Evolution of B-VHF towards L-DACS – L-band Digital Aeronautical Communication System
Michael Schnell
Aerodays 2011, Madrid
Outline
Evolution of B-VHF towards L-DACS1

- Initiation
  - FP6 Project B-VHF
    - Project Facts
    - Goal and Approach
    - Key Characteristics

- L-DACS1
  - Further Development and Evolution
  - Standard proposal L-DACS1
    - Inlay Concept
    - Key Characteristics
    - Measurement Results

- B-VHF
  - Result
Review of FP6 Project B-VHF

Project Facts

- **Project title:** Broadband VHF Aeronautical Communications System Based on MC-CDMA
- **Project lead:** Frequentis AG
- **Duration:** 1.1.2004 – 30.9.2006 (33 month)
- **Effort:** 250 person month (3 M€, 1.8 M€ EC funding)

- **Involved partners**
  - DLR
  - NATS
  - GENERICS
  - DFS Deutsche Flugsicherung
  - Universität Salzburg
  - Universiteit Gent
  - Universidad de las Palmas de Gran Canaria

- **Deutsches Zentrum für Luft- und Raumfahrt e.V.**
  in der Helmholtz-Gemeinschaft
Review of FP6 Project B-VHF

Goal and Approach

- Goal: Concept and test-bed for a digital data link in VHF band
- Approach: Overlay system with VHF voice and VDL Mode 2
- Overlay concept enables in-band transition
Review of FP6 Project B-VHF
Goal and Approach

- **Goal:** Concept and test-bed for a digital data link in VHF band
- **Approach:** Overlay system with VHF voice and VDL Mode 2
- **Overlay concept enables** in-band transition
Review of FP6 Project B-VHF
Key Characteristics

- Physical layer based on OFDM technology
  - OFDM (Orthogonal Frequency-Division Multiplexing) is a mature and spectrum efficient technology (DVB-T, WiFi, WiMAX, LTE)
  - OFDM is highly flexible and scalable
- Forward link (FL): MC-CDMA
- Reverse link (RL): OFDMA

OFDM parameters
- Number of subcarriers: 512 (432 used)
- Subcarrier spacing: 25/12 (2.083) kHz
- Channel bandwidth: 900 kHz
- ACM: Adaptive Coding and Modulation
  - $r = 1, \frac{3}{4}, \frac{2}{3}, \frac{1}{2}$
  - QPSK, 8-, 16-, 64-QAM
From B-VHF to L-DACS1
B-VHF Conclusions and Way Ahead

- Conclusions based on theory, simulations, and test-bed measurements
  - Overlay concept and VHF in-band transition feasible
  - Overlay concept requires additional efforts
    - Implementation of overlay specific techniques
    - Reduced capacity during deployment
- ICAO recommendation on frequency band for future A/G data link
  - L-band proposed since VHF band too crowded
  - WRC 2007 assigned L-band (960 – 1164 MHz) to AM(R)S
- Based on promising B-VHF results Eurocontrol initiated research on “B-VHF like system” in the L-band
  - B-VHF in L-band → B-AMC
    - Broadband Aeronautical Multi-Carrier Communications
From B-VHF to L-DACS1
Via B-AMC to L-DACS1

- Overlay \rightarrow Inlay
- TDD \rightarrow FDD
- Framing structure
- OFDM parameters

Future Comm. Study
Coordination with US ICAO recommendation

- P34, WiMAX
- L-DACS1 (B-AMC core)
- L-DACS2 (alternative)

- OFDM as baseline
- L-band environment
- Propagation conditions
From B-VHF to L-DACS1
L-DACS Development Status

- L-band Digital Aeronautical Communication System (L-DACS)
  - L-DACS1 (based on B-AMC, combined with P34 and WiMAX)
    - Broadband system based on OFDM (WiMAX-, LTE-like)
  - L-DACS2 (based on AMACS, combined with LDL)
    - Single-carrier, narrowband system (GSM-like)

- Current development and standardization status
  - ACP WG-W of ICAO recommendation (2008):
    - Prepare decision on L-DACS1/2
    - Further investigations on L-band compatibility
  - Main working activity: SESAR JU Project P15.2.4
L-DACS1 Overview
Inlay Concept

- L-DACS1 as inlay system for the L-band
  - Available bandwidth: 500 kHz per L-DACS1 FL/RL channel
  - Minimize interference to other systems (out-of-band radiation)
  - Mitigate interference from other systems (robustness), e.g. via pulse blanking and coding
  - Take into account mainly DME system, but also SSR Mode S, UAT and JTIDS/MIDS
L-DACS1 Overview

Key Characteristics

- Main L-DACS1 system parameters
  - Number of subcarriers: 64 (50 used)
  - Sub-carrier spacing: 625/64 (9,765625) kHz
  - Channel bandwidth: B = 488.28 kHz
  - OFDM symbol duration: 120 µs
  - Overall guard time duration: 17.6 (12.8 + 4.8 µs) µs = RC-window + guard

- L-DACS1 data rates & adaptive coding and modulation (ACM)
  - Modulation rate (overall FL + RL): 833.33 ksymbols/s
  - Min. net data rate (QPSK, r=0.45): 291/270 kbit/s
  - Max. net data rate (64-QAM, r=0.68): 1318/1267 kbit/s
L-DACS1 Overview
Ongoing Work

- **L-DACS** development within SESAR Joint Undertaking (SJU project P15.2.4)
  - Compatibility measurement set-up, testing plan, evaluation criteria
  - Development of mock-ups for compatibility measurements
  - Recommendation for selection to ICAO

- **L-DACS1 laboratory demonstrator** developed by DLR
  - Based on current L-DACS1 specification
  - L-DACS1 Tx: Complete implementation incl. frontend
  - L-DACS1 Rx: Frontend + software receiver, offline processing
  - Main purpose: Cover compatibility measurements
L-DACS1 Overview
Measurement Results

- Measurement results with DLR L-DACS1 laboratory demonstrator
- First measurement campaign
  @ DFS labs, March 2011

Interference L-DACS1 → DME

Criteria (60s) fulfilled for
D/U ≥ -12 dB
Real D/U = 22 dB
Margin: 34 dB

64-QAM Signal Constellation

Adjusted Desired DME
Power Level @ DME Rx
Conclusion and Outlook

- With L-DACS1 a system proposal almost mature for standardization exists – originally initiated within the EC funded STREP B-VHF
- EC funded research triggered A/G data link development – from B-VHF to L-DACS1
- This example shows the importance of STREPs and contributions of research organizations to the ATM research program

- First measurement campaign delivered very promising results
- Full compatibility measurement campaign planned in summer 2011
  - Covers whole set of compatibility measurements
  - Results are input to SESAR P15.2.4

Thank You for Your attention!