The German National Project ICONAV

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What is ICONAV?

ICONAV = Integrated Communication and Navigation 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

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

Continuously transmitting LDACS1 ground stations act as pseudolites

GNSS Back-up (APNT)
Extension Towards Navigation
Performance Bounds on Ranging With LDACS1

![Chart 9 ICNS Conference > The German National Project ICONAV > 23.04.2013](chart9.png)
Extension Towards Navigation
Flight Measurement Campaign

Distance, km
from/to

<table>
<thead>
<tr>
<th>Distance</th>
<th>B</th>
<th>C</th>
<th>D</th>
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<tr>
<td>A</td>
<td>60</td>
<td>50</td>
<td>30</td>
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<tr>
<td>B</td>
<td>30</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>C</td>
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<td>43</td>
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</tbody>
</table>

Power Chart

- GSM
- TACN
- LDACS A
- LDACS B
- LDACS C
- LDACS D

Frequency

- <960MHz
- 962MHz
- 965MHz
- 975MHz

Flight Time [min]
Elevation [m]
Extension Towards Navigation
Ranging Results for Station A

Estimated Range

Flight Segment

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Extension Towards Navigation
Ranging Results for Station A – Zoom-in

Estimated Range (Zoom-in)

- Estimated range
- Filtered estimate
- Interpolated GPS range
- GPS range measurement

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Extension Towards Navigation
Ranging Results for Station A – Error Distribution

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

Ranging performance:
\[ \sigma = 10 \text{ m} \]
\[ \mu = 4.1 \text{ m} \]
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!