The German National Project ICONAV

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What is ICONAV?

ICONAV = **I**ntegrated **CO**mmunication and **NAV**igation functionality for sustainable L-band use

Basis: LDACS1

Additional features

HW implementation

Navigation interface

Interface implementation

DLR project LDACS-NAV

Outline

LDACS1 System Overview

LDACS1 Extension Towards Navigation (LDACS-NAV)

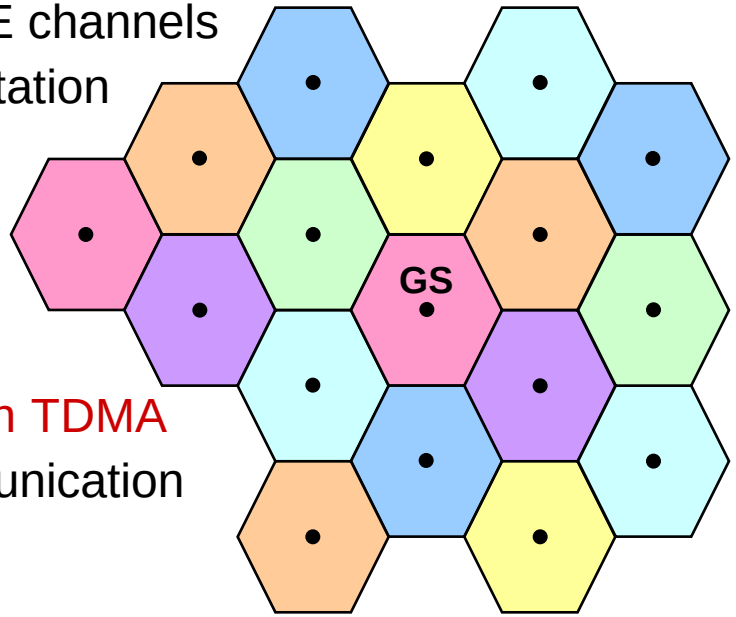
The ICONAV Project

Conclusions and Future Work

LDACS1 System Overview

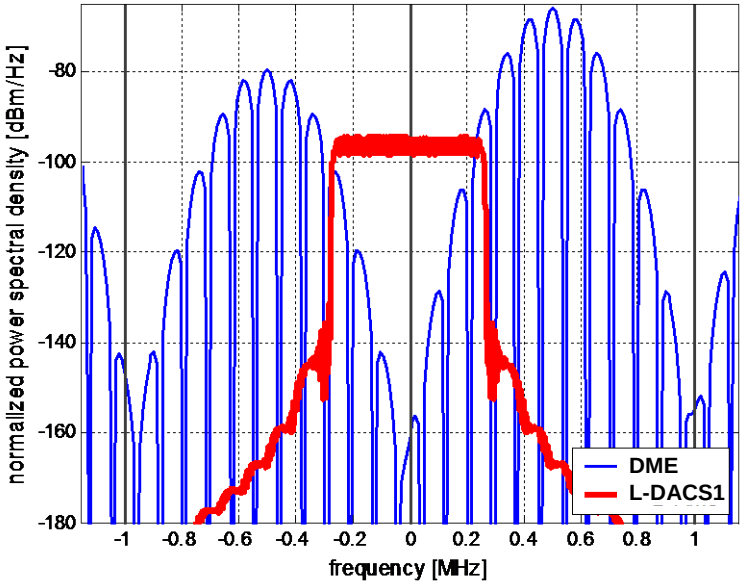
Main System Characteristics

- L-band Digital Aeronautical Communication System, Type 1
- One of two proposals for the future A/G communications link
  - LDACS1 is a broadband system based on OFDM (4G technology)
  - LDACS2 is a narrowband, single-carrier system (2G technology)
- Possibility for inlay system between DME channels
- Centralized communication via ground station
- Cellular deployment concept
- Duplex scheme is FDD
- Multiple-access schemes
  - Forward link: pure OFDM
  - Reverse link: OFDMA combined with TDMA
- LDACS1 supports data and voice communication



LDACS1 System Overview

Inlay Concept



- Preferred deployment scenario – LDACS1 as inlay system for L-band
- OFDM as used within LDACS1 is well-suited for inlay approach
- 500 kHz per LDACS1 FL/RL channel
- Minimize interference to and mitigate interference from other systems
- Compatibility testing with DLR lab demonstrator
  - First tests @ DFS labs are very promising
  - Additional tests @ DFS labs during SESAR P15.2.4
- European wide cell planning considering DME interference onto LDACS1
  - Cells can cover twice the expected 2020 traffic
  - Only half of available channels required
  - Lowest data rate considered (robustness)

Huge potential for future growth

LDACS1 System Overview

LDACS1 Potentials

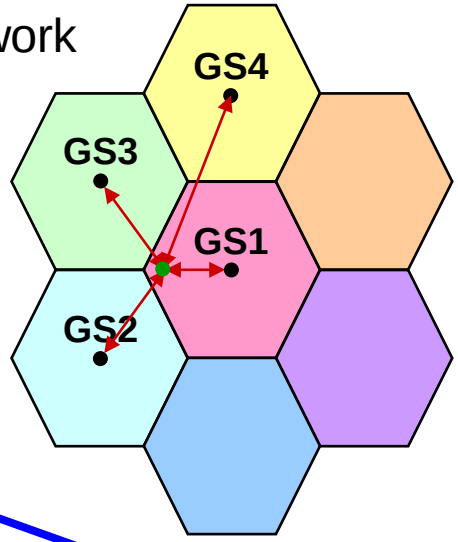
- LDACS1 enables high-capacity aeronautical communications
  - Min. net data rate (FL+RL=overall): 291+270 = 561 kbit/s
  - Max. net data rate (FL+RL=overall): 1.32+1.27 = 2.59 Mbit/s
  - Well suited to serve modern ATM application and future needs
  - Comparison with LDACS2 (overall): 115 kbit/s (70 kbit/s)
- LDACS1 foresees quality-of-service
  - Fast access to resources, both forward and reverse link
  - Low delays for application
  - Different priorities for different applications
- Highly flexible solution with “Long-term Evolution” capability of LDACS1
  - Like LTE, extension towards higher performance
  - Scalability of physical layer design (OFDM)
- Integration of navigation functionality into LDACS1

Extension Towards Navigation

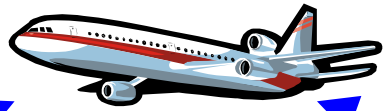
Basic Concept

DLR Project
LDACS-NAV

- The LDACS1 communication system is a cellular network
- Ground stations (GS) are separated in frequency
- GS are synchronized to each other



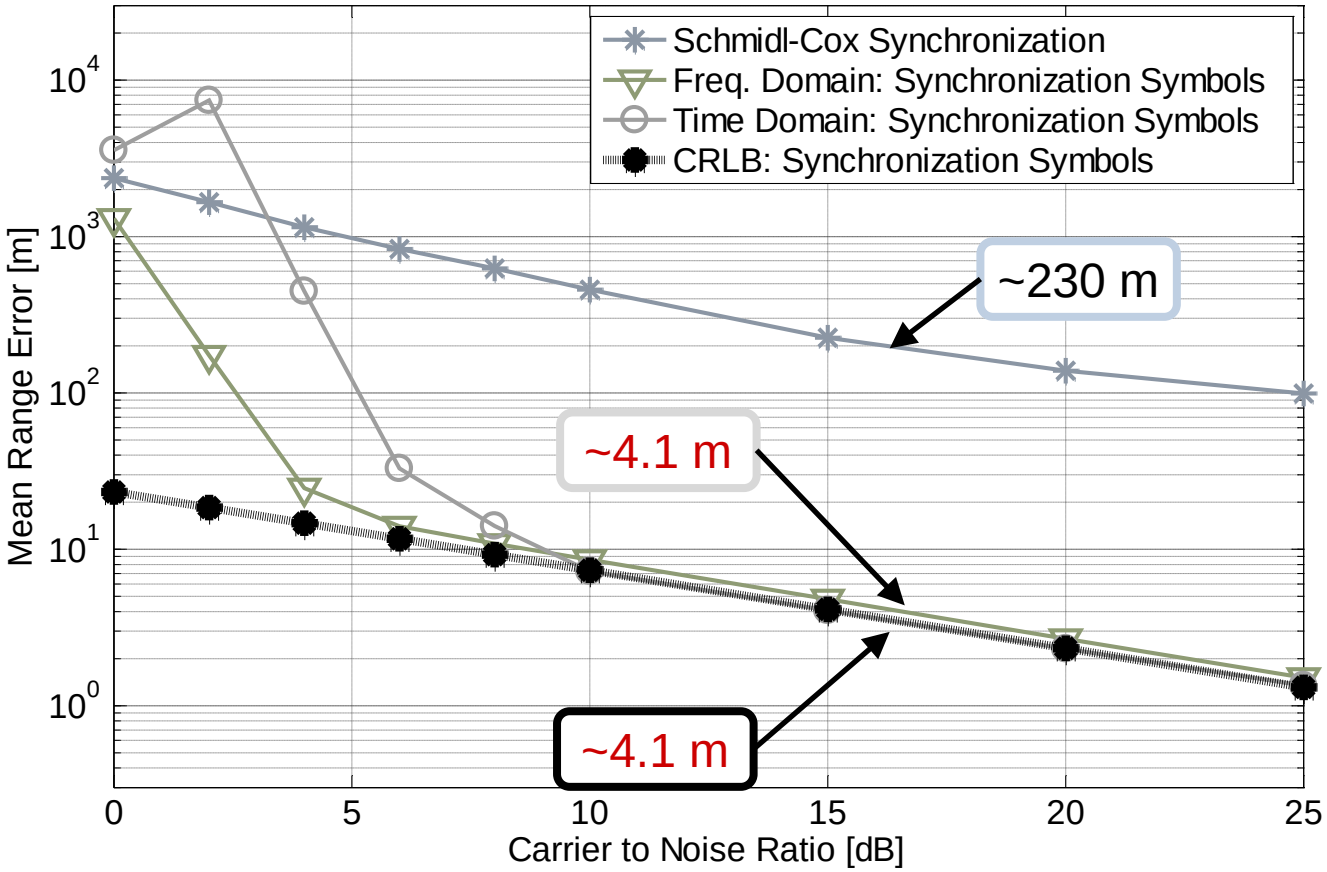
GNSS Back-up (APNT)



Continuously transmitting LDACS1 ground stations act as pseudolites

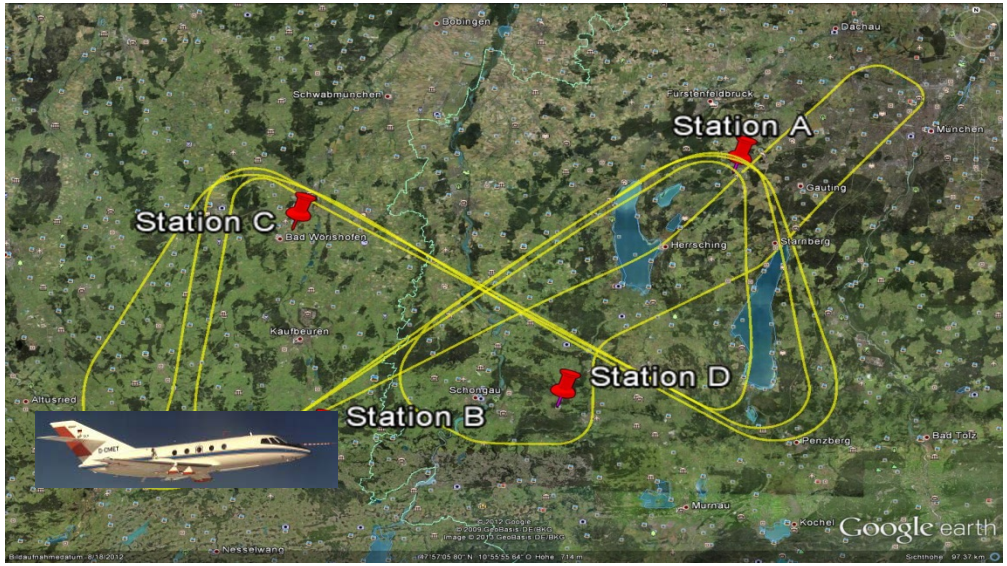
Extension Towards Navigation

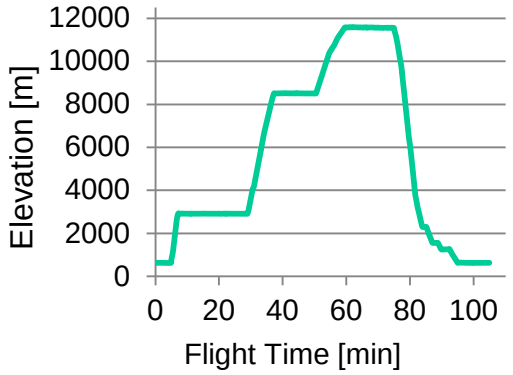
Performance Bounds on Ranging With LDACS1

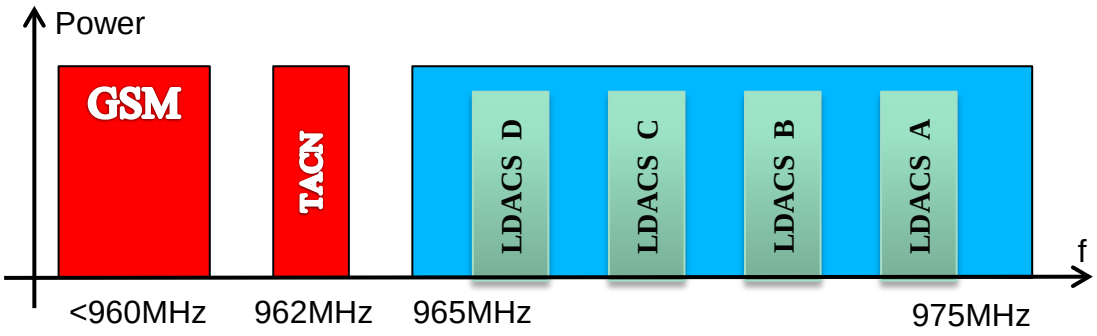


Extension Towards Navigation

Flight Measurement Campaign



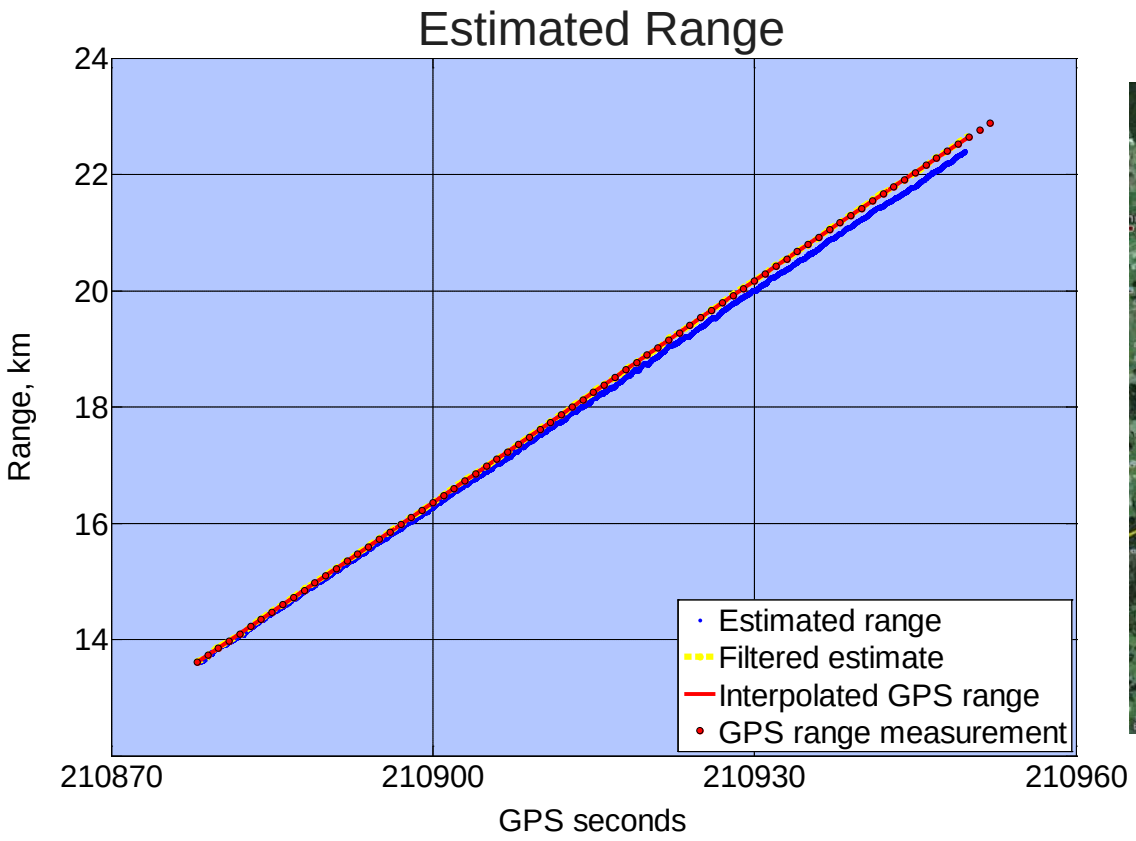




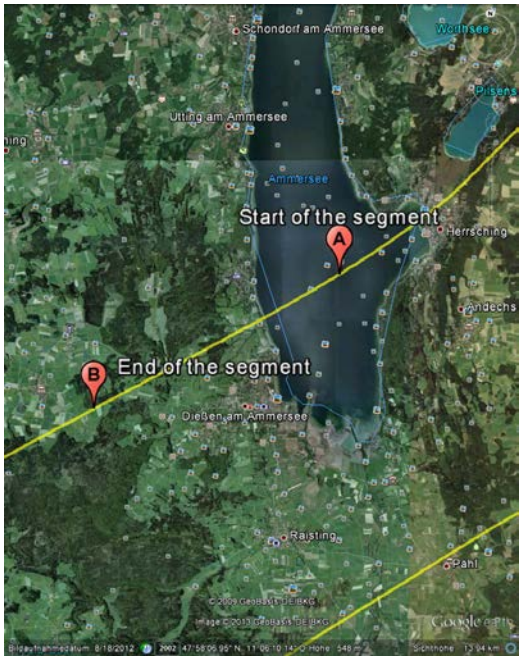
Distance, km from/to	B	C	D
A	60	50	30
B		30	28
C			43

Extension Towards Navigation

Ranging Results for Station A

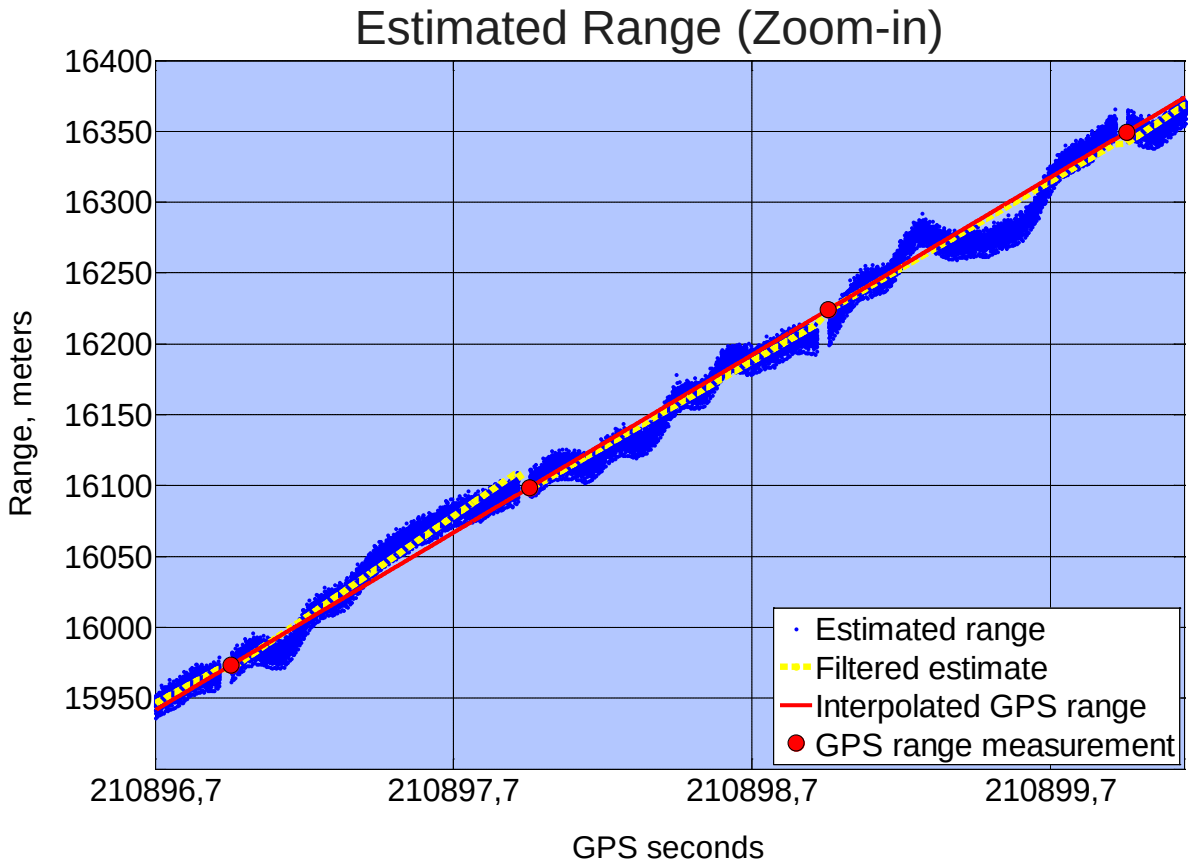


Flight Segment



Extension Towards Navigation

Ranging Results for Station A – Zoom-in



Extension Towards Navigation

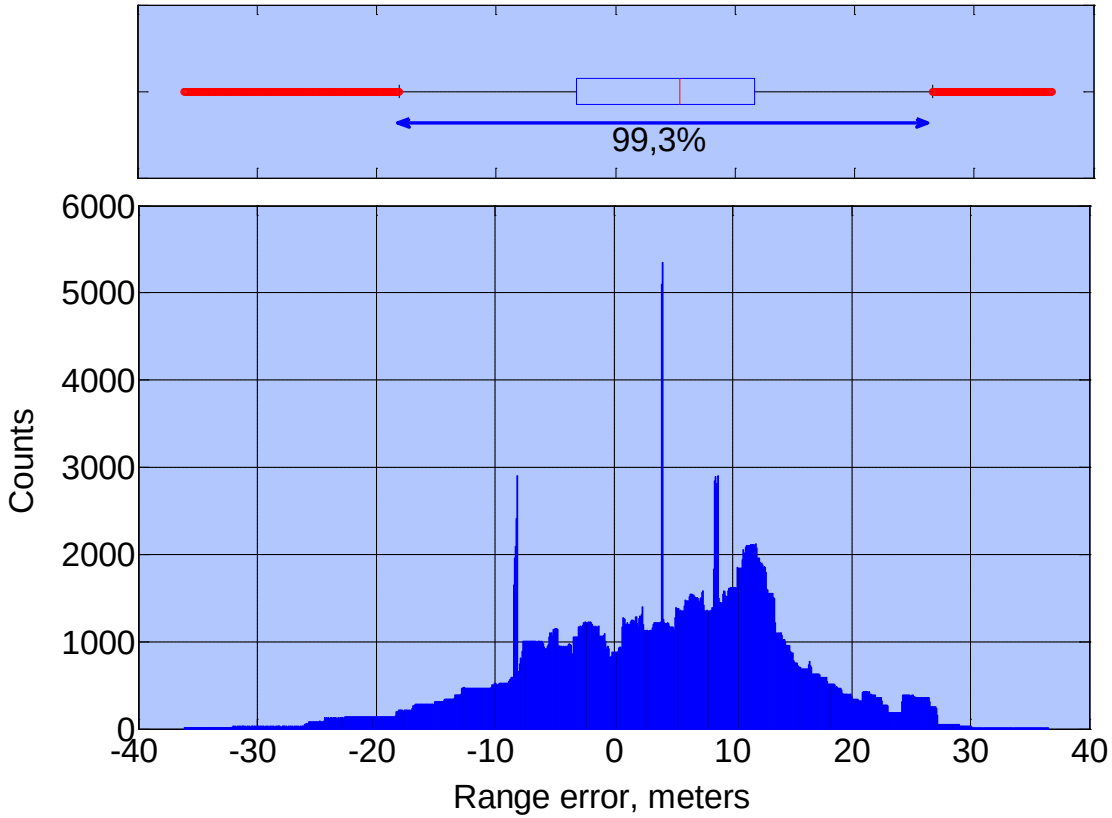
Ranging Results for Station A – Error Distribution

Filtered OFDM ranges
Snapshot length: 80s
Traveled distance: 9 km

Ranging performance:

$\sigma = 10$ m

$\mu = 4.1$ m



The ICONAV Project

Project Facts

- German national project
  co-funded by Ministry of Economy

- Time frame: Jan 2012 – March 2015

- Project Partners
  - Rohde & Schwarz (project lead, HW implementation, frontend design)
  - Rohde & Schwarz SIT (R&S subsidiary, security branch)
  - German Aerospace Center (DLR, knowledge transfer)
  - University Passau (Institute of IT-Security and Security Law)
  - iAd GmbH (SME, HW implementation)
  - BPS GmbH (SME, RF frontend design)

- Strong relation to DLR internal project LDACS-NAV

The ICONAV Project

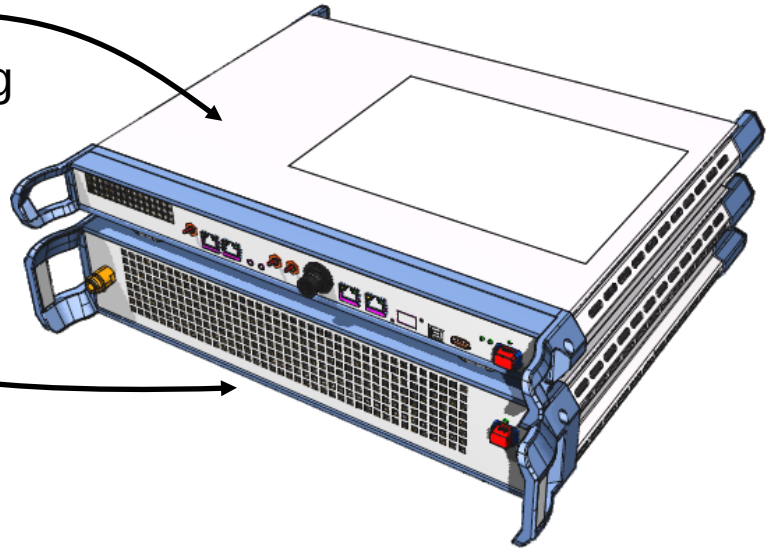
Project Goals

- Transfer LDACS1 knowledge (research, specification) into industry
- Optimize existing LDACS1 specification with respect to performance and industry requirements
- Supplement LDACS1 with additional features, e.g. data security
- Adjust LDACS1 specification to enable integration of navigation services (interface to navigation functionality)
- Develop and implement an industrial LDACS1 HW demonstrator

The ICONAV Project

Hardware Implementation

- Reuse existing R&S Waveform Development Environment (WFDE)
  - WFDE – Digital Unit:
    FPGA based baseband processing
  - WFDE – Transceiver Unit:
    New development for L-band



- Transceiver unit - details:
  - Full duplex transceiver
  - Forward link 960-1009 MHz
  - Reverse link 1048-1164 MHz
  - Transmit power 500 W (peak)
  - Optimization for protection against interference, robust receiver
  - Optimization for protection of other systems, low-noise transmitter

The ICONAV Project

Hardware Implementation – WFDE Digital Unit

The ICONAV Project

Current Status ICONAV and LDACS-NAV

ICONAV Project

- Knowledge transfer	almost finalized
- Optimize specification	almost finalized
- Data security concept	ongoing
- Interface to navigation functionality	ongoing
- Demonstrator development	ongoing

LDACS-NAV Project

- Prepare flight measurements	finalized
- Perform measurement campaign	finalized
- Evaluation of results	ongoing
- Develop integrity concept	ongoing

Conclusions

- Combining communications with a navigation functionality in LDACS1 enables sustainable use of aeronautical L-band spectrum
- LDACS1 is well-suited to serve modern ATM application and future needs
- The German national project ICONAV is a big step towards industrialization of LDACS1 for combined Com/Nav functionality
- First results of the flight measurement campaign within the LDACS-NAV project are very promising
- Intensive exchange of results between the two projects

Thank You !