RTCA

UAS Datalink Architecture Ad-Hoc: Status Report

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RTCA SC203 Committee on Unmanned Aircraft Systems, 18th Plenary

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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

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Analysis of L-DACS

- 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

Base Architecture (Cont)

- 40 ms cycle=28 ms down+12 ms up

- 4 ms turn-around time ⇒ 24 ms down + 8 ms up usable
  - Base: 37.5kHz QPSK 1/2 ⇒ 37.5 kbps
    ⇒ 22.5 kbps down + 7.5 kbps up
  - Video: 225 kHz QPSK 3/4 ⇒ 202.5 kbps down
  - Weather: 37.5kHz QPSK 1/2 ⇒ 22.5 kbps down
- Total spectrum/Cell = 20*37.5+4*225+4*37.5=1.8MHz
- Total Spectrum = 12*1.8 = 21.6MHz for a cluster of 12 cells
- L-Band: Same design
  - 12*20*37.5kHz=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?)

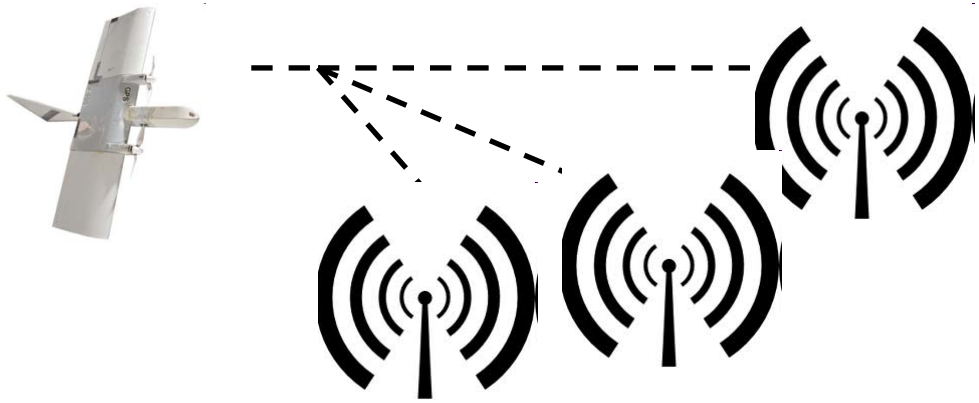
6a. Allocation of Channels

6b. Preemption: Should UAs in emergency be allowed to preempt others?

7. Chaining: Should UAs be allowed to reach ground station through other UAs?

Multiple Receptions [Heppe]

- Parallel reception by multiple ground stations (GSs)

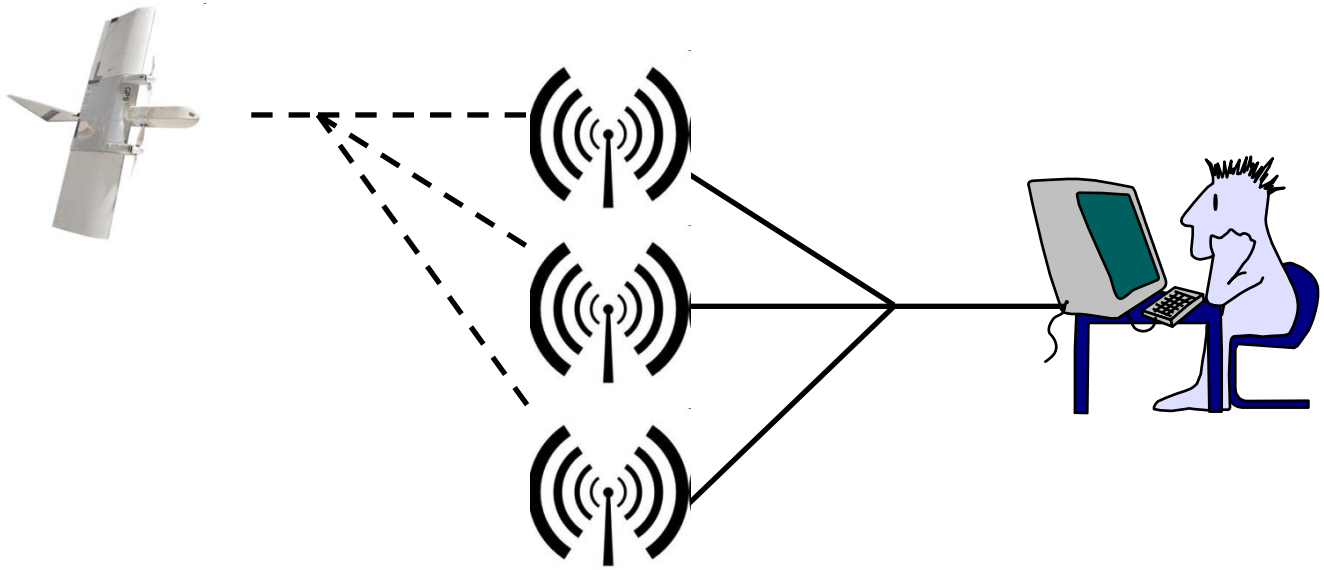


Issues:

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

Multiple Receptions (Cont)

4. Network layer aggregation and uplink availability



Solution: Internet Routing Overlay Network (IRON) by Fred Templin

Measured Data [Wilson]

- Measured data on UAT systems
- Probability of success increases iff reception are uncorrelated
  $\Rightarrow$ Need to find uncorrelated partner ground stations

Dual-Band Availability

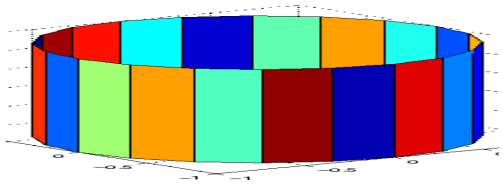
- L-Band GS antennas are omni
- C-Band GS antennas are directional
- C-Band uses the direction from L-Band
- L-Band used for entry+resource requests on both bands
  - Two bands in series
    $\Rightarrow$ Availability =0.998*0.998 =0.996
- Need to make C-band operation independent of L-Band $\Rightarrow$ C-Band entry

C-Band Entry [Heppe]

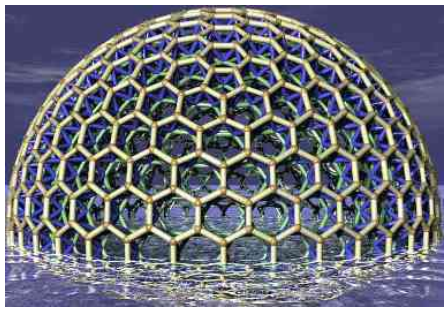
Issue: C-band antennas are directional

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

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



3. E-scan smart Antenna
   (1500 elements, 1m dia)



Summary

- 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, …