



Technische
Universität
Braunschweig

Institute of
Flight Guidance



GBAS CAT II/III concepts for flexible approach procedures

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Content

- Motivation & preparatory work
 - Flexible approach procedures with GBAS
 - Interoperability trials

- GBAS research infrastructure at Research Airport Braunschweig
 - Ground based (GBAS ground station, aviationGATE)
 - Airborne (experimental GBAS equipment)

- Flight Trials
 - On-board system testing
 - Procedure Design

- Conclusion and Outlook

Motivation - Flexible Approach Procedures with GBAS

- GBAS - Ground Based Augmentation System:

- Based on GPS
- Ground station transmits arrival path information and GPS correction data
- Seem less transition from RNAV to approach procedures
- CAT I (GAST-C) certifiable, CAT II/III (GAST-D) in the definition phase



- GBAS offers flexibility

- Different approach path geometries are possible
- Even situation dependent geometries could be used, e.g.
 - due to traffic demand
 - due to wake vortex criteria

Preparatory work: GBAS Interoperability Trials

Scope

- GPS & GLONASS capable GBAS ground station (manufactured and assembled in Moscow)
- Proof of robustness of standards

Contents

- Measurement Campaign in Moscow (April 2009)
 - with mobile equipment
 - discussion with operational involved personal

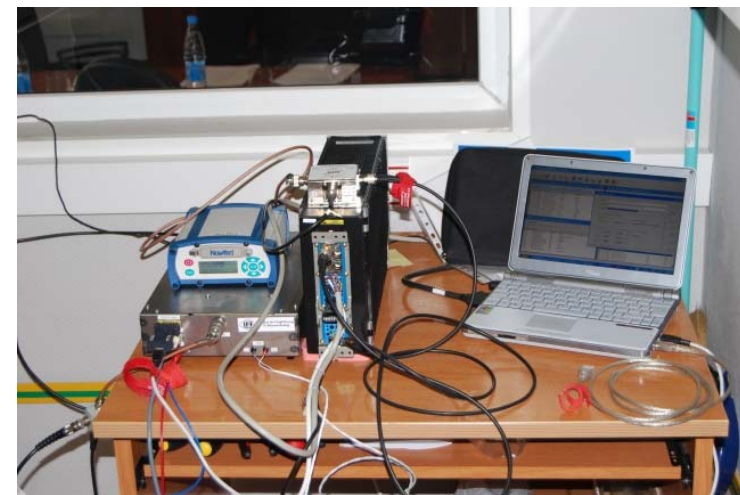
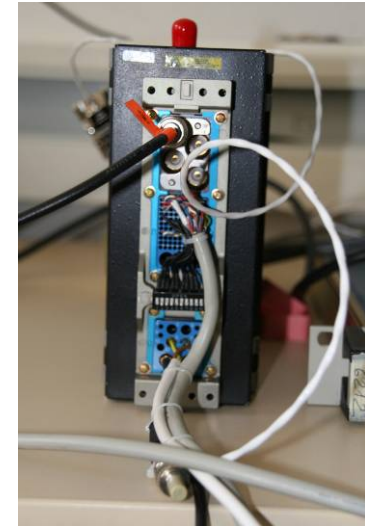
Founded by EUROCONTROL

- as early contribution to SESAR (Single European Sky ATM Research program)

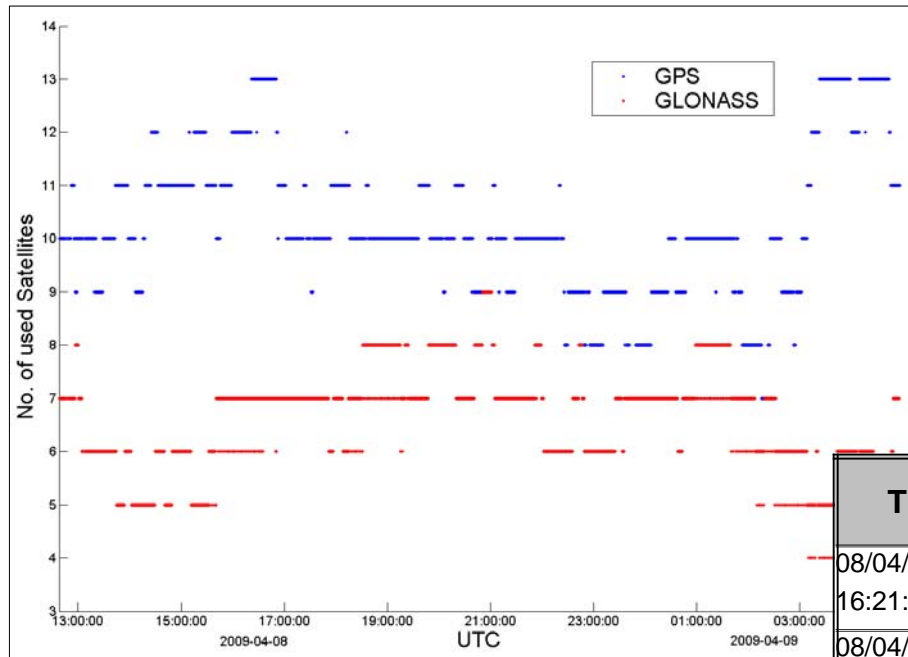
Preparatory work: GBAS Interoperability Trials

Mobile Test Equipment with

- RockwellCollins Multimode-Receiver GLU925 - 330 (Boeing) and - 430 (Airbus)
- Telerad RE9009 VDB Receiver
- NovAtel DL-4 GPS Receiver
- Laptop with recording software (Condor Engineering BusTools)
- Flexible Connector Interface



Preparatory Work: GBAS Interoperability Trials



- Interoperability and robustness tests
- Baseline data for future multi-constellation research

Time	MZC	No of Meas.	PRN	
08/04/2009 16:21:36.11	109.0	13	3, 6, 7, 8, 10, 13, 15, 19, 21, 24, 25, 27, 28	GPS
08/04/2009 16:21:36.21	109.0	7	43, 44, 45, 46, 52, 54, 55	GLONASS
08/04/2009 16:21:36.61	109.5	13	3, 6, 7, 8, 10, 13, 15, 19, 21, 24, 25, 27, 28	GPS
08/04/2009 16:21:36.71	109.5	7	43, 44, 45, 46, 52, 54, 55	GLONASS
08/04/2009 16:21:37.11	110.0	13	3, 6, 7, 8, 10, 13, 15, 19, 21, 24, 25, 27, 28	GPS
08/04/2009 16:21:37.21	110.0	7	43, 44, 45, 46, 52, 54, 55	GLONASS

- Use of extended MT1
- Use of more than 18 SV' s
- Transmission of MT5

Preparatory Work: GBAS Interoperability Trials

Ops Feedback – GLONASS/GPS

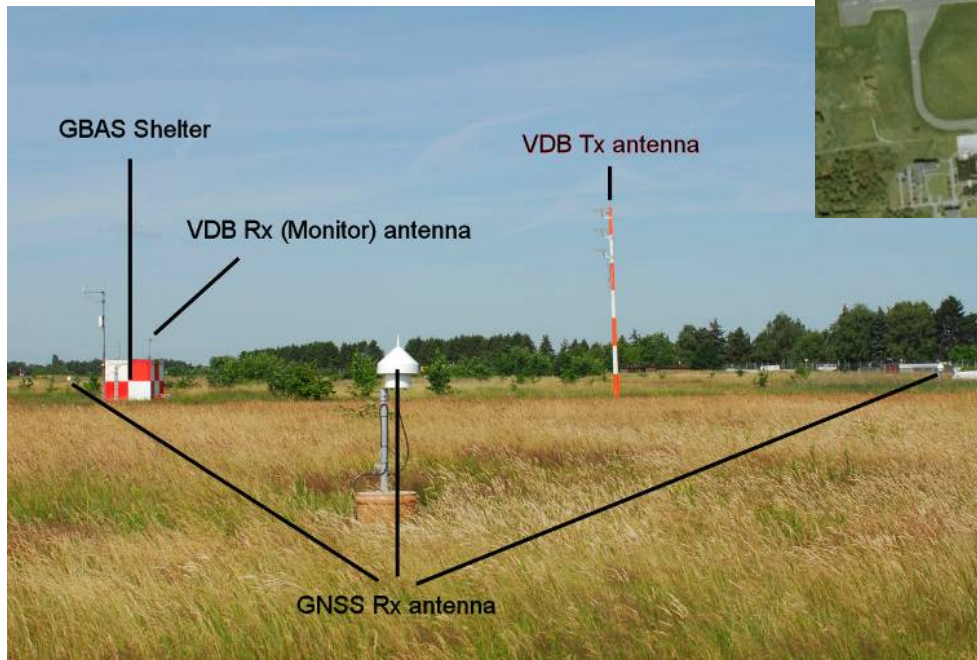
Note: Remote ops with high availability targeted – different adaptation for high density airspace

- Fleet operations: Some differences unavoidable (installed and test equipment, intervals and procedures)
- Pilots: Minimal differences (procedures / clearances / flight plan); ATC needs aircraft equipment knowledge
- ATC: Clearances depending a/c equipment and GNSS availability.
Note: in Russia ATC responsible for nav aids in clearance
- Procedure design: Differences in operational availability are factor in design
- Aircraft approval: Verification with single/multiple constellations



Research Infrastructure - GBAS Ground Station

Thales GBAS Ground Station
(owned by DLR)



Research Infrastructure - aviationGATE

Adaption of aviationGATE infrastructure for GBAS tests in dual-constellation environment

aviationGATE:

Galileo Test Bed around
Braunschweig Research Airport
covered area: 5,000 km²

9 pseudolites:

- 5 inner circle
- 4 outer circle

2 reference stations

frequencies: E1, E5a, E5b

user defined / variable

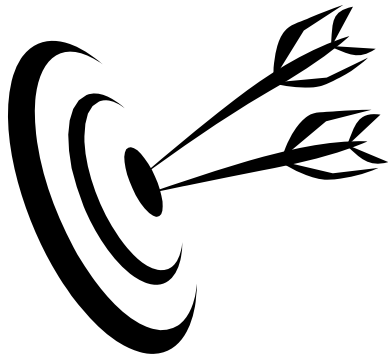
- navigation message
- time synchronisation



Research Infrastructure - aviationGATE

Adaption of all system components needed

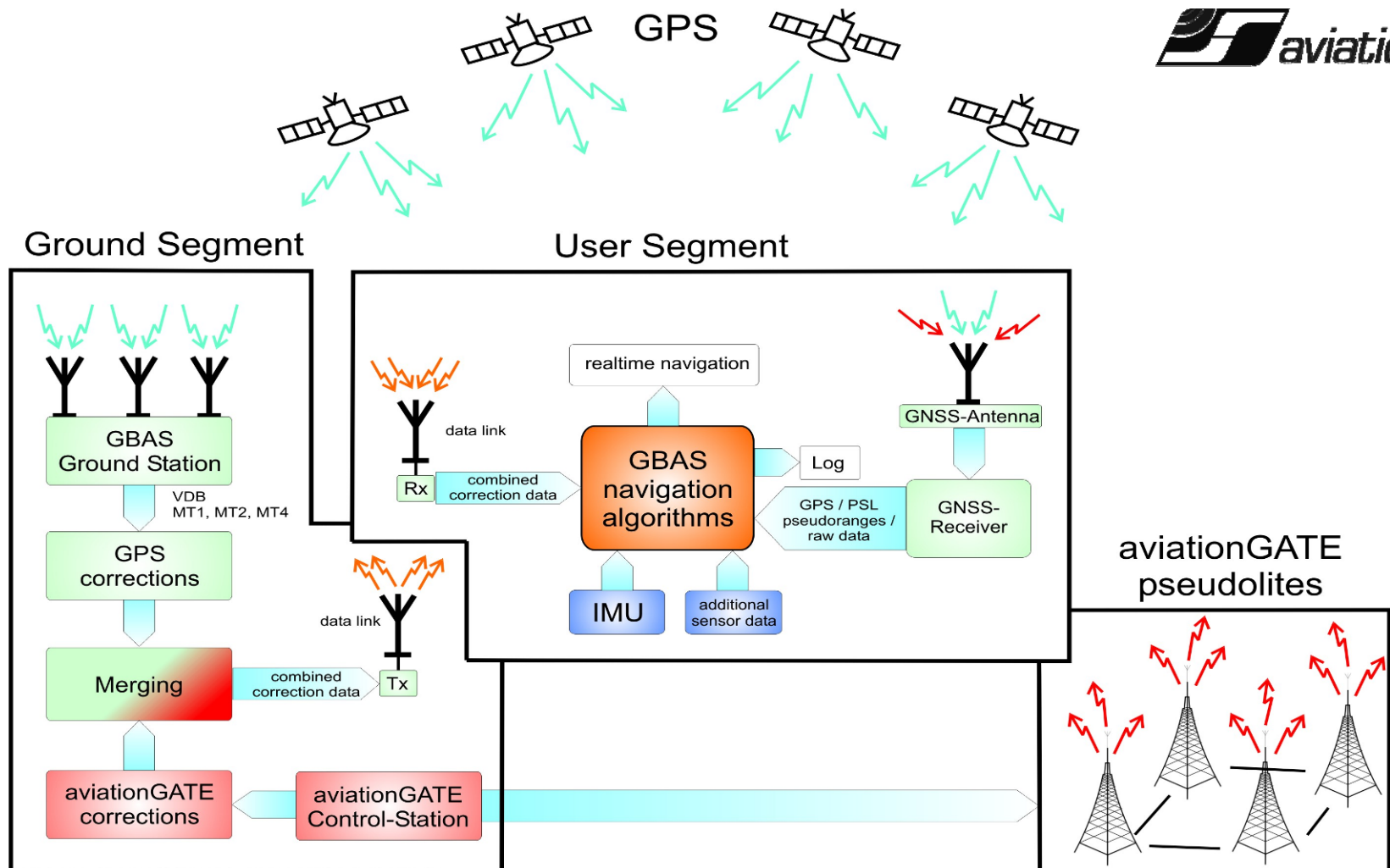
- Further development of aviationGATE
- Extension of experimental GBAS/INS on-board equipment
- GBAS/INS navigation & monitor algorithms



Test environment for
dual-constellation
GBAS Research



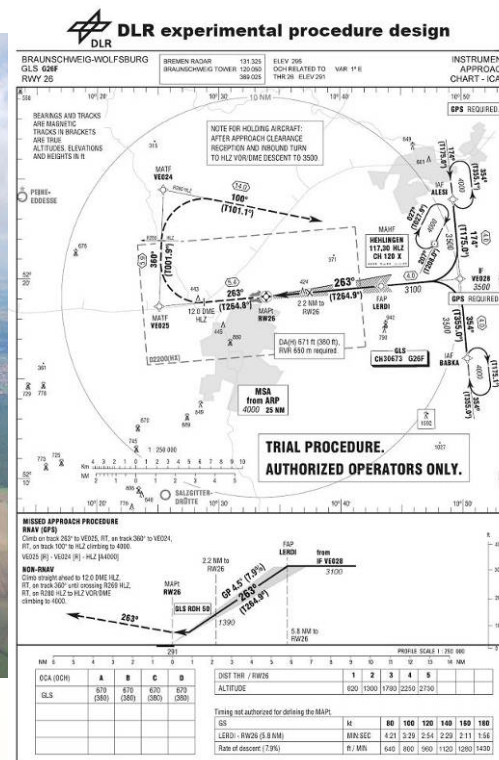
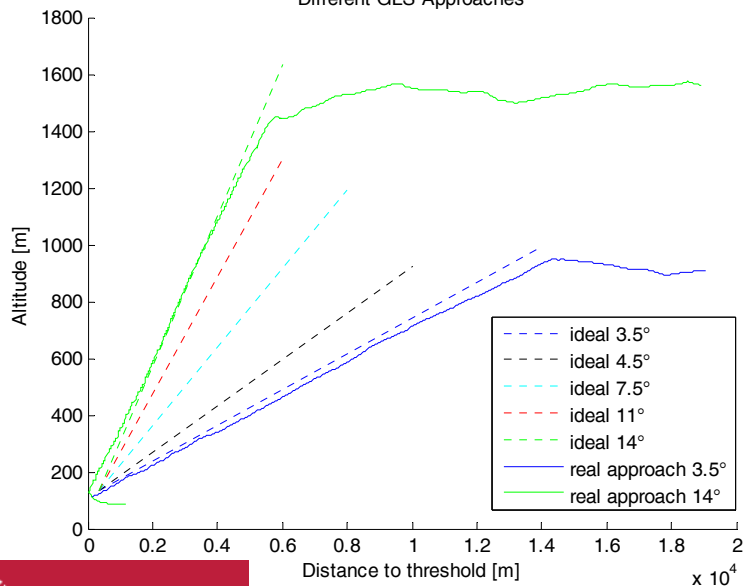
Research Infrastructure – extension of aviationGATE



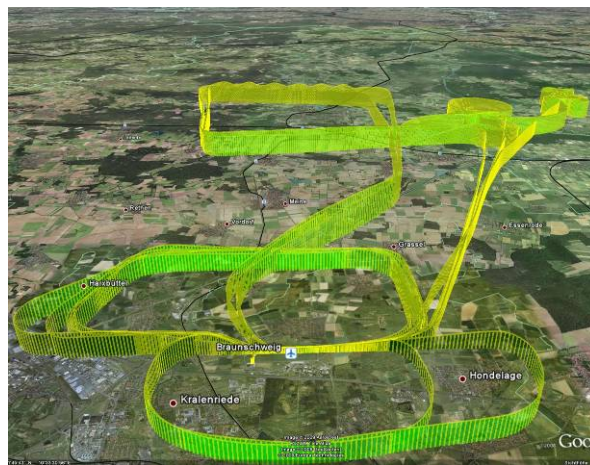
Research Infrastructure – airborne equipment



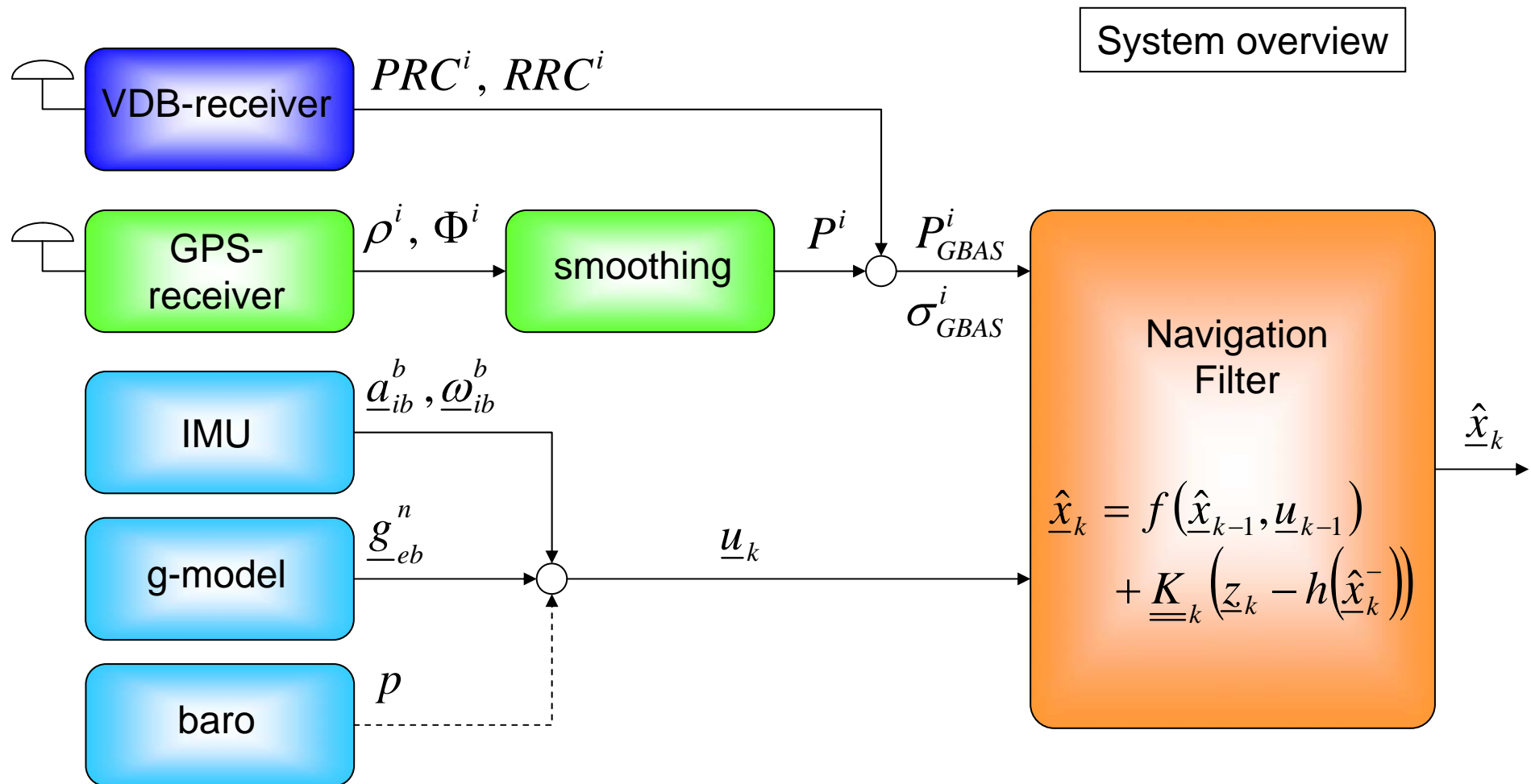
Different GLS Approaches



GBAS Flight Trials Braunschweig - TUBS



Research Infrastructure – GBAS/INS On-Board Equipment DO 128-6



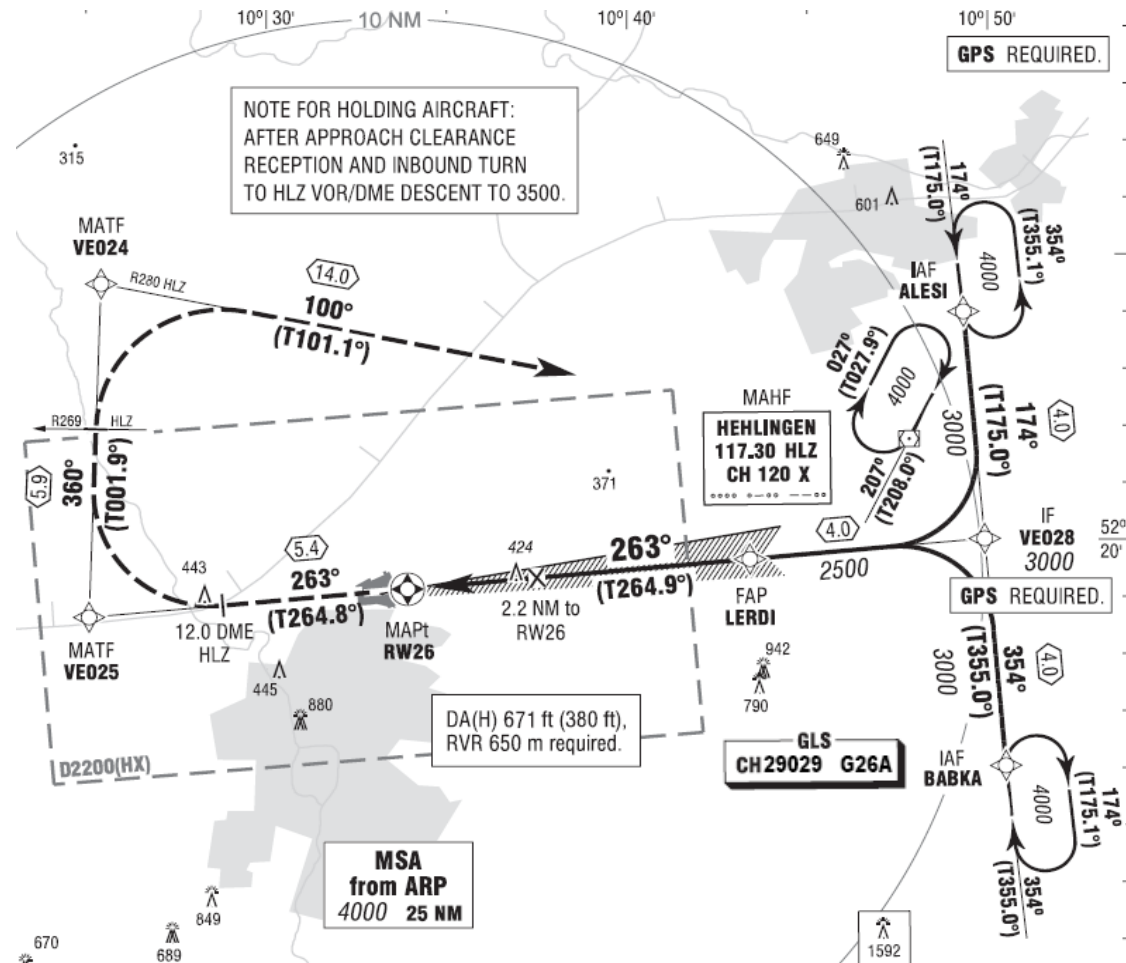
GBAS Flight Trials Braunschweig - DLR



- Validation with experimental A320 aircraft and operational used aircraft (B737, Air Berlin)

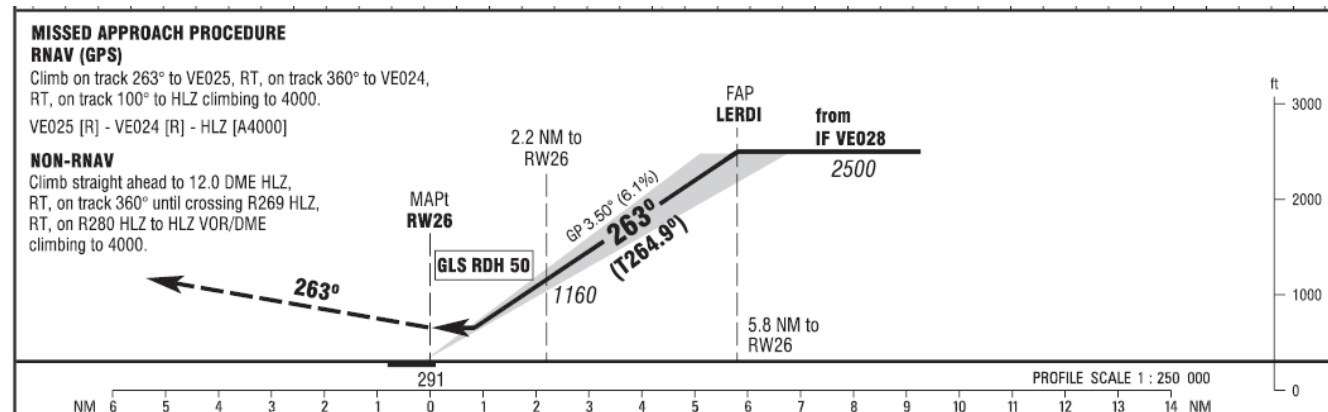
GBAS Procedure Design – DLR

- Initial procedures based on already implemented RNAV procedures
- Transition from „ILS-Look-Alike“ towards steep and curved approaches
- Validation in simulation and flight trials



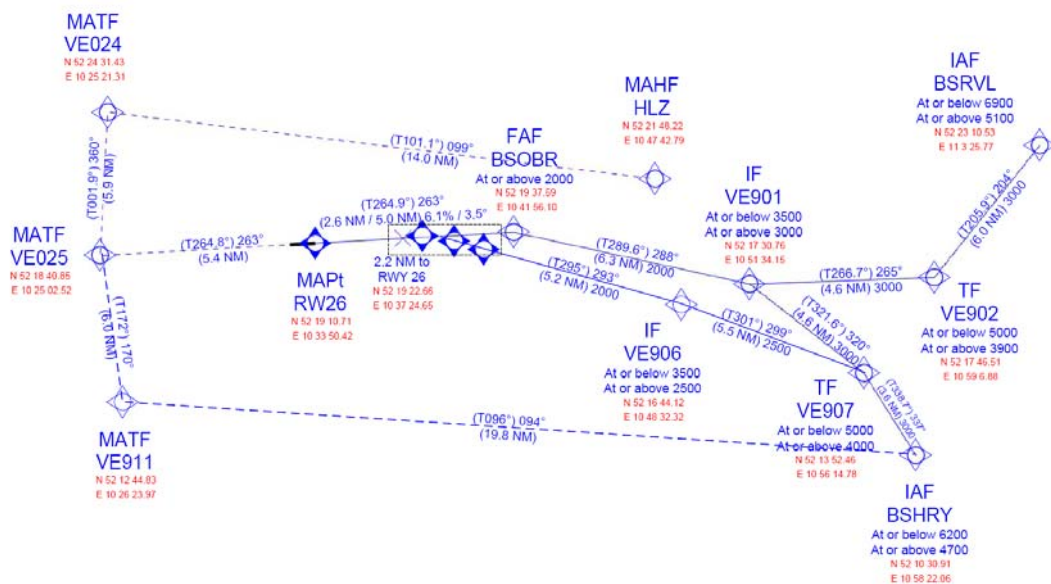
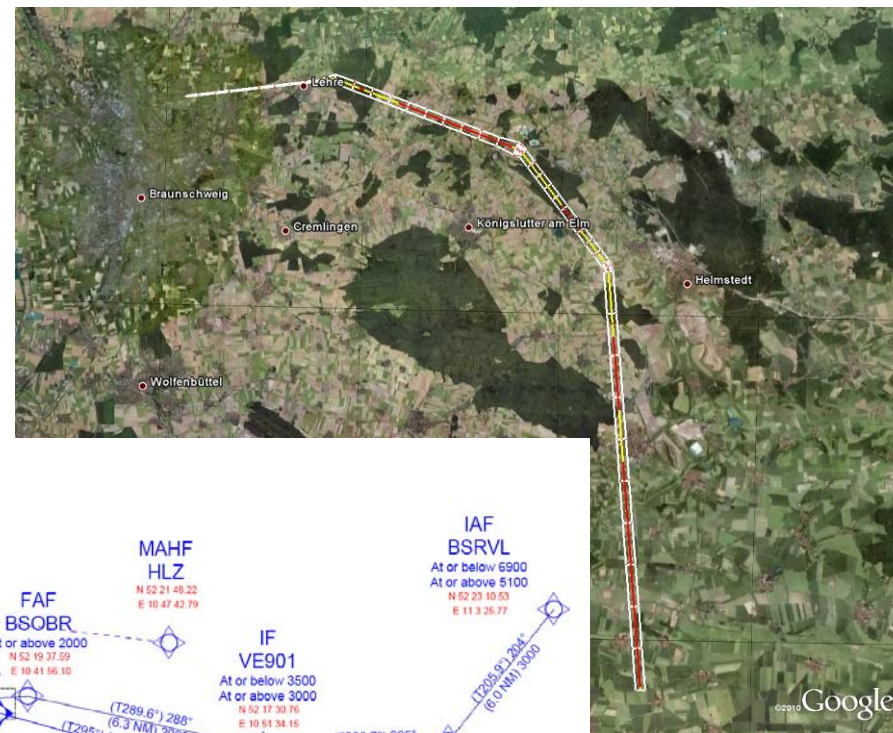
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GBAS Procedure Design – DLR

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Conclusions and Outlook

- Braunschweig offers a unique research and test environment for GBAS approach procedure design and testing
- Curved and segmented approach procedures have been shown and validated with research and commercial aircraft
- Even with high requirements for GAST-D approaches these flexible approach procedures will be possible
- Continuous work will be done at Research Airport Braunschweig by University and DLR

Thank you for your attention!

Any Questions?

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