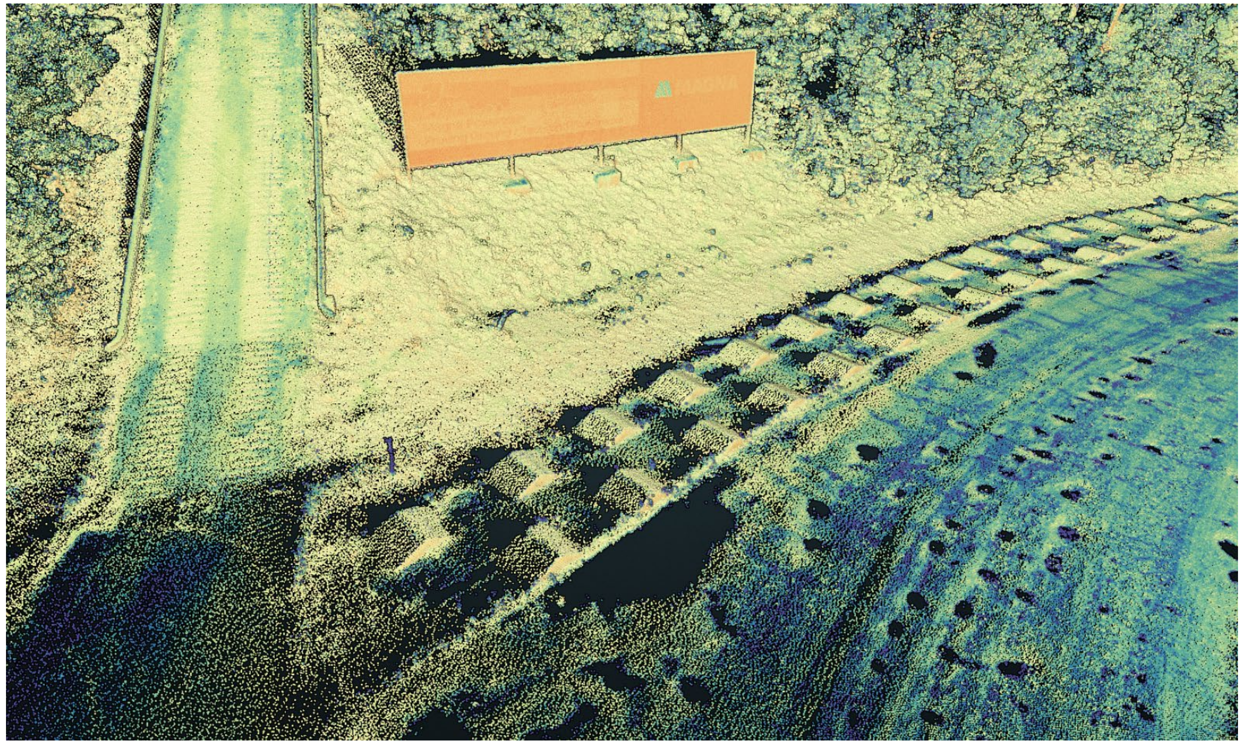
as of https://www.digitrans.expert/teststrecke/

Some Elements as represented in the Digital Twin of the Proving Ground



Outdoor Rain Plant

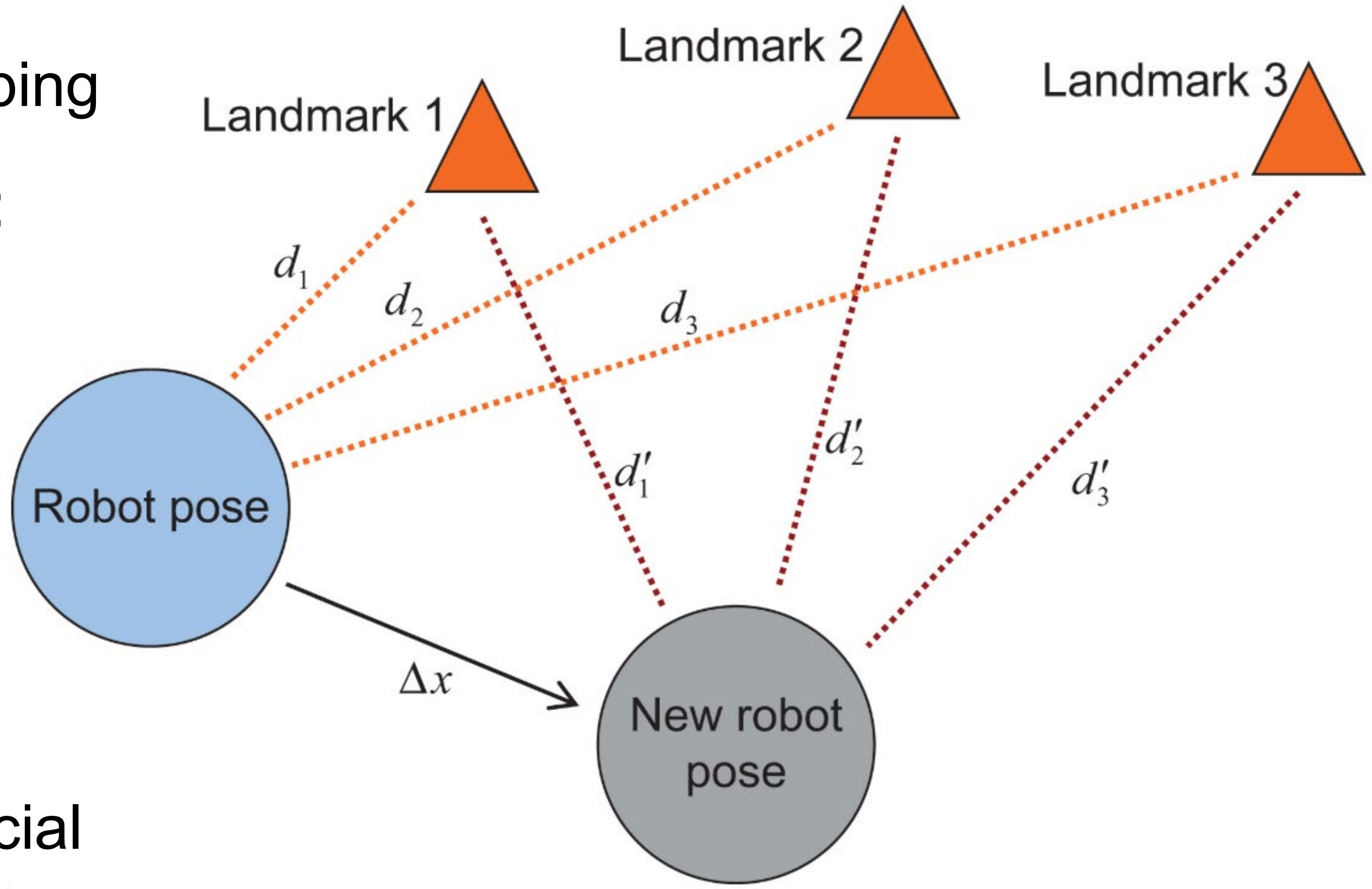
Washboard track



For analysing relevant test results the importance of precise PNT is crucial

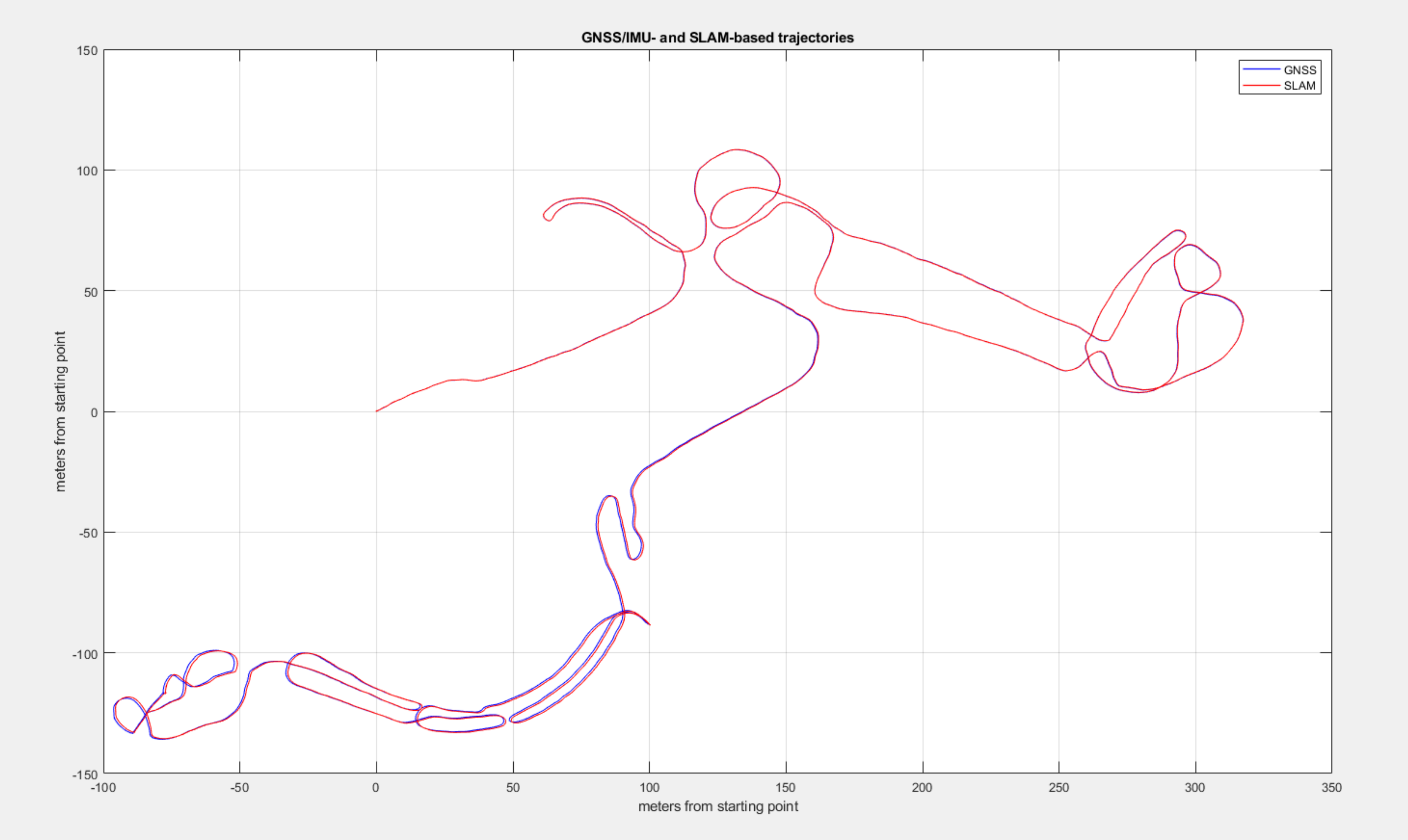
GNSS/IMU- and SLAM-based Trajectories may be used

- SLAM = Simultaneous localization and mapping
- Several algorithms available, categories are:
  - filter based SLAM
  - graph based SLAM
  - deep learning based SLAM
- Several free software packages available for download in the internet
- In JR currently use of the Viametris commercial SLAM tool

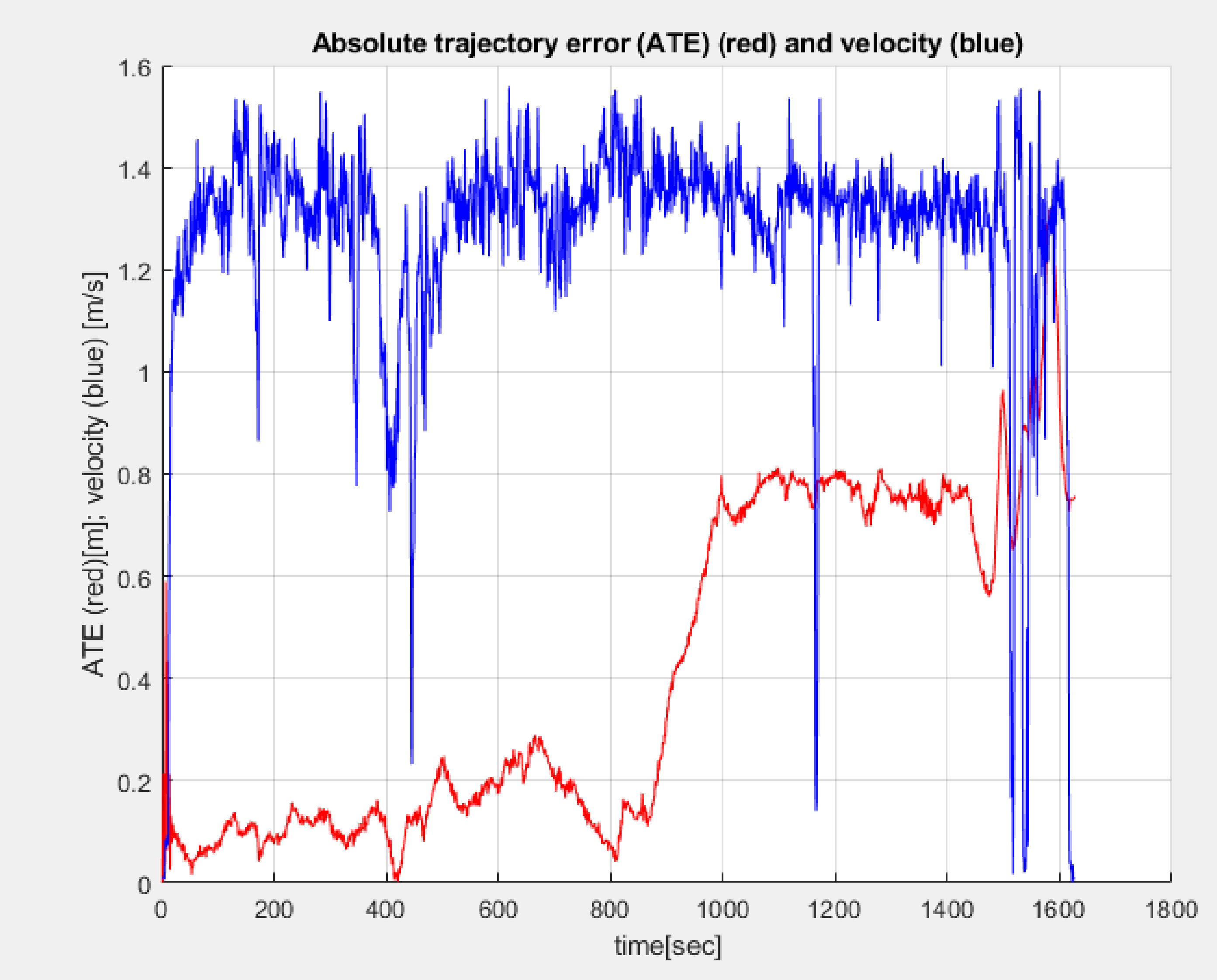


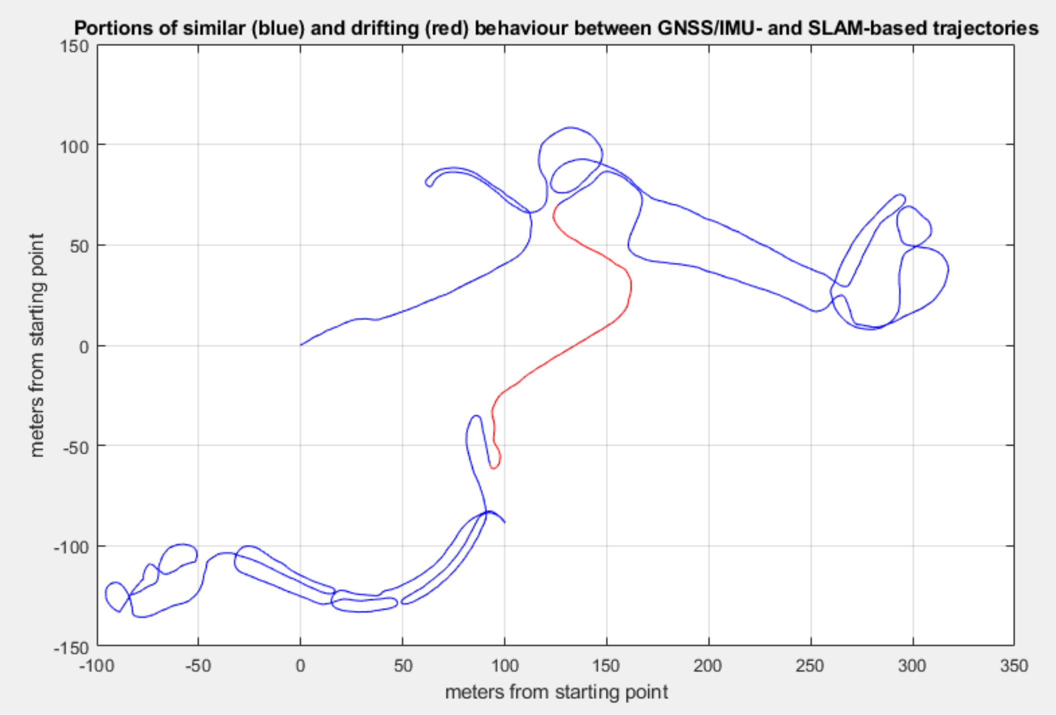
https://journals.sagepub.com/doi/full/10.1177/1729881420919185

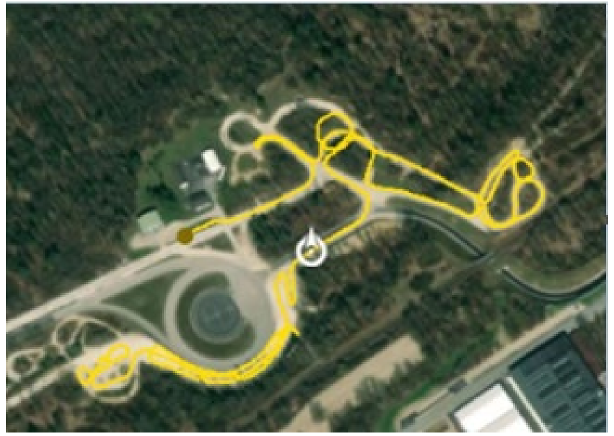
Comparison of GNSS/IMU- and SLAM-based trajectories on an Individual Case



Differences between GNSS/IMU- and SLAM-based trajectories

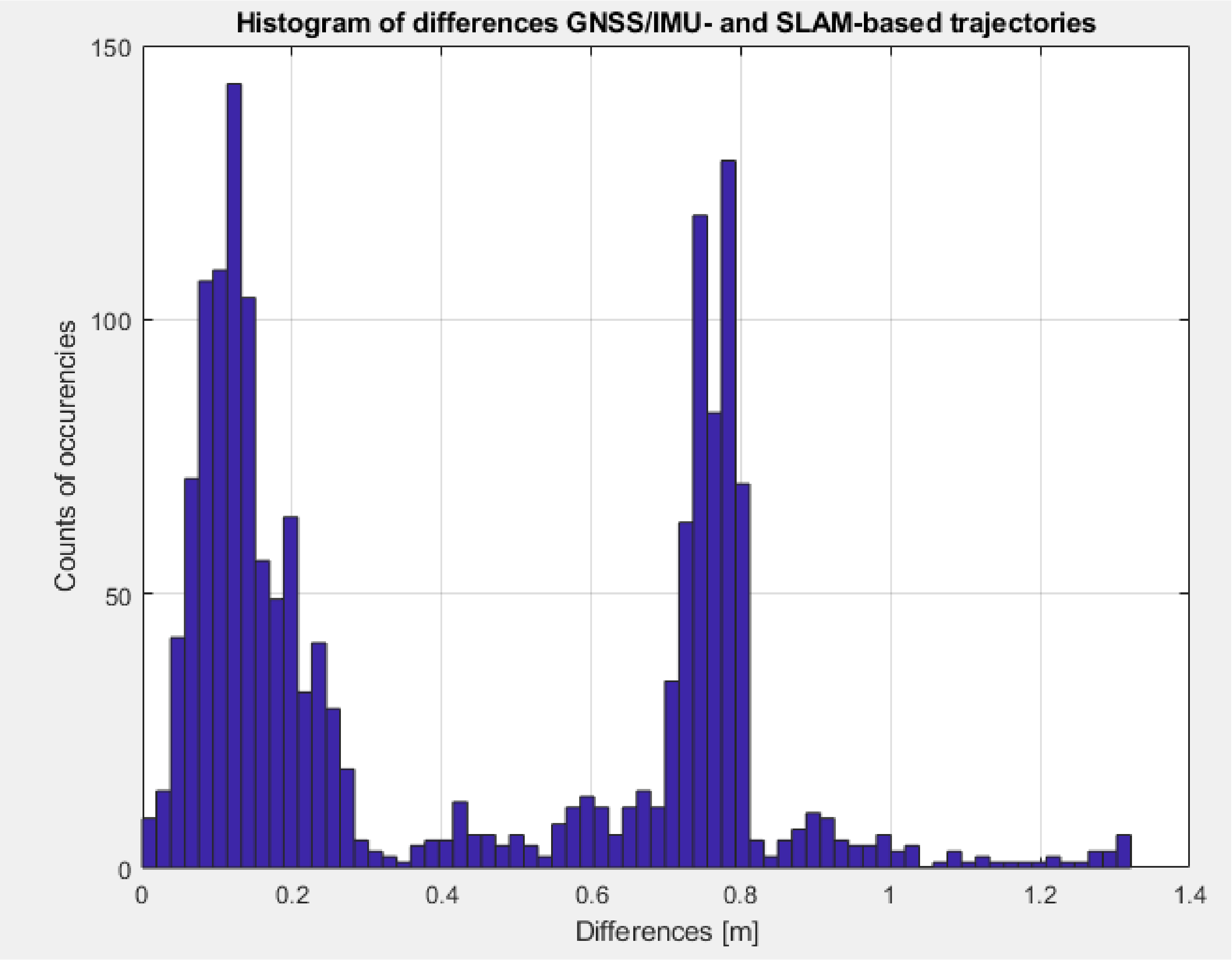






Histogram of differences between GNSS/IMU- and SLAM-based trajectories

- Four destinct portions visible:
  - Accumulations approx. around 0.1m and 0.76 m
  - Only few occurencies 0.3 – 0.7 m and above 0.85 m
- Previous graph of differences over time shows drifting behaviour from approx . 0.1 to 0.7 m
- Differences jittering around 0.76 m for some 7 minutes with a deviation of approx. +- 6.5 cm only
- Reason for drift over approx. 3 minutes and 0.75 m still unknown, no correlation with velocity, acceleration or curve radius, neither obvious environmental conditions.
- Further analyses ongoing, aiming also for alternative SLAM algorithms / implementations



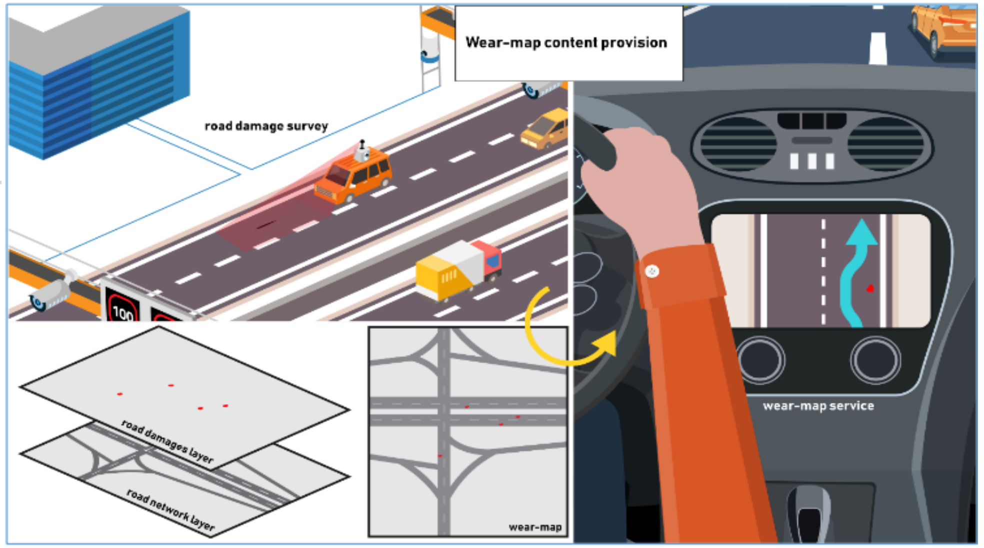
Differences between GNSS/IMU- und SLAM-based trajectories

- The GNSS/IMU-based trajectory may deviate from reality
  - The GNSS signals are shadowed, blocked or received via multipath propagation
  - The IMU may drift, especially in situations of slow or homogeneous motions
  - GNSS interference or spoofing
- The SLAM-based trajectory may deviate from reality
  - Poor association of obstacles in different scans (reflecting surfaces, etc.)
  - Moving obstacles (strong wind in forests, etc.)
  - Poor input data by laserscanner or camera
- Bad mapping of GNSS/IMU- and SLAM-coordinates certainly also causes differences

=> The combination of GNSS/IMU- and SLAM-based trajectory results in reliable PNT data with high accuracy

ESERCOM-D
SAFE AND EFFICIENT ROADS
https://esercomd.eu/
EUSPA European Union Agency for the Space Programme

UC1 - Wear-map content provision

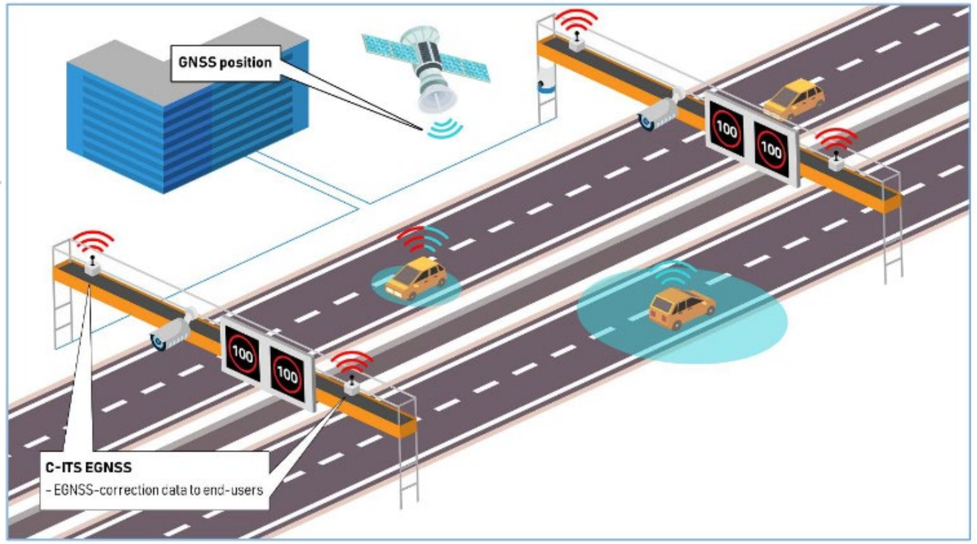


- Road wear layer for digital twin system of road operators
  - Cost-efficient sensor system for road operator vehicles.
    - EGNSS + IMU + Camera
  - Automated AI-based processing workflow to automatically detect, classify and georeference road wear
  - Make road surface issues visible in the digital twin
  - Provide road wear information to drivers via standardized messages and RSUs (C-ITS communication)

Sample Application:
Digital Twins in ESERCOM-D

ESERCOM-D SAFE AND EFFICIENT ROADS
EUSPA European Union Agency for the Space Programme
https://esercomd.eu/

UC2 - GNSS corrections provision



- cm-level localization for automated vehicles
  - Galileo HAS and OSNMA
  - Provision of HAS and/or RTK corrections
    - On motorways via RSUs (C-ITS)
    - In rural areas via AMQP broker used for cellular communication between infrastructure and vehicle
  - Real-time reception of correction data within the vehicle for cm-level accuracy
- Road damage avoidance manoeuvres (lane change and in-lane) having
  - the geo-referenced road damage information and
  - the cm-level localization information

=> Safe Roads

Summary and Conclusions

- Digital Twins are of great benefit in automotive applications.
- Their (geometric) accuracy is crucial, espcially of the scanning systems‘ trajectories.
- A set of test digital twin data was recorded and analyzed
- An agreement of GNSS/IMU- and SLAM-based trajectories of approx. +- 6.5 cm was found, but also significant drifts
- A sample application is ongoing in the project ESERCOM-D, optimizing the sustainability of roads
- The combined information from GNSS/IMU and SLAM-results already allows very precise trajectories. Further analyses are ongoing.

Thank you for your Attention!

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