Neue Konzepte für die Nutzung von Globalen Navigationssatellitensystemen (GNSS, inklusive Galileo) in Häfen

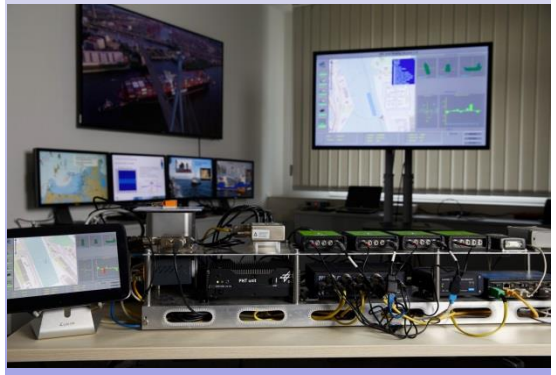
Dr. Ralf Ziebold
Institut für Kommunikation und Navigation
Abteilung Nautische Systeme

Gliederung

- Kurzvorstellung Abteilung Nautische Systeme
- Maritimes Adaptives GNSS Sicherheitskonzept für Hafenanwendungen
- Hochgenaue Positionierung in Häfen und Binnenwasserstraßen

Institute of Communication and Navigation

Nautical Systems

WG	Multisensorsystems	Maritime Services	Traffic Surveillance
work content and topics	- Robust and reliable PNT data provision (Integrity) - PNT Unit - Sensor fusion	- Maritime Backup Positioning Service R-MODE - Integrity monitoring by augmentation systems	- AIS Monitoring/Plausibility - Target detection and tracking (Radar) - Fusion of AIS & Radar
			
Facilities	Real Time Multi-Sensor Framework (SW-Toolbox)		
	MGBAS in Research Port Rostock; R-Mode Testbed in the Baltic		
	Vessel “Baltic Taucher 2”, test systems like ECDIS, Radar, AIS		

Maritime Adaptive GNSS Safety Concept

MAGS
Maritime Adaptive GNSS Safety Concept

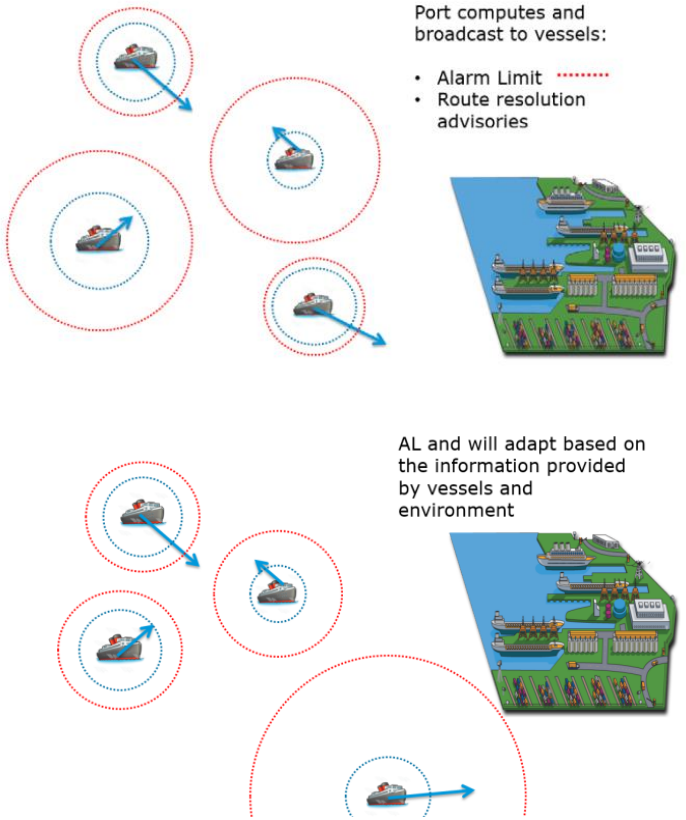
esa

Type of Project: ESA funded project – General Studies Programme

Consortium: DLR (Lead), MUS, UL and SIRM-UK (Subcontractors)

Duration: 18.6.2018 – 18.12.2019 (18 month)

Main Goal: Definition of a new maritime GNSS SoL service based on an adaptive safety concept



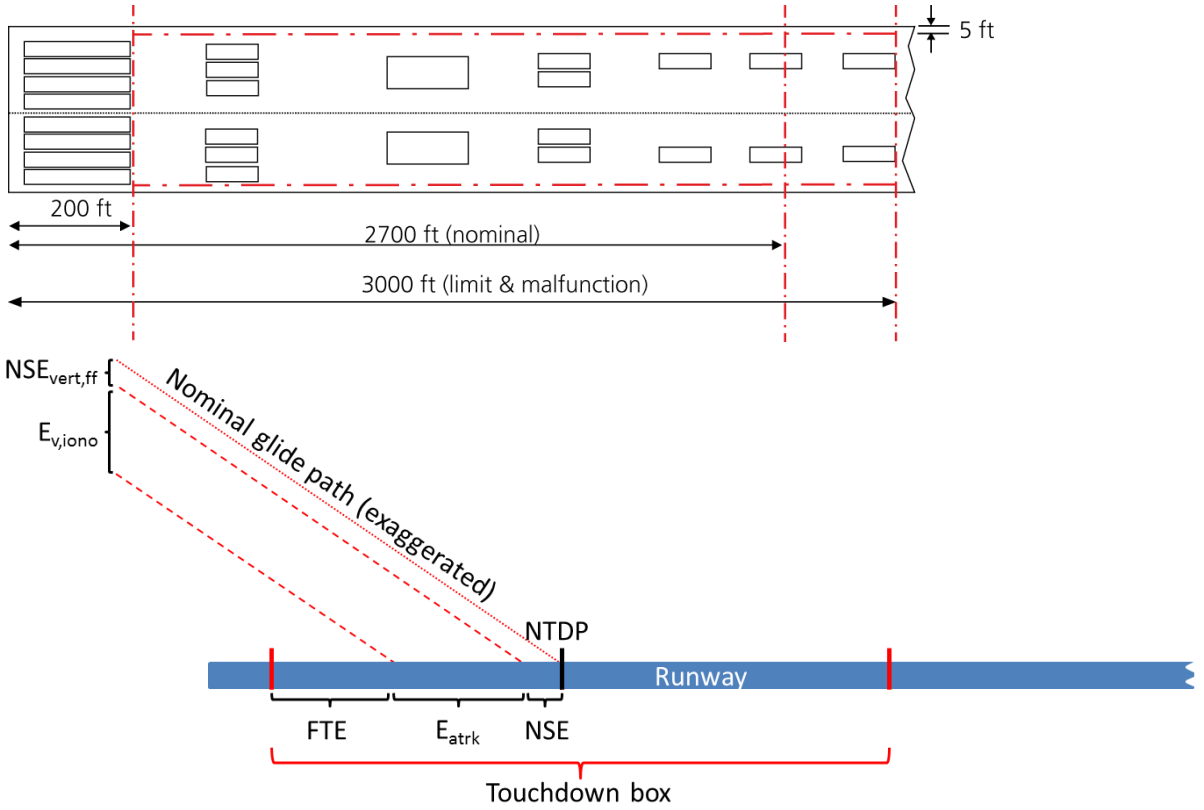
Source: ESA Statement of Work – Maritime Adaptive GNSS Safety Concept (MAGS))

DLR
University of Ljubljana
AKADEMIA MORSKA SZCZECIN
sirm

Existing GNSS safety concepts

- Fully developed GNSS safety concept only for aviation
  - Largest similarities: automatic landing

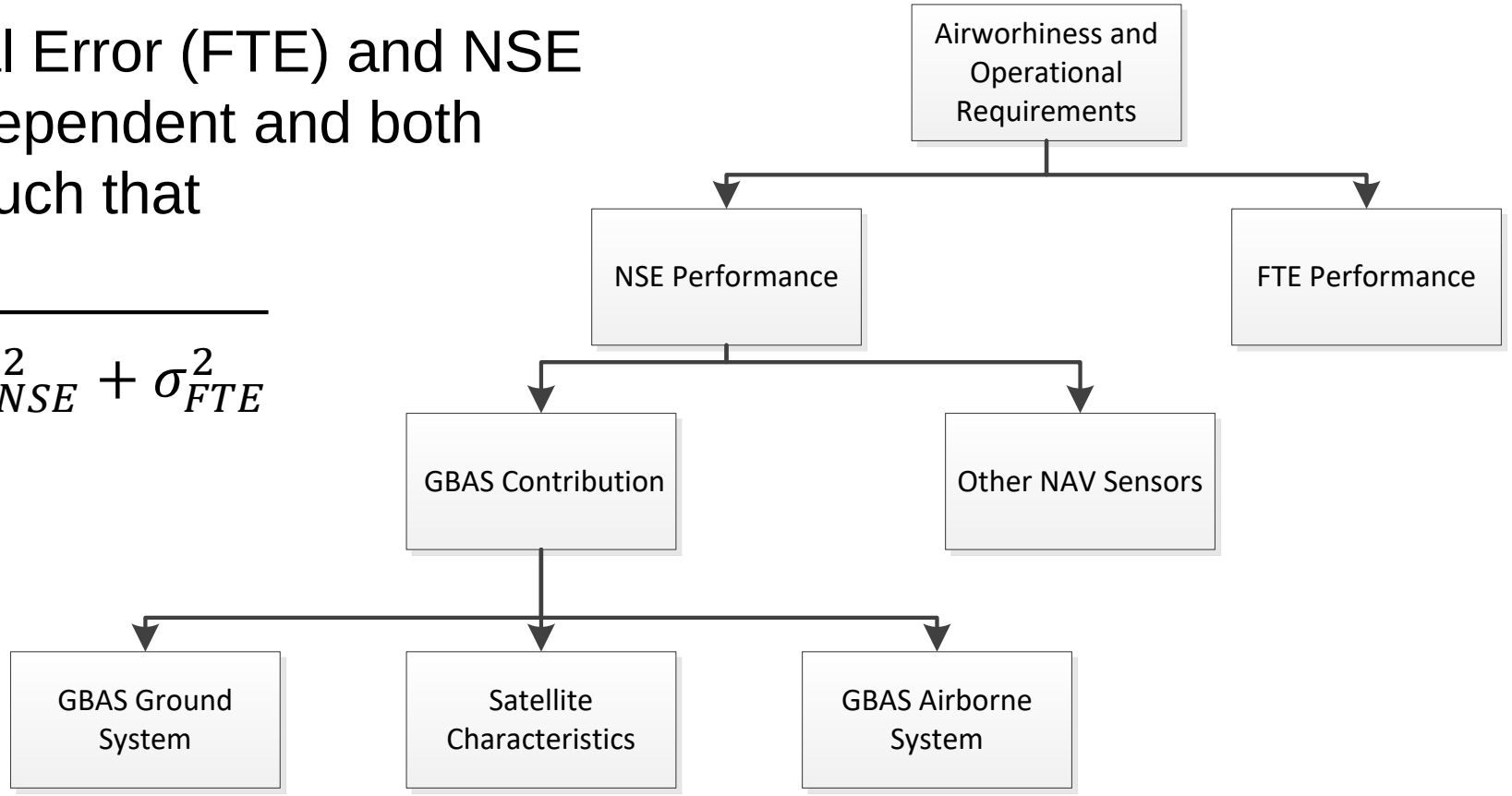
Aicraft has to touch down within pre-defined area on the runway with given probability



Aviation: Allocation of errors between different systems

Aircraft Flight Technical Error (FTE) and NSE are assumed to be independent and both Gaussian distributed such that

$$\sigma_{TSE} = \sqrt{\sigma_{NSE}^2 + \sigma_{FTE}^2}$$



Conclusions for maritime applications

Challenges

Aviation	Maritime
• No obstacles	• Possibility of grounding, walls, other vessels ⇒Multiple vessels have to be taken into account
• Open sky conditions	• Multipath due to infrastructure or other vessels
• Few types of aircrafts ⇒ Flight technical error easy to derive	• A lot of different types of vessels
• Positioning as a single point	• Positioning + Heading of vessel as 2D object
• Autopilot ⇒ Deterministic output	• Captain ⇒ Non-deterministic output, upper limit for error budget difficult

Definition of MAGS application for port operation

- Current state of the art navigation in ports
  - Navigation using lookout, shipborne + shore based RADAR, GNSS

- Possible application of MAGS
  - *Navigation in ports under bad visibility conditions*
    - Potential benefits:
      increasing safety, enabling of higher traffic density (efficiency), Less infrastructure ?

  - *Enabling automatic driving for port operation*
    (track pilot, maritime autonomous surface ships)
    - Challenges: MAGS concept implementation only in combination with development of automated steering of vessels in port applications

Definition of MAGS concept

MAGS Concept

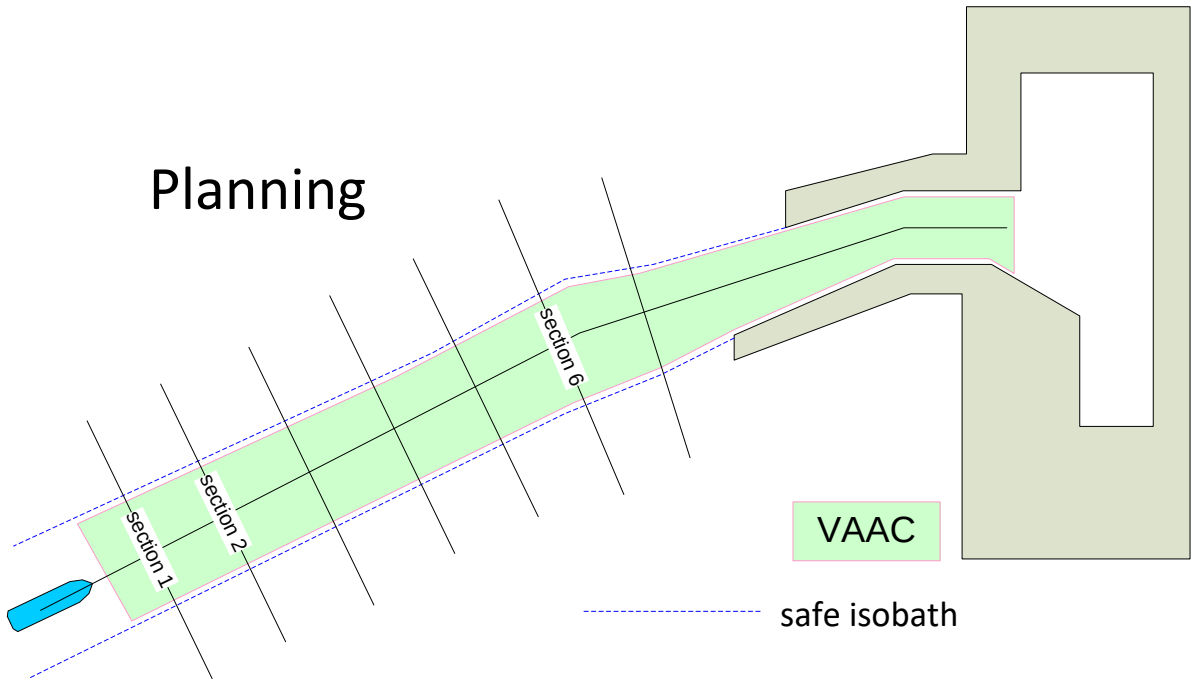
Port approach planning phase

Monitoring phase

MAGS Concept Definition

Port approach planning phase

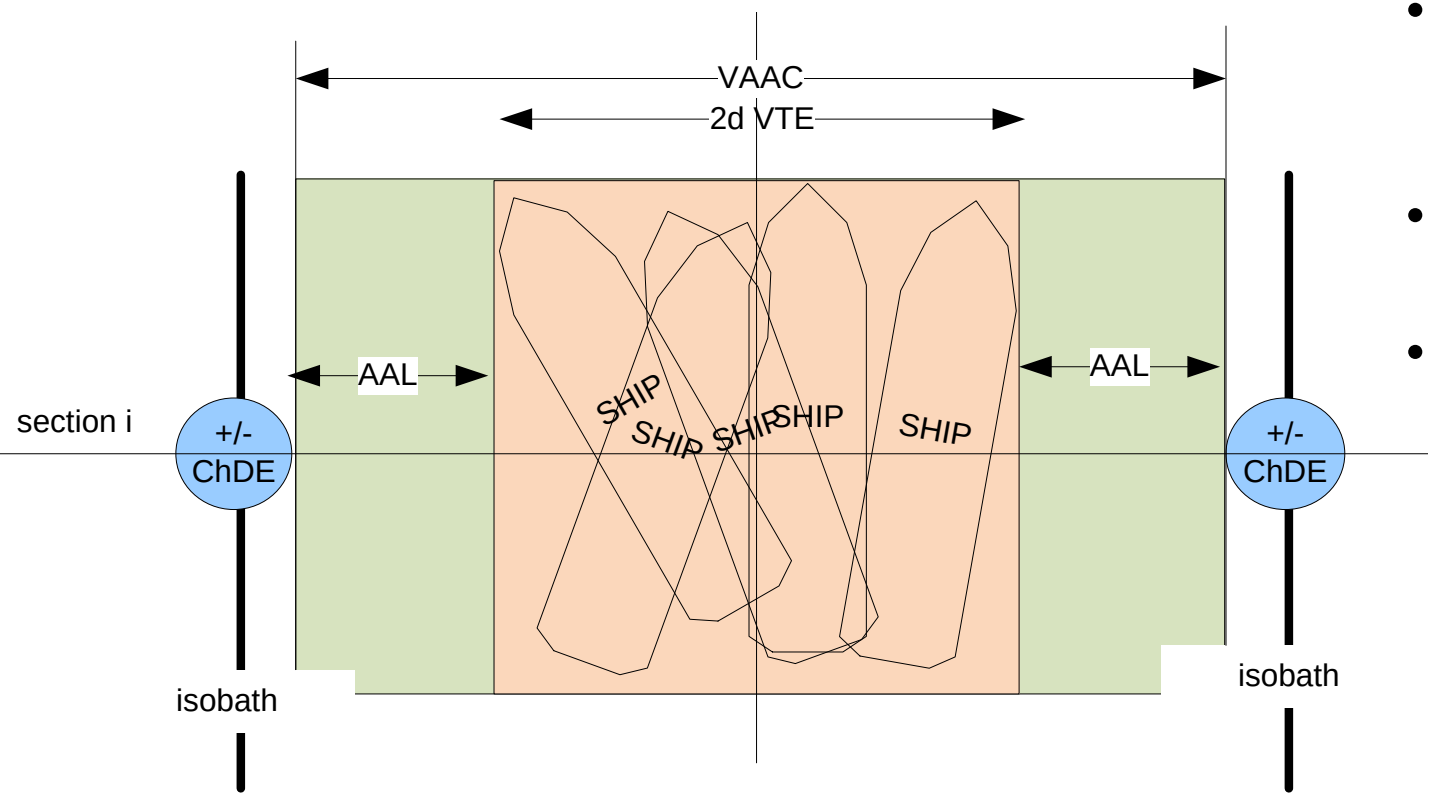
- When: before starting port approach
- What: VTS (Vessel Traffic Service) provides optimum, obstacle free route including safety margins to the vessel



Virtual Adaptive Approach Channel (VAAC): is provided by the VTS taking the available water area and other traffic into account. The VAAC is defined in a geodetic reference frame

MAGS Concept Definition

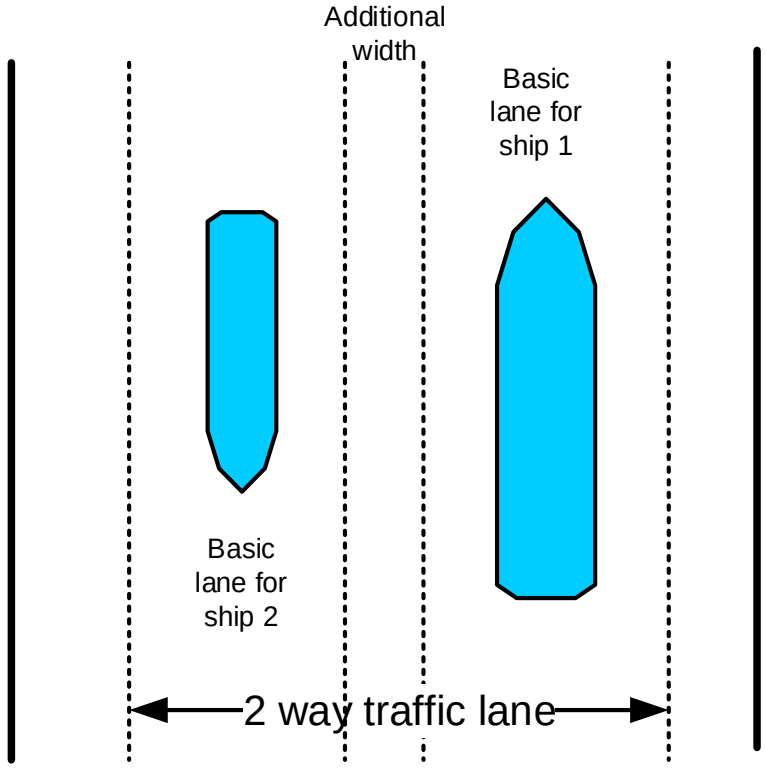
Calculation of adaptive alert limits in planning phase



- for given vessel and given conditions an overbound of 2d vessel technical error (2d VTE) is calulated for each waypoint
- based on VAAC and 2dVTE adaptive alert limit is calculated for each waypoint
- based on the performance forecast for the GNSS system together with its augmentation services the feasibility of a GNSS based navigation for that vessel is evaluated and a decision is taken to allow port approach based on GNSS positioning

MAGS Concept Definition

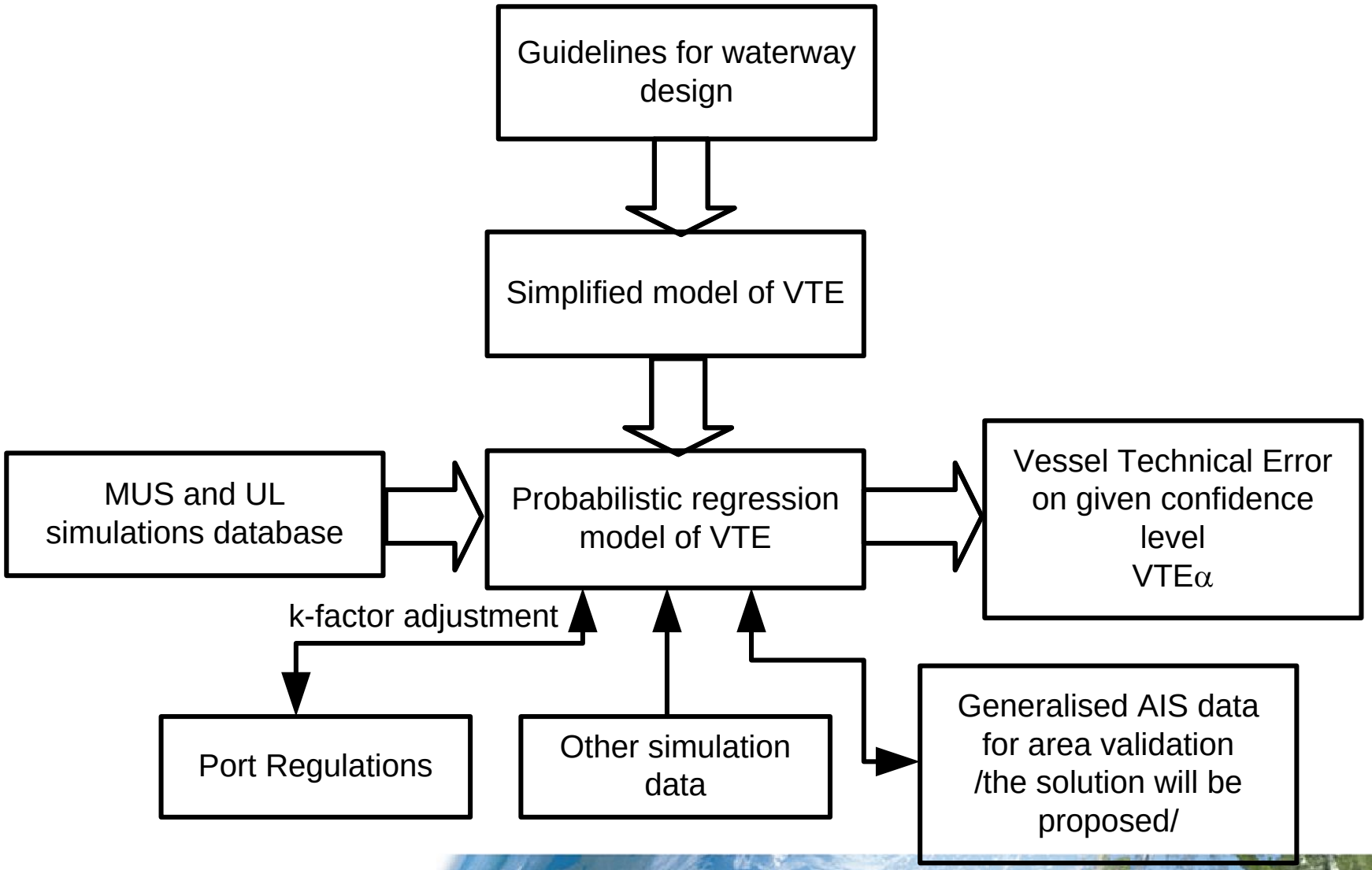
Planning Phase: Consideration of other vessels



VTS provides VAAC-s as spatio temporal routes for all vessels within the port ensuring save opeartion of each vessel

MAGS concept definition

Planning phase: Determination of 2dVTE



MAGS concept definition

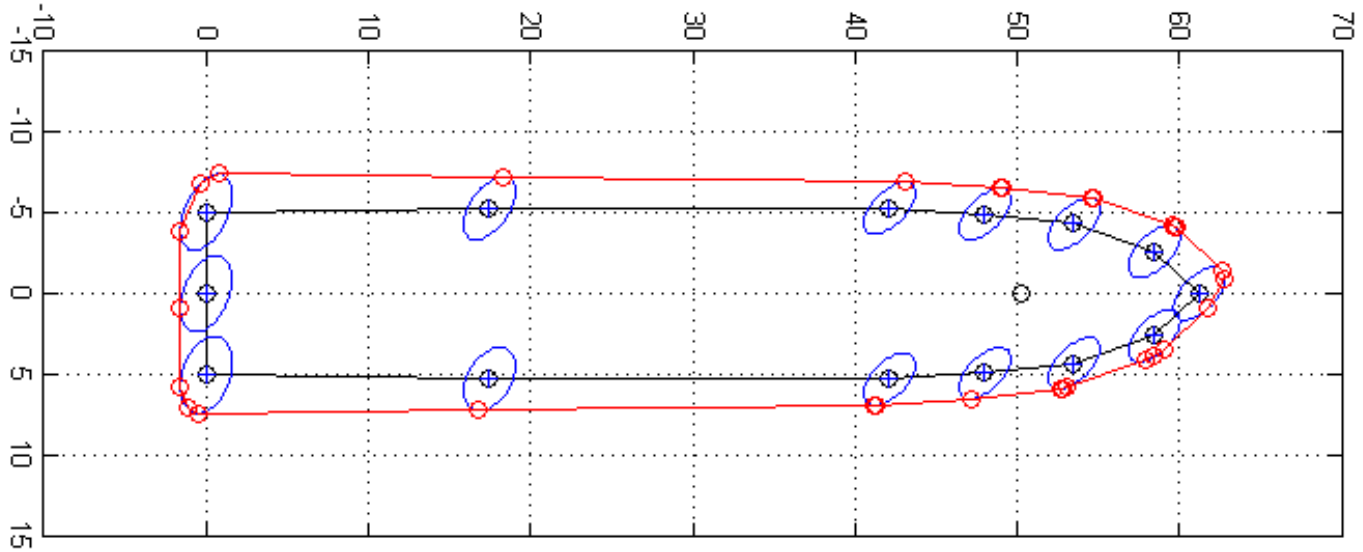
Monitoring phase

- Horizontal Protection Level (HPL) is continuously calculated and checked against the Adaptive Alert Limit (AAL)
- drift angle and cross track error (distance to planned trajectory) is measured and checked against the maximum error in the assumption
- Additionally the Marine Vessel Protection Area (MVPA) is calculated

MAGS concept definition

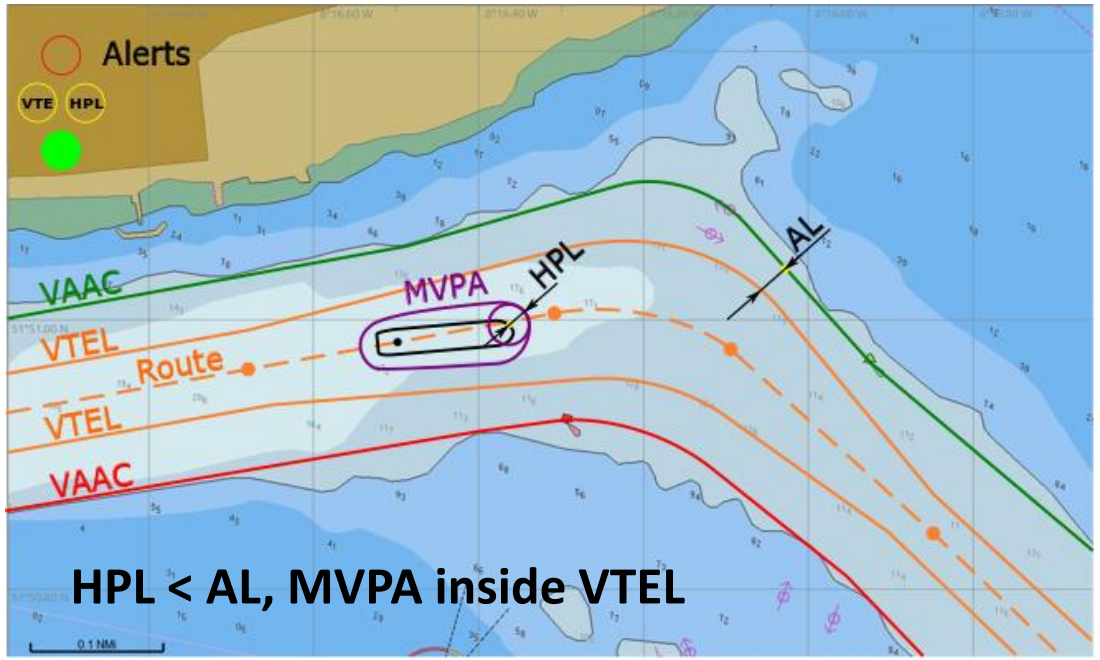
Marine Vessel Protection Area (MVPA)

MVPA: bounding spline representing the furthest points of uncertainty ellipses in respect to the ship's hull contour (includes uncertainty in position and heading)

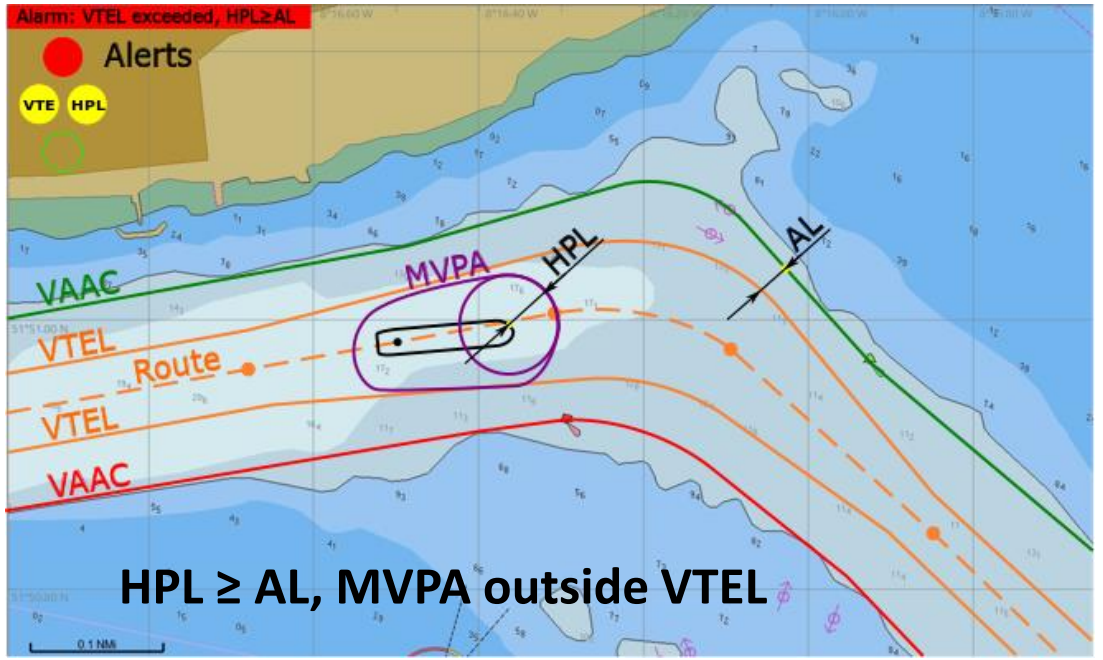


MAGS concept definition

Monitoring phase: Display to mariner



HPL < AL, MVPA inside VTEL



HPL ≥ AL, MVPA outside VTEL

Conclusions

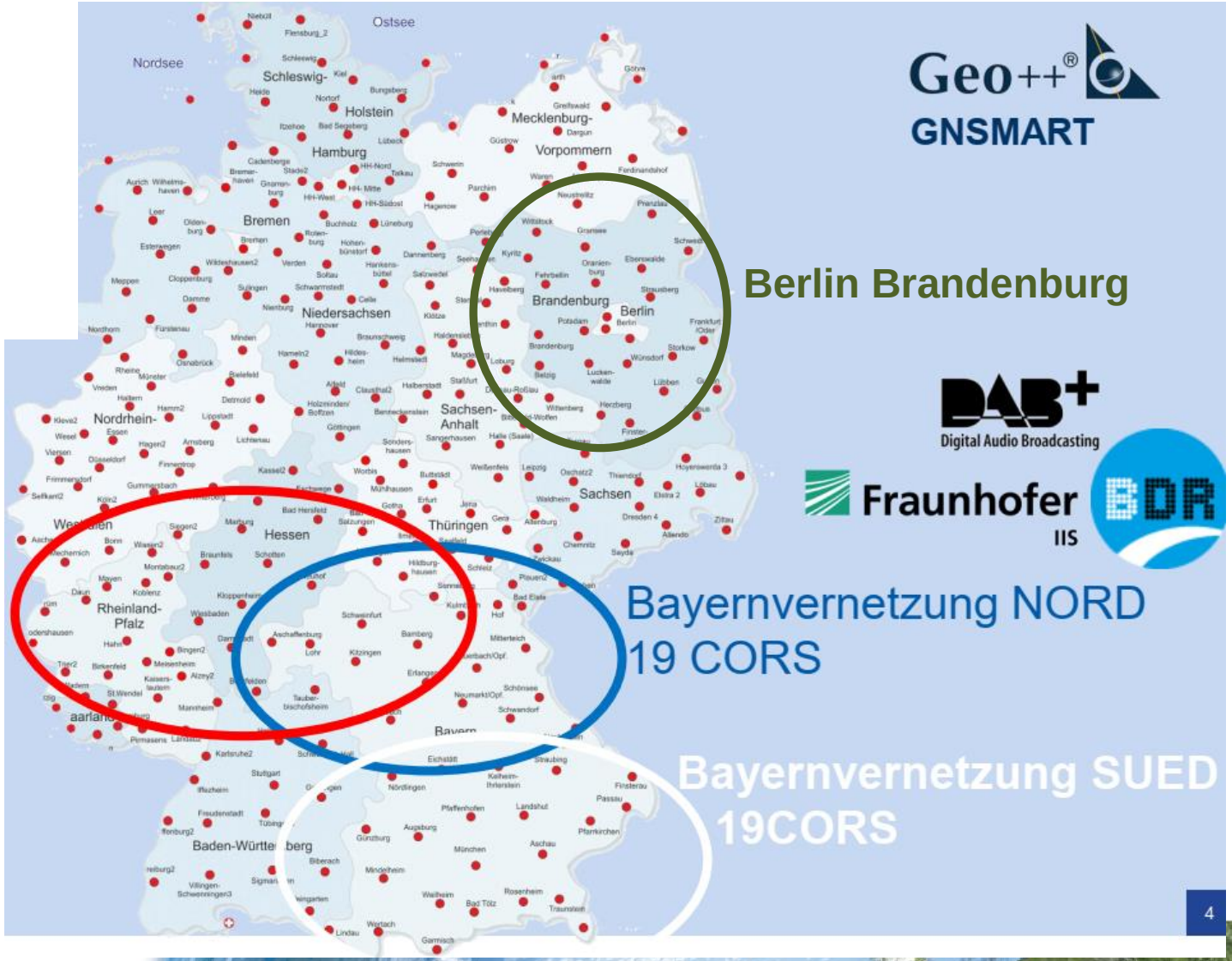
- Maritime GNSS Safety Concept developed
- Phase 1: Port Approach Planning
  - VTS provides vessel with recommended routes + safety margins (VAAC)
  - VTS determines overbound of 2d vessel technical error (2d VTE)
  - based on VAAC and 2dVTE adaptive alert limit (AAL)is calculated
  - feasibility of a GNSS based navigation is evaluated + decision
- Phase 2: Monitoring
  - Vessel HPL checked against AAL
  - Maritime vessel protection area calculated + checked against VAAC
- Adapt planning when required by traffic situation

=> Next step: Validation of concept in real live

Hochgenaue Positionierung in Häfen und Binnenwasserstraßen

Arbeitsgemeinschaft der Vermessungsverwaltungen der Länder der Bundesrepublik Deutschland

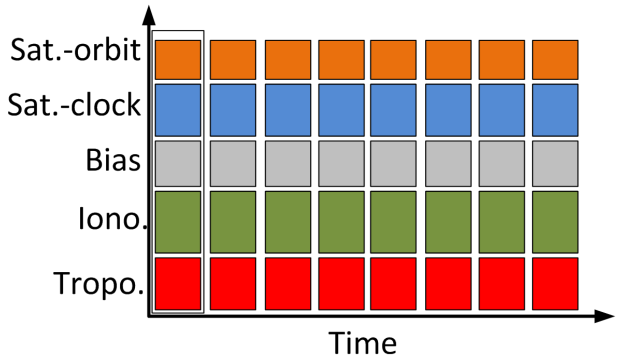
DLR as pilot user
for PPP/RTK service
of SAPOS (AdV)



Kind of Correction data

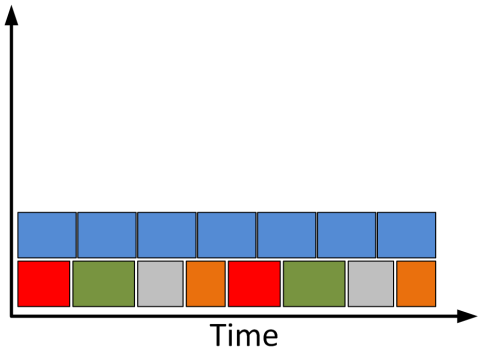
Real Time Kinematic (RTK)

- OSR (Observation state representation)
- For every observation one correction (every frequency, every satellite)
- Big amount of data (> 3 kbits/s)
  linear increasing with increasing number of satellites (GPS, GLONASS, Galileo, Beidou)
- Standardized (RTCM 3.1x)

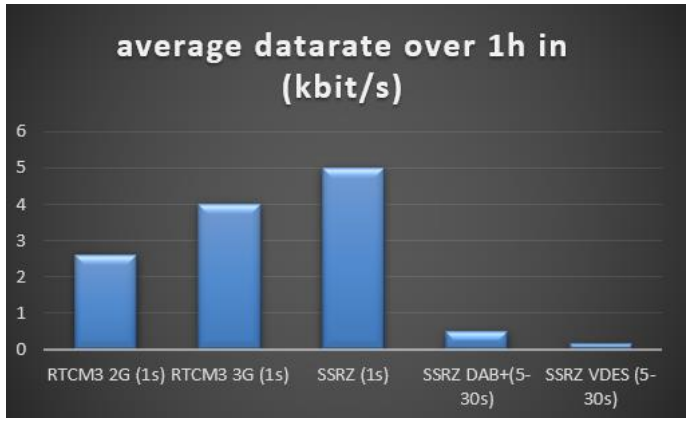


Precise Point Positioning (PPP)

- SSR (Space state representation)
- Split in different error components (clock, orbit, troposphere, ionosphere..)
- Less amount of data (~ 2 Kbits/s)
  => VDES broadcast capable
  VDES VHF Data Exchange System
  Next generation of AIS
- Not (fully) standardized



PPP/RTK Results



- SSRZ datastream optimized for vessel application

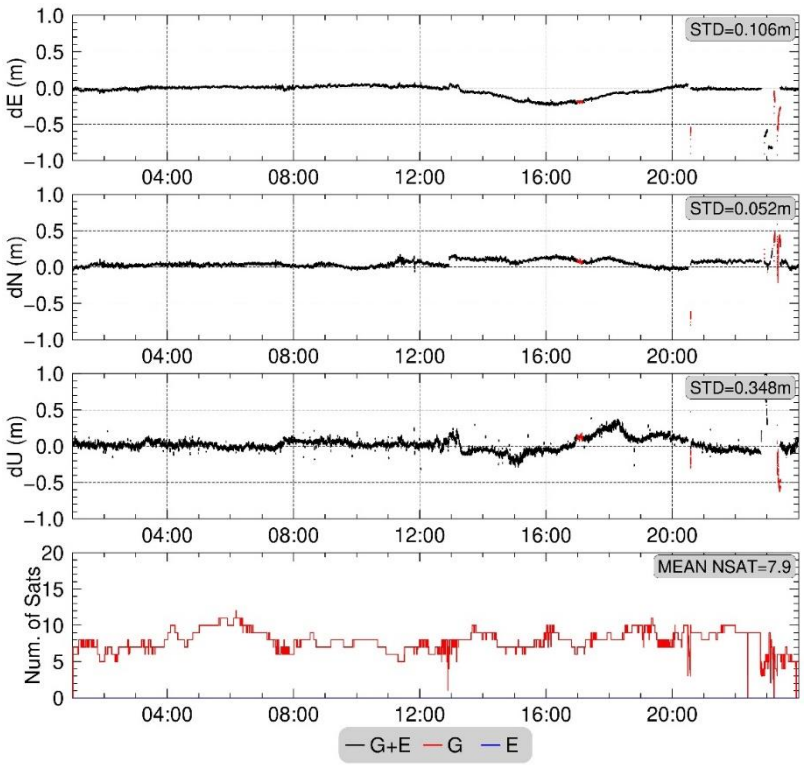
⇒ Broadcast over VDES possible

- Satisfying horizontal accuracy
- Service still in experimental phase

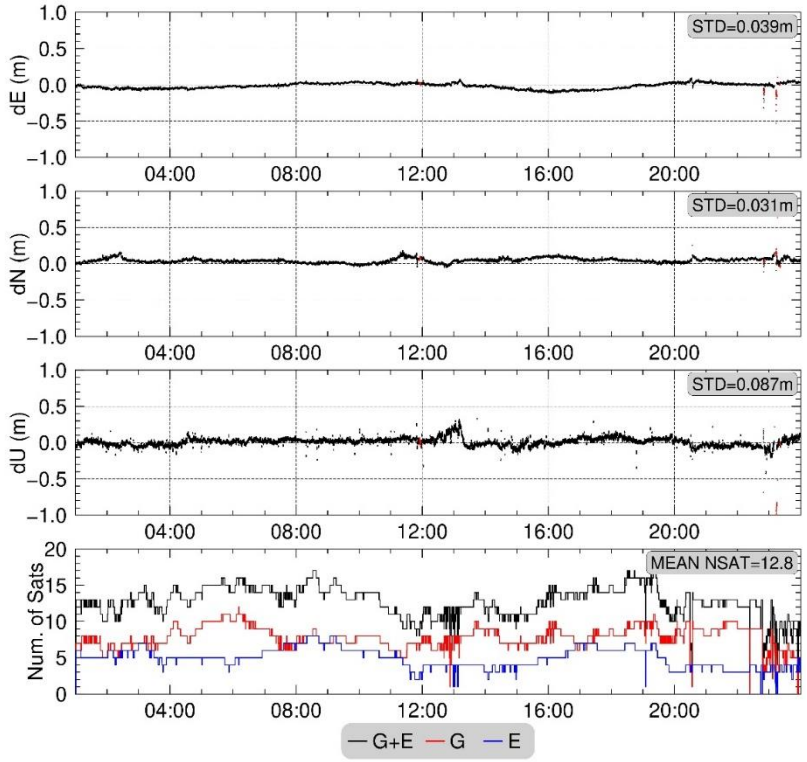
=> Large potential for highly accurate vessel positioning

GPS and Galileo PPP with Wide-Lane AR (Ambiguity Resolution) static data

GPS PPP Solution with AR



GPS and Galileo PPP Solution with AR




Thank You For Your Attention !
Ralf.Ziebold@DLR.de