NAV – CAR

Lane-sensitive positioning and navigation for innovative ITS services

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Projekt Nr. 819743

AUSTRIAN SPACE PROGRAMME

ÖSTERREICHISCHES WELTRAUMPROGRAMM

Outline of Presentation

- Introduction, Overview
- Services requiring precise positioning and lane-sensitive navigation
- Derived Technical Specifications
- Technical OBU Implementation
- Test tracks and drives for urban and alpine scenario
- Some details on selected results
- Summary and conclusions

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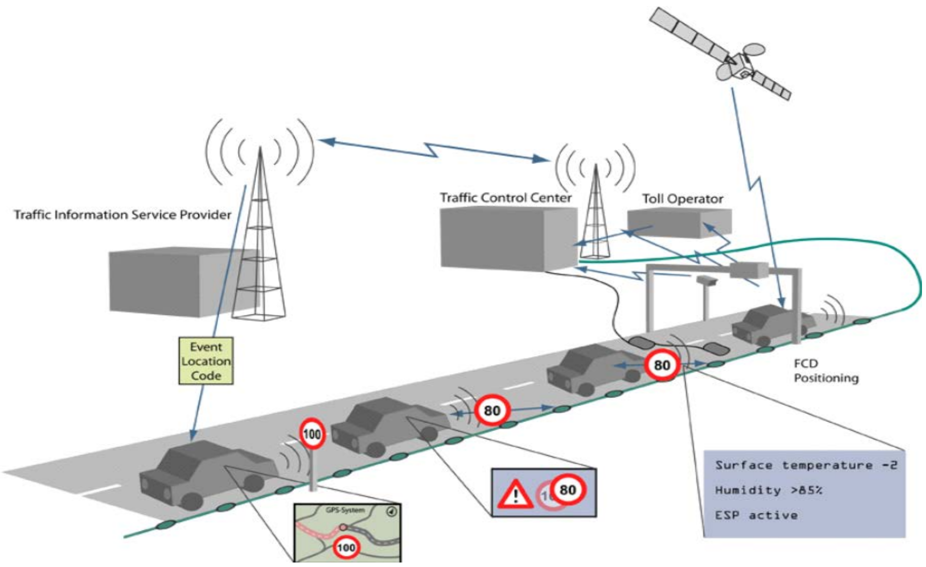
NAV-CAR as Follow-Up of COOPERS



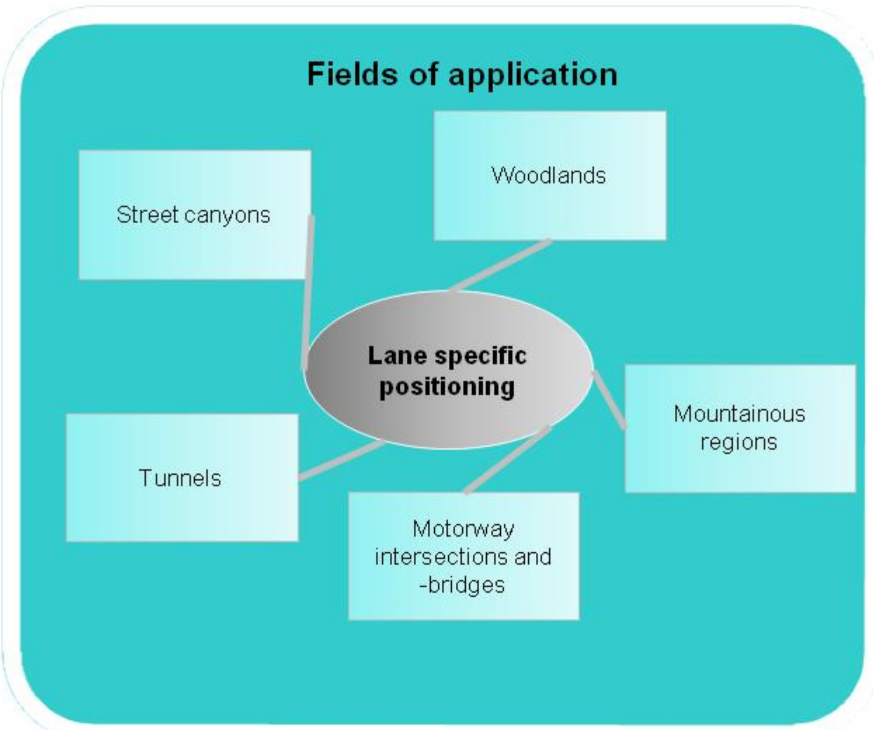
COOPERS system

Vision of COOPERS

- Vehicles are connected via continuous wireless communication with the road infrastructure on motorways, exchange data and information relevant for the specific road segment to increase overall road safety and enable co-operative traffic management.

Goals of NAV-CAR

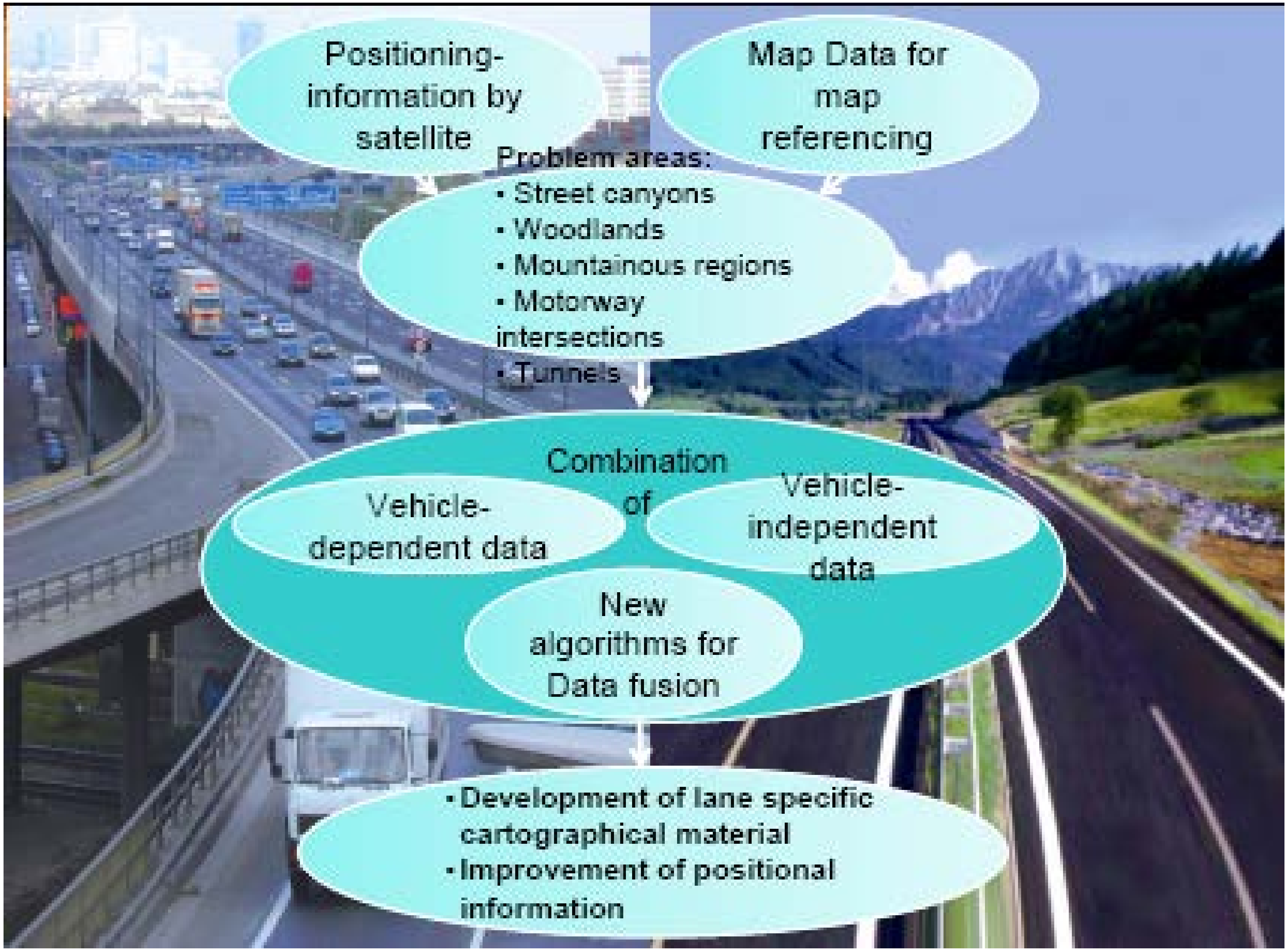
NAV-CAR (Improved NAVigation in Challenging Areas by Robust Positioning)



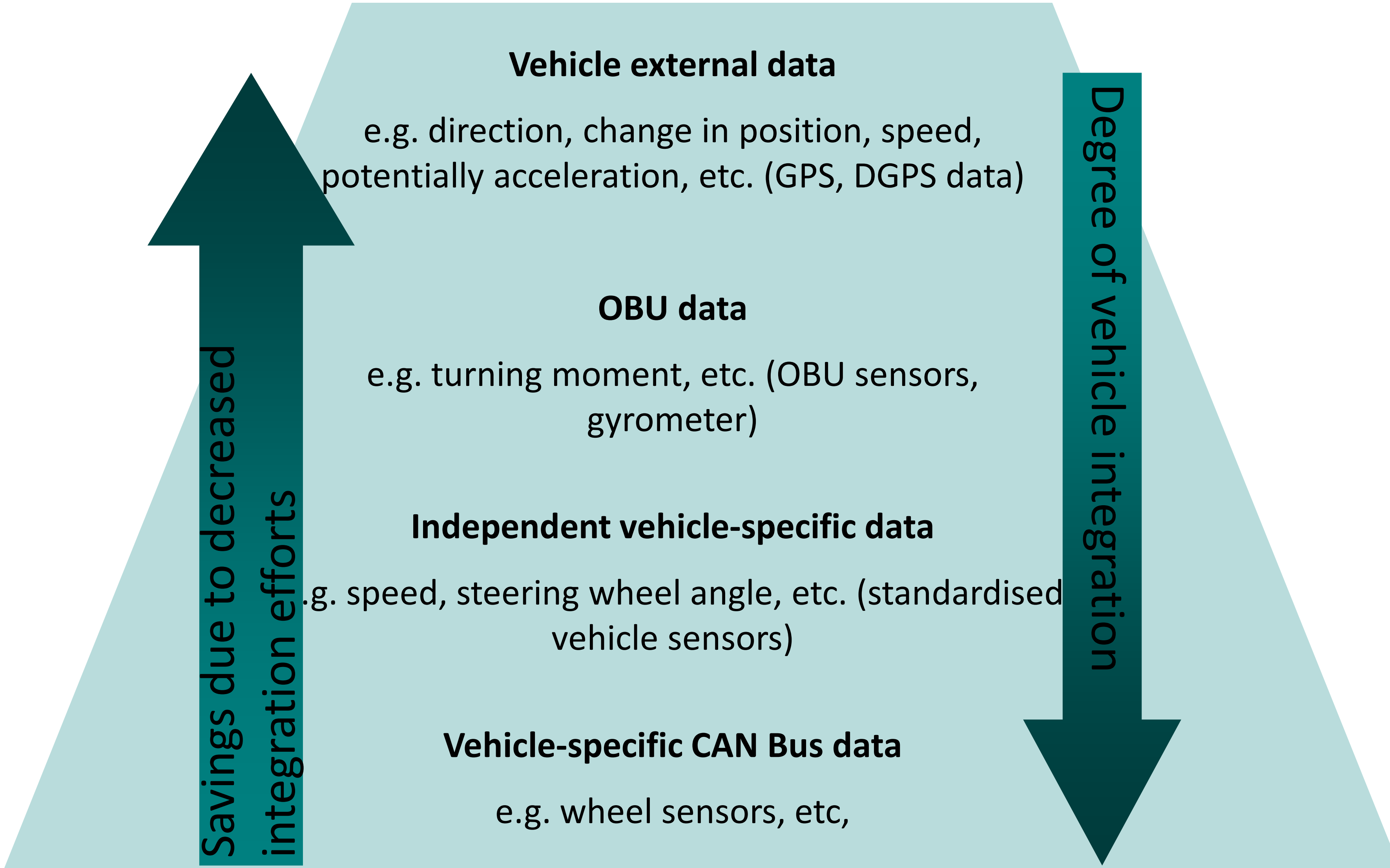
Fields of application of NAV-CAR

- Specific environments: reliable, continuous satellite connection not available
- Goals
  - Increase robustness (e.g. bridging GPS holes)
  - Improve accuracy (e.g. providing lane information)
  - Enhance reliability (e.g. indicating current accuracy)

Goals of NAV-CAR



Levels of Data



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Potential Services

NAV-CAR: Examples for lane-specific services

- Road Surface Examination
  - Surface Analysis (Exact Positioning of Road Defects),
  - Optimization of Road Surface Examination (road condition such as temperature) for gritters
- Generating and Updating of Maps
- Lane-specific Traffic Light Control / Regulation
- Distance Measurement between cars (driving behaviour, accident analysis, micro-traffic models)

Potential Services

NAV-CAR: Examples for lane-specific services

- Traffic Flow Management beyond COOPERS
  - More accurate lane banning, lane keeping, auxiliary lane utilization
  - Lane-specific Speed Profiles
  - Tracking and warning (wrong-way drivers)
- Optimization and tracking of maintenance work, winter services etc.
- Interesting Services for Emergency Services (e-Call)
  - exact accident localisation (time-efficient action planning)
  - exact localisation of the caller
  - accurate route calculation

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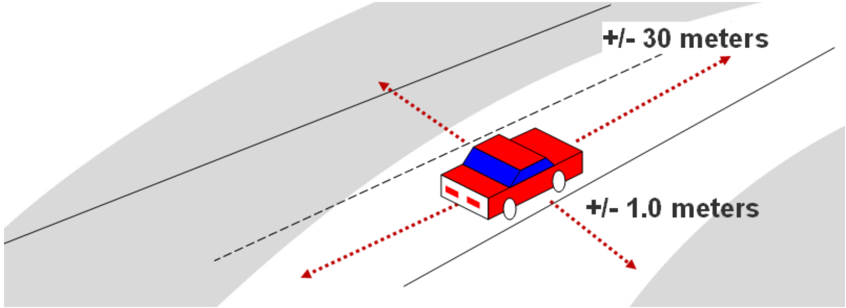
Derived Technical Specifications



Requirements for lane specific navigation

- Preconditions: precise navigation of cars
  - Longitudinal: +/- 30 m → Goal of COOPERS, reached ☑
  - Transversal:
    GPS precision sufficient for demonstration drives (12 m)
- Ideas for follow-up: precise navigation → NAV-CAR
  - Transversal: +/- 1 m (for lane specific services)
  - Vertical position accuracy: +/- 3 m
  - Update rate of position information: 0,8 sec (80 km/h < 1m)
  - Time stamp of each position data (internal clock sync. with GPS)
  - Data display (real-time feed back to driver if sensor data are ok)

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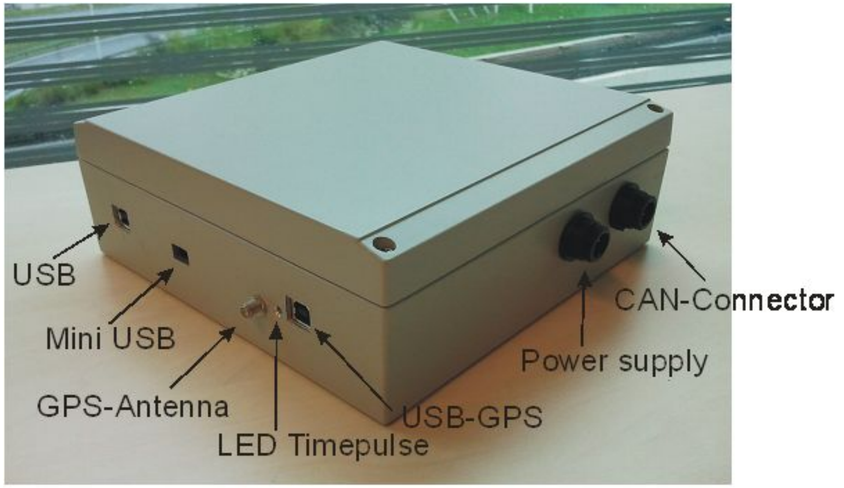
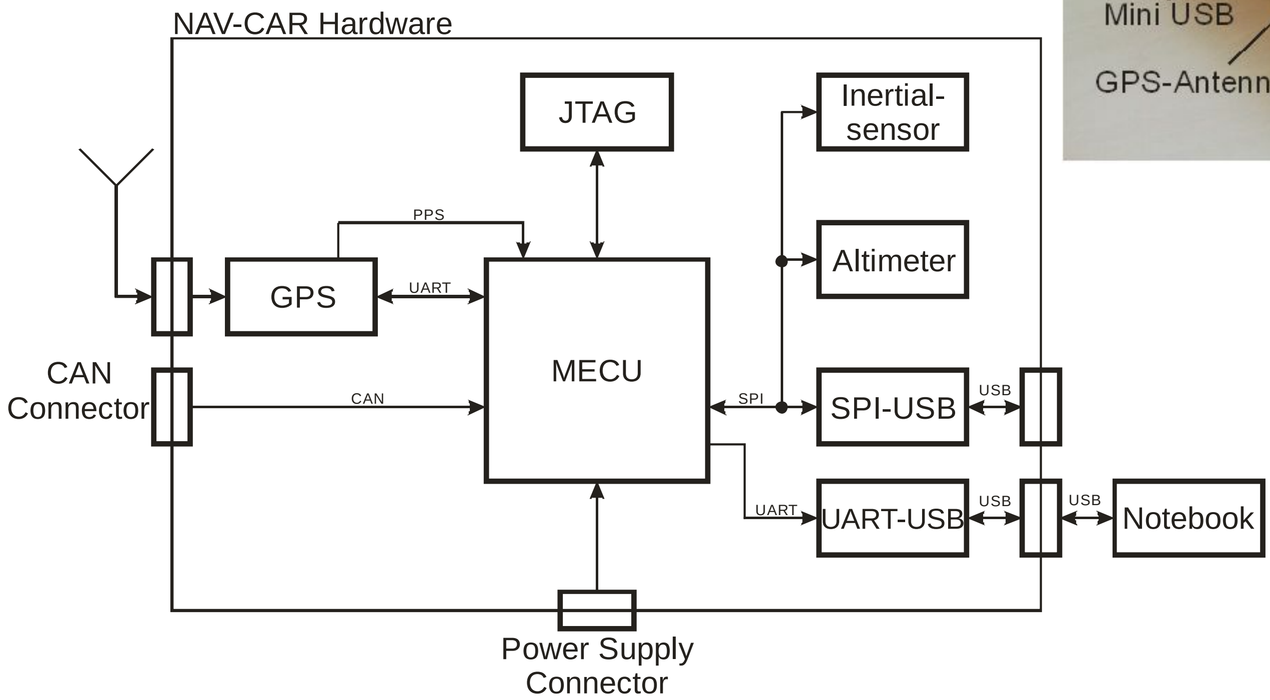
On Board Unit

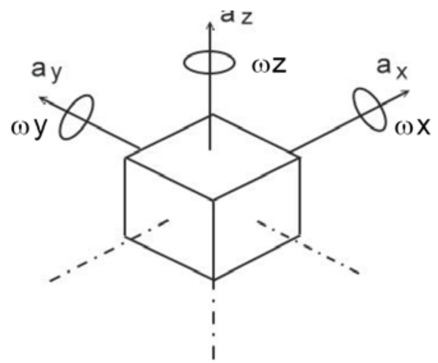
- Overview NAV-CAR OBU

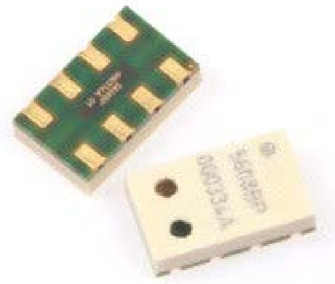




On Board Unit

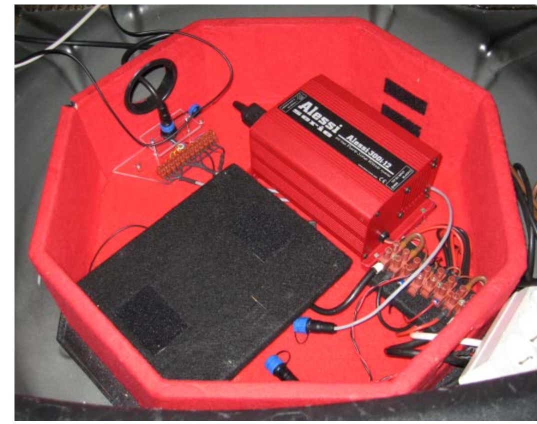
- Characteristics OBU (1):
  - GPS-module:
    - U-blox, series 6
    - External antenna
    - Time pulse (1PPS)
  - Inertial Sensor 6 degrees of freedom:
    - 3 rotation sensors (Gyroscope)
    - 3 linear sensors
    - Internal temperature sensor for correction
  - Altimeter:
    - 5 x 3mm miniature
    - High resolution mode (20cm)
  - CAN-bus:
    - Vehicle high-speed CAN-bus
    - Sample of interesting data
  - USB-Interface (Laptop)

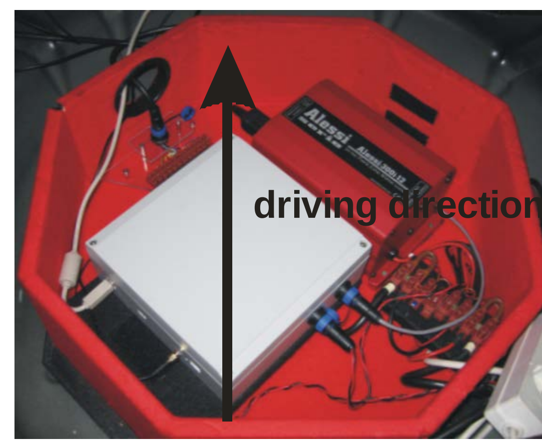




On Board Unit

- OBU in test car
  - Ford Focus Test car
  - OBU connected to the car (power, CAN)
  - External GPS-antenna





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Validation scenarios

- Szenario 1: Urban Motorway (Vienna: Kaisermühlen – Inzersdorf)
- Szenario 2: Alpine Motorway (Brenner Autobahn)

- Goal:

Lane dependent accuracy, even under difficult topological or environmental conditions

Testing of both scenarios, comparison with RoadSTAR Reference Data

Reference data Roadstar

- Data collection hardware

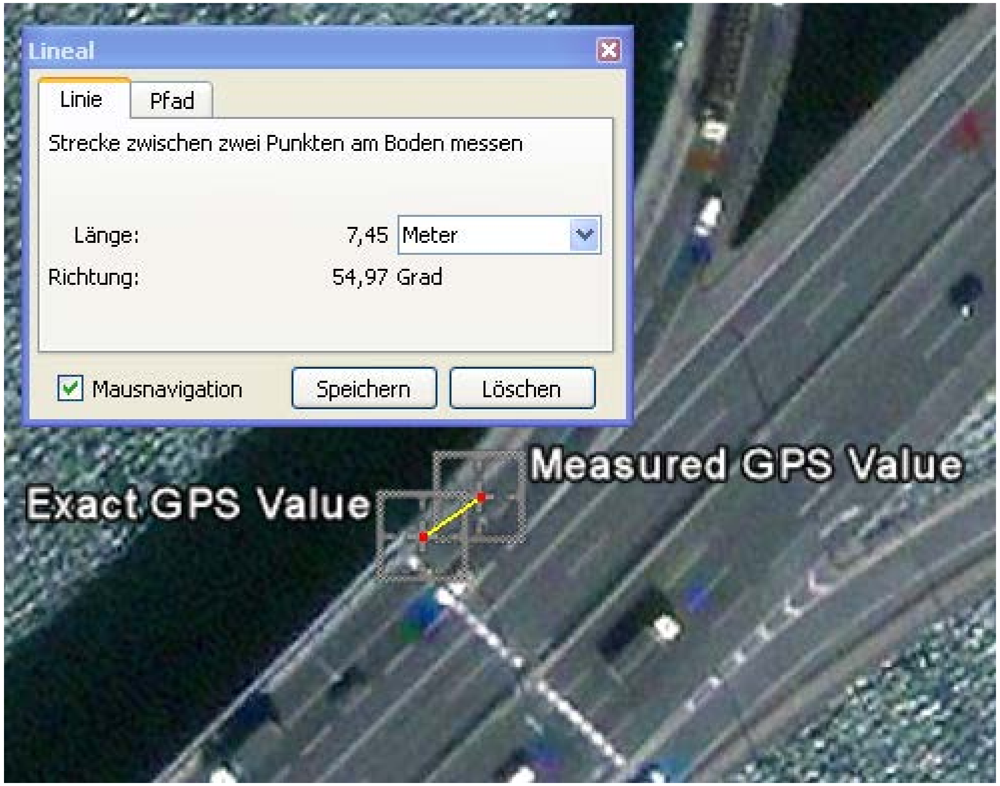
Test track #1: urban highway

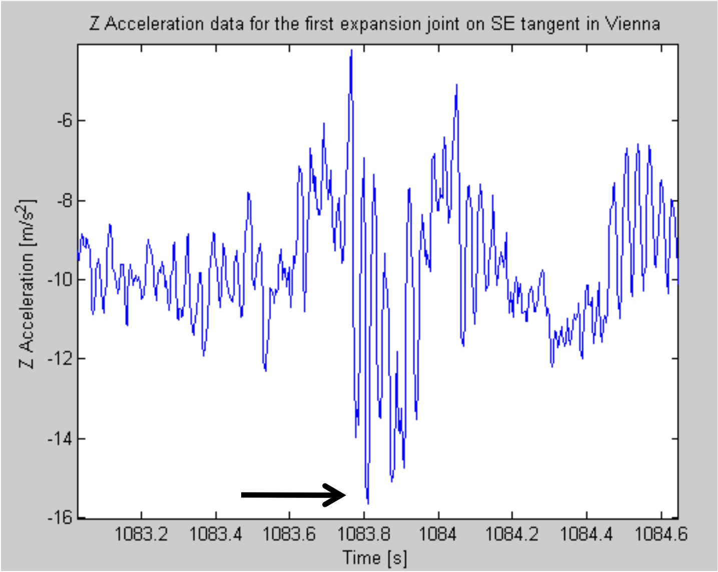
- Vienna – „Süd-Ost Tangente“: Evaluation of IMU- und CAN-Data in combination with GPS-Daten

Clover leafs („Knoten Prater“)
3-D positioning !

Results

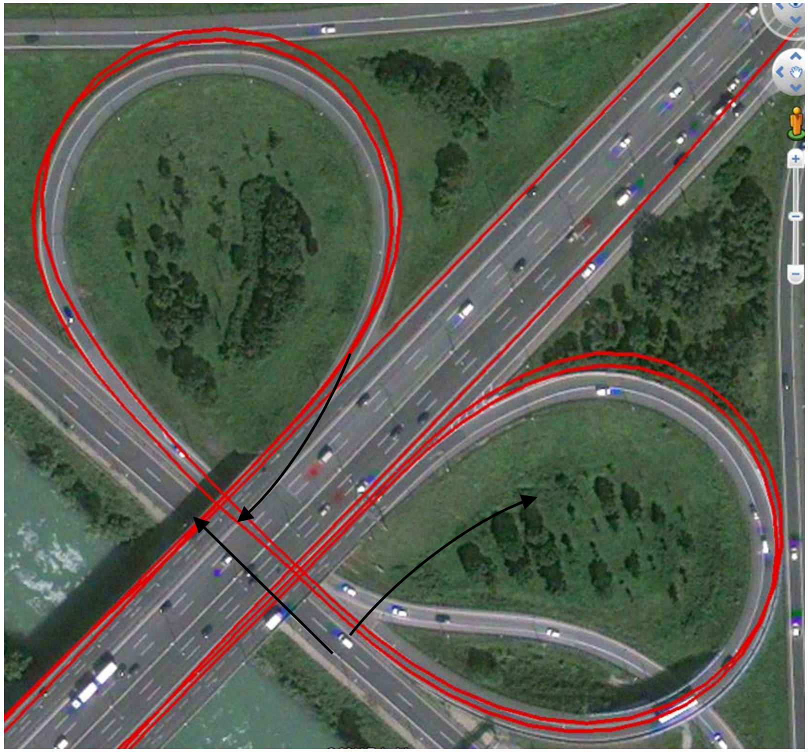
- Measurement of longitudinal precision of GPS
  - By exact position of separating expansion joints on bridges with IMU-Data (Z-acceleration) is GPS-precision calculated

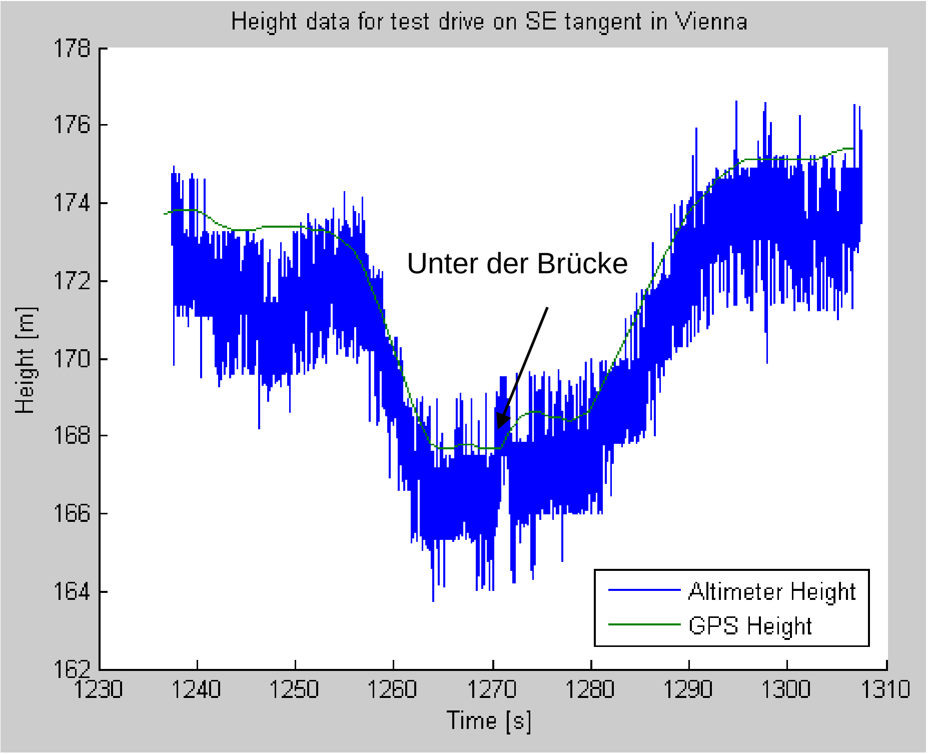




Results

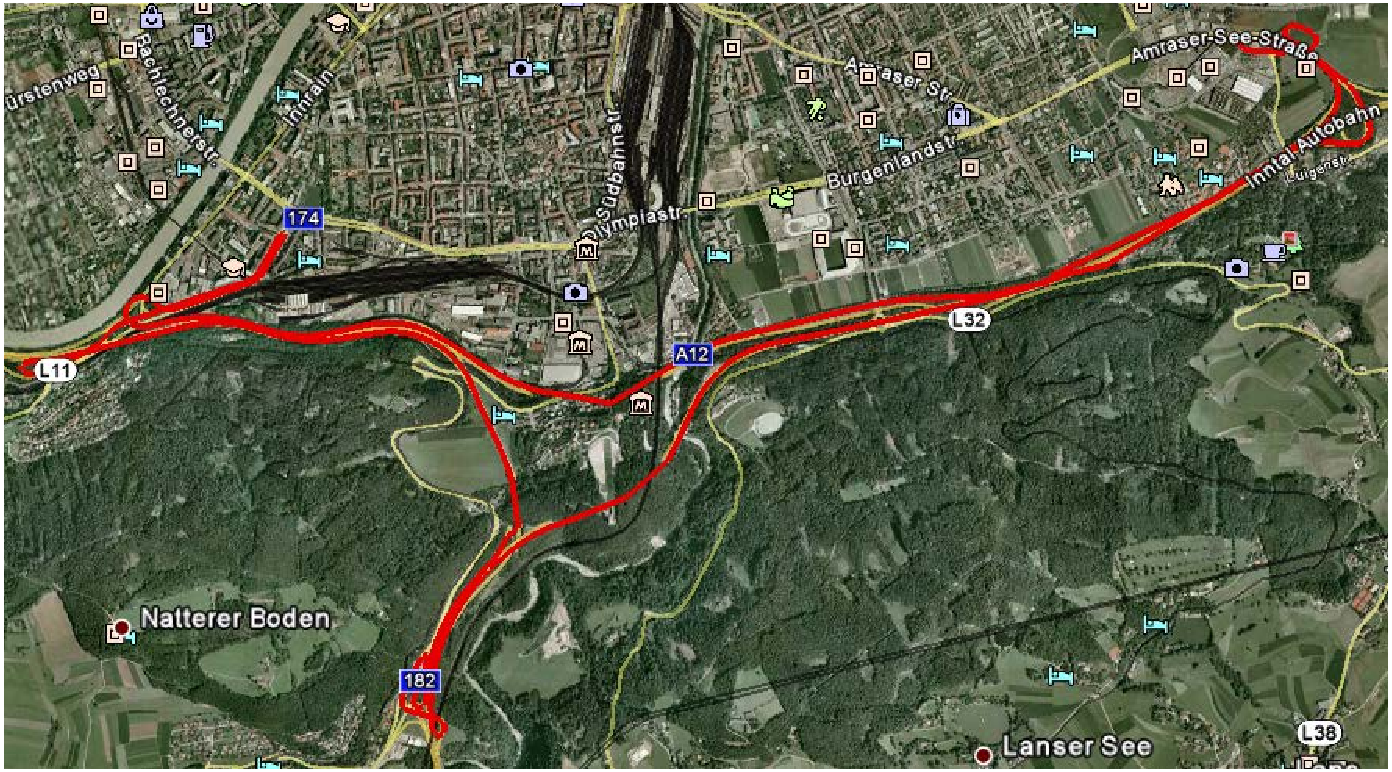
- Height measurement (bridges at clover leafs)
  - with Altimeter resp. GPS it is possible to decide if a vehicle is under a bridge or not (relative precision of 3m is achieved)





Test track #2: alpine highway

– Innsbruck/Brenner: evaluation of Galileo data (simulation, terrain specific model available)
– Test drives: evaluation of CAN-Data, lane specific data
– (A12 → A11 → A12)



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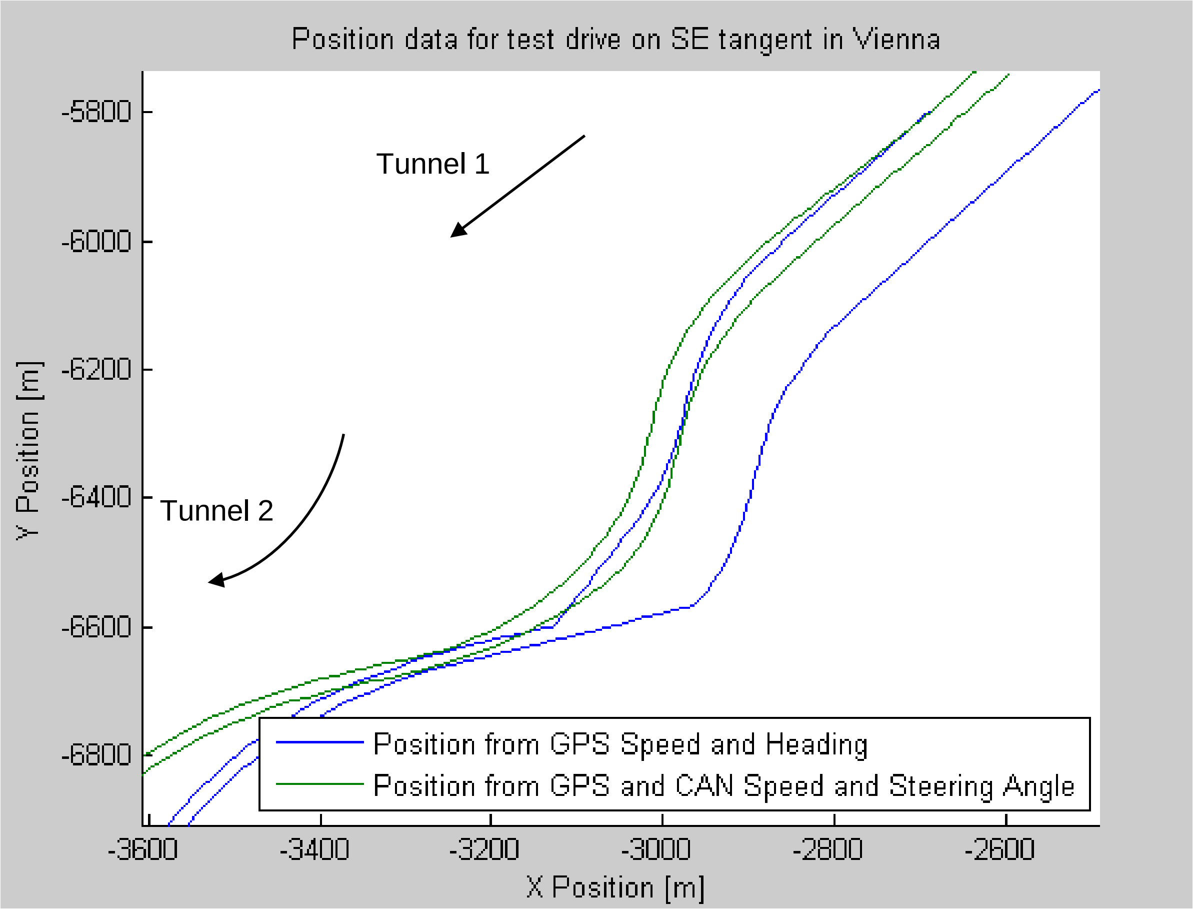
Results

Improvement/complementation of GPS-trajectory using CAN-data

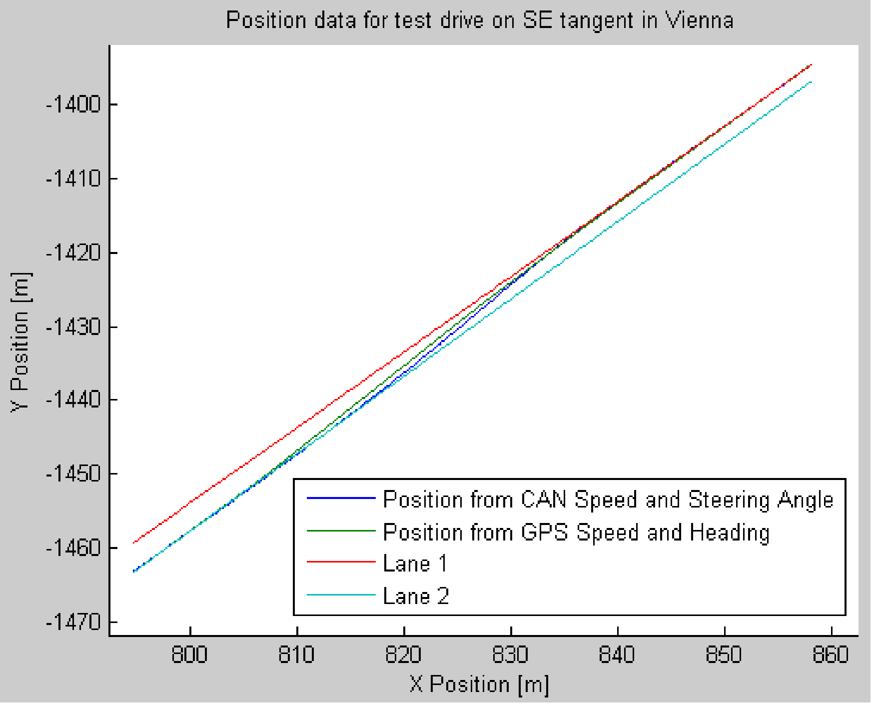
– data, where GPS does not provide fix are complemented by CAN-Data (GPS Speed, Heading, CAN Speed und Steering Angle)

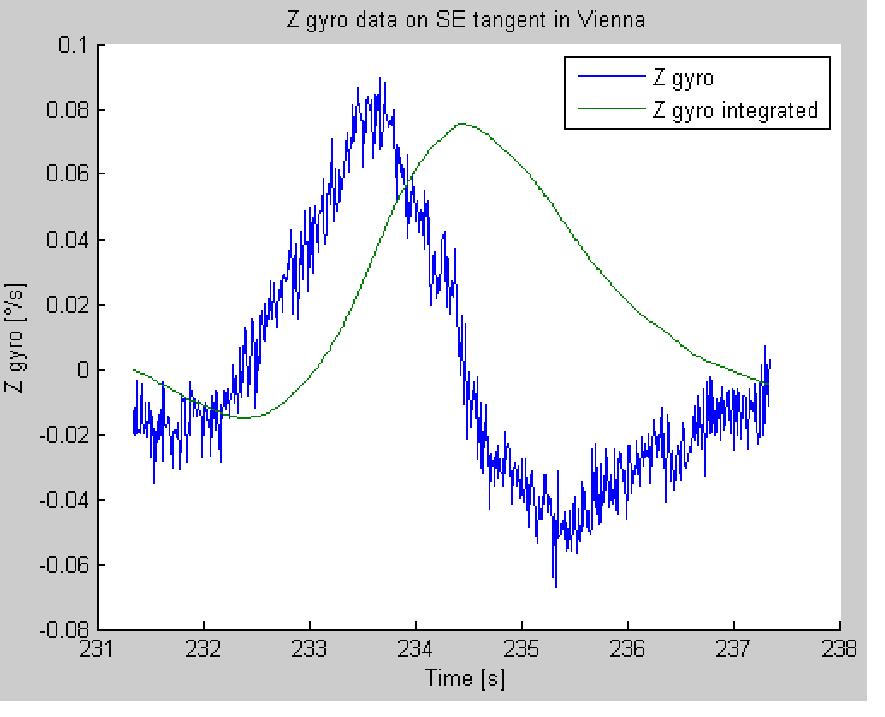


Results

Detection of lane change

- Lane change is identified very precise by CAN-Data combined with GPS-Data and qualitatively with Z-Gyro-Data (integrated Gyro-Data indicate if car continues in same direction after lane change)





Galileo Simulation

- NAV-CAR: Galileo simulation (pwp Systems)

Simulation (GSSF):

Simulation:
- GPS
- Galileo

→

GPS-Compare:
- Simulation
- Measurement

→

Result:
Proof of Simulation quality

Test trial:

Measure:
- GPS
- Gyroscope
- Odometer
- etc.

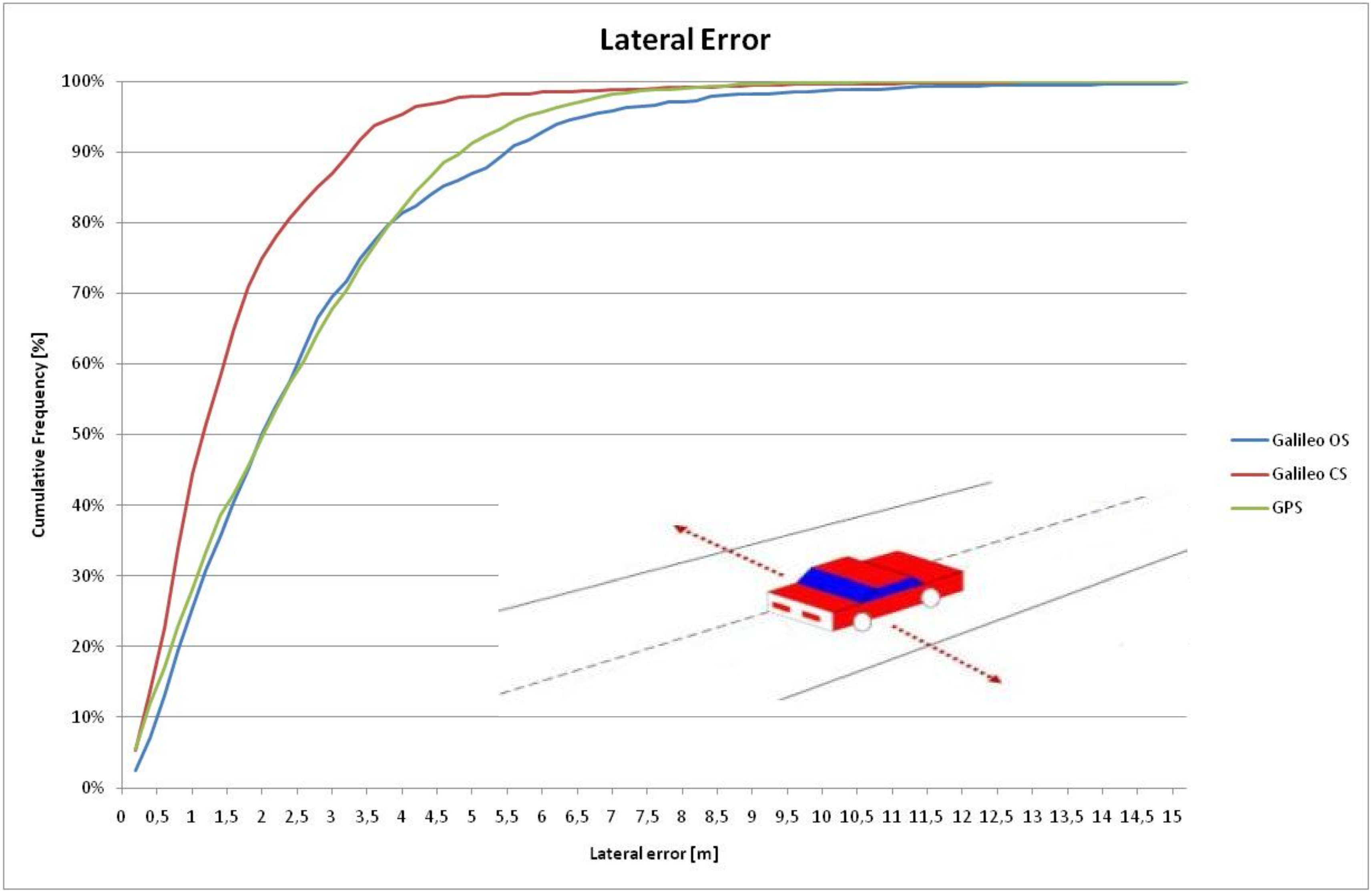
→

Application:
- Galileo / GPS
- Gyroscope
- Odometer
- etc.

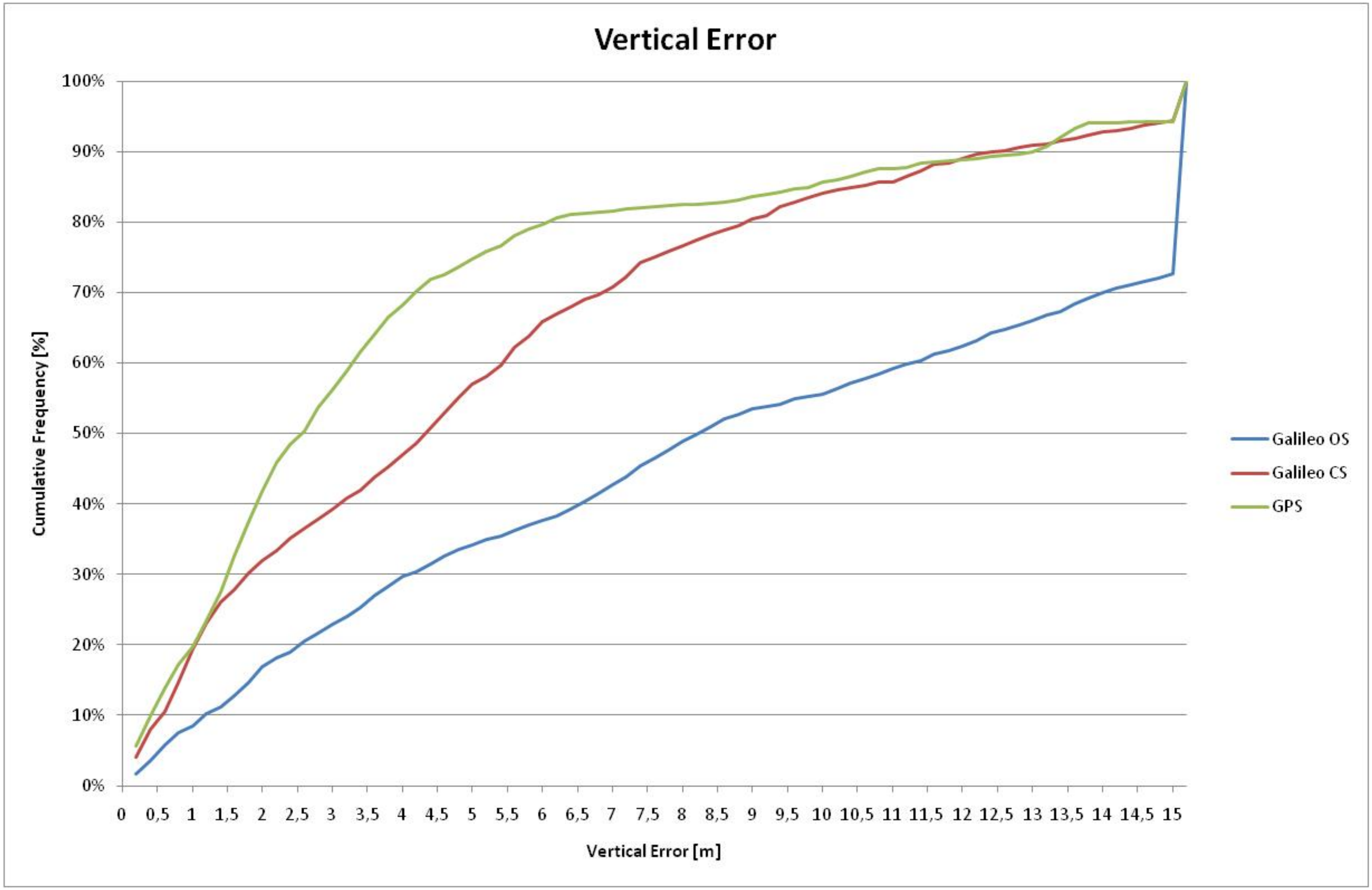
→

Result:
Potential of Galileo for the Application

Galileo Simulation - Results



Galileo Simulation - Results



Results Galileo-Simulation

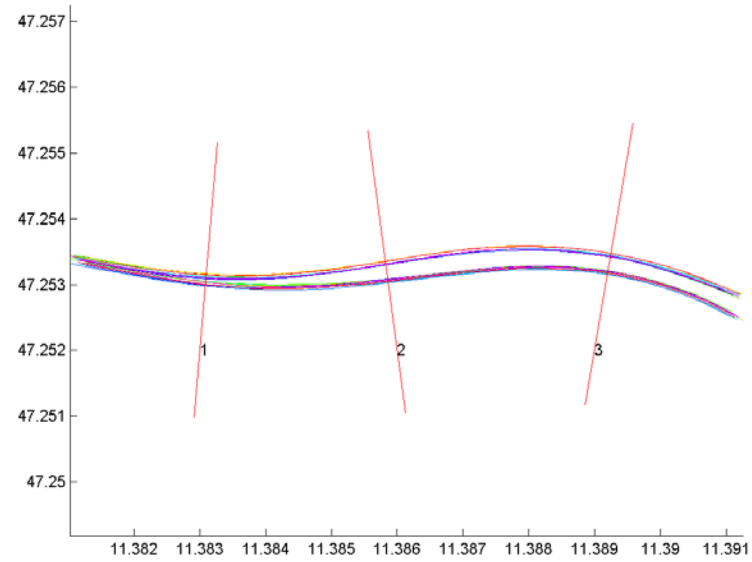
- Lateral accuracy
  - Requirement: +/- 1m
  - GPS: 25% der Punkte
  - GALILEO Open Service: 25% of measurement points
  - GALILEO Commercial Service: 50% of measurement points
- Vertical accuracy
  - Requirement: +/- 3m
  - GPS: 56% of measurement points
  - GALILEO Open Service: 23% of measurement points
  - GALILEO Commercial Service: 40% of measurement points
  - **BUT ... !**

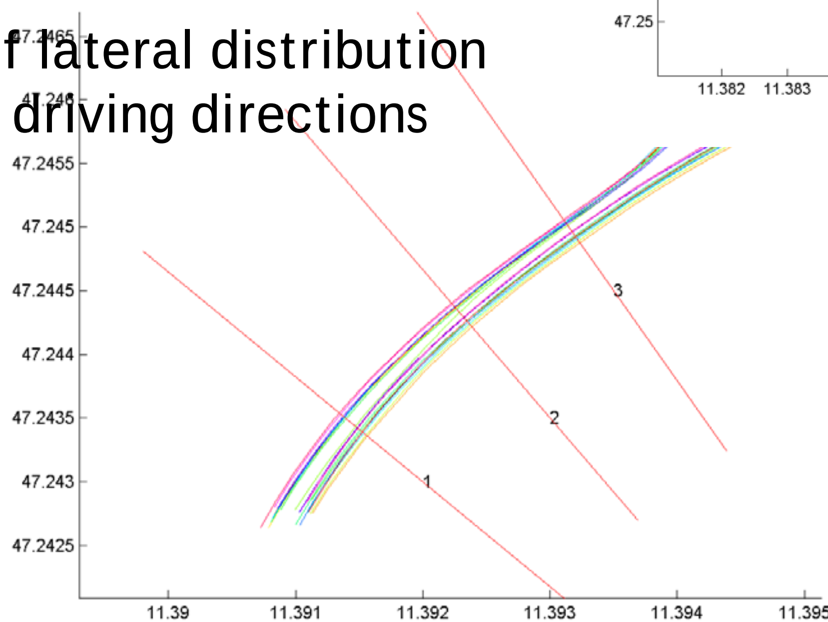
Results Galileo-Simulation

- Significant difference in accuracy between lateral and vertical accuracy!
- Why?
  - Reference building: Initial error in simulation higher
  - Referenz building: time is not bound
  - Calculation of position in simulation:
    Pseudo-ranges from simulation, position is calculated by „Single-Point-Positioning“ – does not use information from preceding positions
- whereas: GPS-Position calculation is based on „Automotive-Profile“ → algorithm is smoothing values by taking into account preceding values and performance!

Enhanced Maps

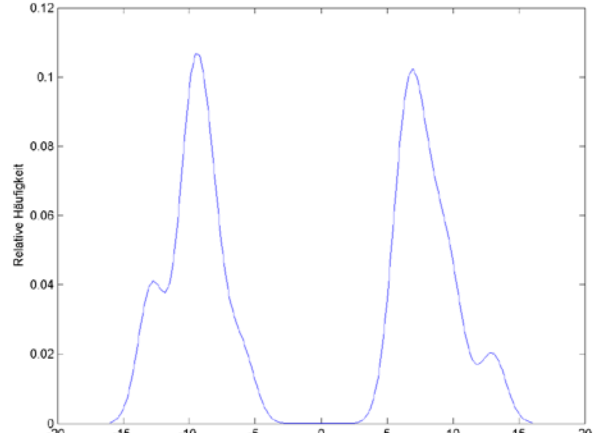
- Analysis of Data
  - Selection of segments of test tracks, both driving directions
  - Visualisation of data as trajektories
  - Definition of orthogonal segments
  - Analysis of lateral distribution over both driving directions





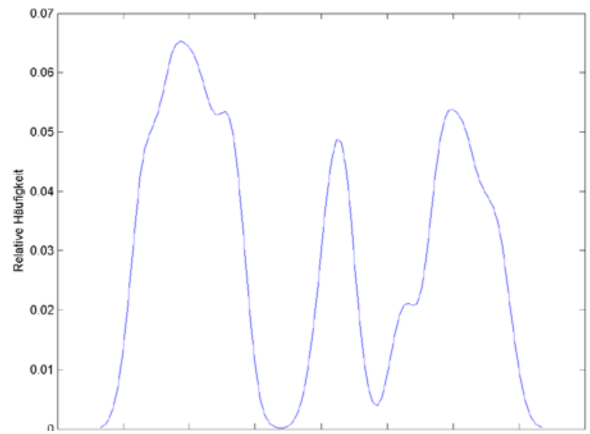
Enhanced Maps

- GPS



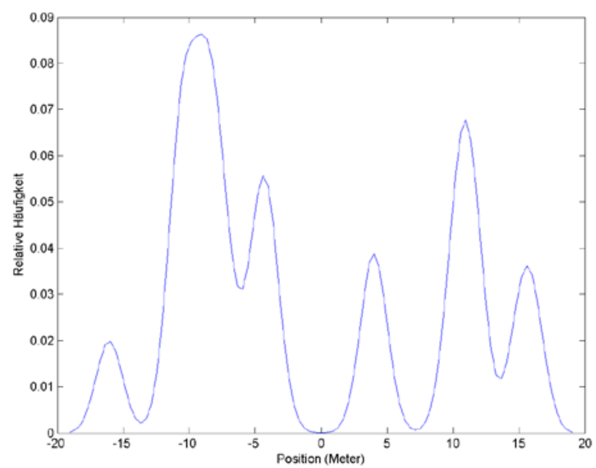
only driving directions clearly marked

- Galileo OS



better resolution: indication of lanes

- Galileo CS



distinct lanes visible

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Summary

Results of the demonstrations at the urban highway:

- Result 1: CAN data (speed, steering wheel angle) can be used to complete GPS data (e.g. in tunnels) → Continuous trajectory is guaranteed.
- Result 2: the longitudinal accuracy of GPS can be measured using well defined points where exact GPS values are available and which can be easily detected (e.g. expansion joints) → requirements with respect to longitudinal accuracy of GPS are easily achievable
- Result 3: the position of the car on or under the bridge can be measured using GPS or altimeter → Accuracy of height precise enough (3 m) for mapping on street maps.

Summary

Results of the demonstrations at the urban highway:

- Result 4: the lane change can be detected both using CAN (speed, steering wheel angle) and GPS data. It can also be detected in a qualitative manner using gyro data of the IMU → **Lane specific navigation possible in combination with precise street maps**
- Most important for OBU manufacturers is the fact, that using only vehicle independent data (CAN data speed, steering wheel angle, altimeter and IMU) is considerably improving OBU performance and positioning. Further vehicle dependent CAN data was examined (e.g. wheel speed) but did not result in any further improvement.

Summary

Results of the demonstrations in the Alpine environment:

- Result 1: In contrast to currently available GPS signals, the simulated Galileo commercial service positions provide promising results for the automated generation of enhanced maps with lane accuracy.
- Result 2: Regarding height information, the Galileo simulation shows varying results, which is partially due to inaccuracies of the simulation parameters.

Final NAV-CAR 2 validation workshop (June 8th, 2011):

Issues identified to be of crucial relevance to practice:

(1) Stability of data,
(2) Real-time information about the degree of reliability,
(3) Costs of OBU,
(4) Problems related to the IMU sensor (difficult calibration for each individual IMU).
(5) Need for further research was identified with regards to IMUs (Elaboration of quality of low-price segment, (faster) self-calibration, interoperability of the software (mid-level devices in particular)).

Thank you for your kind attention!

http://www.nav-car.at/de/documents (download)

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