UAS Datalink Architecture Ad-Hoc: Status Report

Participants: Frank Box, Tim Brown, Leo Globus, Steve Heppe, Raj Jain, Fred Templin, Warren Wilson, Kwong-Sang Yin

Presented by Raj Jain, Jain@acm.org

RTCA SC203 Committee on Unmanned Aircraft Systems,
18th Plenary
October 20, 2010
Datalink Architecture Ad-Hoc

- Participation Open
- Teleconference on alternate Tuesdays at 1:30PM ET.
- Next Meeting: October 26, 2010
- For meeting details, please contact Raj Jain, jain@acm.org
L-Band Digital Aeronautical Communication System

Two projects funded by Eurocontrol for civil aviation

L-DACS1: OFDMA+FDD

L-DACS2: TDM+TDD

OFDMA is better than TDM in terms of interference resistance

TDD is better than FDD for asymmetric traffic

GSM900 towers located near the airport could interfere with L-DACS2 systems

Conclusion: L-DACS1 is better of the two. TDD would make it even better

⇒ Formation of the ad-hoc group
⇒ Started with discussion on Warren Wilson’s proposal
Base Architecture [Wilson]

- Uses both L (960-1164 MHz) and C (5030-5091 MHz) Bands
- L-band compulsory, C-Band optional (for medium/large UAs)
- C-band for high-throughput video+weather
- OFDM
- TDD ⇒ No simultaneous sending/receiving
- Individual or Networked control:
  Multiple controllers can optionally share a ground station
- 69 nmi radius cells, Total 20 UAs, 4 Video UAs, 4 Weather UAs per cell
- 20 Hz rep rate required ⇒ 50 ms
40 ms cycle = 28 ms down + 12 ms up

28 ms

12 ms

4 ms turn-around time \(\Rightarrow\) 24 ms down + 8 ms up usable

- Base: 37.5 kHz QPSK 1/2 \(\Rightarrow\) 37.5 kbps
  \(\Rightarrow\) 22.5 kbps down + 7.5 kbps up
- Video: 225 kHz QPSK 3/4 \(\Rightarrow\) 202.5 kbps down
- Weather: 37.5 kHz QPSK 1/2 \(\Rightarrow\) 22.5 kbps down

Total spectrum/Cell = 20 \times 37.5 + 4 \times 225 + 4 \times 37.5 = 1.8 MHz

Total Spectrum = 12 \times 1.8 = 21.6 MHz for a cluster of 12 cells

L-Band: Same design

- 12 \times 20 \times 37.5 kHz = 9 + 1.4 = 10.4 MHz for a cluster of 12 cells
Datalink Architecture Issues

1. Need to enhance availability over 0.998  
   (Effect of 2-bands)
2. Common Architecture for Civil+UA  
   (20 UAs vs. 200 aircrafts)
3. OFDMA carrier spacing for Doppler
4. Support both networked and non-networked controllers  
   (Look into Femto cells, VDL4 for ideas)
5. 4ms Guard time: Need finer analysis  
   (one-way or round trip delay?)
6a. Allocation of Channels
6b. Preemption: Should UAs in emergency be allowed to preempt others?
7. Chaining: Should UAs be allowed to reach ground station through other UAs?
Parallel reception by multiple ground stations (GSs)

**Issues:**
1. All ground stations will need to sync time slots: GPS
2. Each ground station receiver will need to support multiple channels: Receivers are low cost. FFT can help cover a wide spectrum.
3. Encrypted transmissions: Primary GS shares the key with selected neighbors
4. Network layer aggregation and uplink availability

Solution: Internet Routing Overlay Network (IRON) by Fred Templin
Measured data on UAT systems

Probability of success increases iff reception are uncorrelated

⇒ Need to find uncorrelated partner ground stations
L-Band GS antennas are omni
C-Band GS antennas are directional
C-Band uses the direction from L-Band
L-Band used for entry+resource requests on both bands
  - Two bands in series
    ⇒ Availability = 0.998*0.998 = 0.996
Need to make C-band operation independent of L-Band ⇒ C-Band entry
Issue: C-band antennas are directional

1. Rotating antenna:
   (5 deg beam, 72 dwells/sec $\Rightarrow$ 3s/cycle)

2. Omni-directional
   Sectorized Antenna
   (300 elements, 10m dia)

3. E-scan smart Antenna
   (1500 elements, 1m dia)
Reception at multiple ground stations may help improve the availability of downstream transmissions.

Multiple hops ⇒ Need to look at higher layers of networking.

L-Band and C-Band operation needs to be independent ⇒ C-Band entry.

Outstanding issues: Scalability, OFDMA carrier spacing, Ad-hoc mode, preemption, chaining, …