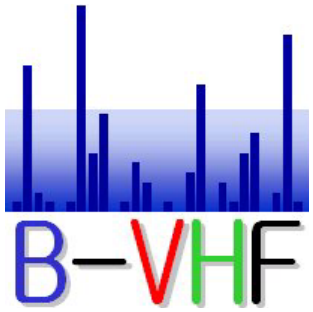


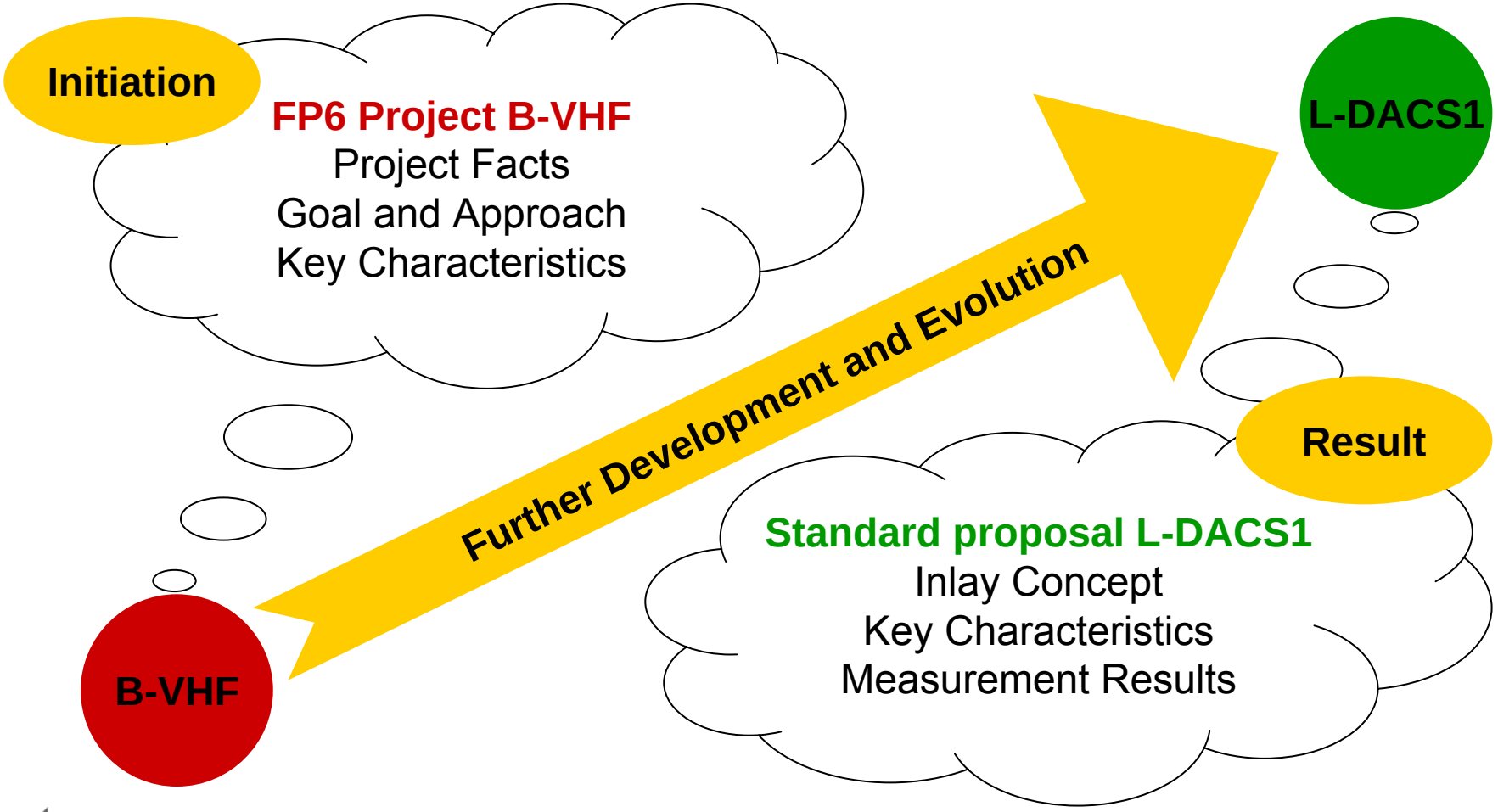
Evolution of B-VHF towards L-DACS – L-band Digital Aeronautical Communication System

Michael Schnell

Aerodays 2011, Madrid

Outline

Evolution of B-VHF towards L-DACS1



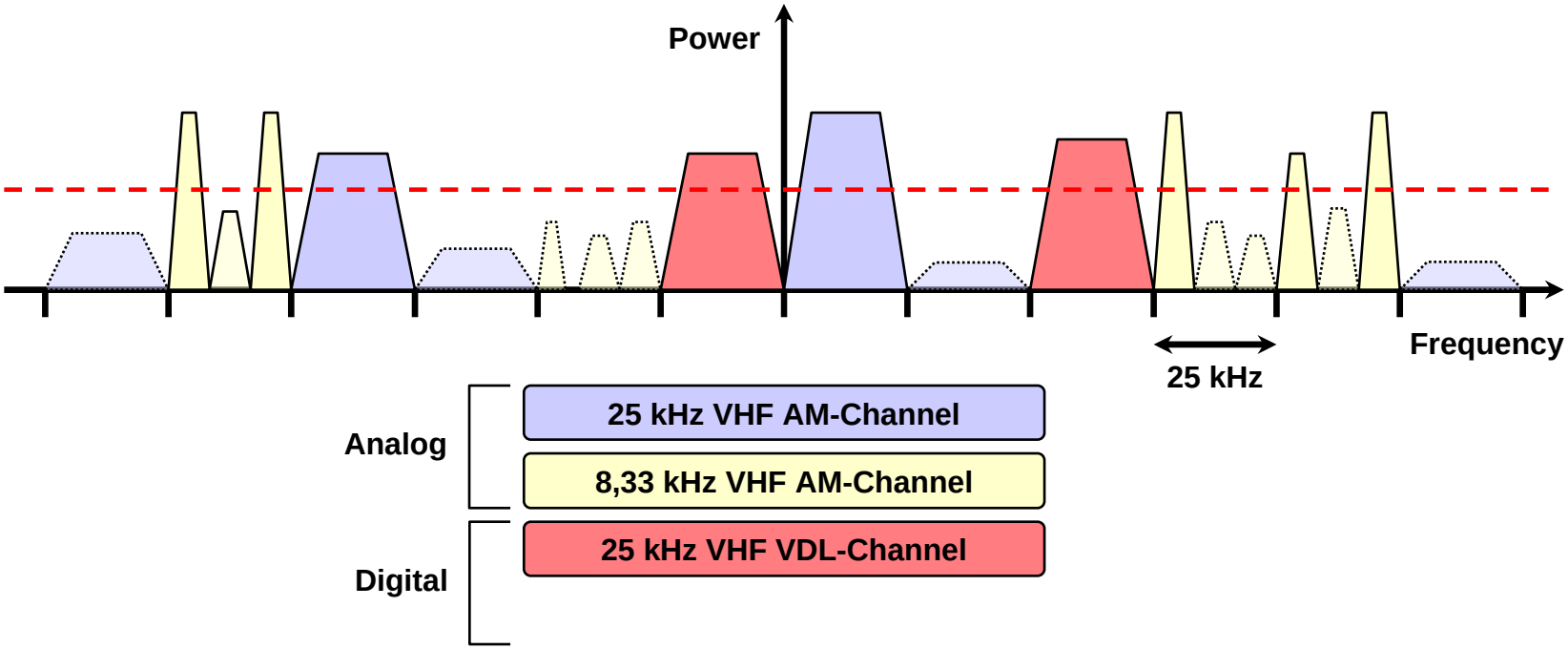
Review of FP6 Project B-VHF

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

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



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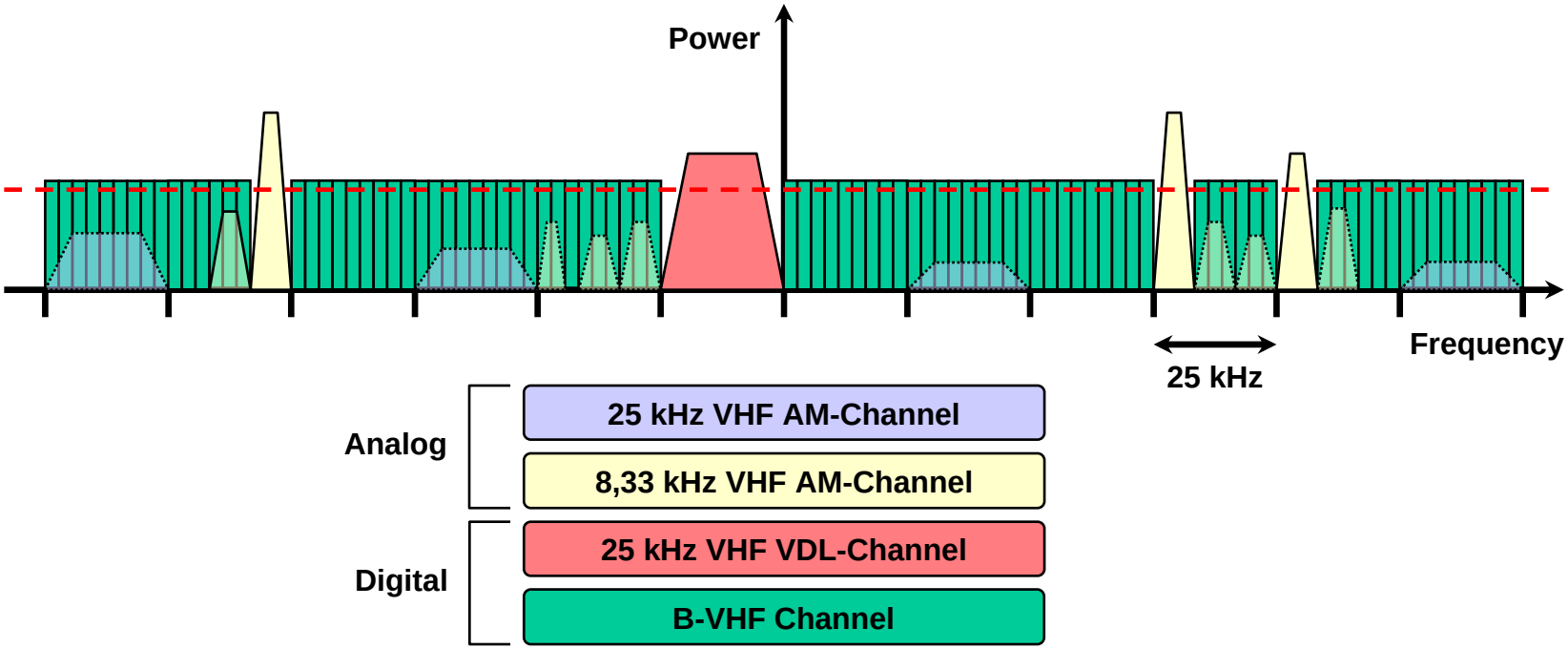


Review of FP6 Project B-VHF
Key Characteristics

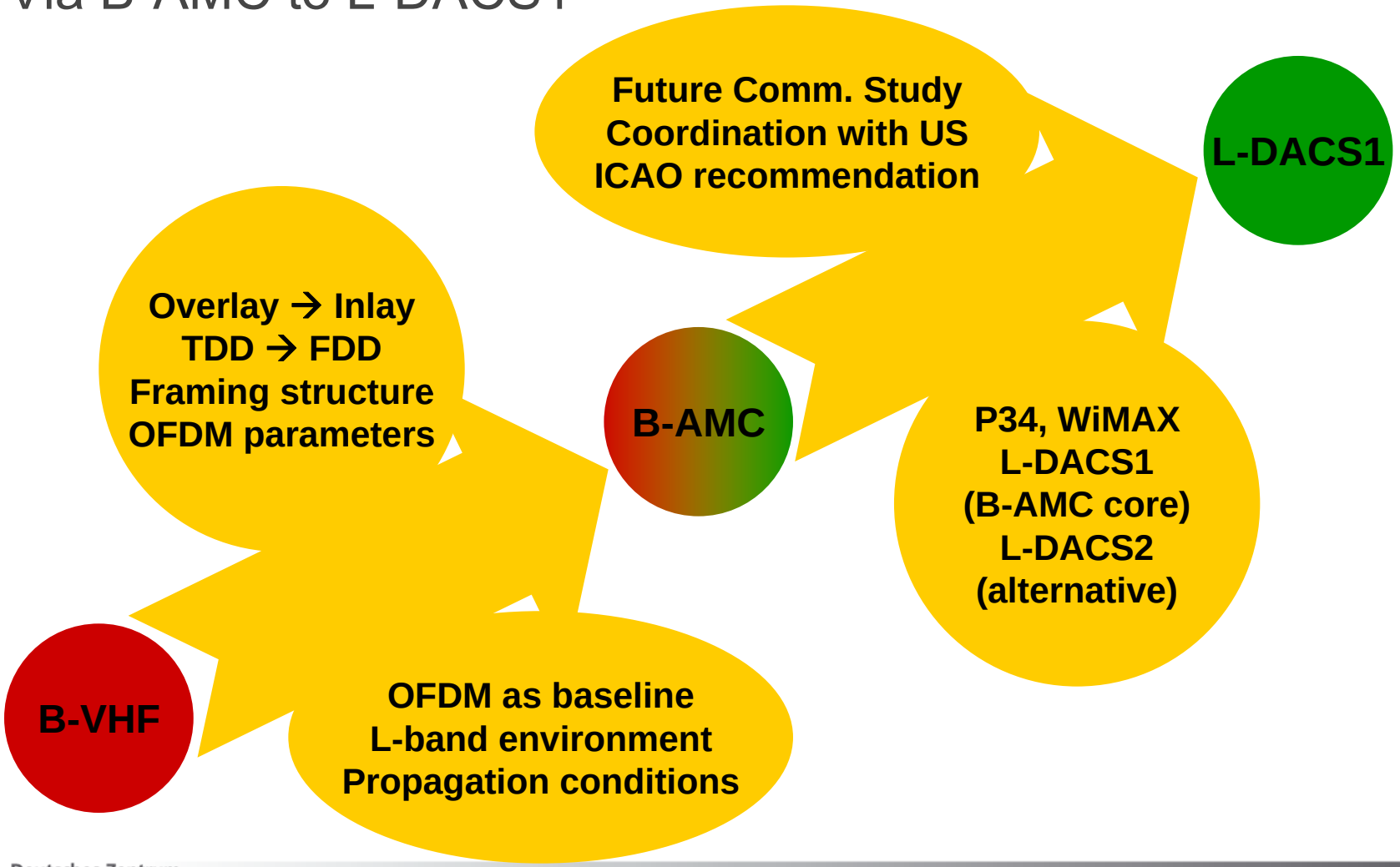
- Physical layer based on OFDM technology
  - OFDM (Orthogonal Frequency-Division Multiplexing) is a mature and spectrum efficient technology (DVB-T, WiFi, WiMAX, LTE)
  - OFDM is highly flexible and scalable
  - Forward link (FL): MC-CDMA
  - Reverse link (RL): OFDMA
- OFDM parameters
  - Number of subcarriers: 512 (432 used)
  - Subcarrier spacing: 25/12 (2.083) kHz
  - Channel bandwidth: 900 kHz
  - ACM: Adaptive Coding and Modulation: r = 1, ¾, ⅔, ½; 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



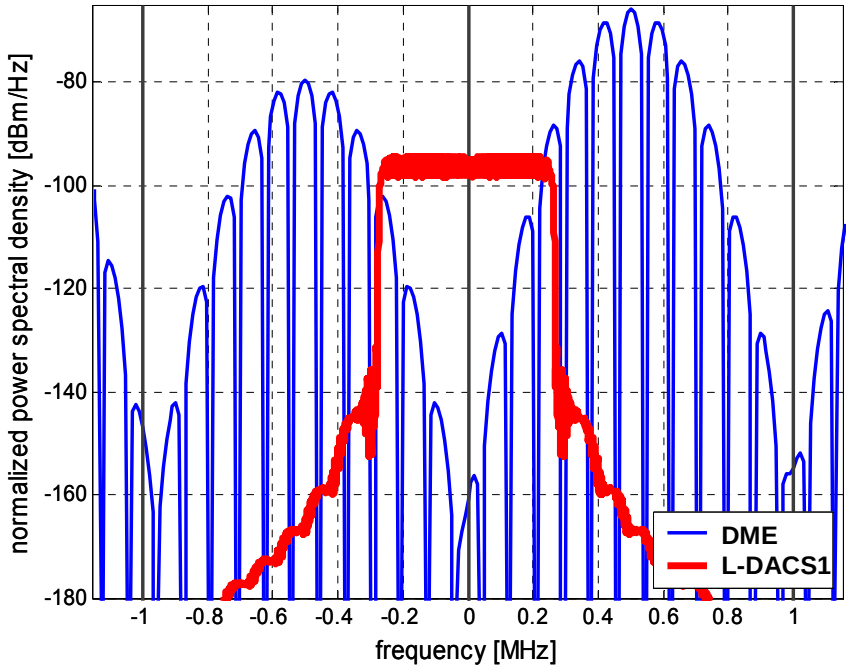
From B-VHF to L-DACS1
L-DACS Development Status

- 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 = RC-window + guard — 17.6 (12.8 + 4.8 µs) µs

- 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

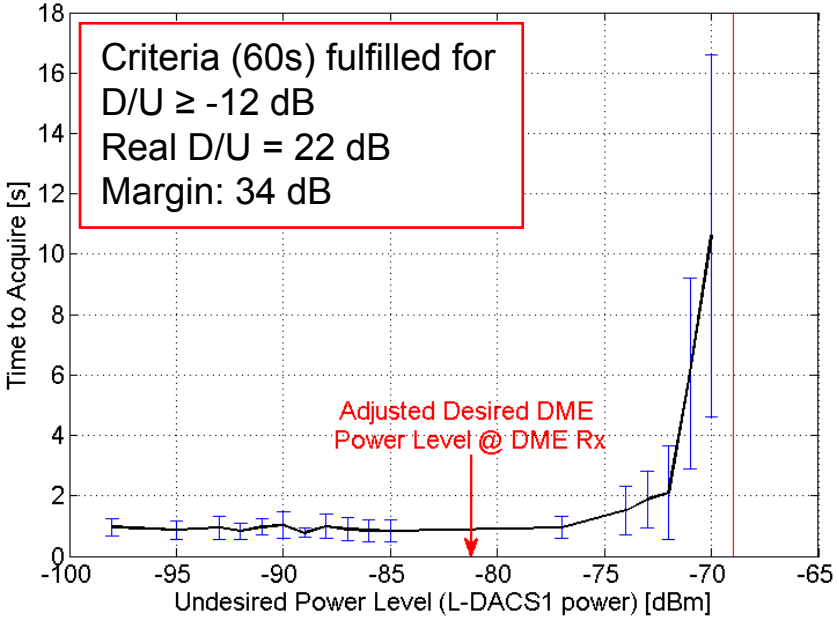
- L-DACS1 laboratory demonstrator developed by DLR
  - Based on current L-DACS1 specification
  - L-DACS1 Tx: Complete implementation incl. frontend

  - L-DACS1 Rx: Frontend + software receiver, offline processing
  - Main purpose: Cover compatibility measurements

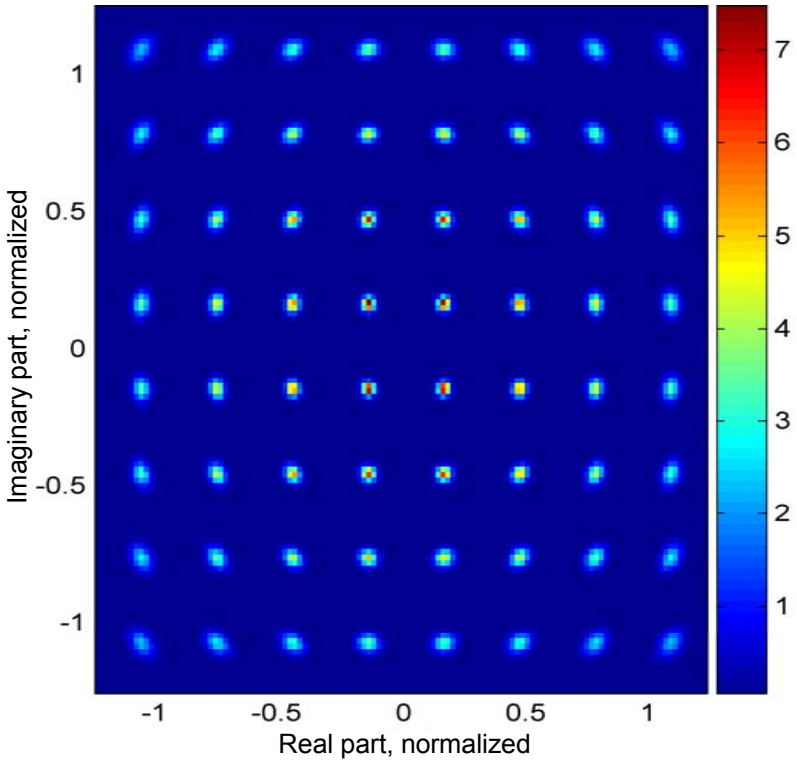
L-DACS1 Overview
Measurement Results

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

Interference L-DACS1 → DME



64-QAM Signal Constellation



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

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- 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!