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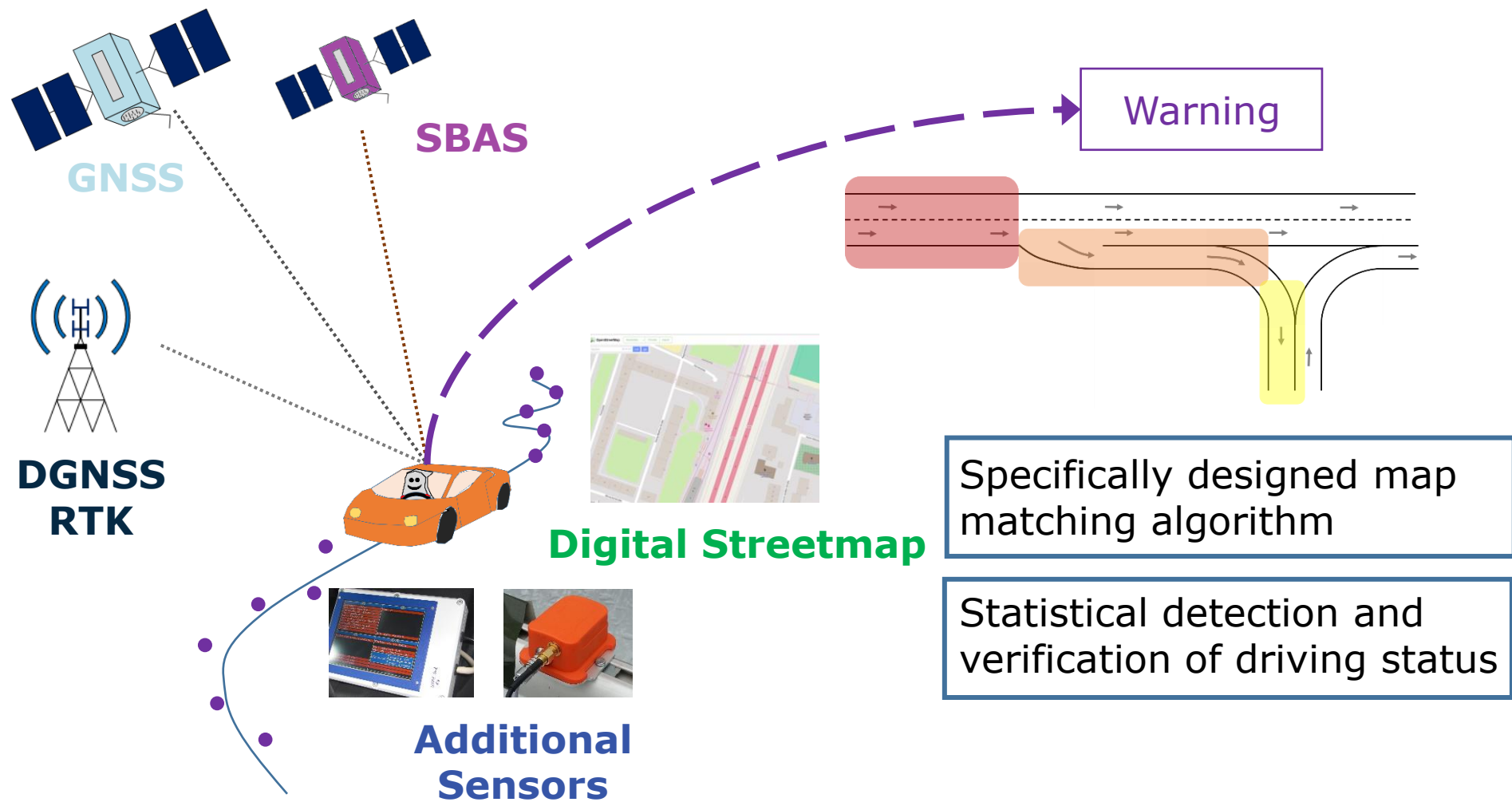
Performance Comparison of Different GNSS-based Multi-Sensor Systems for Detecting Wrong-way Driving on Highways

Andreas Schütz

ION GNSS+

09/29/2017

Ghosthunter Wrong way driving Detection



Real World vs. Test Track

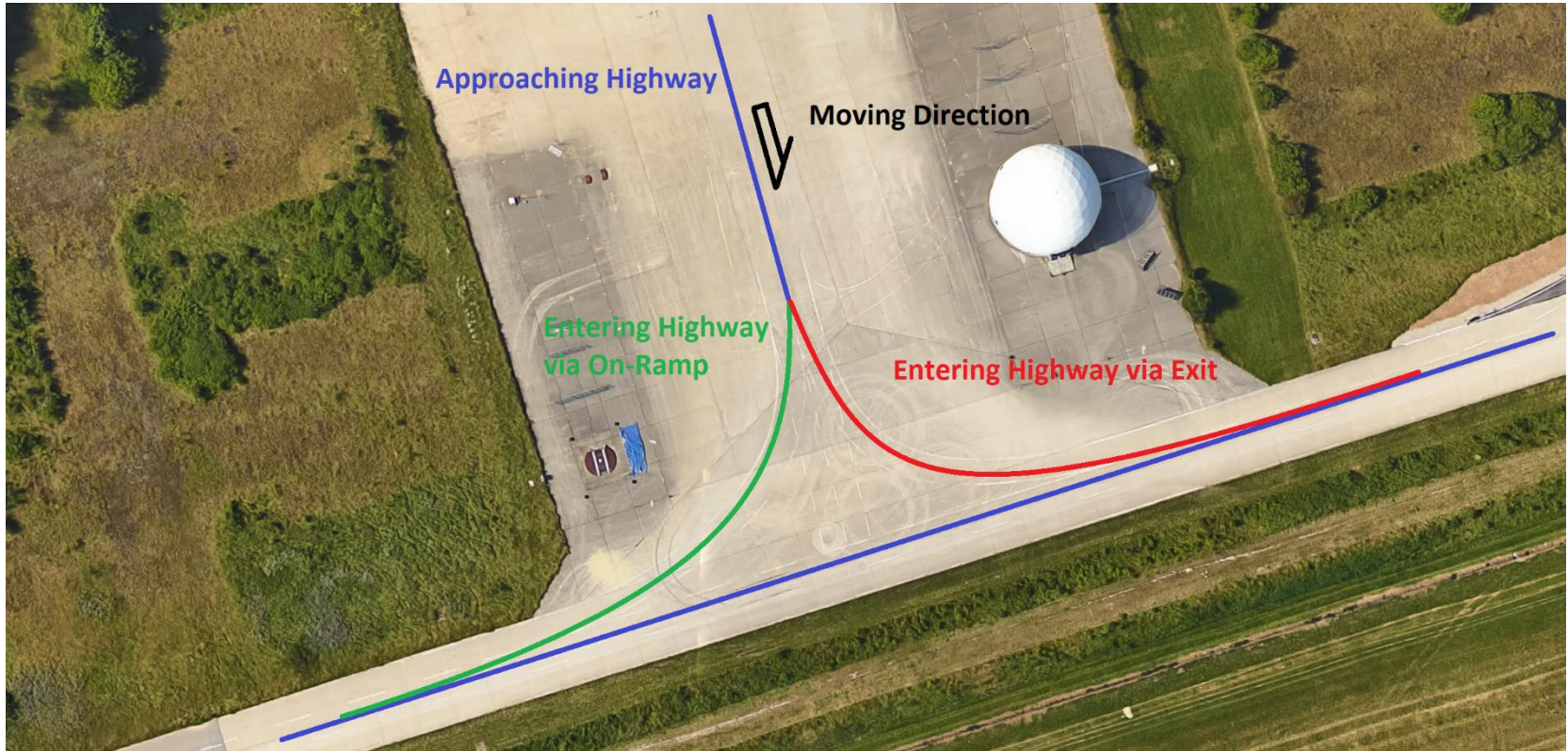
Highway on-ramp/exit
emerging from
adjacent lanes



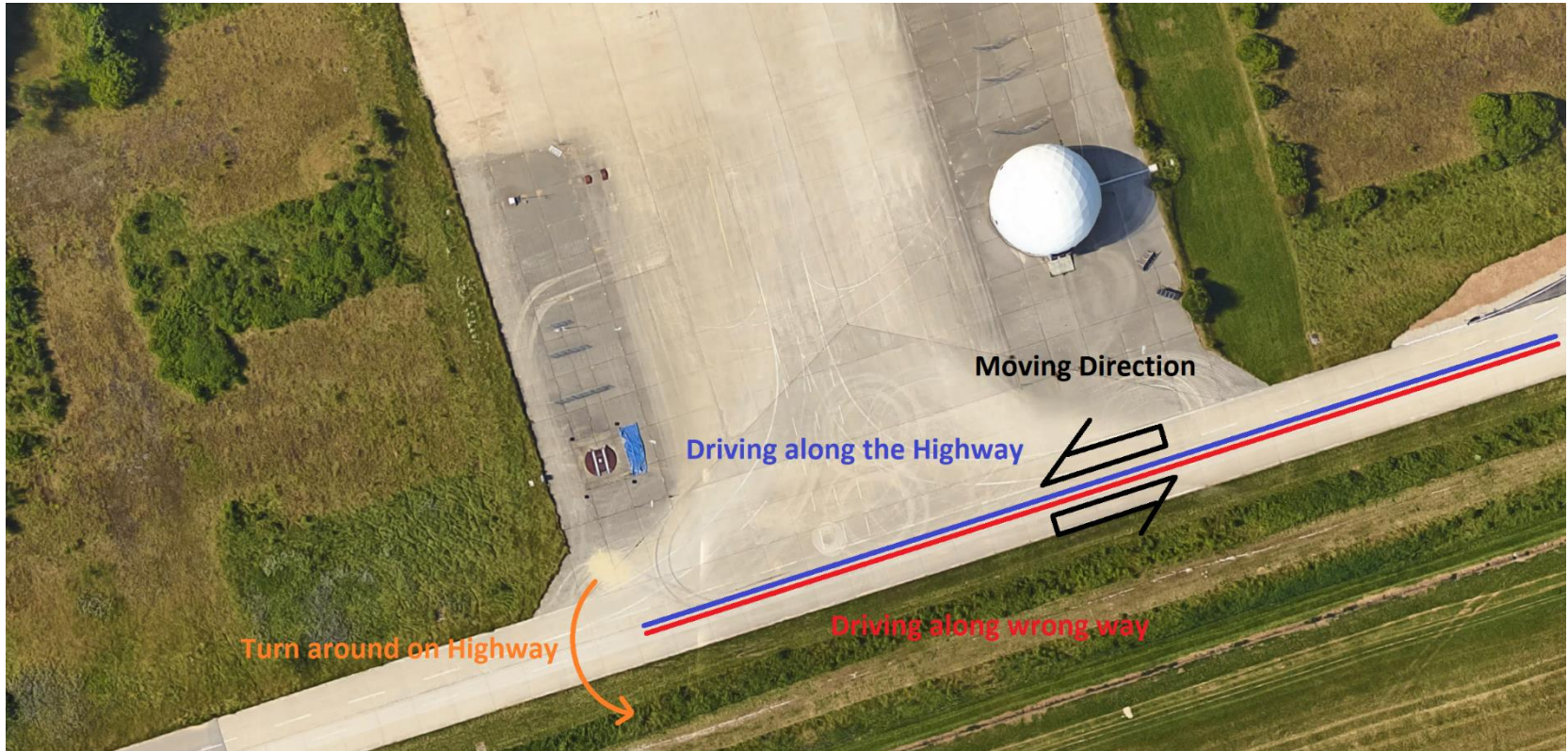
University track



Scenario 1: Exit instead of On-Ramp

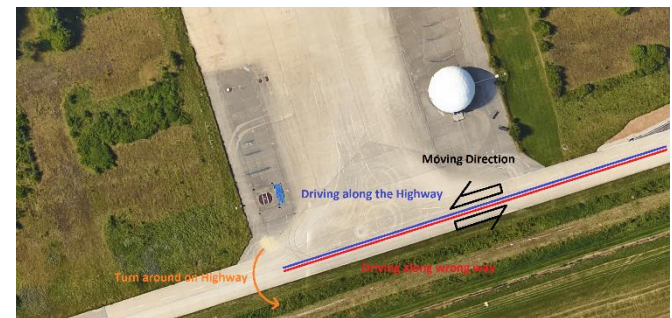
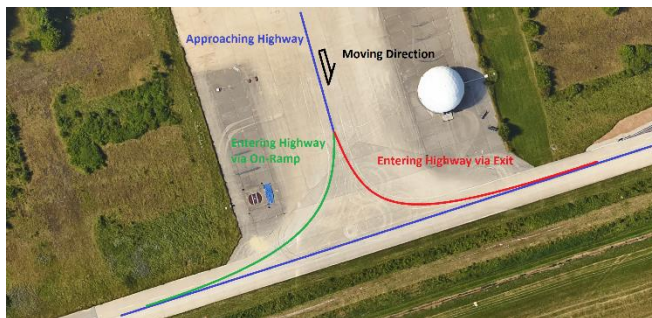


Scenario 2: U-Turn on Highway



Evaluation

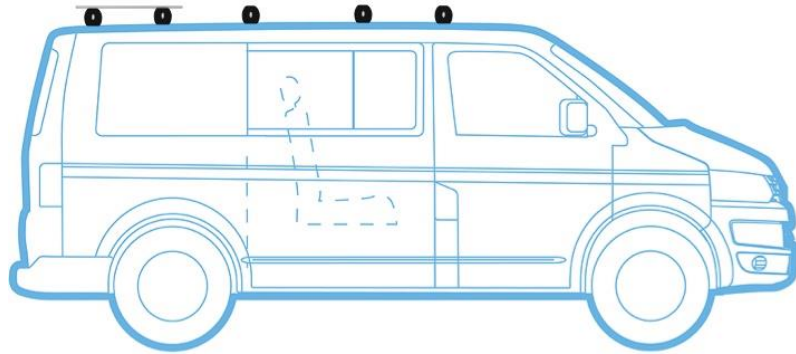
- Perform measurements for both scenarios
- Establish reference trajectory/reference sensor combination
- Obtain synchronous measurements from multiple sensor combinations
- Evaluate effect of multiple/changing environmental conditions (occlusions etc) on the sensor performance



Test Vehicle



Antenna mount point



IMU mount point



Modified VW T5 Bus

Accessible vehicle sensors

Fixed sensor mounting points

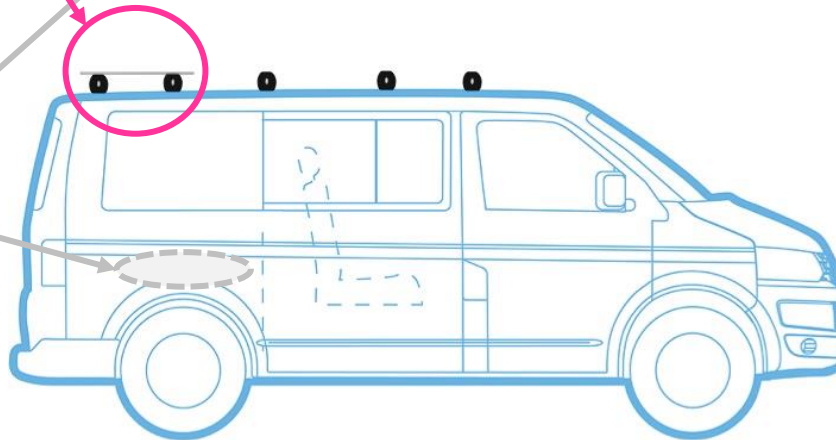


System 1 (Reference System)



Commercial off-the-shelf multi frequency (L1,L2,E5) multi GNSS RTK

Tactical grade FOG IMU (typical gyro bias drift $0.5^\circ/\text{h}$, strapdown)



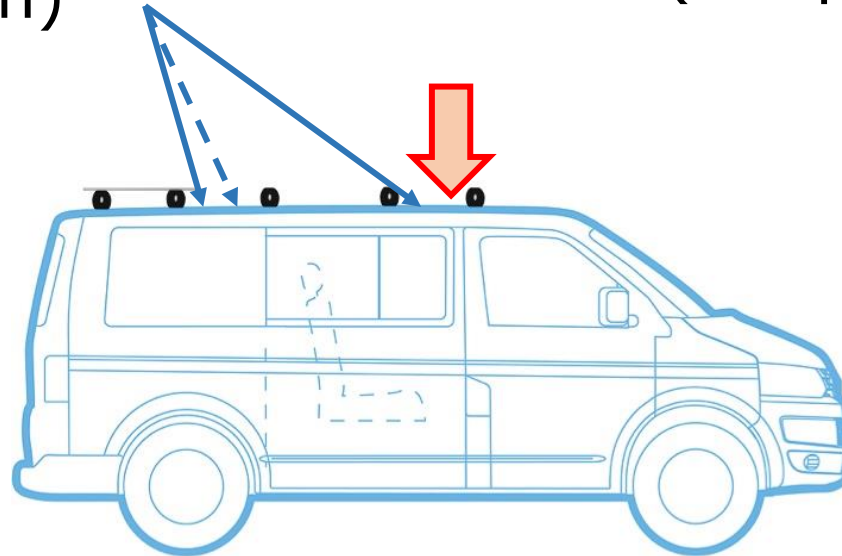
System 2 & 3

System 2:

- Commercial RTK pos. and attitude system
- 3 GPS/GLO dual freq. rec. & MEMS IMUs (strapdown)

System 3:

- COTS low cost single frequency (L1) multi GNSS receiver coupled with MEMS IMU (strapdown)



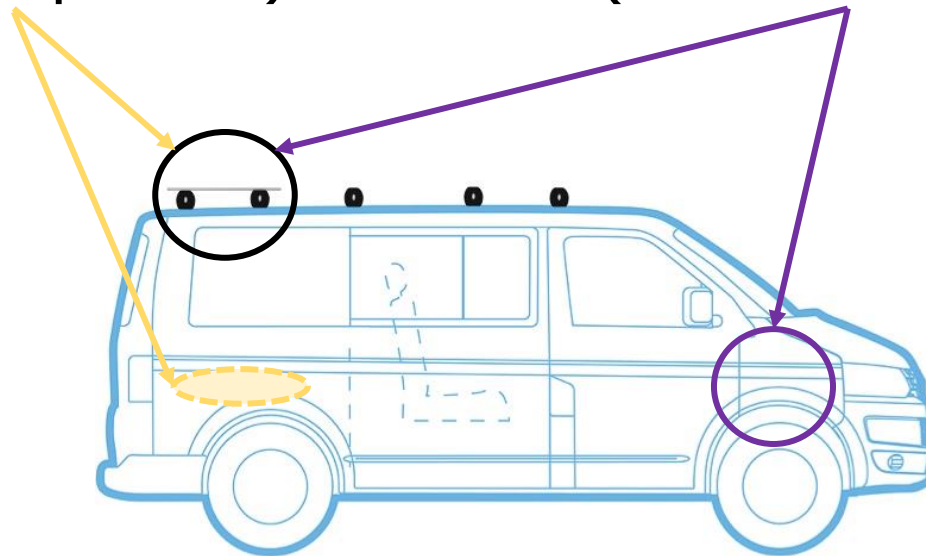
System 4 & 5

System 4:

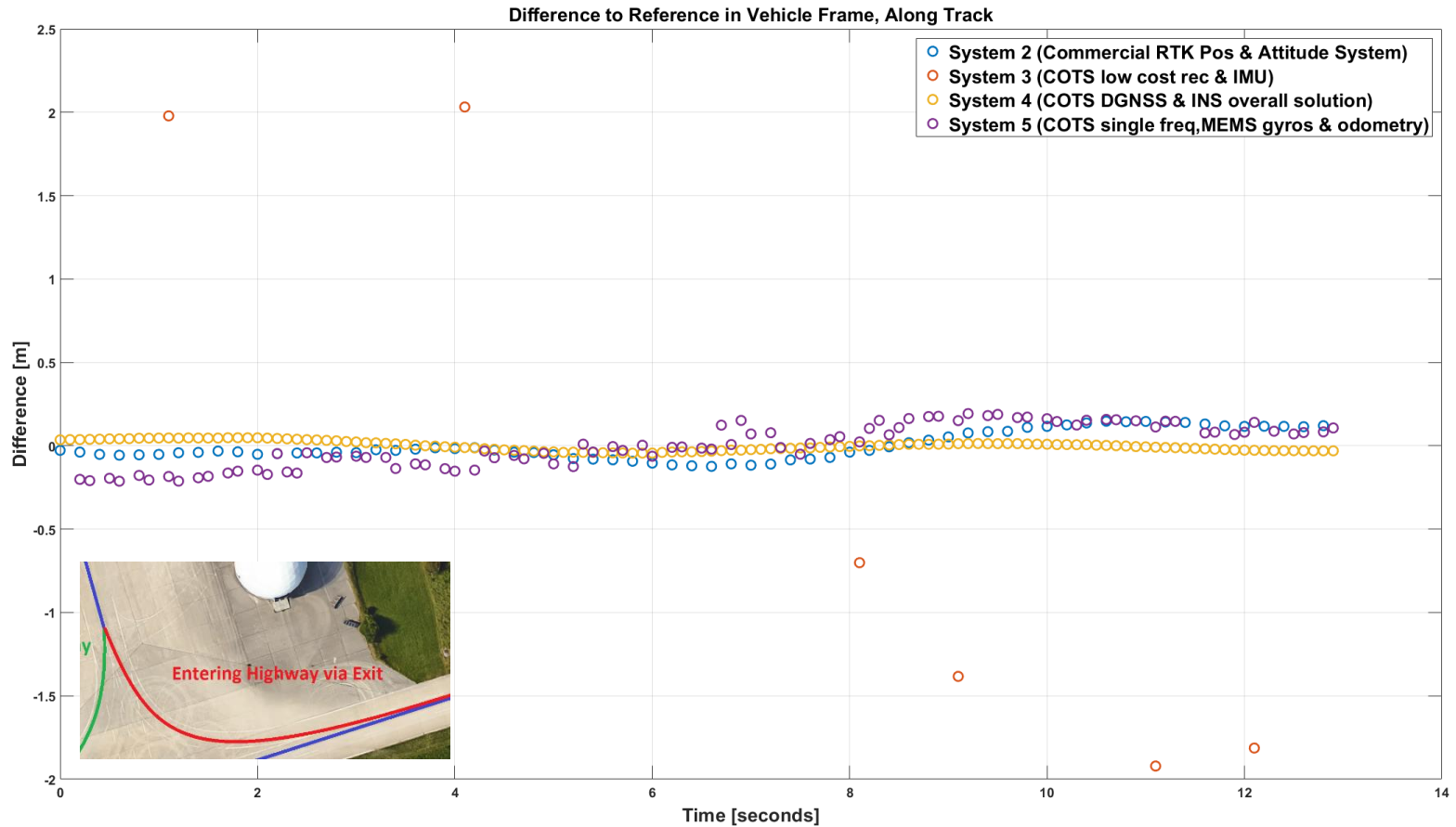
- COTS multi frequency (GPS/GLO triple, GAL/BEI dual) DGNSS (RTK) coupled with INS (strapdown)

System 5:

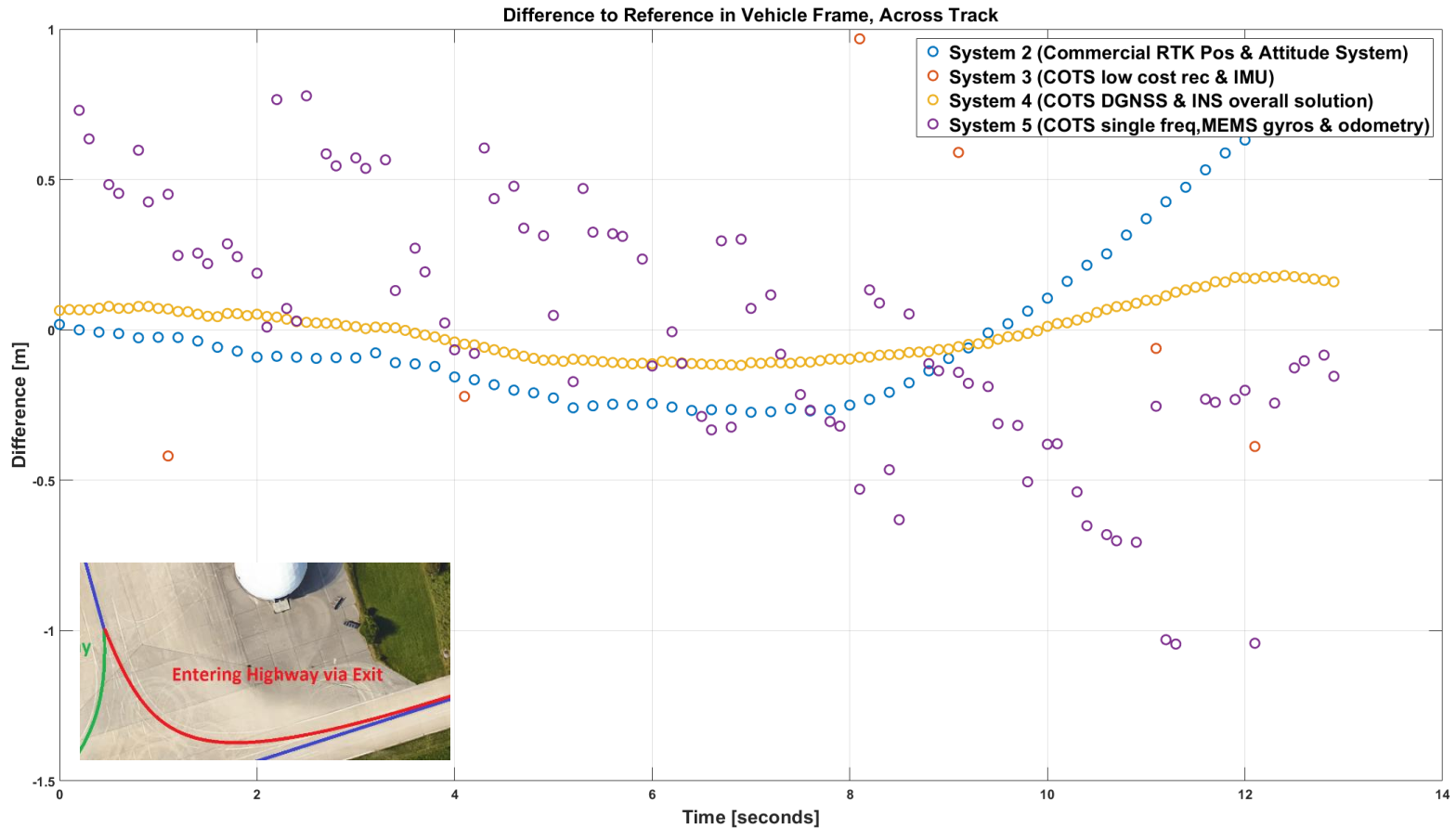
- COTS single frequency GNSS (L1) coupled with MEMS gyros and vehicle odometry (dead reckoning)



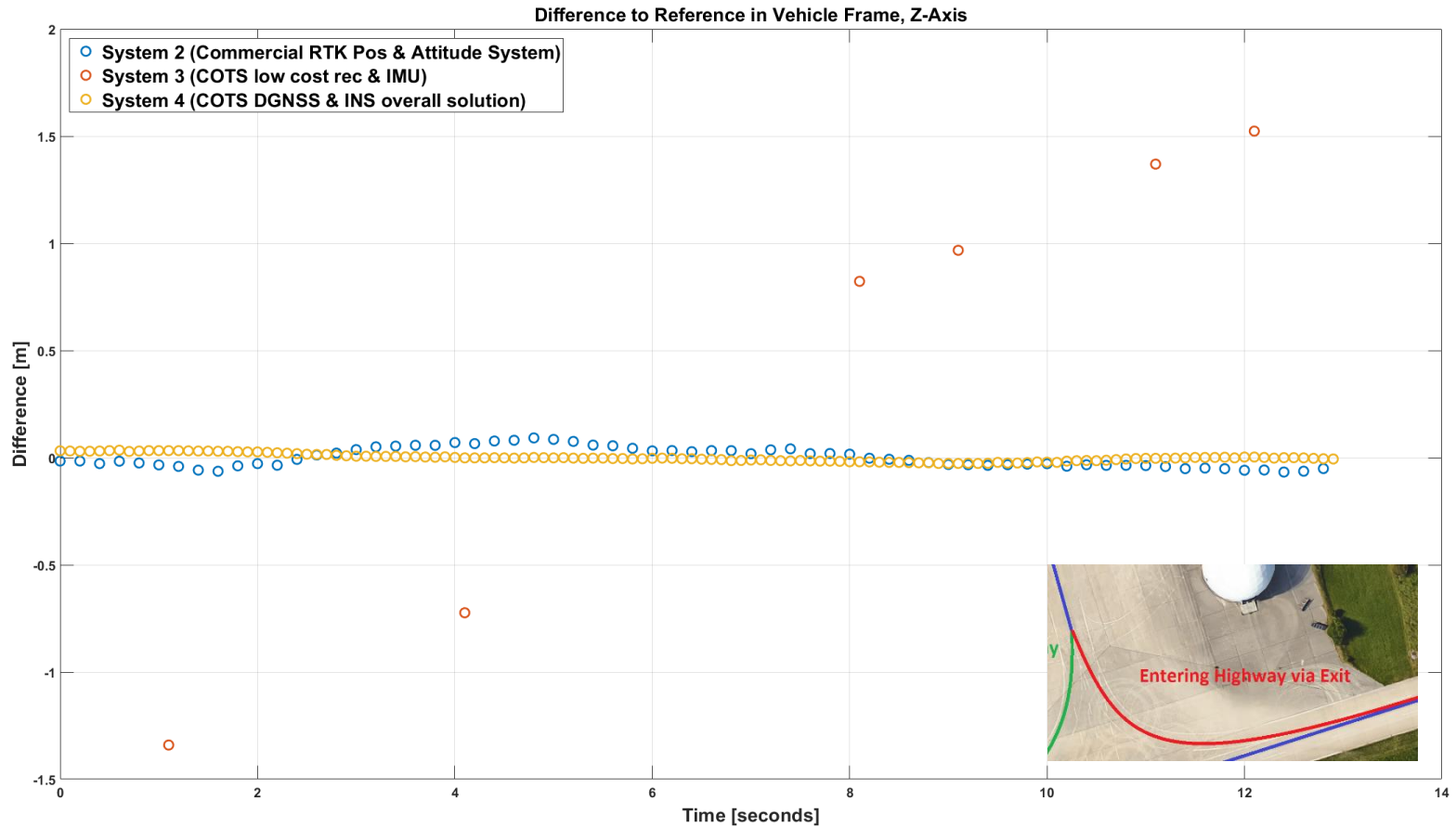
Performance Scen. 1, Along Track



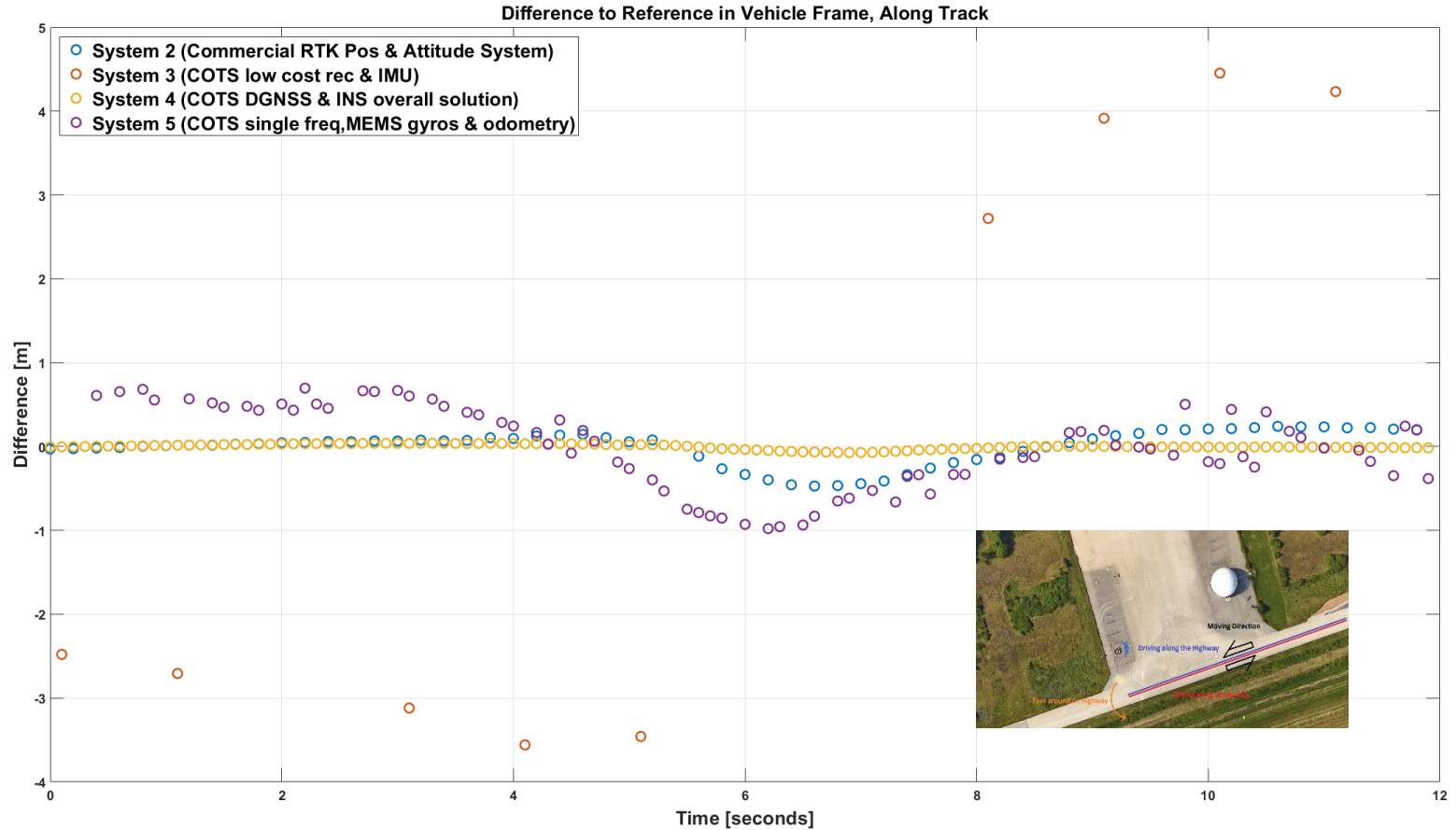
Performance Scen. 1, Across Track



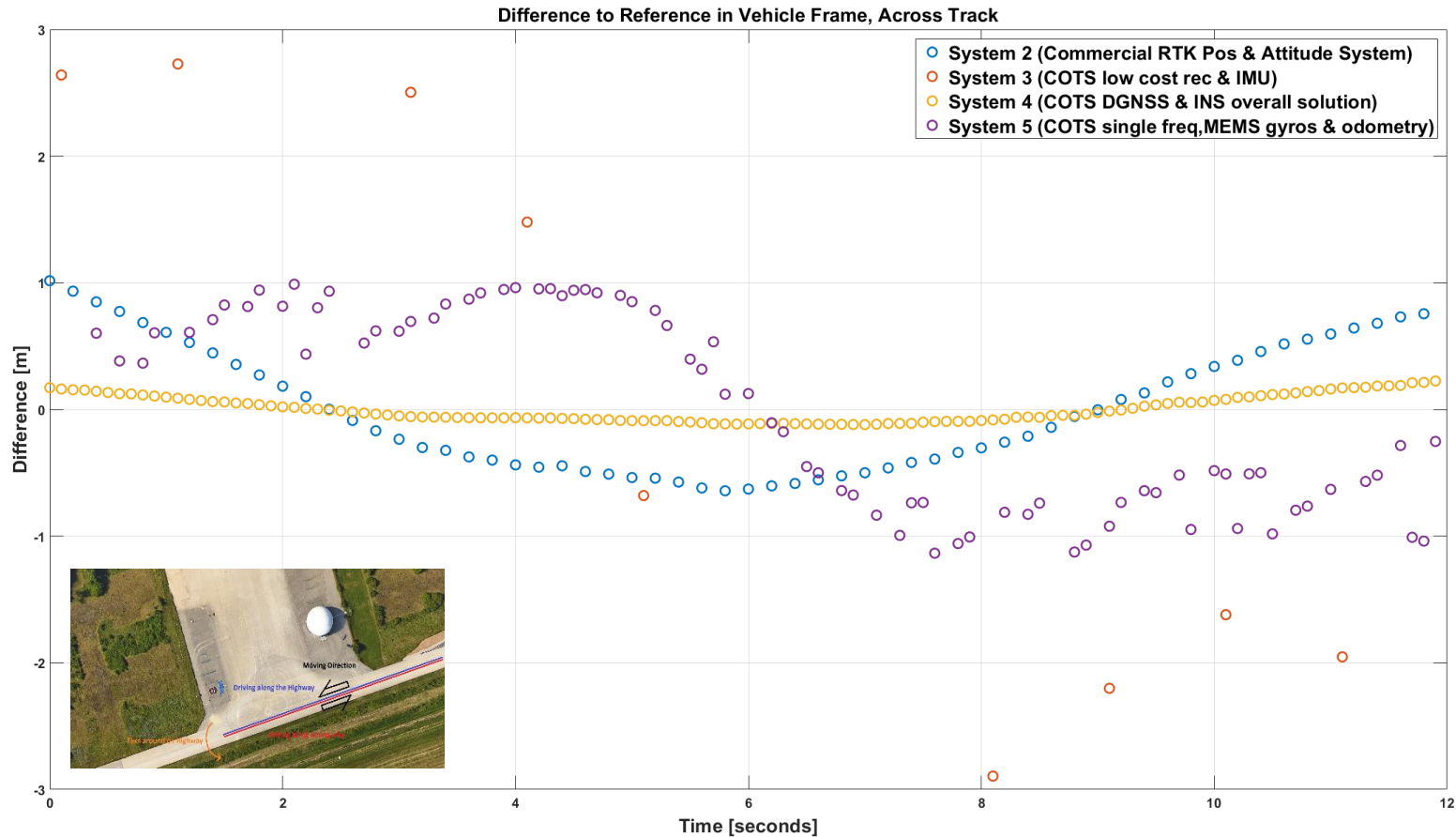
Performance Scen. 1, Z-Axis



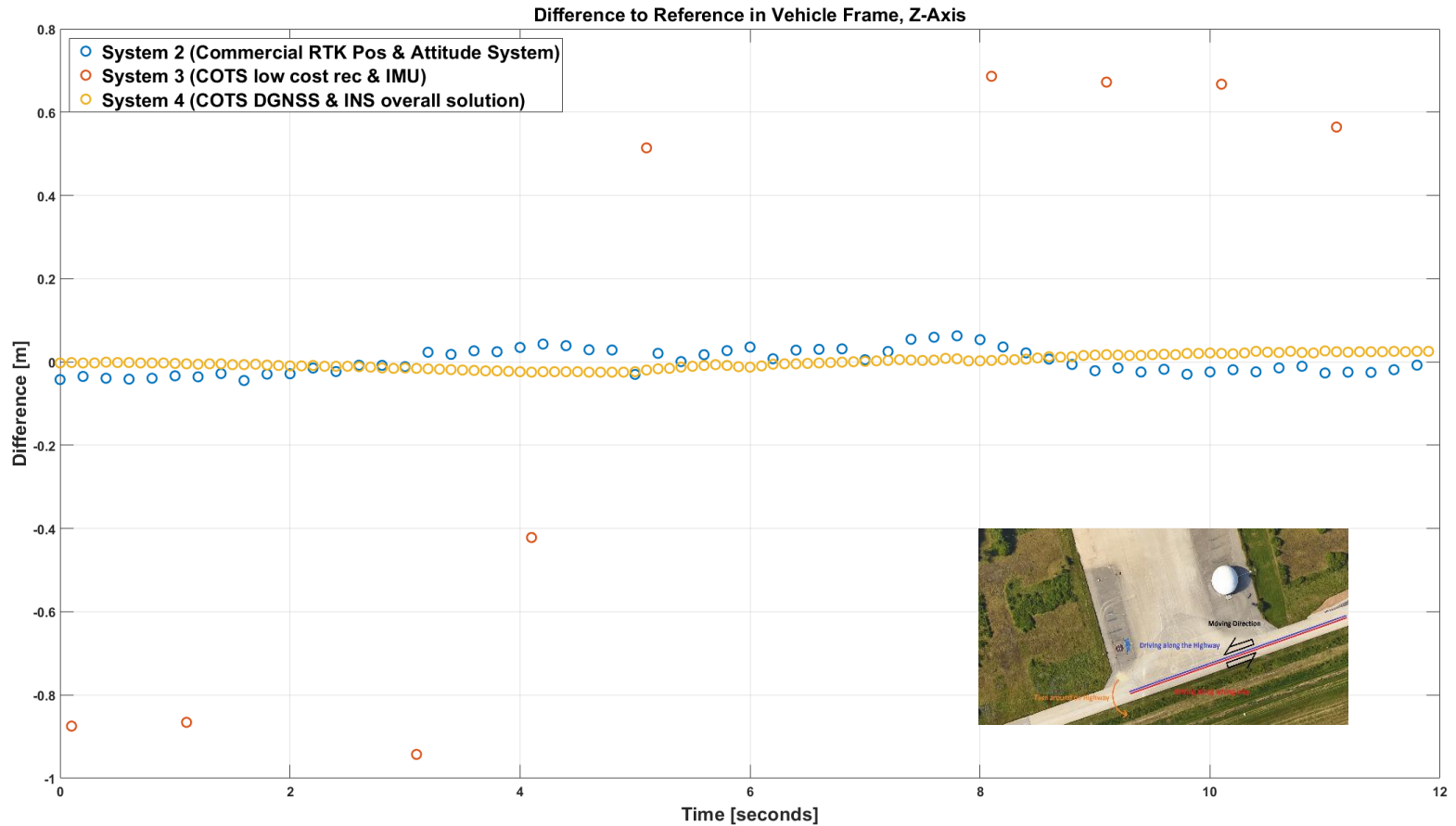
Performance Scen. 2, Along Track



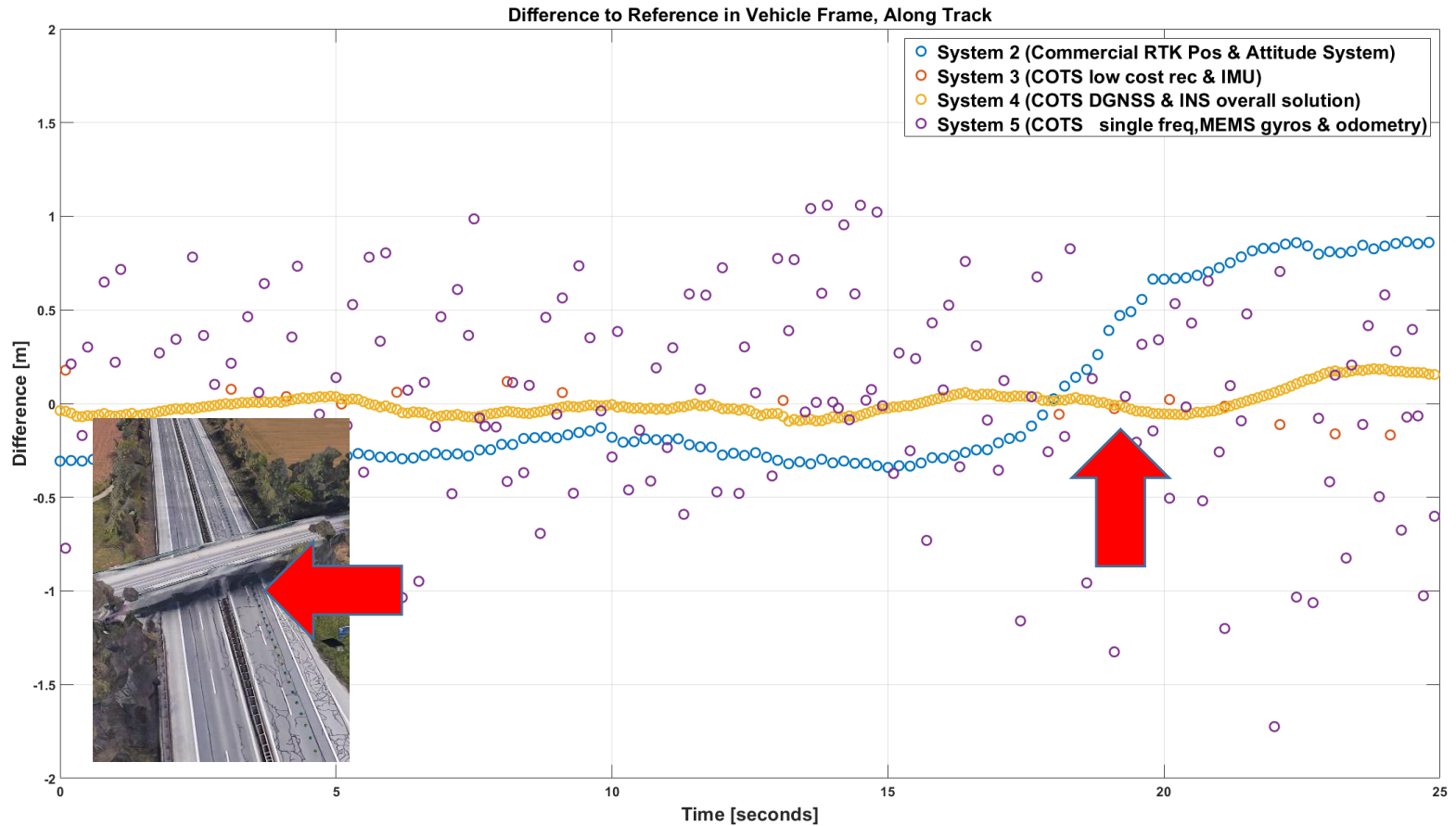
Performance Scen. 2, Across Track



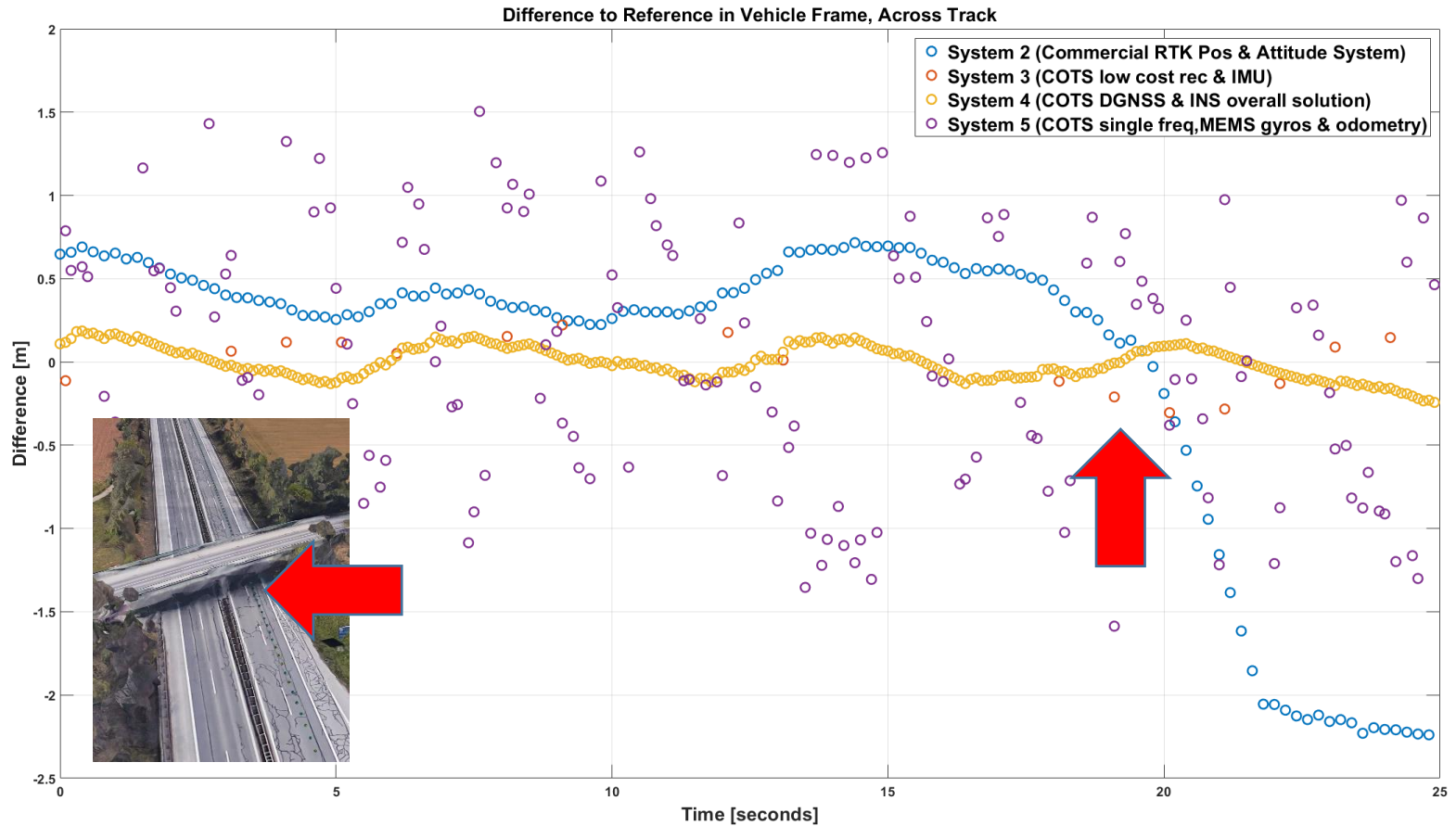
Performance Scen. 2, Z-Axis



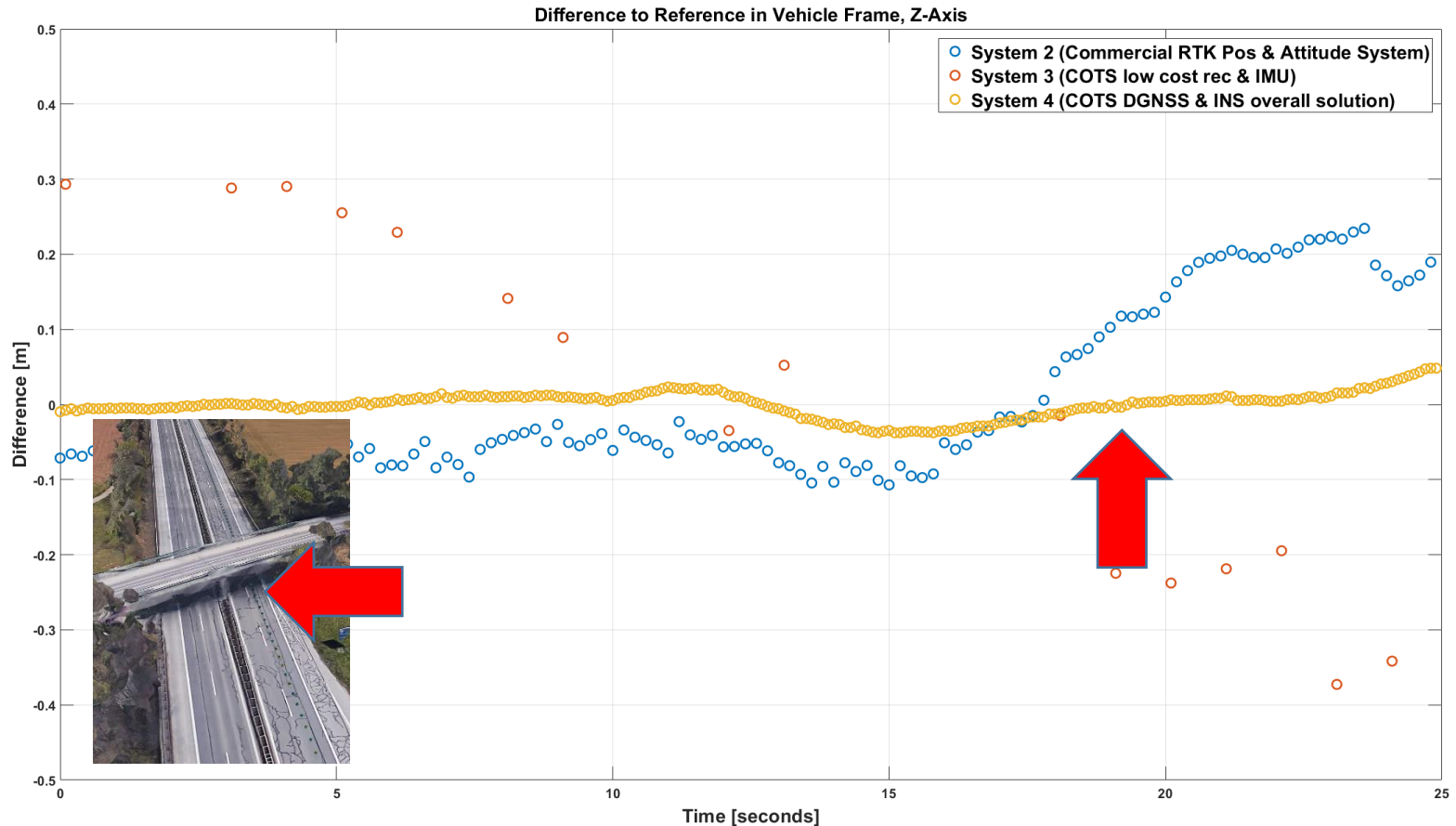
Highway Drive – Along Track



Highway Drive – Across Track

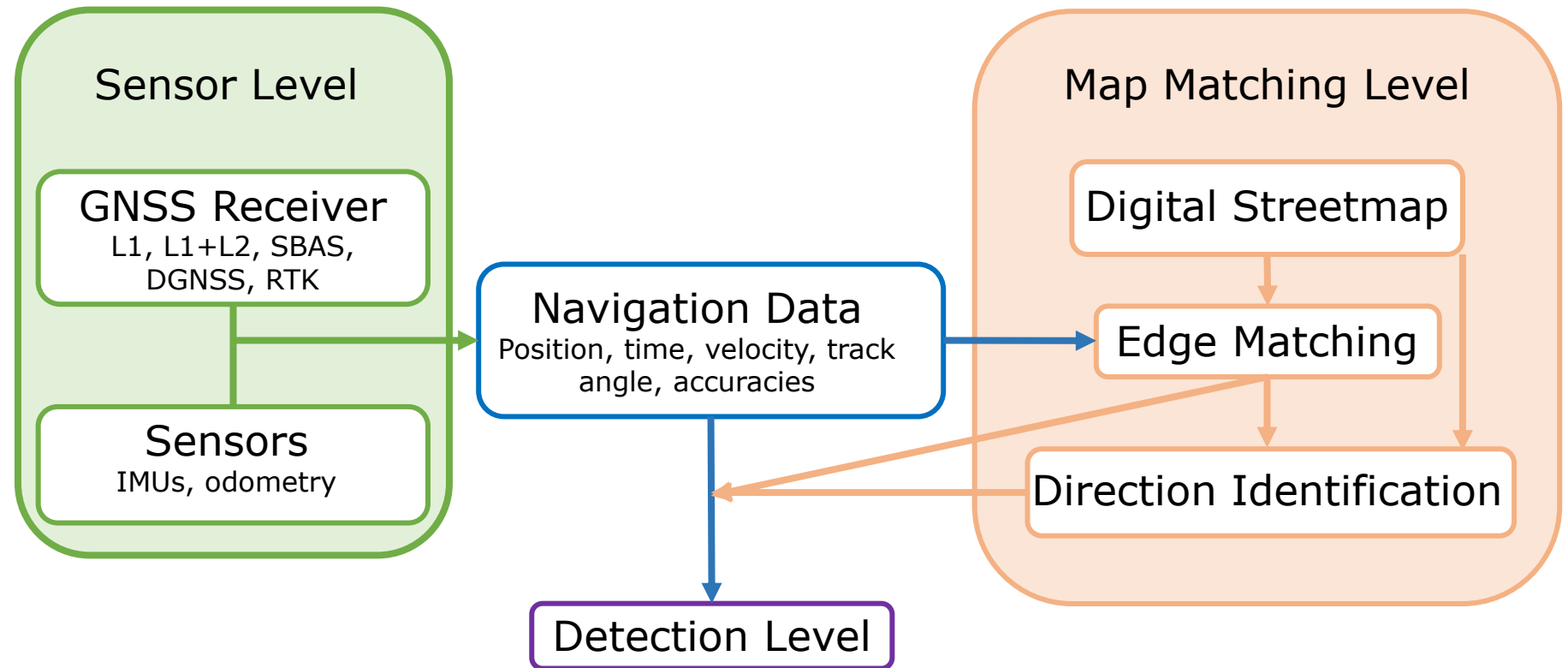


Highway Drive – Z-Axis



System 3 measurements due to sampling issues not included in the following wrong-way driving detection evaluation

Overall Detection Process



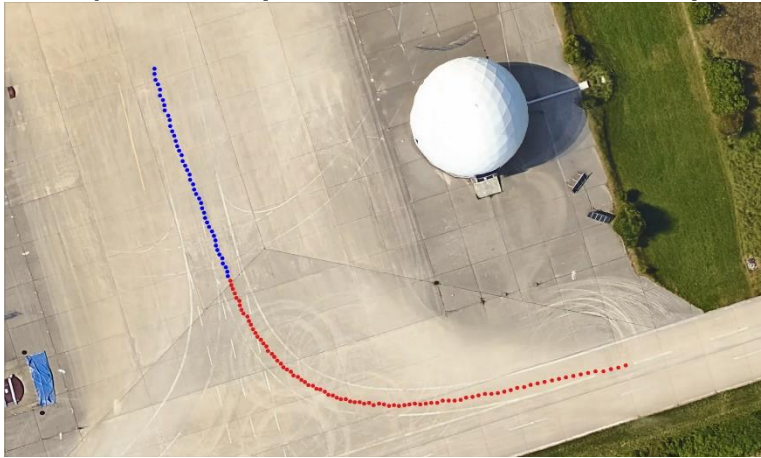
● OK

● Possible wrong way

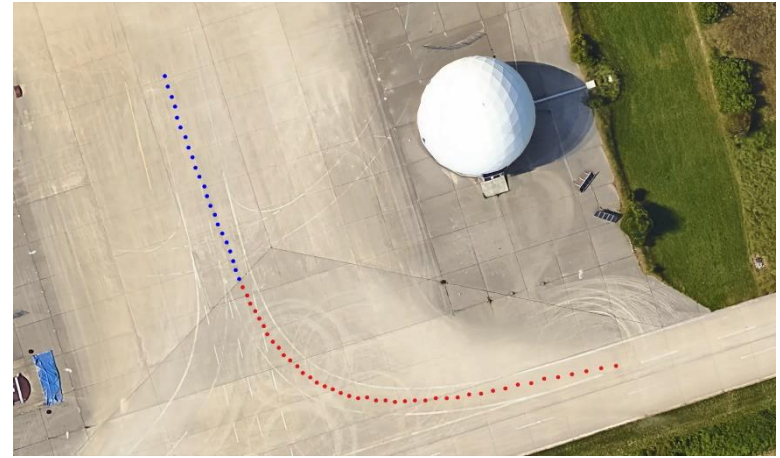
● Wrong Way

Detection: Sys. 1,2,4,5 (Scenario 1)

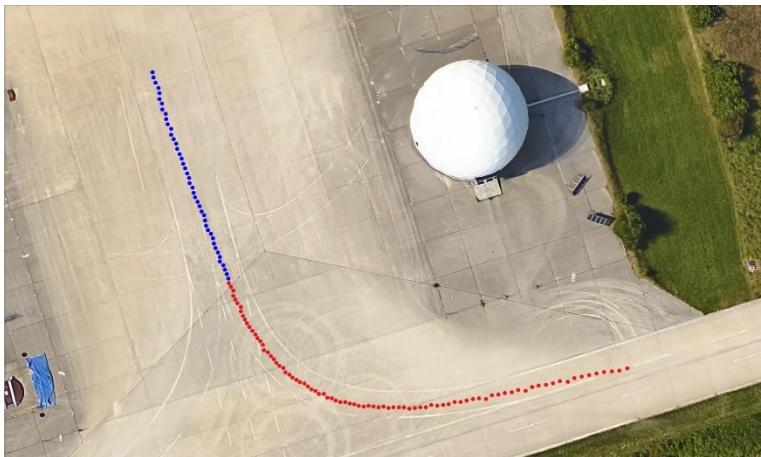
System 1 (RTK, Tactical FOG IMU)



System 2 (RTK Pos & Attitude System)



System 4 (DGNSS & INS solution)



System 5 (single freq., MEMS gyros & odometry)

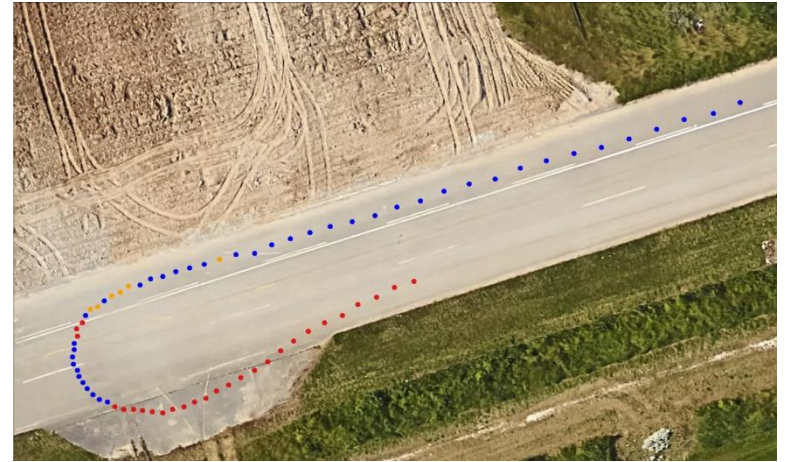


Detection: Sys. 1,2,4,5 (Scenario 2)

System 1 (RTK, Tactical FOG IMU)



System 2 (RTK Pos & Attitude System)



System 4 (DGNSS & INS solution)



System 5 (single freq., MEMS gyros & odometry)



Evaluation Summary

- On a clear course towards a multi-system testing platform/vehicle
- Work-in-progress, still issues in the sensor setup and synchronization of the measurements on board the vehicle
- Promising results for the wrong-way driving detection with nearly every sensor system



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Universität  München

Contact

Andreas Schütz

Institute of Space Technology and Space Applications

Universität der Bundeswehr München

Email: andreas.schuetz@unibw.de

Phone: +49 (0)89 6004 4038

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