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Using Galileo services for highly automated inland vessels

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Requirements for Provision of Position – Navigation and Timing Data



- Horizontal Passing a waterway lock
- Vertical Bridge passing



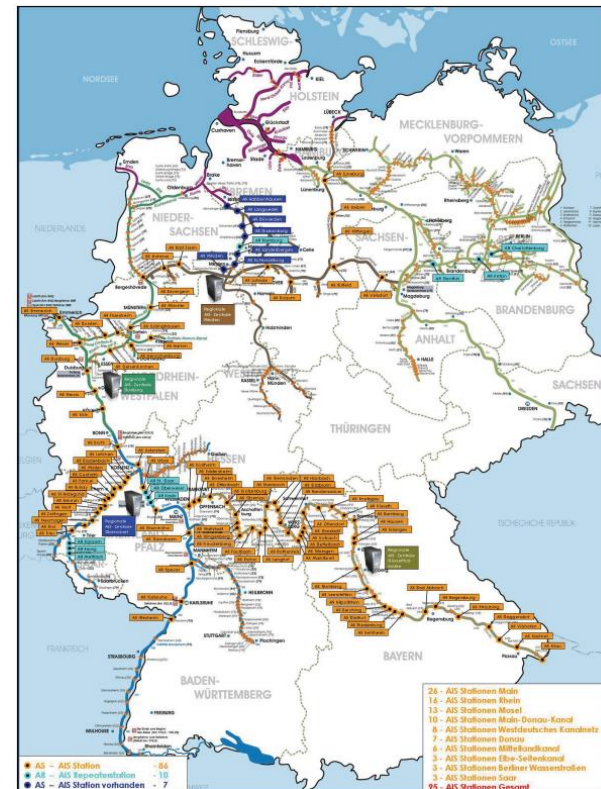
=> dm horizontal



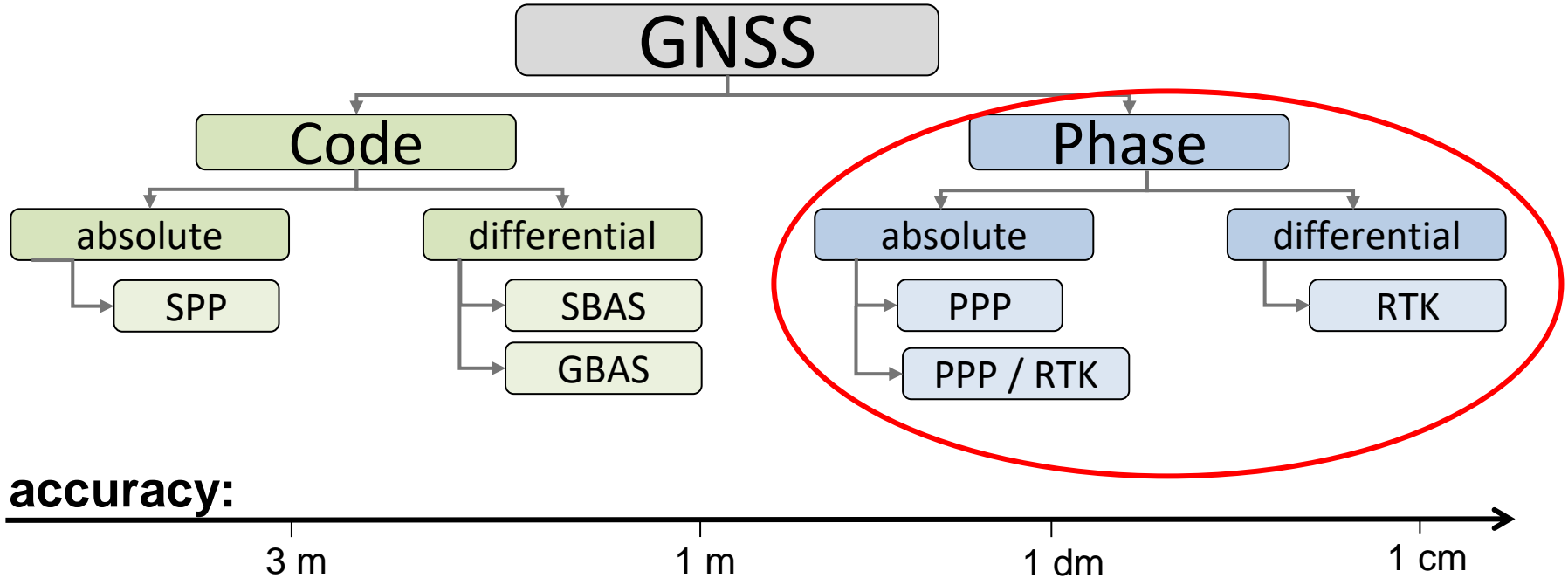
=> dm vertical

=> GNSS correction data required, should be provided by communication channel available on inland waterways

=> AIS / VDES Station network or satellites



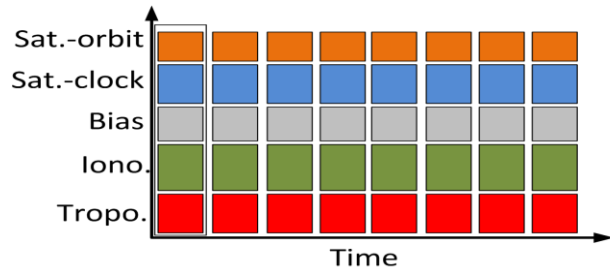
Satellite based PNT for inland navigation: Overview



Kind of Correction data for precise GNSS positioning

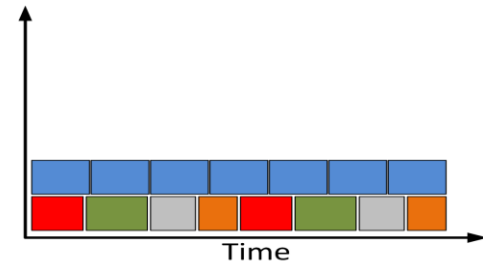
Real Time Kinematic (RTK)

- OSR (Observation state representation)
- For every observation one correction (every frequency, every satellite)
- Big amount of data (> 3 kbits/s)
- Requires two way communication
- Standardized (RTCM 3.1x)



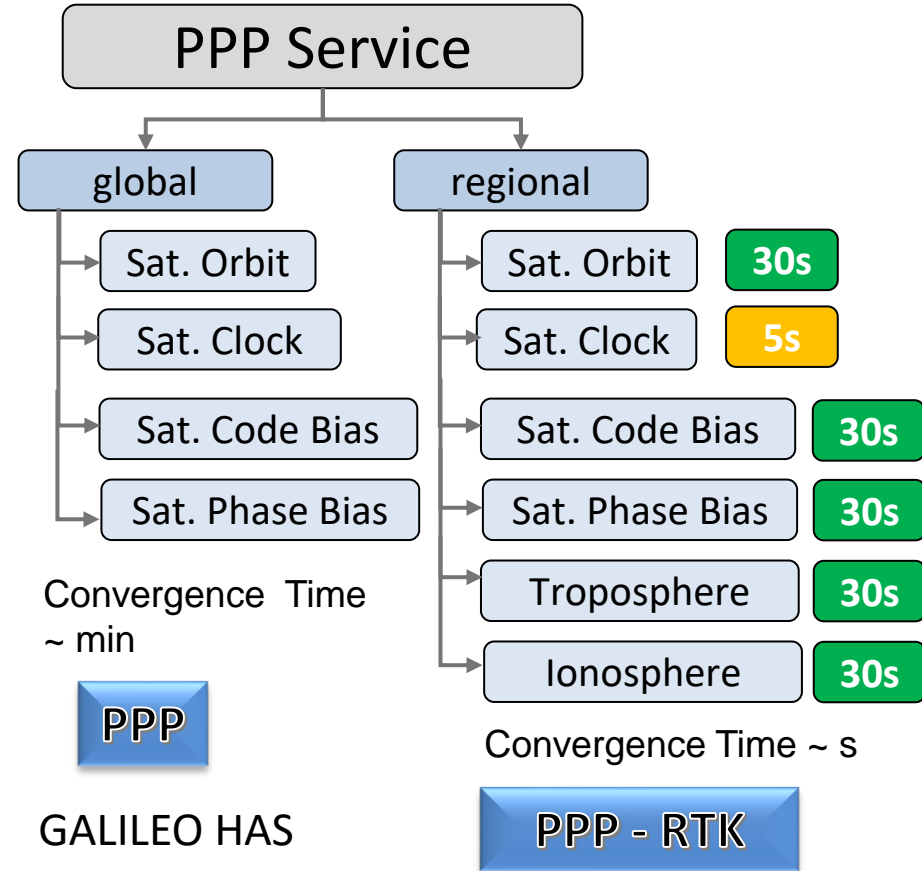
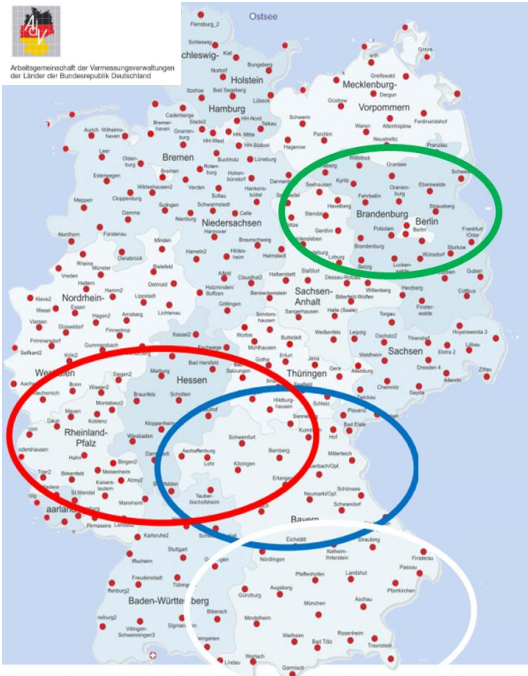
Precise Point Positioning (PPP)

- SSR (Space state representation)
- Split in different error components (clock, orbit, atmospheric)
- Less amount of data (< 1 Kbits/s)
- Broadcast capable
- Not (full) standardized



PPP Service provision

Cooperation with SAPOS Germany for PPP-RTK



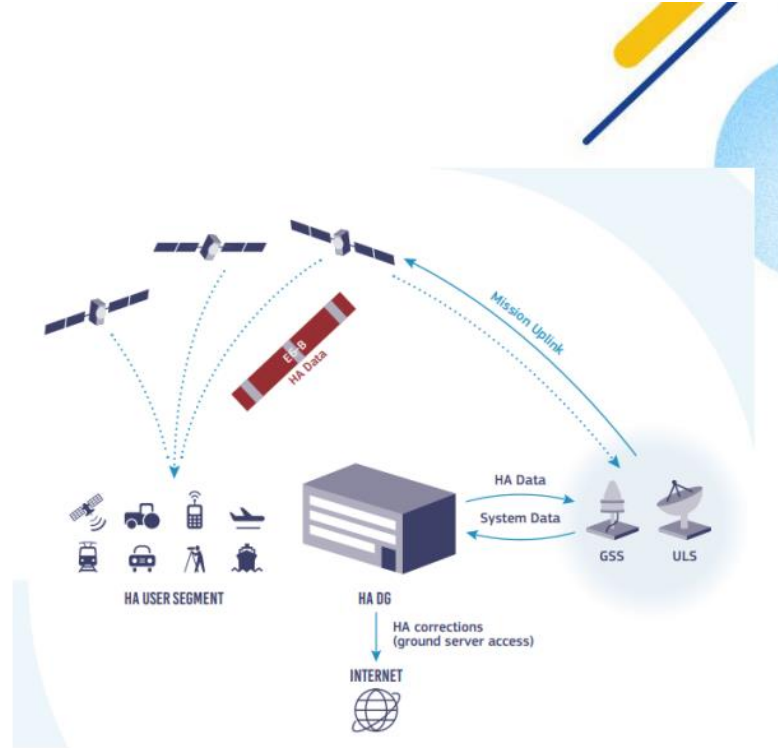
GALILEO High Accuracy Service (HAS) worldwide PPP Service

WHAT IS THE GALILEO HAS

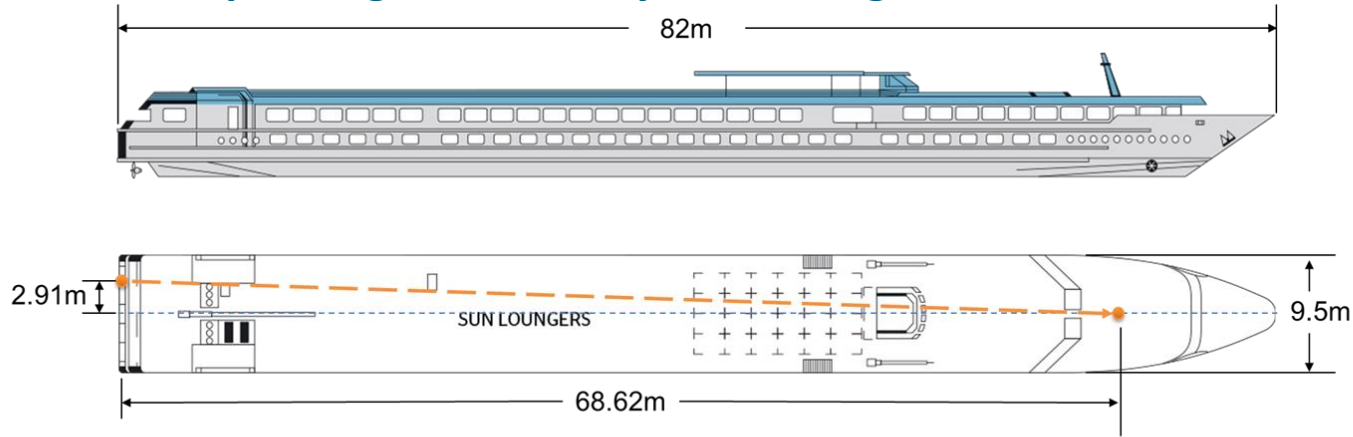
- Galileo HAS provides precise corrections for satellite orbit, clock and signal biases
- Galileo HAS corrections distributed via
 - Galileo satellites, E6-B signal (1278.75 MHz)
 - Internet
- Typical accuracy in the decimetre level (after convergence), with Precise Point Positioning (PPP) receivers
- (Almost*) global coverage and free

Target accuracy: 20cm (horizontal 95%)

Convergence time: 300s



Automatic passing a waterway lock using RTK/PPP with ,MS Victor Hugo'



Stern Antenna



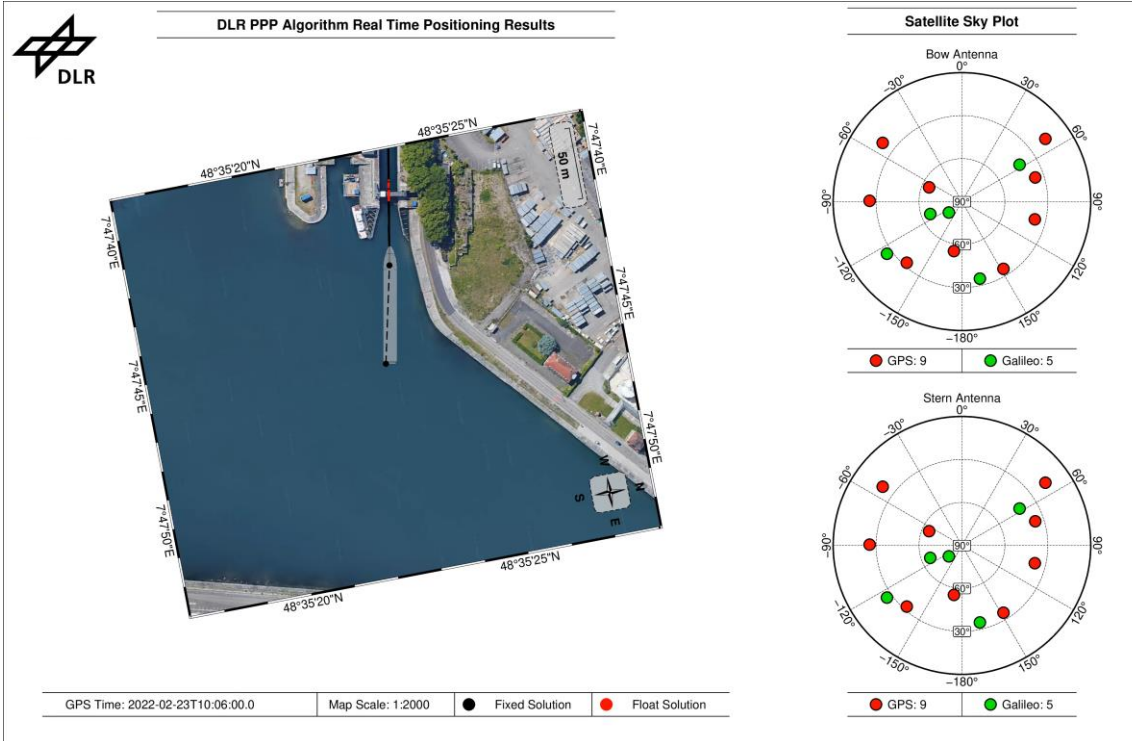
Receiver + PNT Unit



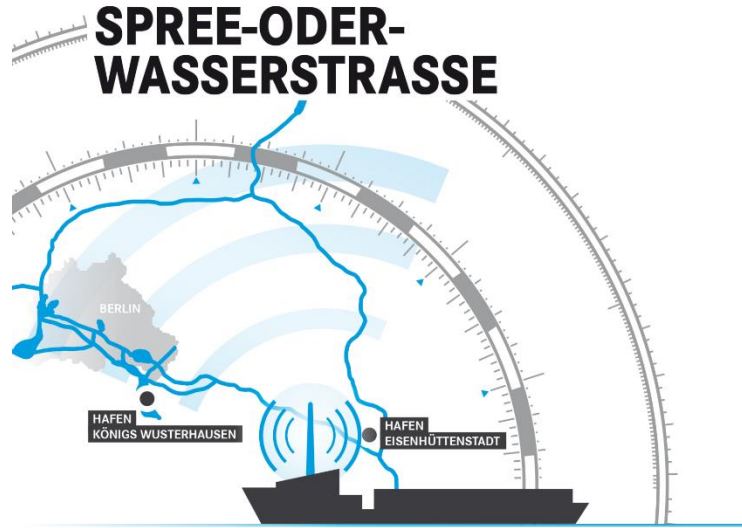
Bow Antenna



First automated entering of a waterway lock using PPP/RTK GALILEO+GPS

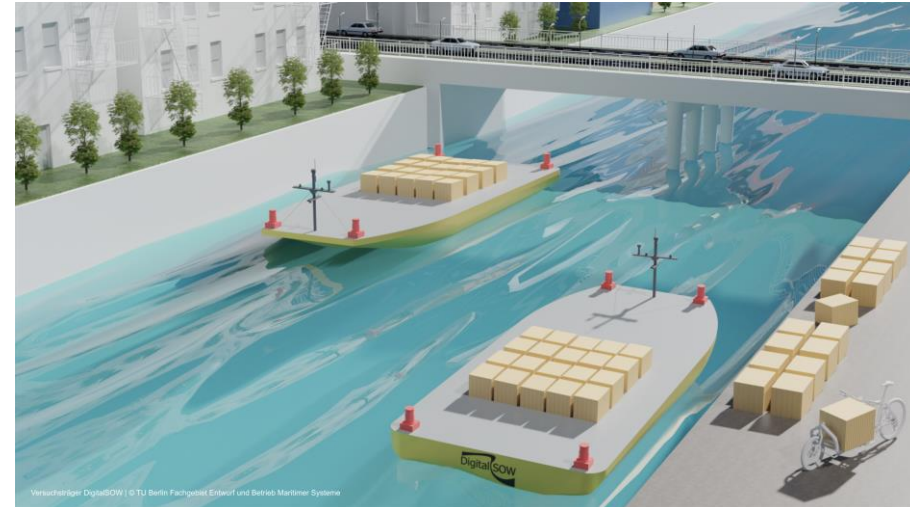


Digital Testbed on Spree-Oder-Waterway

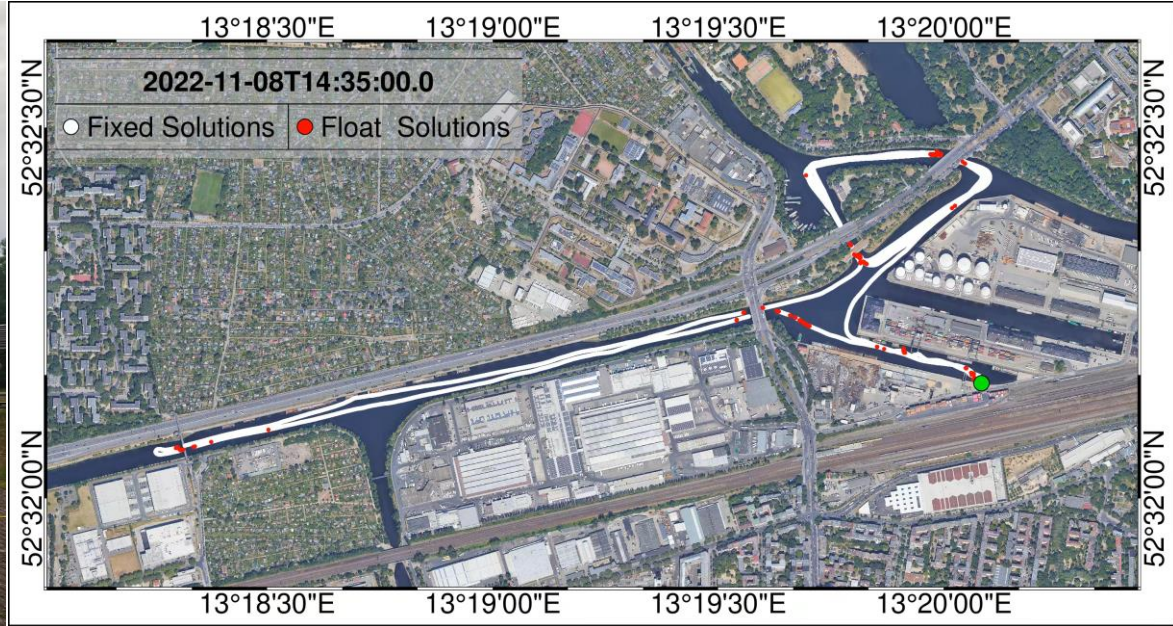
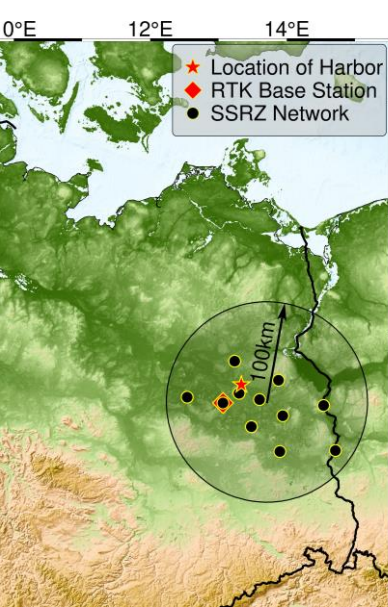


- Autonomous transport with new types of ships and new types of cargo
- Self-organizing
- Part of intermodal logistics chains (e.g. between two logistics centers)

- includes canals, rivers, lakes locks
- limited traffic volume
- proximity to Berlin => potential application for city logistics



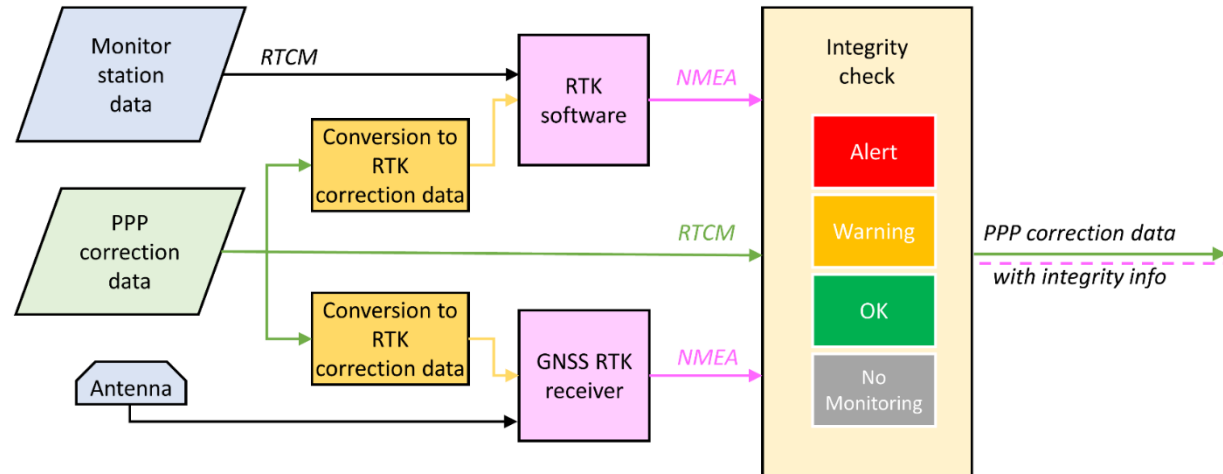
Validation of PPP-RTK in the Digital Testbed on the Spree-Oder-Waterway in Berlin



Shoreside Integrity concept for PPP / RTK service

- Check of the PPP-RTK correction data (Pre-Broadcast Monitoring)
 - Effect of the correction data checked before transmission
 - SSR2OSR converter needed due to lack of PPP-RTK capable receiver
 - RTK positioning of an independent GNSS monitoring station
 - Software- or hardware-based solution
 - Flow diagramm:

For details see exhibition



Using GALILEO HAS Service for inland vessels

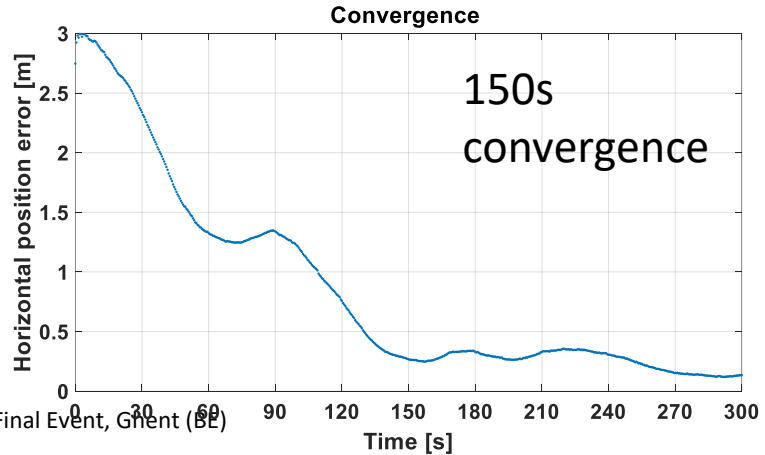
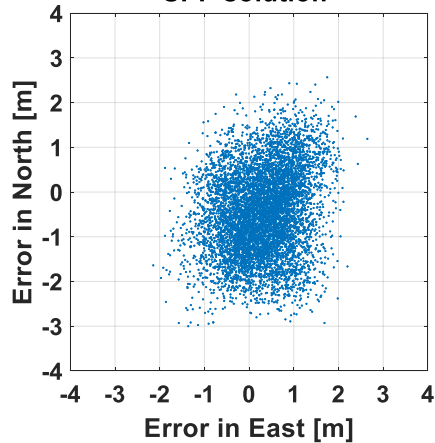
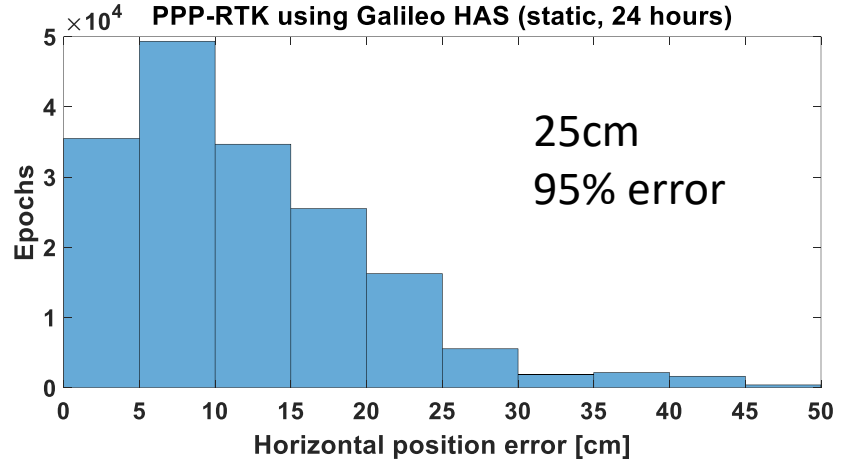
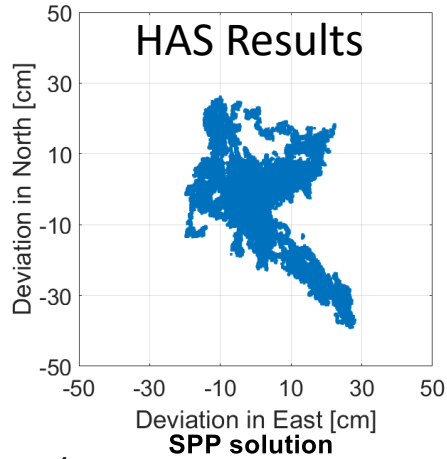
Goal:

Steering autonomous vessel by using GALILEO HAS positioning

Development steps

- Adapting DLR own PPP algorithms to the usage of GALILEO HAS
- Using GALILEO HAS over TCPIP
- Performing static + dynamic tests

First Galileo HAS Results : static results 24h

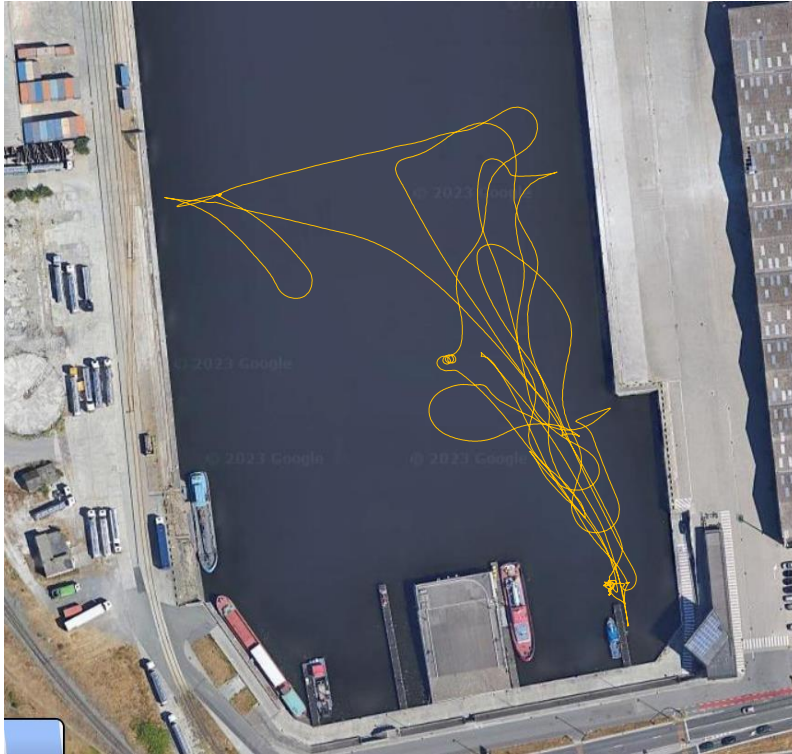


Integration of DLR GALILEO HAS positioning with KUL sensor box



- Sensorbox: Septentrio RTK positioning (benchmark)
- Splitter of antenna signal to DLR Galileo HAS positioning
- DLR NMEA results via TCP/IP to sensorbox

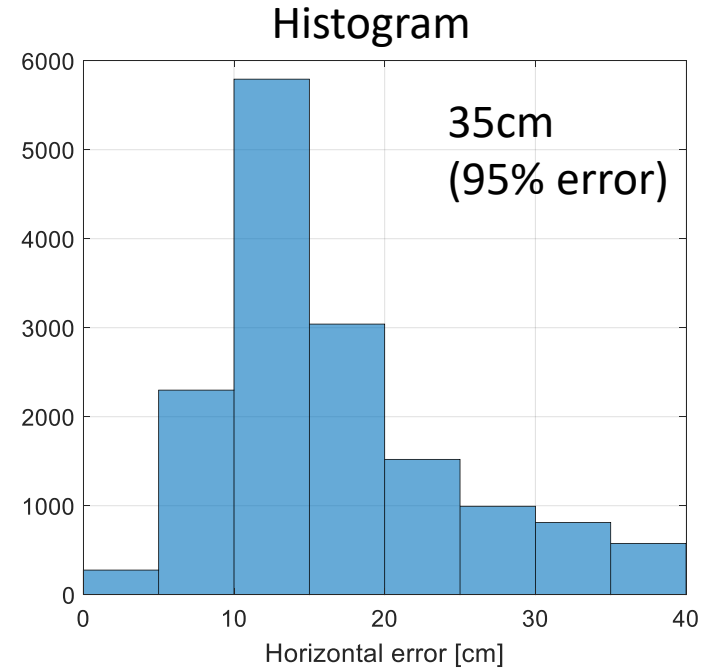
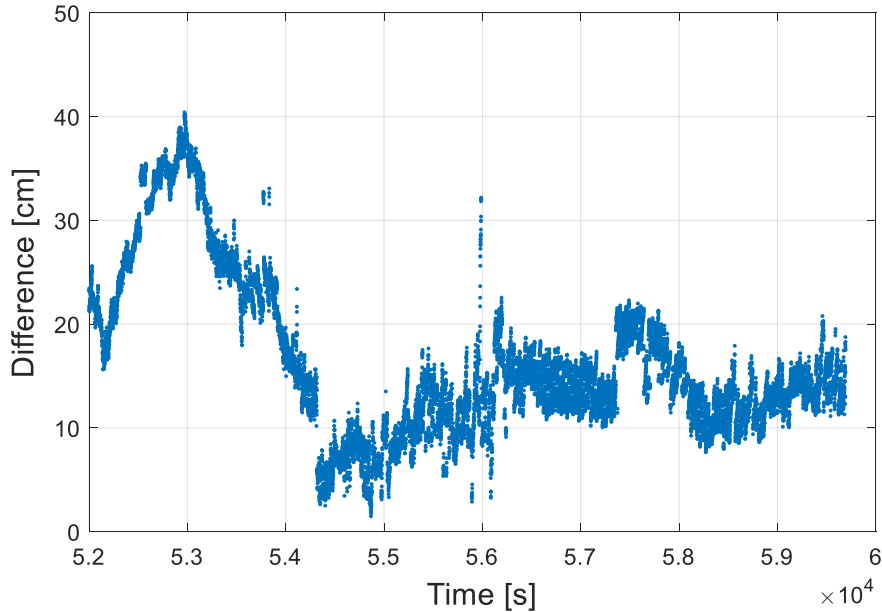
Galileo HAS dynamic results with KUL vessel in Ghent



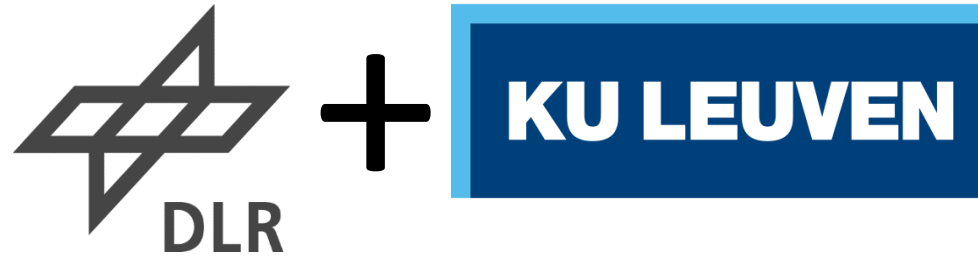
Challenging environment with obstructions and multipath from other vessels and port infrastructure

Galileo HAS dynamic results with KUL vessel in Ghent

- Positioning results using RTK as reference (first fast analysis)



Automated steering of an inland vessel using Galileo HAS Service



Yes we made it 😊

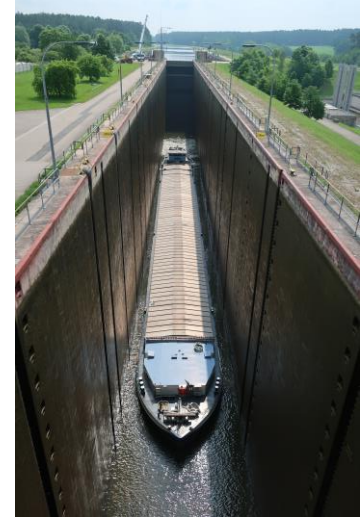
First time realized 2023/10/11

Live Demo today

Summary & Outlook

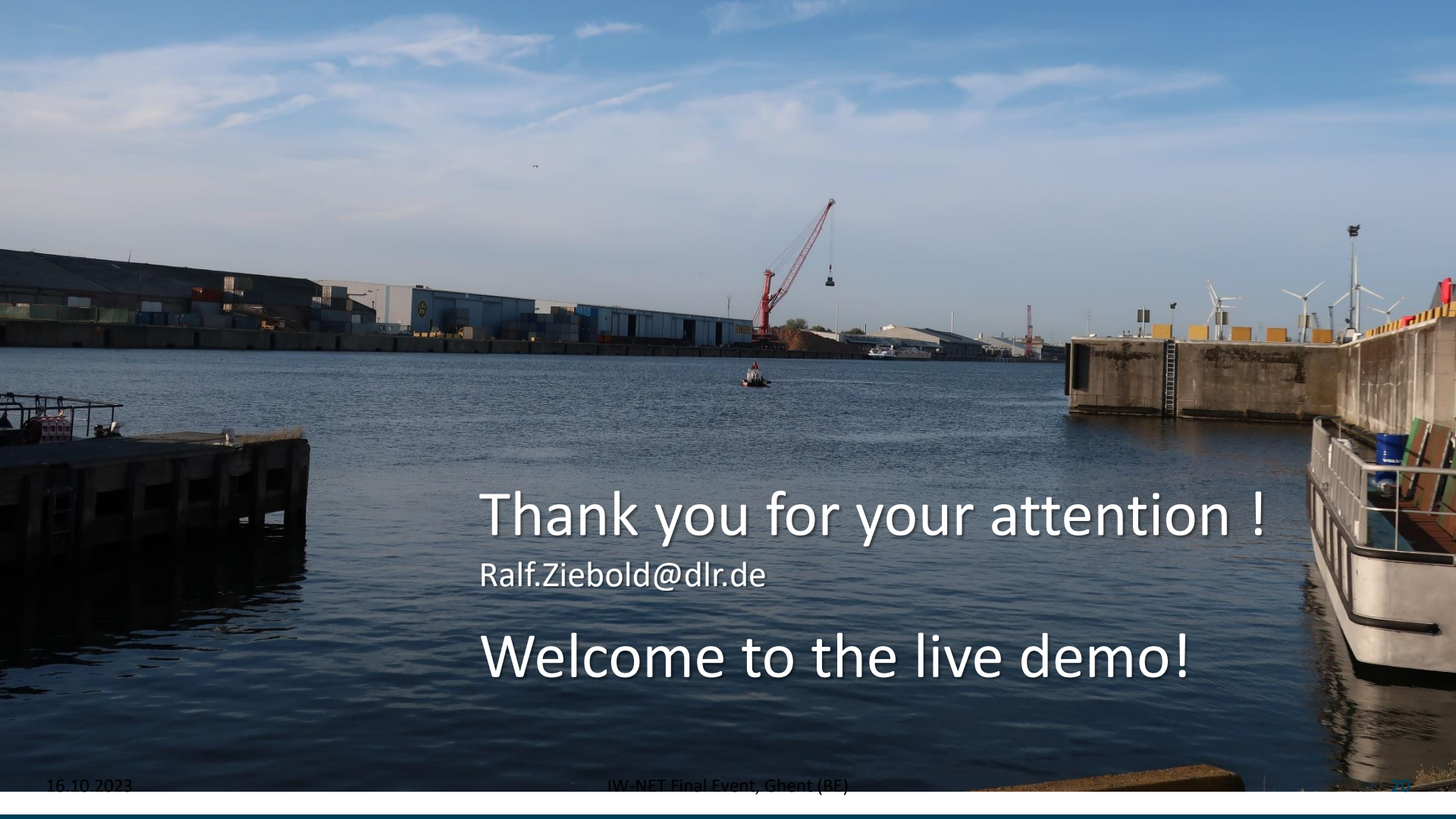
GALILEO services are a key enabler for inland vessel automation

- Increasing number of usable satellites
=> important for areas of decrease satellite visibility
- Enabling PPP-RTK with SAPOS service for advanced driver assistant functions
- High Accuracy Service:
=> world wide available service
20-30cm accuracy
=> enables automated steering of vessels
limitations due to long convergence



Outlook

- Galileo HAS implementation in commercial receivers soon
- GALILEO HAS phase two: incl. local corrections for Europe: reduction of convergence
- SAPOS PPP-RTK German wide service development
- Integrity for phase based positioning



Thank you for your attention !

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Welcome to the live demo!