

Presenting LDACS – Webinar 2

LDACS Functionalities and Capabilities

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A large, high-resolution image of the Earth from space occupies the right half of the slide. It shows a curved horizon with a deep blue atmosphere. The landmasses of Europe and Africa are visible, with green vegetation and white cloud formations. The text "Knowledge for Tomorrow" is overlaid on the bottom right of this image.

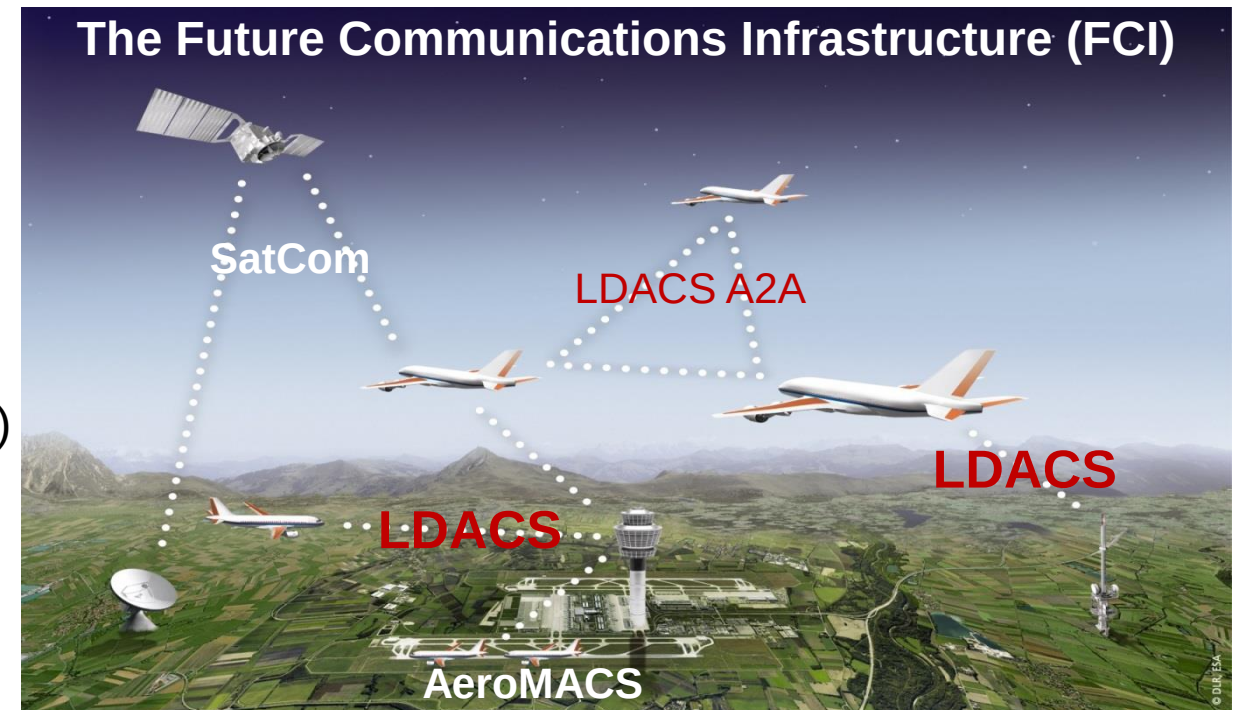
Knowledge for Tomorrow

Brief LDACS Overview

LDACS stands for L-band Digital Aeronautical Communications System and is

- **the** upcoming broadband and secure **terrestrial communications system** for aviation
- originally designed under EUROCONTROL contract and further developed in the framework of the joint FAA/Eurocontrol “Future Communications Study”
- now being refined within SESAR 2020
- exclusively designed for **aviation use** in protected aeronautical L-band with AM(R)S allocation
- well positioned in SESAR’s ATM Master Plan and essential part of the FCI
- well reflected in ICAO’s **Global Air Navigation Plan**
- under **ICAO standardization** (Communications Panel)

LDACS is a **mature technology for aviation!**
Flight trials have taken place March/April 2019



Brief LDACS Overview

LDACS System Characteristics

- Especially **designed for aeronautical communications**
 - Adjusted to aeronautical channel characteristics (high speed, large coverage area)
 - Adjusted to protected aeronautical L-band environment with its existing CNS systems
 - Designed to overcome existing deficiencies of current aeronautical communications systems
- Secure **data** link and **voice** communications
- State-of-the-art technology as used in LTE/4G
- Based on OFDM modulation technology
 - Orthogonal Frequency-Division Multiplexing
 - Multi-carrier technology
 - Modern, **highly flexible and scalable**
- Efficient **adaptive coding/modulation** and interleaving
 - Covers QPSK, 16-QAM, 64-QAM
 - Concatenated coding

Main LDACS Parameters:

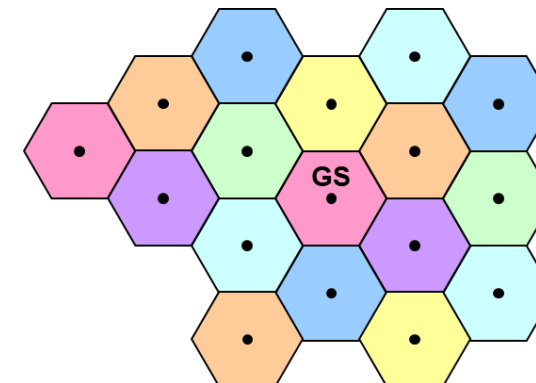
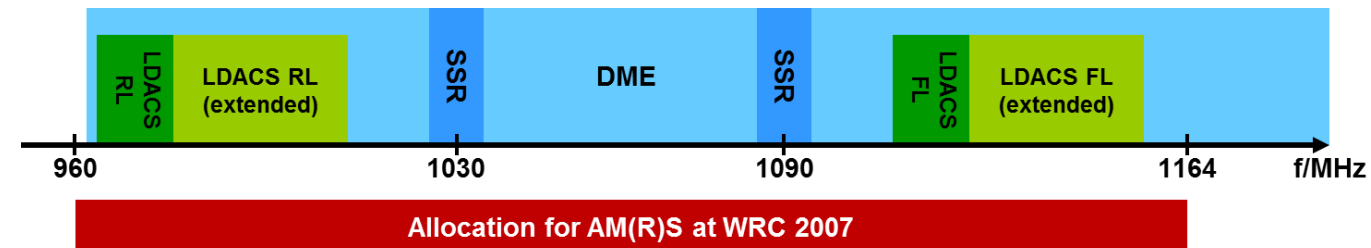
Number of subcarriers	64 (50 used)
Bandwidth	625 / 488 kHz
Subcarrier spacing	9,765625 kHz
Net data rate	550 kbit/s – 2,6 Mbit/s (at least 50-times VDL Mode 2 capacity)



Brief LDACS Overview

LDACS System Characteristics

- Deployment in **coordination with existing L-band systems**
 - Suppression of out-of-band radiation towards other L-band systems
 - Mitigation of L-band interference from other L-band systems
 - Frequency channel planning and LDACS station siting
- Apply **FDD** as duplexing scheme
 - Forward Link: 1110 – 1125 (1156) MHz
 - Reverse Link: 964 – 979 (1010) MHz
- **Cellular** communications concept
 - Neighboring cells use different frequency channels
 - Far away cells can re-use LDACS frequency channels
 - Frequency re-use of 7 is planned



LDACS Communications Functionality

Communications is the main LDACS functionality

Communications Capabilities

- **Broadband Connectivity** to enable modern ATM concepts
 - LDACS is based on technology as applied for LTE/4G mobile radio systems
 - High-rate data communications with **550 kbps – 2.6 Mbps** per channel (**55 – 260 times VDL2**)
- **Improved communications performance** to overcome current deficiencies
 - LDACS provides both **data link** connectivity and **digital voice**
 - **Low-latency** transmission through coordinated channel access
 - Service priorities ensure low-latency and high continuity of service for safety-critical ATS and AOC
 - **No co-channel interference** problems as experienced during VDL2 data link deployment
- **Secure transmissions** through built-in cyber-security means
 - Ensuring mutual entity authentication
 - Protecting **confidentiality**, **integrity** and **authenticity** of messages
 - Ensuring **availability** and **continuity** of service
- Supported **network protocols**: **ACARS**, **OSI** and **IPS**



LDACS Communications Functionality

Communications Capabilities/Applications

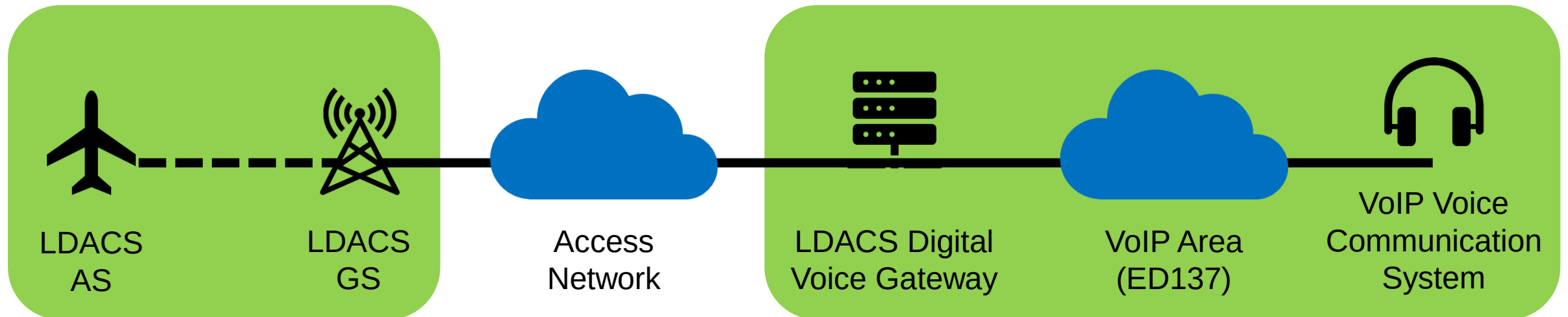
- Simultaneous transmission of **ATS and AOC** services
 - Each service transmits according to its **priority** suitable for the service requirements
 - Transmission of **high-volume AOC data** while ensuring **immediate access for safety-critical services**
- LDACS covers **ATN/B1** and **ATS/B2** as well as emerging **ATS/B3** and is expected to comply with RCP/RSP at least up to the emerging **RCP60** and **RSP60** requirements
- LDACS is foreseen to additionally cover **future services to enable ATM modernization** as for example
 - Full 4D trajectory based operations (**TBO**)
 - **Flight-centric ATM**
 - Secure connectivity to the flight deck (**EFB**)
- LDACS enables **single-pilot operations** through supporting respective applications – up to back-up C2 data link in case the (single) pilot onboard is incapacitated
- LDACS enables **secure and improved GBAS**
- LDACS covers **ADS-C** including the Extended Projected Profile (**EPP**)



LDACS Communications Functionality

LDACS Digital Voice

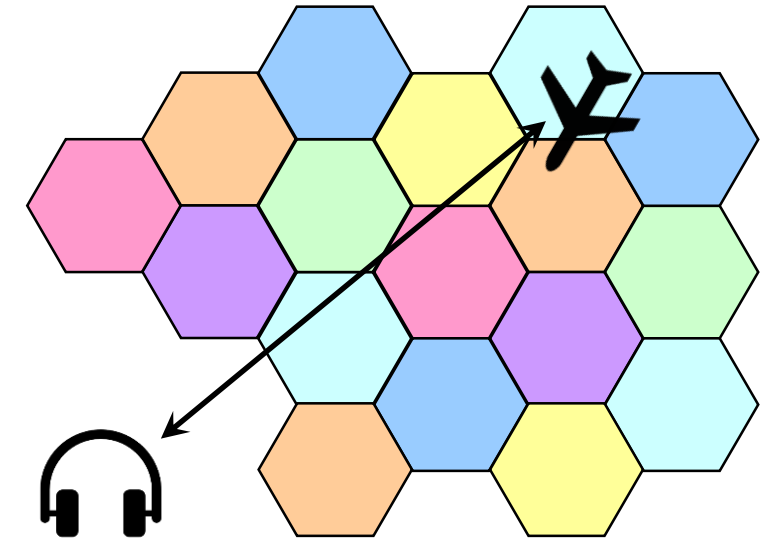
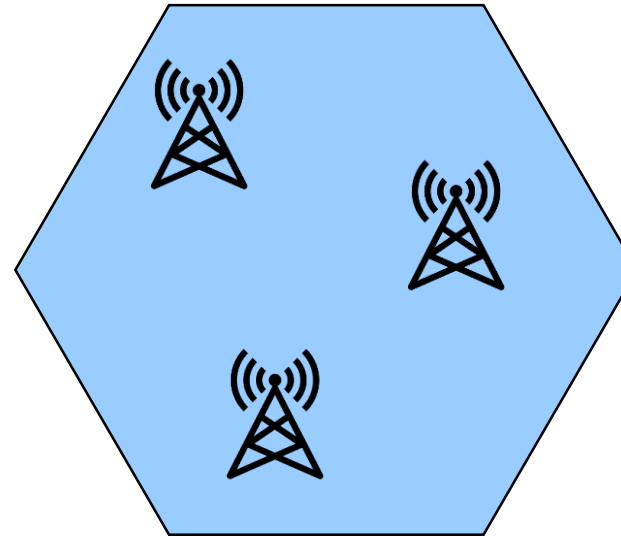
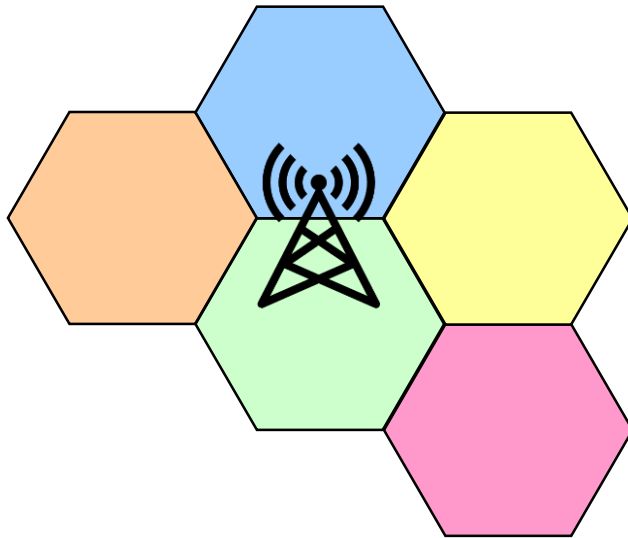
- LDACS **digital voice technology** builds on established VoIP technology in the ground network
 - Voice gateway connects LDACS to a **standard VoIP area** (ED137) and VoIP communication system
 - LDACS ground station (GS) has **direct access** to resources for digital voice transmission
 - LDACS airborne station (AS) can **reserve resources** (a virtual circuit) for digital voice transmission



LDACS Communications Functionality

LDACS Digital Voice

- LDACS **digital voice channels** are independent from the physical LDACS deployment
 - One LDACS ground station can **serve multiple ATC voice sectors**
 - One ATC voice sector **can be served by multiple LDACS ground stations**
 - Voice circuits can be **completely independent of current ATC voice sectors** (flight centric ATM)

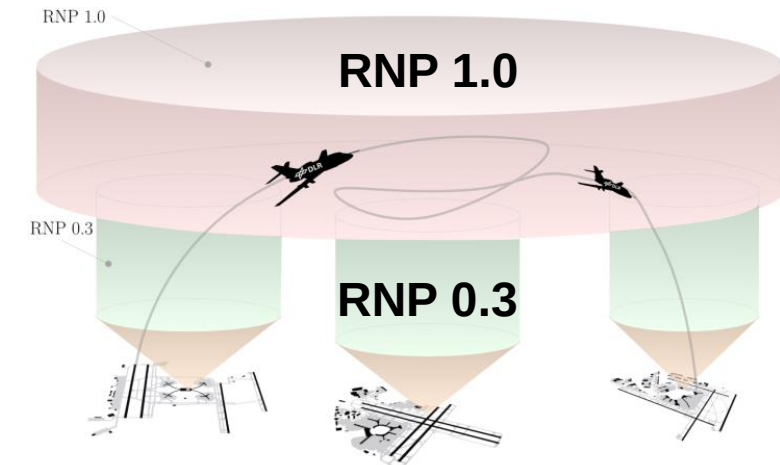


LDACS Navigation Functionality

Navigation Capabilities

- The LDACS navigation functionality is foreseen as **back-up to existing navigation means**, e.g. to GNSS
 - LDACS as a **complete APNT** solution (APNT = Alternative Positioning, Navigation, and Timing)
 - LDACS as important part of **modular APNT** (DME, **barometric height sensor**, **inertial sensors**)
- RNP-based navigation for APNT
 - RNP 1.0 (1604 m NSE) widely
 - RNP 0.3 (307 m NSE) where needed
- Achievable accuracies with LDACS: **RNP 1.0** up to **RNP 0.3**
- **No changes** to original LDACS signal required
- Only additional requirement for navigation functionality: **precise synchronization** of LDACS ground stations
 - Requirement for communications: in the order of microseconds ($< 1.6 \mu\text{s}$)
 - Requirement for Navigation: in the **order of tens of nanoseconds** ($< 50 \text{ ns}$)
 - GNSS disciplined low-cost Rb atomic clock; runs free in case of GNSS outage (around 10 ns)
 - Time-transfer via fiber-optical network (fiber-optic time-transfer) plus Rb atomic clock (around 1ns)

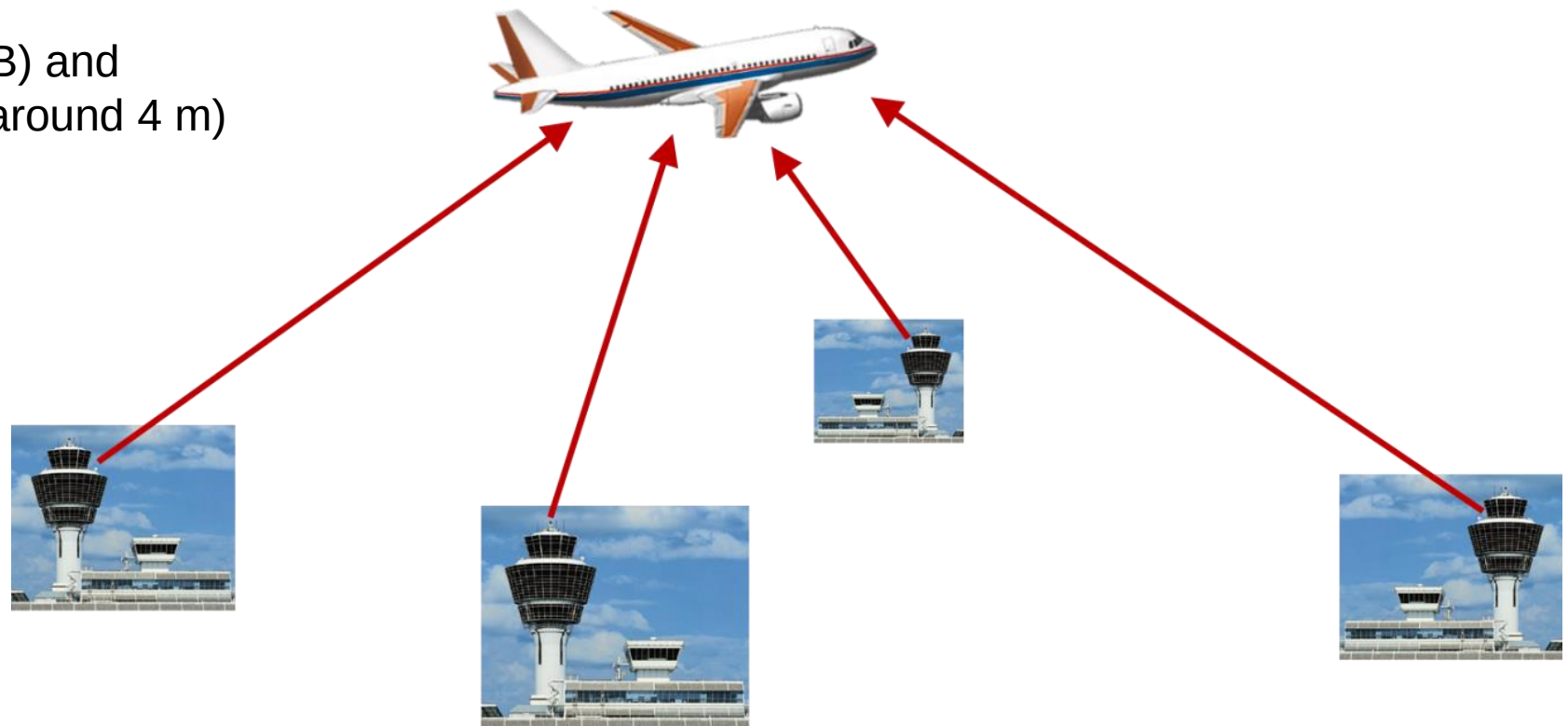
Navigation is a secondary LDACS functionality



LDACS Navigation Functionality

LDACS Navigation – Basic Principle

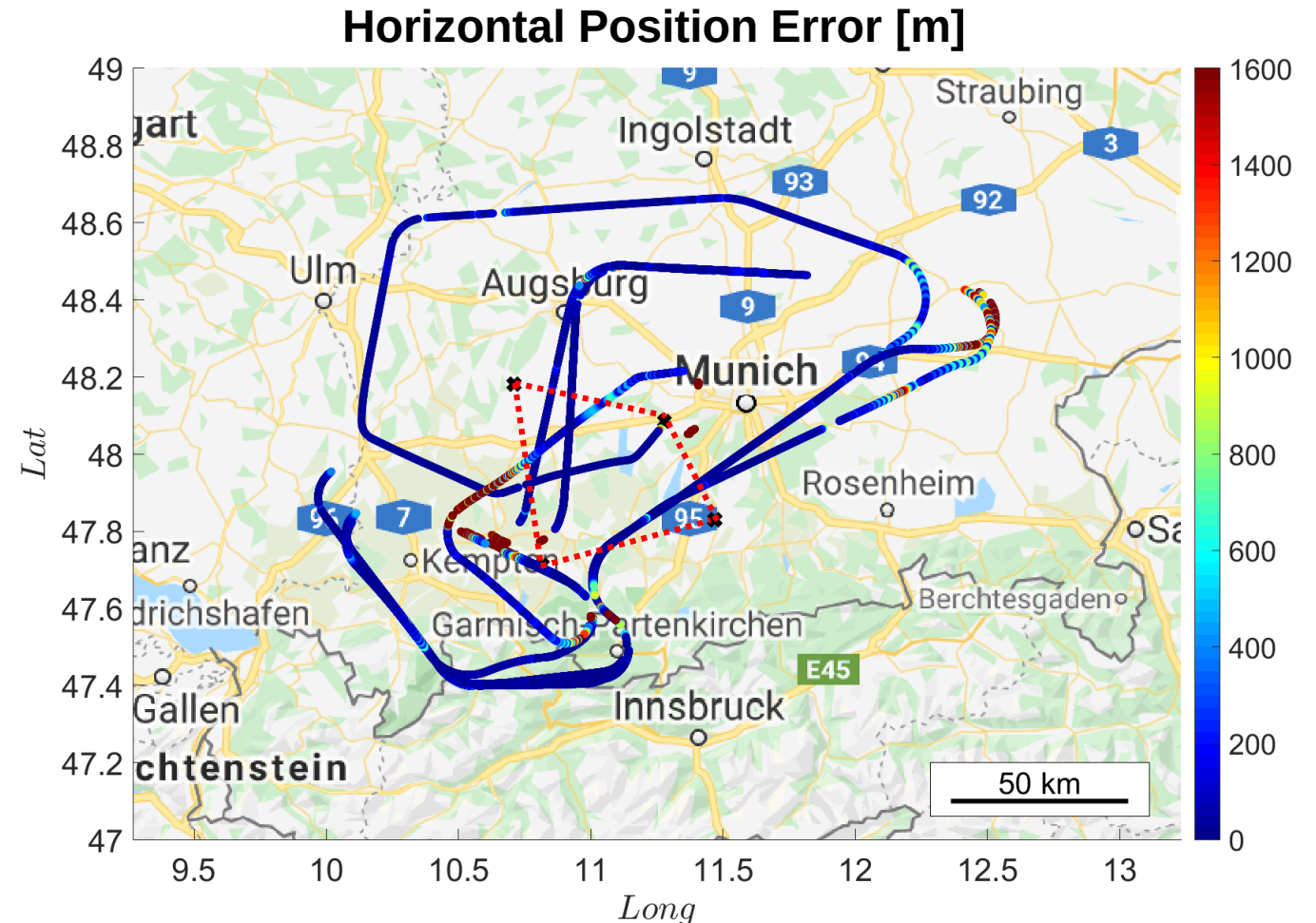
- LDACS ground stations act as pseudolites
“GPS on ground”
- Concept proved in **theory** (CRLB) and **simulations** in 2012/13 (RMSE around 4 m)
- Concept proved in **flight trials** in 2013, 2015, 2018 and 2019
- Achievable **RMSE** (measured)
 - 20 m (range)
 - 80 m (horizontal position)



Results: Horizontal Pos. Error

Performance Results

- Results taken from navigation flight trials in 2018 performed by DLR with an experimental, temporary deployment
- Performance measure: Horizontal Position Error (**HPE, 95 percentile**)
- Results within **main area**: 78.53 m
 - Achieves **RNP 0.3**
- Results **including outside area**: 936.11 m
 - Still achieves **RNP 1.0**
 - Indicates that less stations are required for achieving RNP 1.0



Summary and Outlook

Summary

- LDACS covers **C**ommunications (primary functionality), **N**avigation (secondary functionality)
- **Secure broadband communications** is heavily required for CNS/ATM modernization
- LDACS offers **APNT** almost for free and covers **S**urveillance applications like **ADS-C EPP**
- LDACS has the necessary **capacity and performance** to enable ATM modernization and to deliver APNT

Outlook

- This year, additional L-band compatibility tests are planned to **derive final frequency planning criteria**
- In summer 2022, **additional validation flight trials** for LDACS are planned within SESAR 2020
- End of 2022, LDACS is expected to reach **TRL 6** at the end of SESAR 2020
- ICAO standardization is ongoing with current envisioned **applicability by 2024**



Thank you for your attendance!

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For more information, see:

www.ldacs.com

