Opportunities and Challenges of GNSS as a Basic Telematics Sensor for Assisted and Autonomous Driving

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https://tu-dresden.de/bu/verkehr/vis/itvs?set_language=en

Agenda

1. **CV, Chair and Topics of University Research**
2. Definition of GNSS/GPS as a basic sensor for traffic telematics
3. GNSS in multimodal transport modes in relation to connected driving
4. Indoor solutions using pseudo GNSS backup systems
5. Conclusion and future outlook

1. CV Oliver Michler, University Full Professor

Scientific and Professional Positions (since 1993)

1993 - 1997	Scientific Staff and PhD-Research of TU Dresden, Faculty of Electrical and Computer Engineering
1997 – 2000	Scientific Project manager at Video-Audio-Design GmbH as a Telkom-Partner
2000 – 2005	Scientific Staff at Fraunhofer Institute for Transportation and Infrastructure Systems Dresden (FhG-IVI)
2005 – 2008	Professor at University of Applied Sciences Dresden in Signal Processing and Electronic Measurement Techniques
2010 – 2017	Head of department of TUD-Researchgroup at FhG-IVI
2008 –	Full Professor at TU Dresden in Systems Information Technology, Faculty of Transportation and Traffic Sciences
2019 -	Director of TU Dresden of Institute of Traffic Telematics
2017 -	Scientific advisory board member of MRK AG, Metirionic and ISCons GmbH as a knowledge transfer research

Research topics

data-driven and model-based approaches, wireless mobility systems over all traffic carriers and services, autonomous driving, intelligent vehicle, next generation technologies based of communication/localization/sensing, software defined radio

1 University of Technology in Dresden (TUD) The "Friedrich List" Faculty of Transport and Traffic Sciences

A unique, interdisciplinary competence center for transportation sciences

- Dresden Institute of Automobile Engineering
- Institute of Railway Vehicles and Railway Technology
- Institute of Railway Systems and Public Transport

- Institute of Logistics and Aviation
- Institute of Transport Planning and Road Traffic
- Institute of Traffic Telematics
- Institute of Transport and Economics

ITVS
Informationstechnik für Verkehrssysteme

Technological and Market Progress in Transportation & Mobility

Changed Education in Transportation Engineering (Diploma, Bachelor, Master / international)

1 Fields of competence (ITVS)

Communication networks
Pico cell
(ZigBee, BLE, UWB, Lifi, …)

Communication networks
Micro cell
(Mobil radio, WLANp, …

Communication networks
Macro cell
(DAB+, …)

Multi Modal Traffic Carriers
Digital Synergies

Environmental perception via LIDAR / Camera

Multi-GNSS-tracking
(GPS, GALILEO, …)

Environmental perception via Radar

Multi-sensor data fusion (Integrity)

Precise georeferencing

1 Traffic ICT and Research fields of Chair competence

- **Overview:**



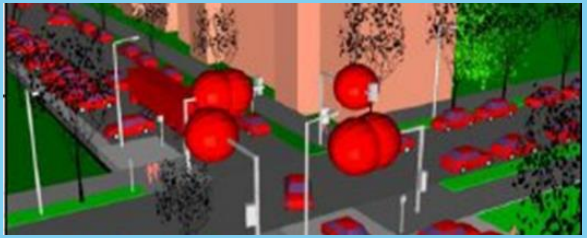
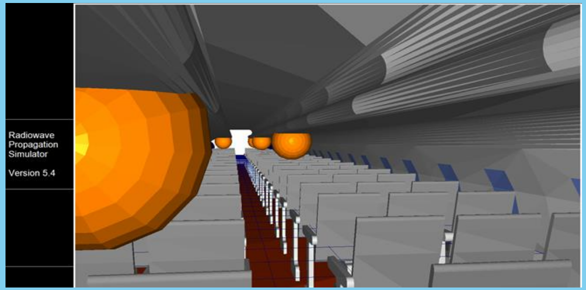


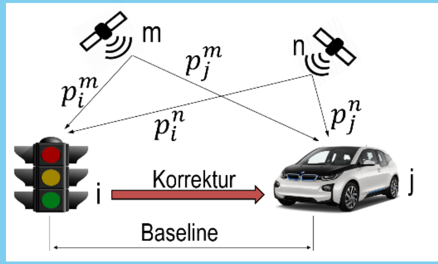

Simulation
Emulation
Radio planning

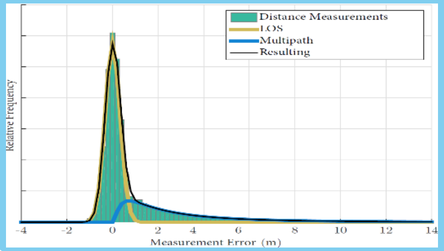
Networking
Localisation
Sensing

Lab Environment
Experimental - Vehicles
Test fields

Big data
Statistics
Methodology
Procedures
AI/ML





1 Research focus: Digital Synergies in Projects / Industry Applications

Connected and automated driving

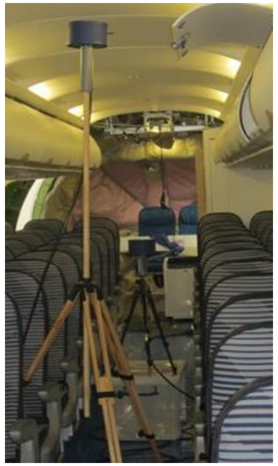
IVS-AMP, IVS-LOK, Fast Sign

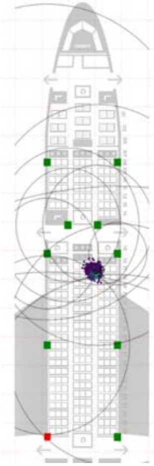
Intelligent rail transport

AZubiG
Messstraba

Innovative air traffic

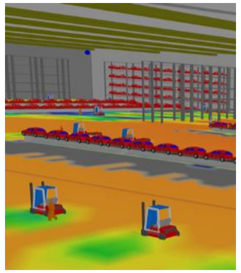
NELA, ConCabInO, CabiNET, CANARIA , ADKT, INTACT, isCabine, …





Production 4.0

IOPS
DROPS



Inland vessel navigation 4.0

PiLoNav
DigiShip

Forestry 4.0

AutoDrone & HarvesterNavi

Overview of all current / previous projects: https://tu-dresden.de/bu/verkehr/vis/itvs/forschung/forschungsprojekte?set_language=en

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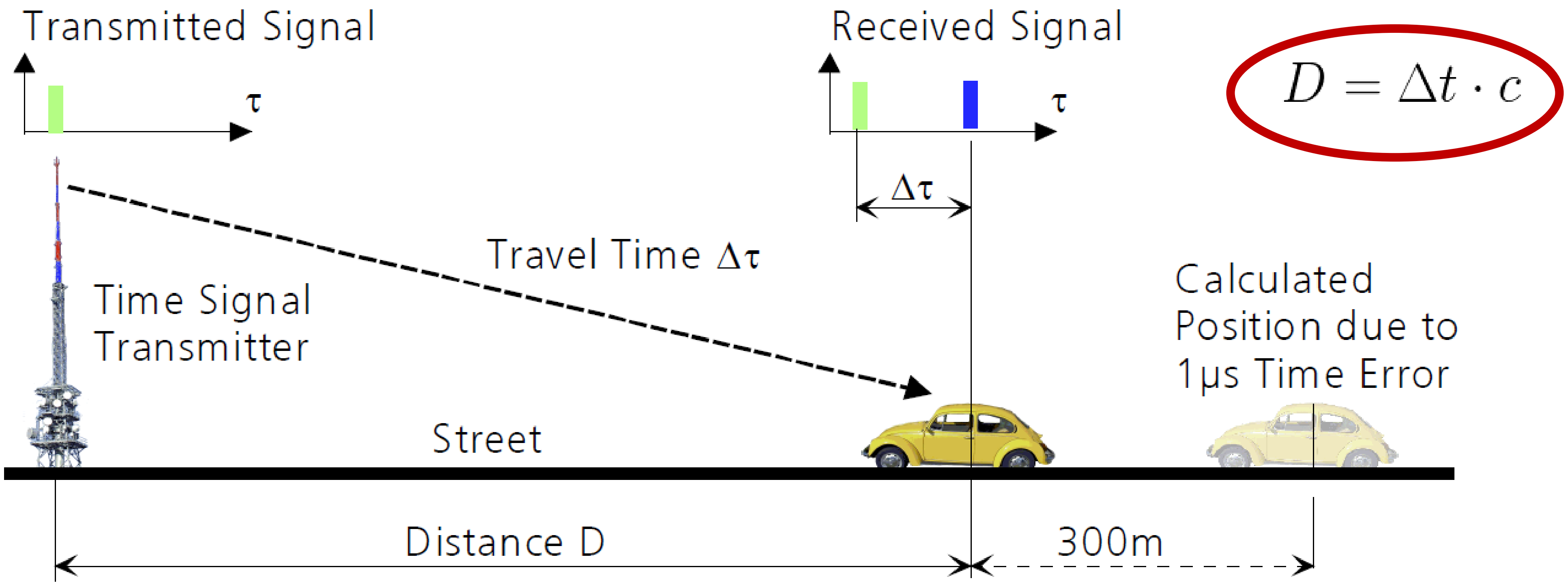
2 Definition of GPS as a basic sensor for telematics - Motivation

- Knowledge about location on earth is a central prerequisite for many applications of transport telematics

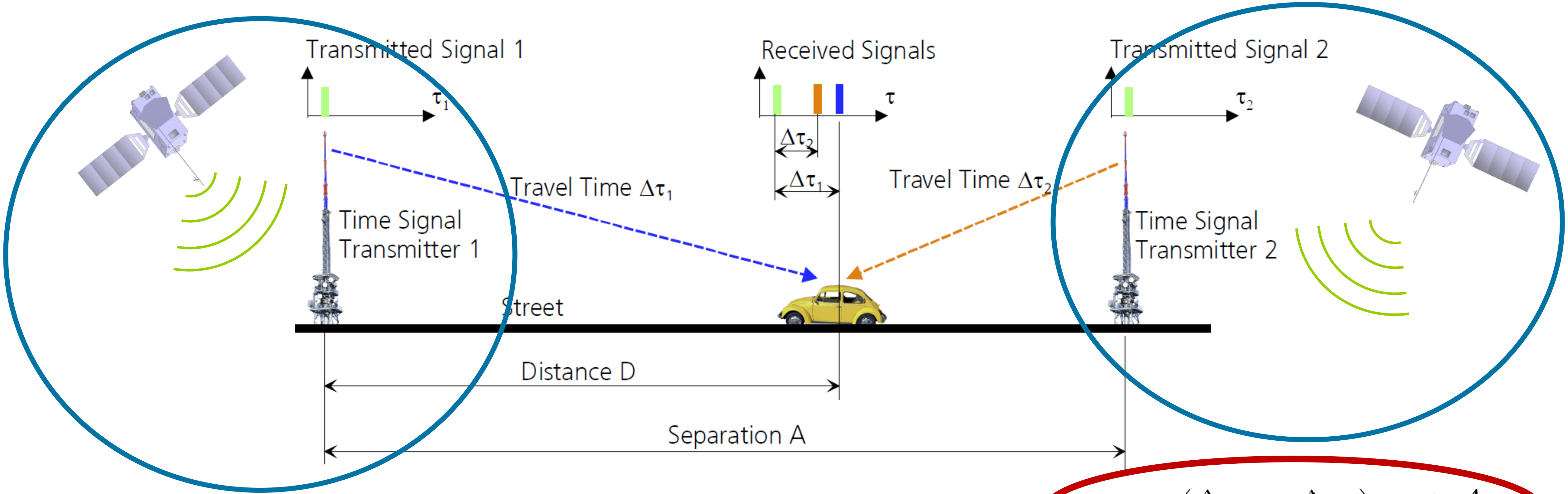
2 Satellite communication and navigation basics

- Basic principle of position determination:
  - Time-of-flight measurement at the receiver leads to a distance measurement via the correlation of the speed of light (synchronisation required).



2 Satellite communication and navigation basics

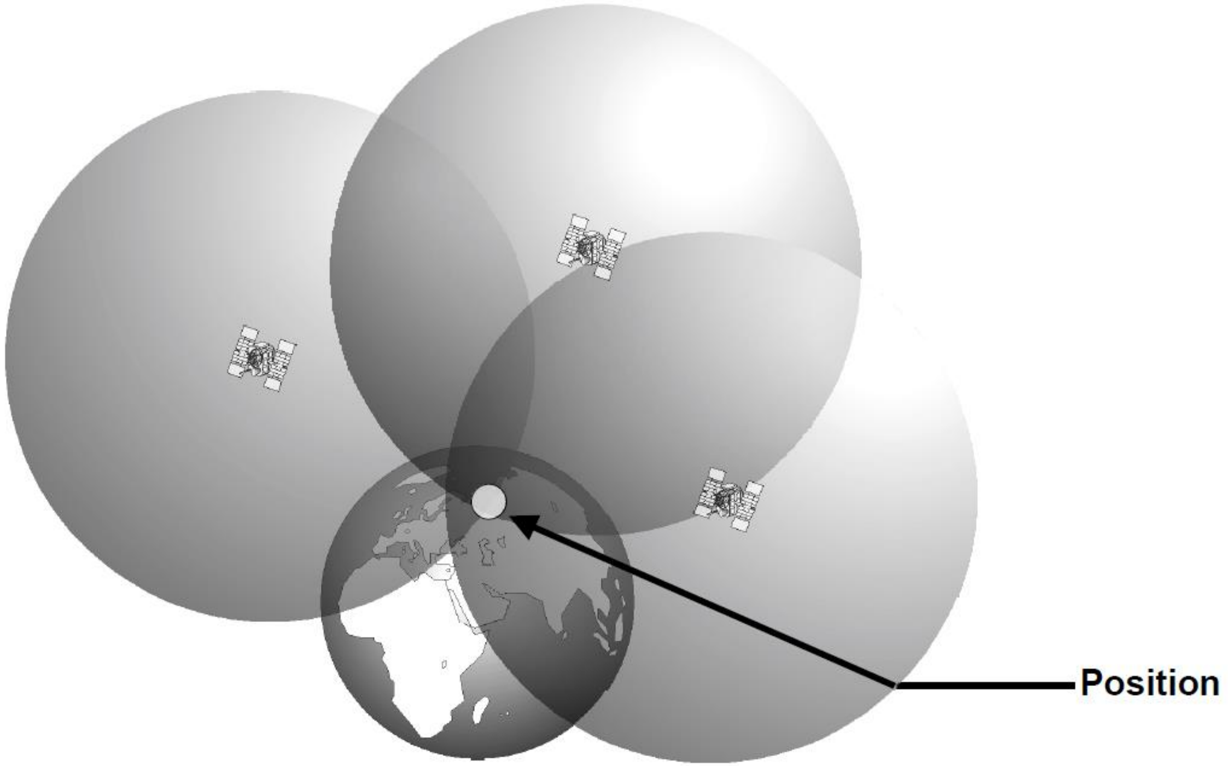
- Basic principle of position determination:
  - Synchronization error of the receiver can be compensated by a second, time-synchronised transmitting station (pre-condition: distance between transmitting stations known)



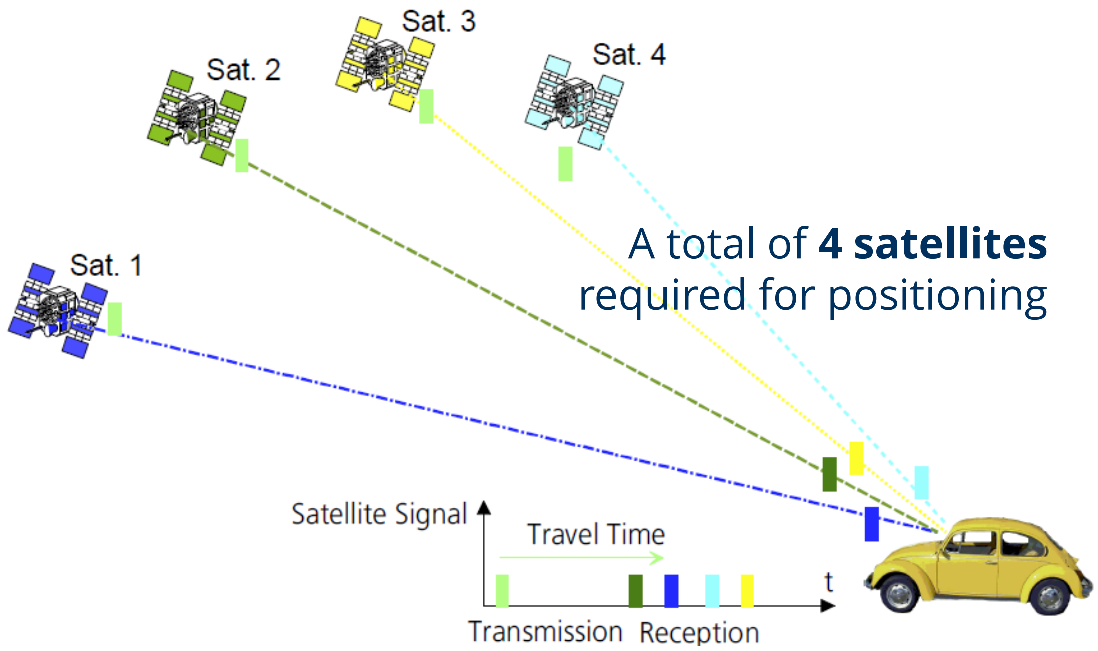
$$D = \frac{(\Delta\tau_1 - \Delta\tau_2) \cdot c + A}{2}$$

2 Satellite communication and navigation basics

- Localisation in three-dimensional space:
  - 3 satellites for positioning



- Localisation by means of signal: propagation times:
  - 1 Satellite to determine the time offset

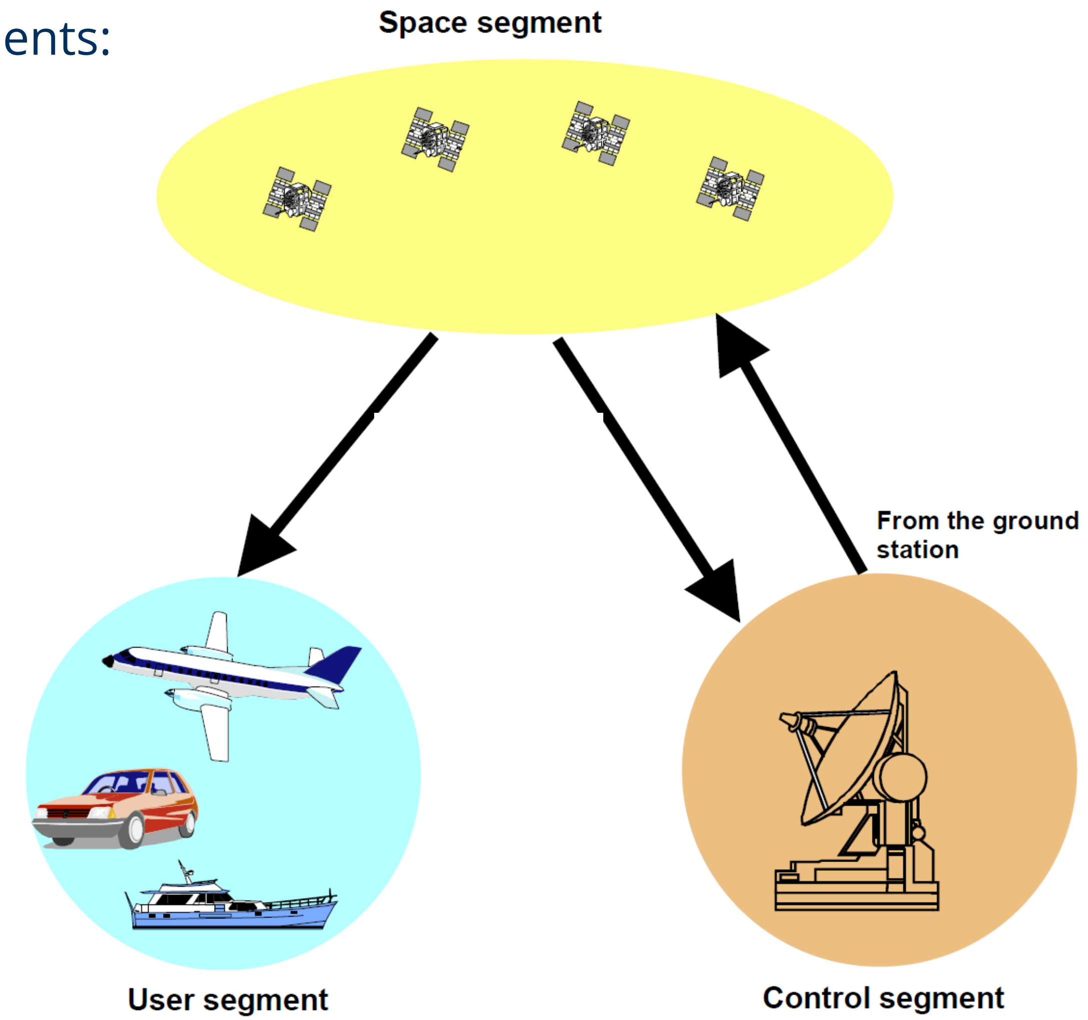


- Question: Under which conditions are 3x, 2x, 1x Satellite sufficient ?

2 Satellite structure and systems

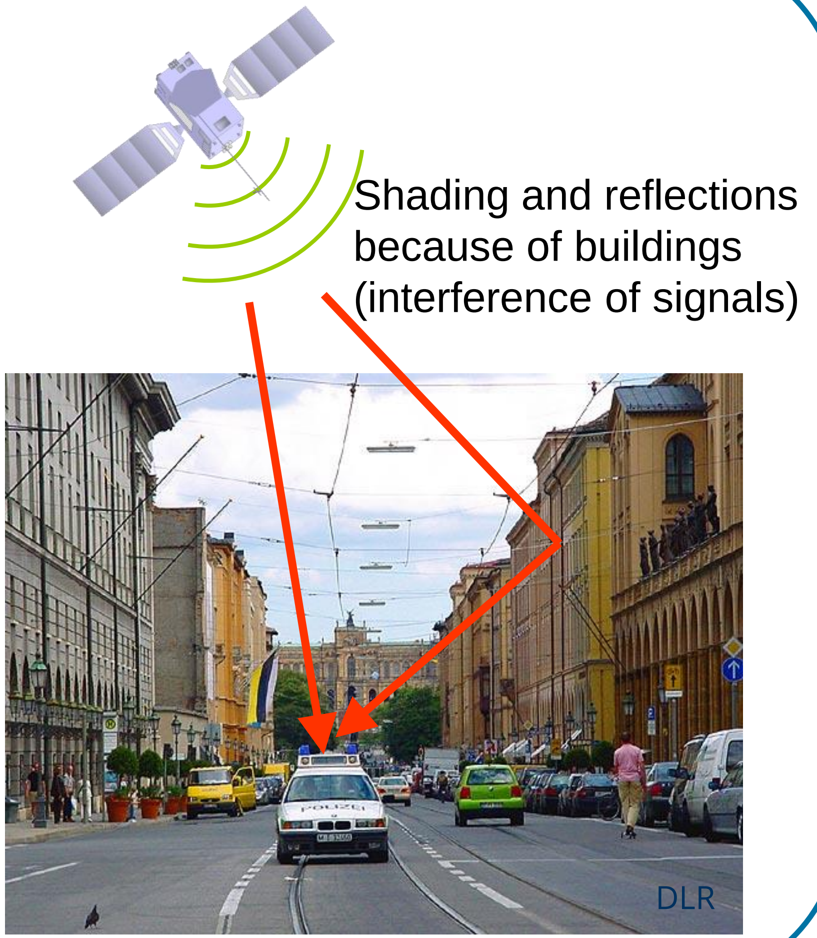
➢ General GNSS structure:

- Segments:

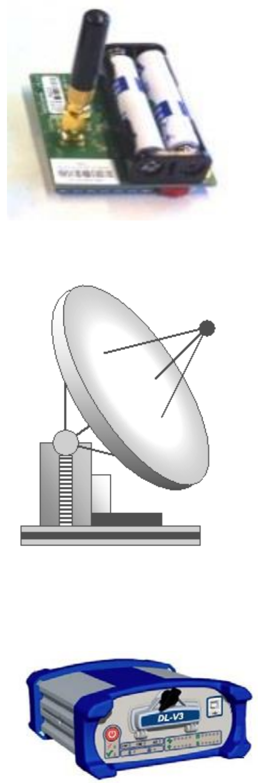


2 GNSS Challenges in stand-alone positioning

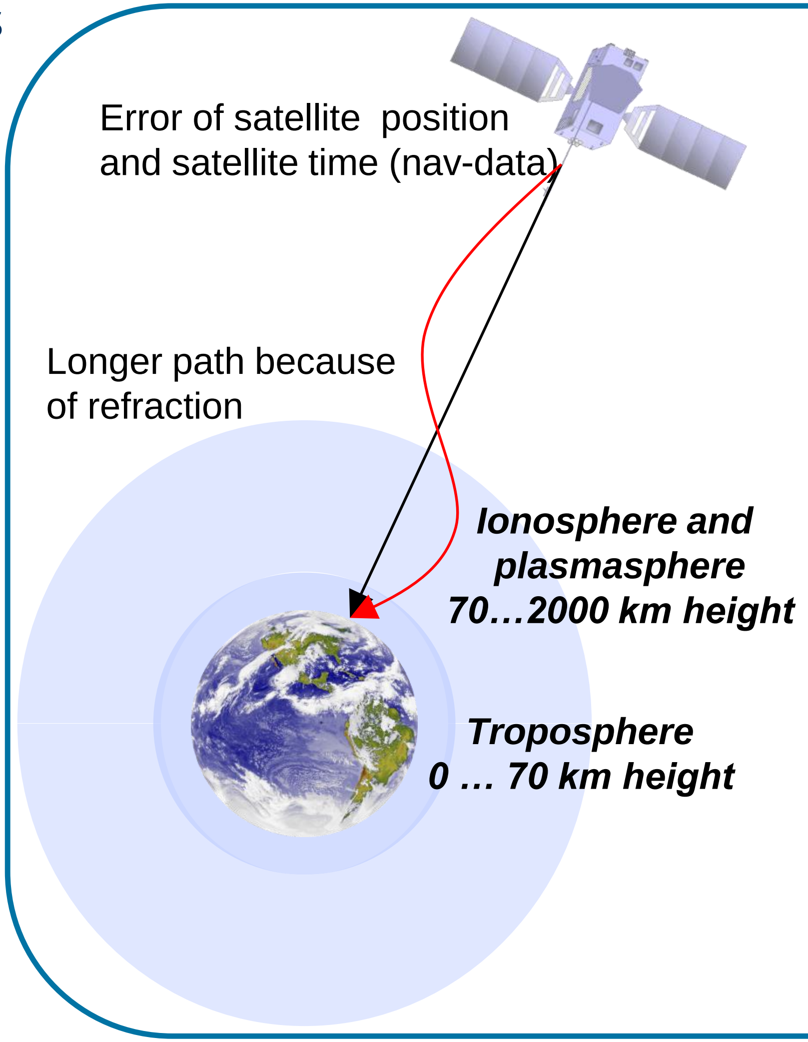
- Multipath:



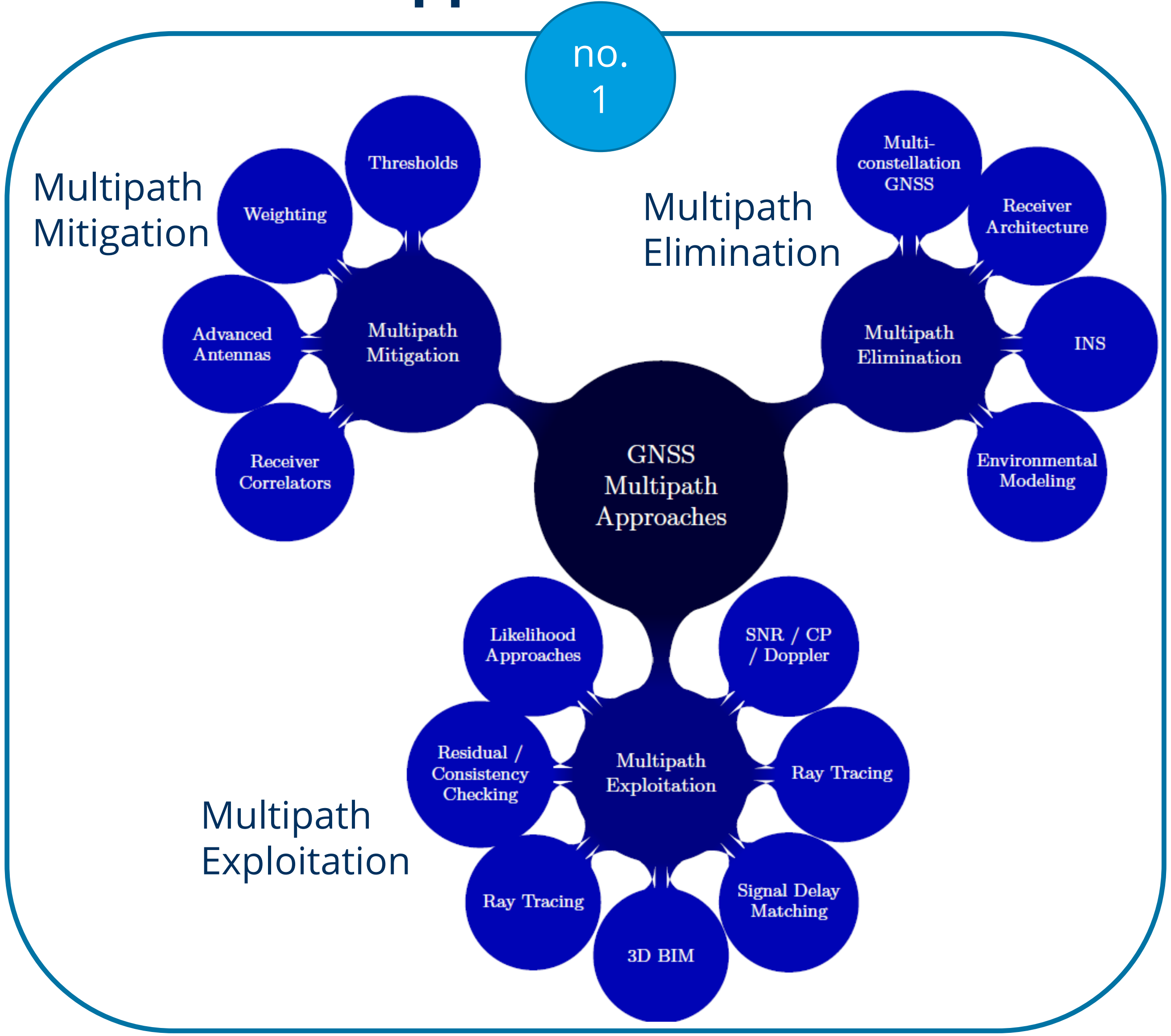
- Jamming / Interference and HW/SW-Impacts

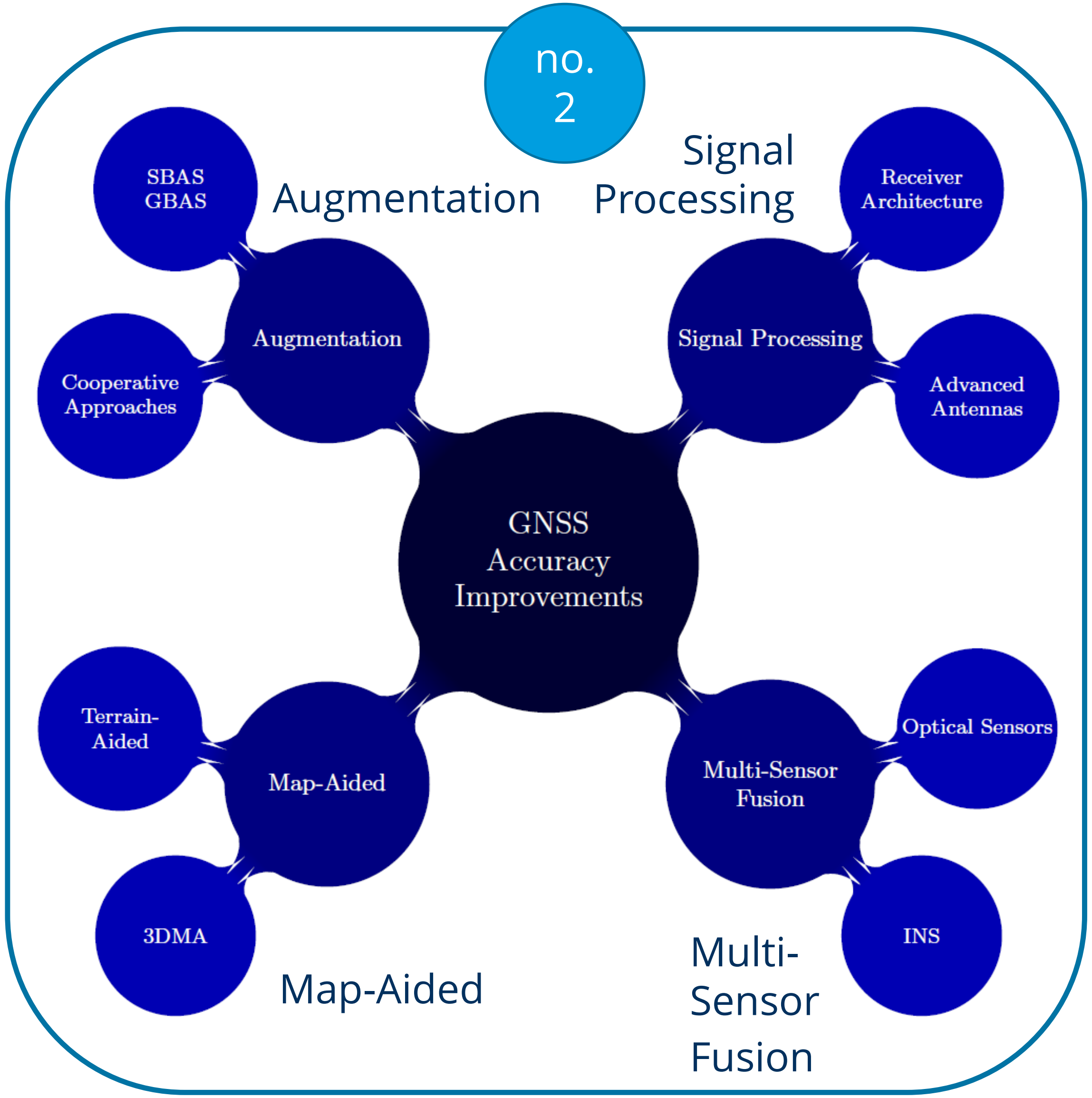


- Refractive and Synchronisation errors:



2 General approaches to increase accuracy of GNSS (Overview/Expertise)





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3 GNSS in multimodal transport modes in relation to connected (and autonomous) driving

- Transport fields of competence (ITVS) – Multi modal GNSS applications

3 GNSS-basics in Automotive applications (research points)

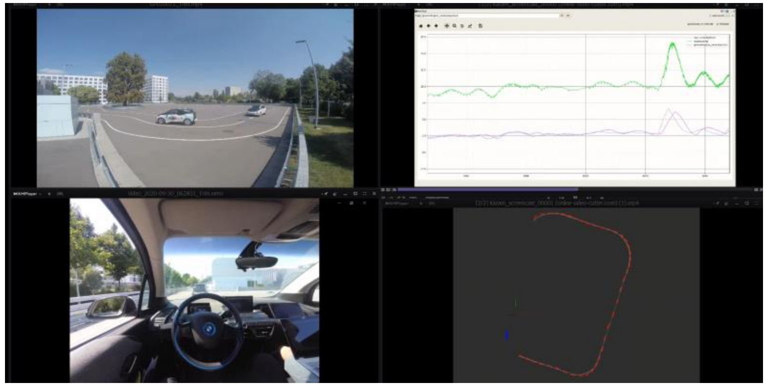
Speed specification is fixed so not good

Speed specification as a range is more comfortabl

LSA-green

LSA-red

3 GNSS-basics in Automotive applications (research points)



Fix Trajectory

Platooning

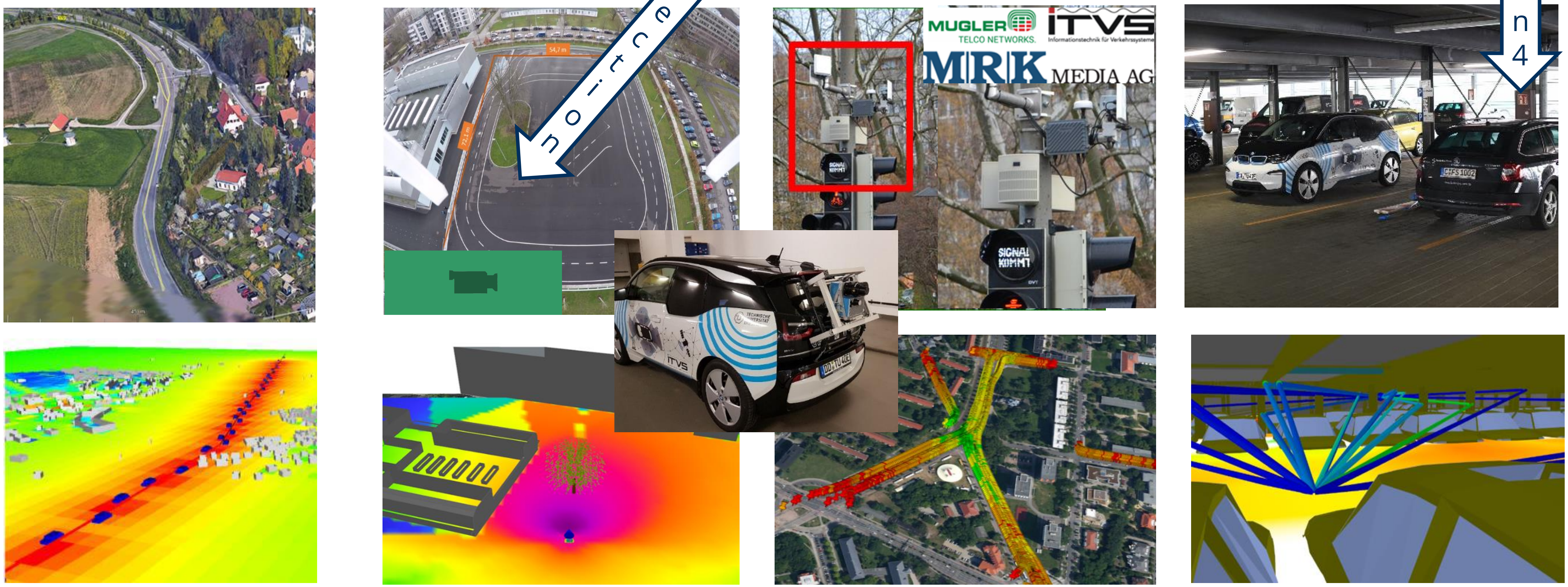
3 GNSS-basics in Automotive applications (research points)

➢ Tracing a trajectory and platooning application (Automotive test field HTW-Dresden)

Section 4

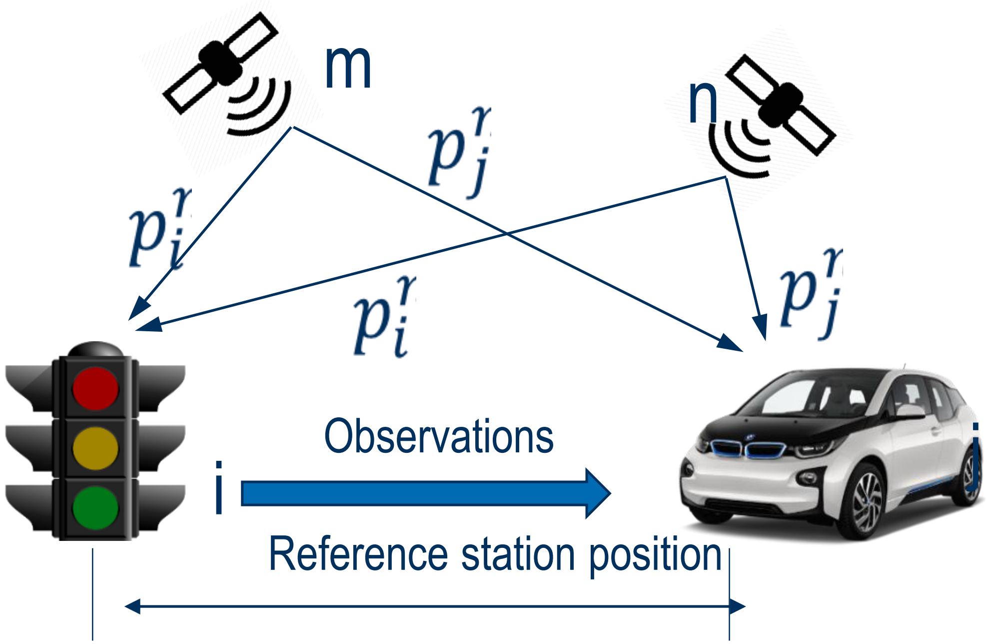
Section

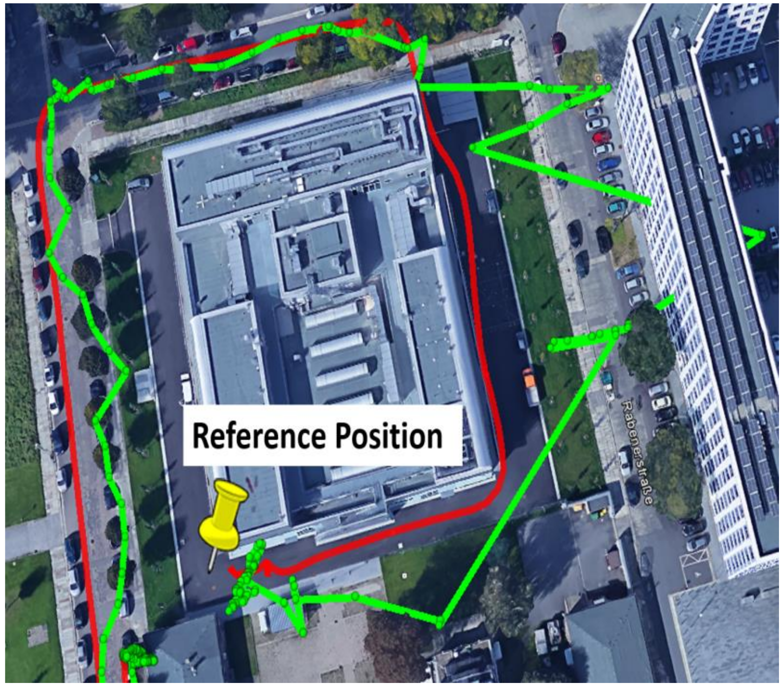
Test field highway → Test field area → Test road crossing → Parking garage

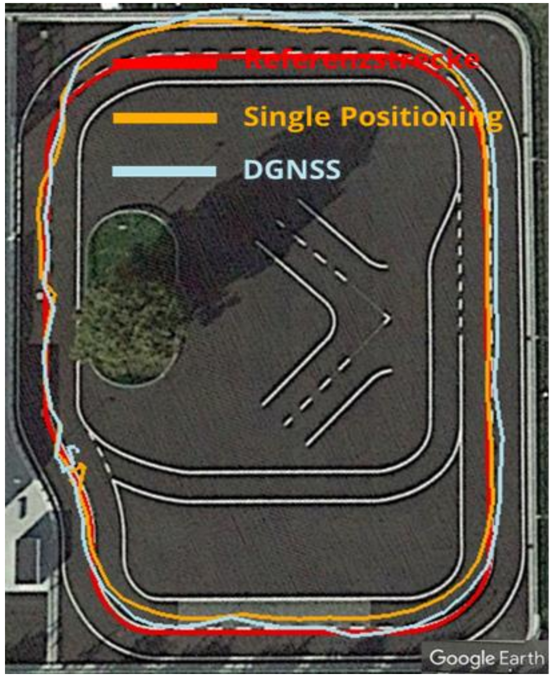


3 GNSS-basics in Automotive applications (research points)

- Tracing a trajectory and platooning application (Automotive test field HTW-Dresden)



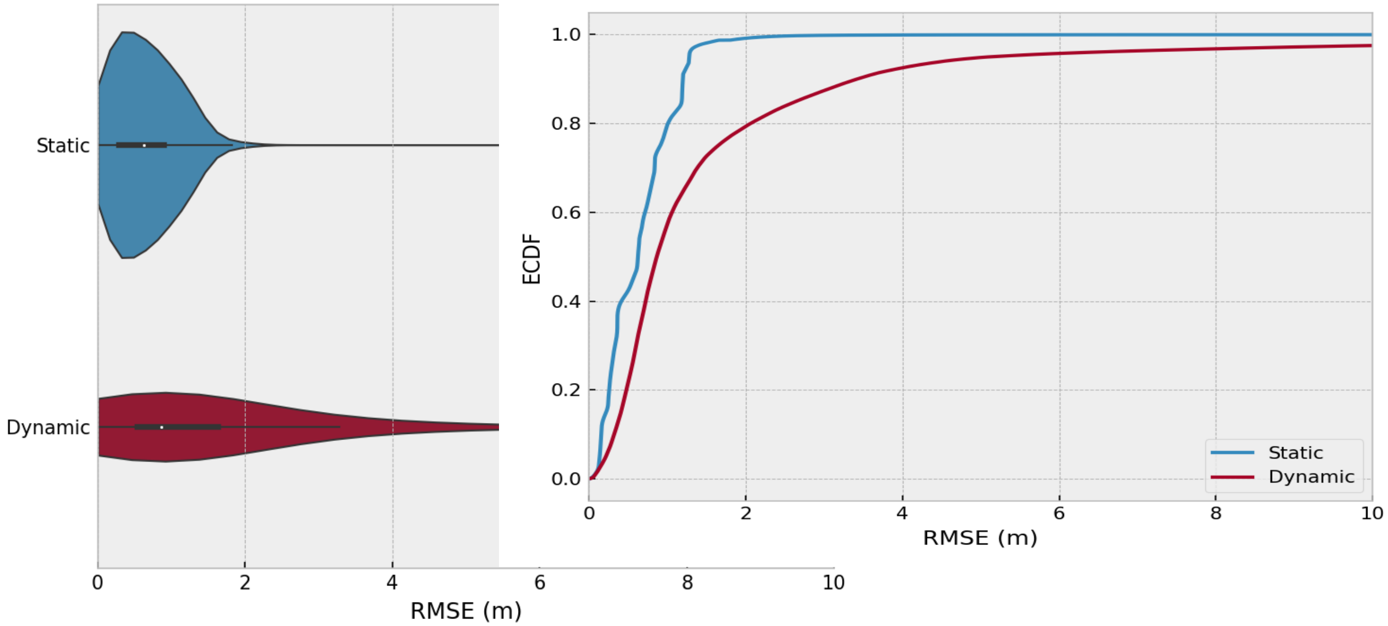


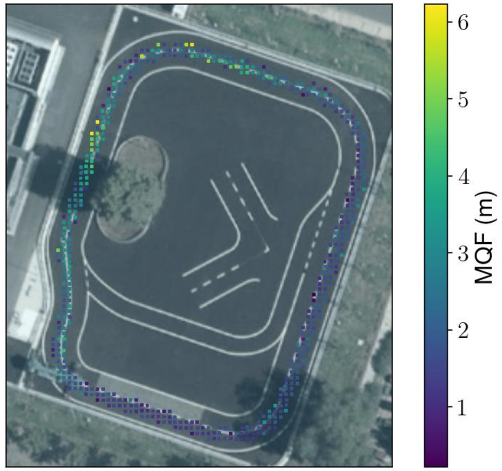


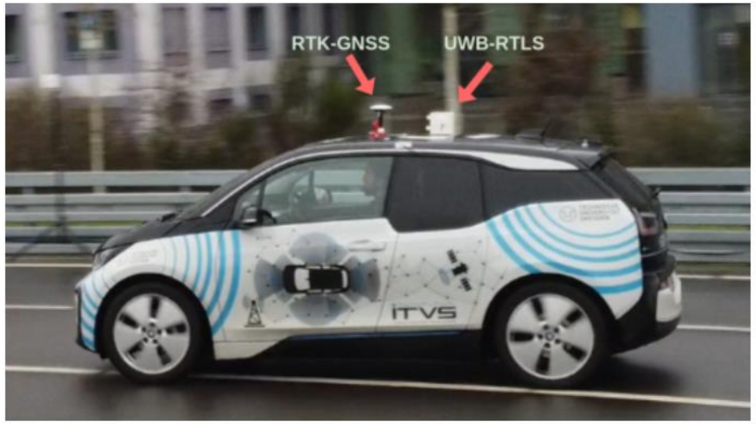
$$DD_{i_1,i_2}^{k_1,k_2}(P(j)) = \rho_{i_2}^{k_2} - \rho_{i_1}^{k_2} - \rho_{i_2}^{k_1} + \rho_{i_1}^{k_1} + c(\delta t_{i_2} - \delta t_{i_1}) - c(\delta t_{i_2} - \delta t_{i_1}) + \underbrace{dd_{ion}(j)}_{\to 0} + \underbrace{dd_{trop}}_{\to 0} + dd\epsilon$$

⇒ Elimination / Reduction of correlated error terms

3 GNSS-basics in Automotive applications (research points)





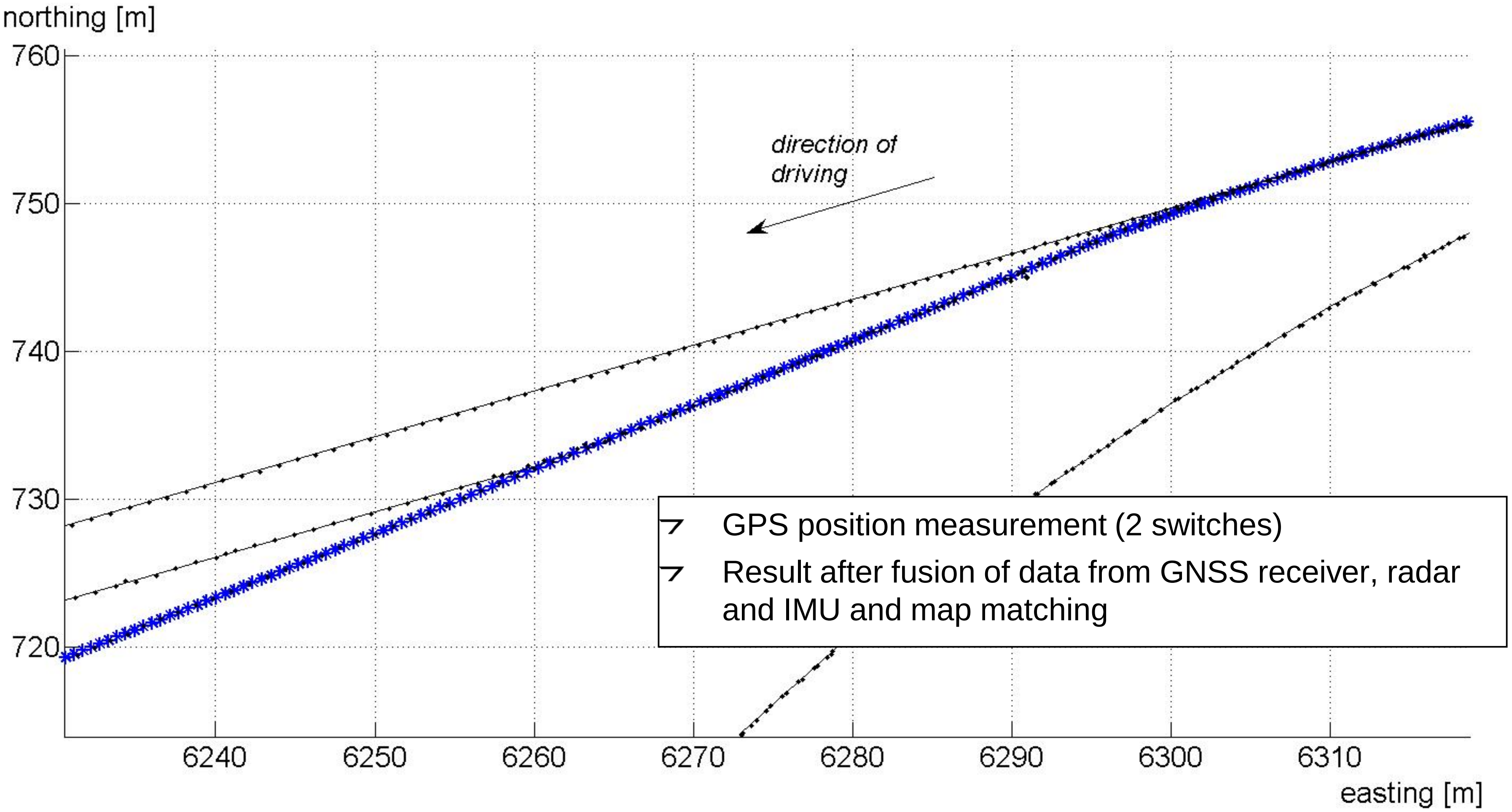


3 GNSS-basics in Train applications (research points)

- Assisted and automated driving of rail vehicles and freight wagons /

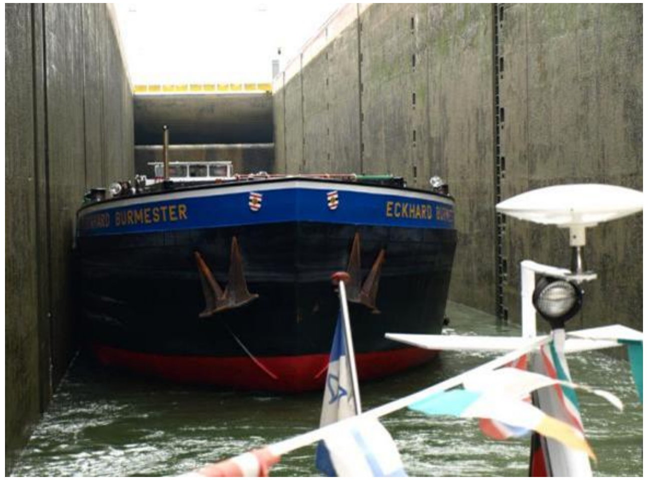
3 GNSS-basics in Train applications (research points)

- Track-selective localization through sensor data fusion

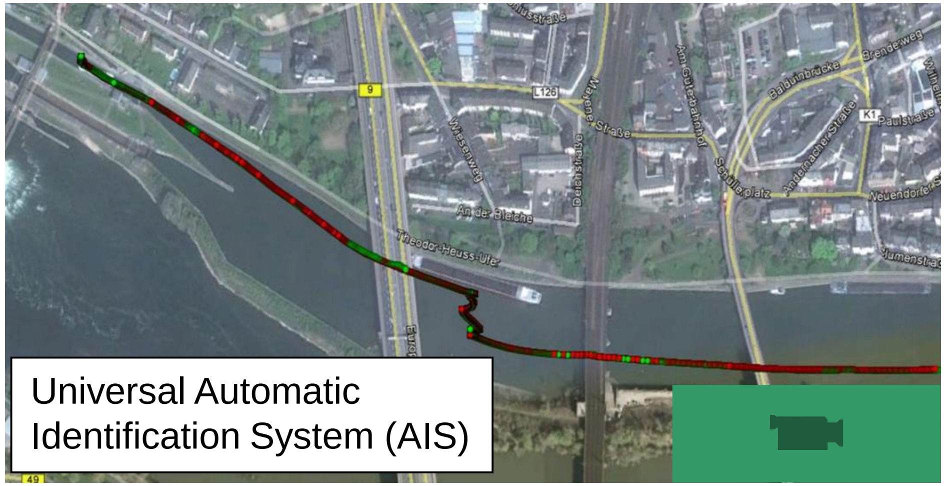


3 GNSS-basics in Shipping in applications (research points)

- Assisted and automated driving of Inland vessels and rescue systems (AIS)



Inland Ship Lock



Universal Automatic Identification System (AIS)

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4 Indoor solutions using pseudo GNSS backup systems

- GNSS-Availability or Accuracy aren`t complied? What can we do ...

1b

4

5

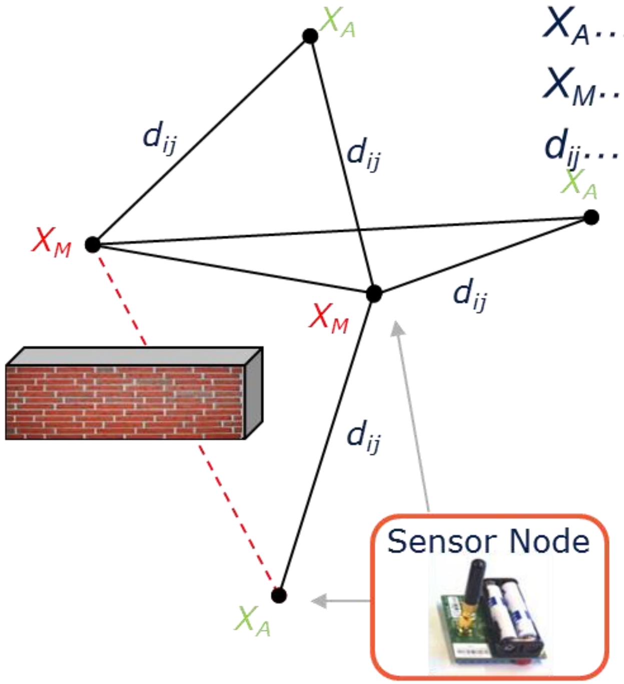
6

Ranging over Pseudo Satellites | Solution | **Wireless Sensor Networks (WSN)**

Received Signal Strength	Time of Arrival	Phase of Arrival	Angle of Arrival	Cell of Orgin
RSS	ToA	PoA	AoA	CoO

4 Indoor solutions using pseudo GNSS backup systems

➢ Positioning Process in Wireless Sensor Networks

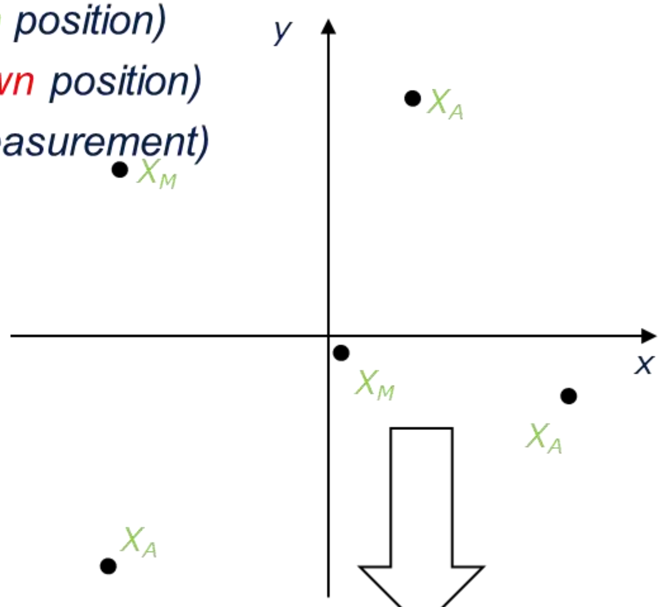


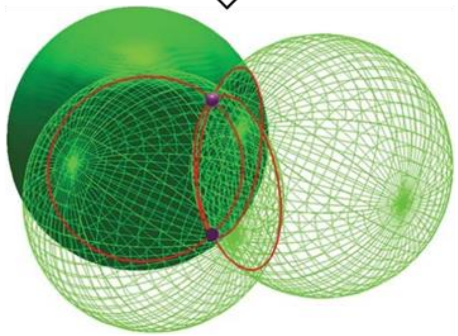
X_A… anchor node (known position)

X_M… mobile node (unknown position)

d_{ij}… ranging (distance measurement)

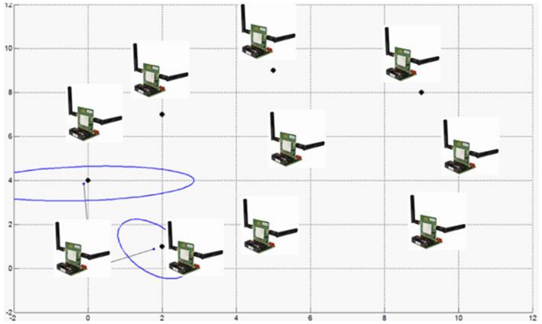
$X_M = f\,(X_A\,,\,d_{ij})$





Set of Equations

$$d_i^2 = (x_i - x)^2 + (y_i - y)^2 + (z_i - z)^2$$



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5 Conclusion and future outlook

One fixed fully automated vehicle

MixFutureTraffic

Fully connected safety vehicles in mixed traffic types

5 Conclusion and future outlook

- GNSS is the basic sensor in multimodal traffic telematics for outdoor environments
- Location errors can be minimized through signal processing and data fusion
- WSN can solve indoor positioning tasks as pseudo GNSS

- **Future:** High precision universal position sensor for hybrid vehicles (cross-modal)

„If I had asked the people what they wanted, they would have said faster horses .“
(Henry Ford / 1863-1947)

Source: www.duden.de

?

Soure: www.edle-oldtimer.de/ford-t-modell

?

Source: https://youtu.be/wHJTZ7k0BXU

Thank you for your attention!

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TU Dresden,
Chair of Transport Systems Information Technology

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