Spectrum: the invisible but essential enabler of CNS/ATM

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SESAR digital academy

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Technical Innovation & Evolution in Aviation

- From Cockpits to Air Traffic Control Centers
  - **What about CNS?**

DC-3 (1935)

B-737 (1967)

A-330 (1994)

B-787 (2013)

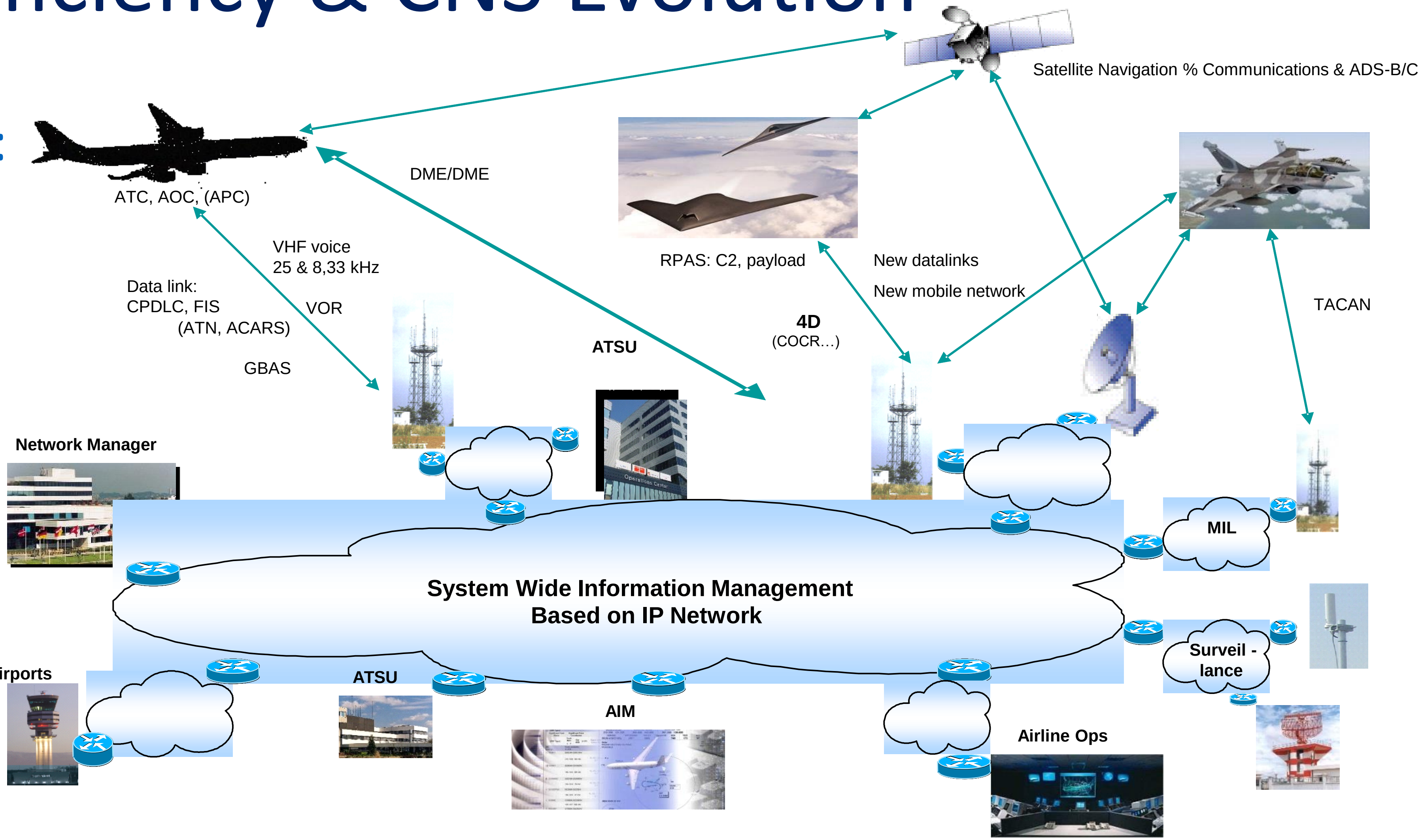
Perspectives on Aeronautical Spectrum

- Large Telecom Company, Innovation Lead
- Airline Executive, Head of Aircraft Fleet Purchasing

- Airline Passenger
- State Radio Regulator

Spectrum Efficiency & CNS Evolution

- Growth Options:
  - **In-Band**
  - **In-Channel or**
  - **New Band**
- COM: Data
- NAV/SUR: Positioning Accuracy & Integrity



SESAR I Spectrum Efficiency Study

The project contracted by Eurocontrol (as a contribution to SESAR PJ14-01-01) to LS telcom and Osprey and was broken into four tasks:

1. A summary of existing spectrum efficiency metrics and their suitability to be applied to aeronautical systems
2. Applying these metrics to different aeronautical systems, where it is found possible to do so, and to identify the gaps where it is not
3. Specifically examine the systems that co-operate in the L-band using case studies to determine the extent to which the band is fully utilised
4. Consider the wider goal of making better use of aeronautical spectrum, through a range of techniques and make recommendations as to changes which may be able to improve efficiency

Raw Metrics

The normal <u>raw</u> spectrum efficiency metric is: bits/second/Hz

Some aeronautical systems (VDL, LDACS) fit this definition nicely, however those whose primary purpose is location do not.

- A radar with an operating range of 200 NM, resolution of 1/128 NM and bearing accuracy of ± 0.25º could discern 36 million unique locations. Rotating every 6 seconds, equates to an 'information rate' of 6 Mbps
- This excludes the trade-offs between measurement error and SNR, however provides a way to convert location into an equivalent bit rate

Typical results for some aeronautical systems (in bits/second/Hz):

- VOR: 0.043, VDL Mode 2: 0.2, LDACS: 0.4 to 2.6,
  SSR (Mode A/C): 0.03~0.05, SSR (Mode S): ~0.16

Typical results for some non-aeronautical systems (in bits/second/Hz):

- GSM: 0.8, WiFi: 1.35, LTE (excluding MIMO): 0.5~4.0, DVB-T2: 0.9~6.3

Some aeronautical systems achieve reasonable 'scores' whereas others (e.g. VOR, ILS) do not

LS telcom
Smart Spectrum Solutions

Next extension to efficiency metric is to consider area: bits/second/Hz/km^2

This takes no account of propagation conditions

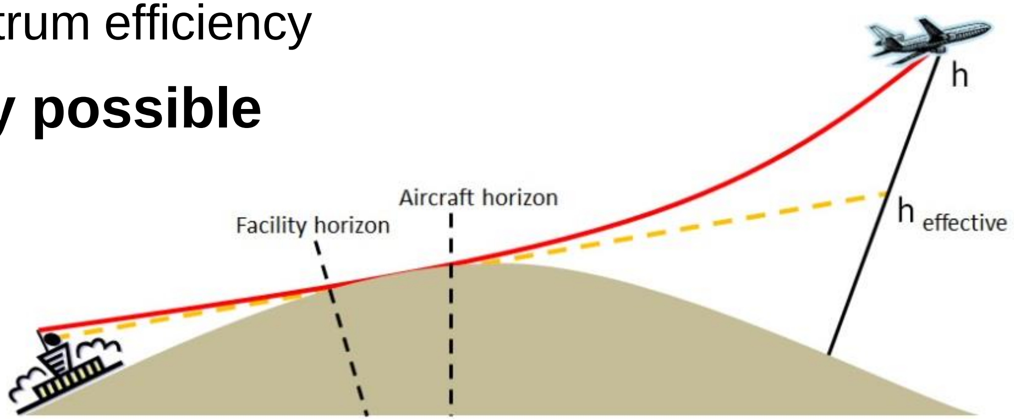
- Aeronautical propagation is virtually free space: signal ∝ 1/distance^2
- Terrestrial propagation factors in shadowing and terrain: signal ∝ 1/distance$^{3 \text{ to } 4}$

The aim of such metrics is to measure the 'density' of service provision over a given area, assuming usage is very dense.

- No account is taken of right-sizing the level of service to meet the required demand
- It is assumed that greater frequency re-use equals greater spectrum efficiency

It is also important to compare like with like, and many possible interpretations of the metrics exist

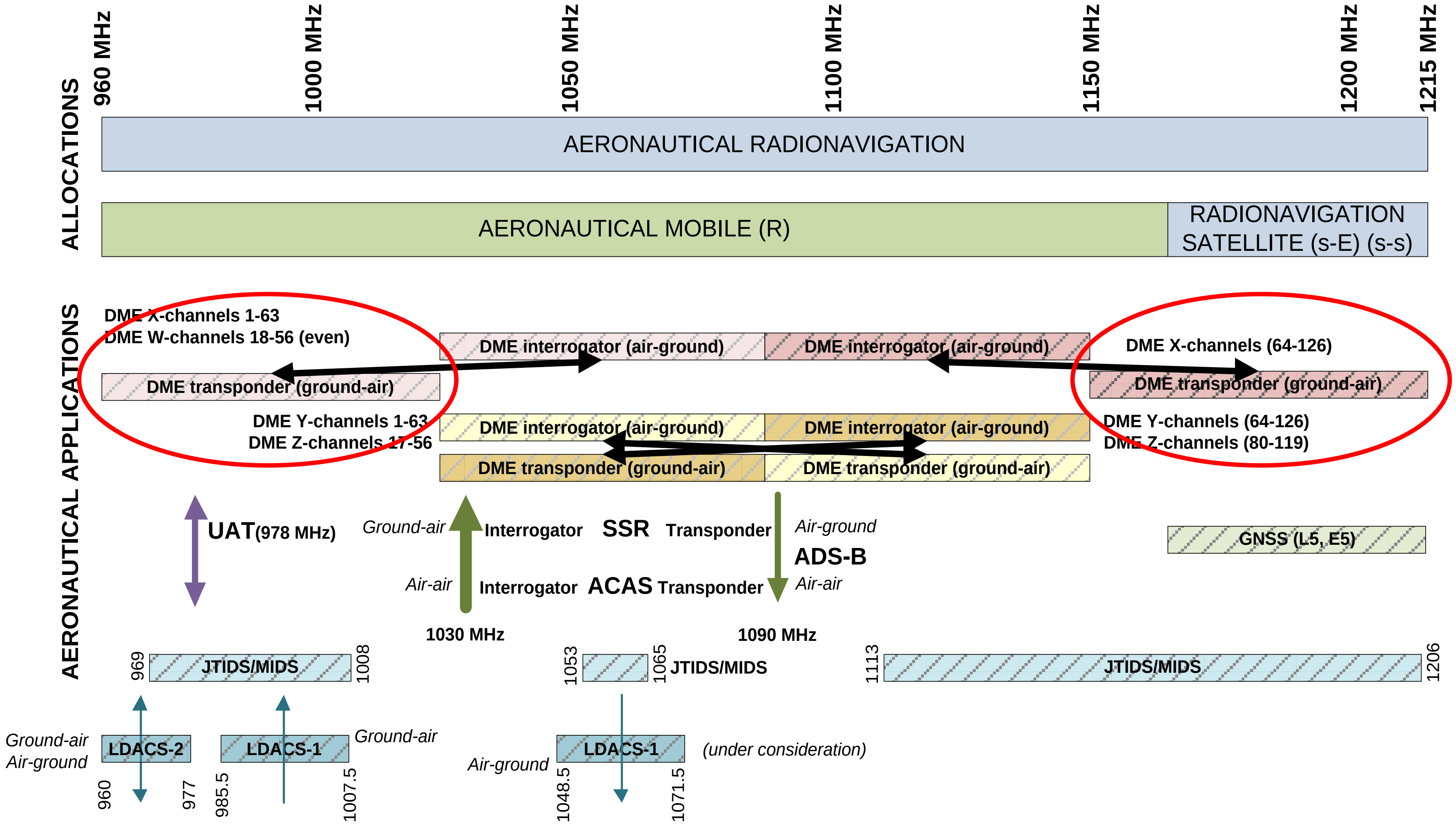
- Are 'bits/second' the transmitted data rate, or the useful information payload (i.e. after error correction)?
- Does 'Hz' relate to channel width, occupied bandwidth or bandwidth sterilized?



No raw metrics consider that integrity or accuracy have a value!

Main Conclusions of Spectrum Efficiency Study

- Not possible to use metrics to derive priorities for spectrum efficiency improvement
  - **Adding data to DME does not provide a significant data rate, LDACS better**
- Instead, considered "L-Band Legacy Factors"
  - **If DME channel assignment planning was optimized, RNAV coverage could be achieved with less channels (50% - many simplifying assumptions)**
  - **State of the art technology could provide all of CNS services in about 20 MHz**
- Current activity in SoI76 ICNS evaluating if DME channels can be re-planned
  - **Decoupling from VOR (enabled by PBN Implementation)**
  - **Determine feasibility of freeing up a portion of L-Band Spectrum to enable a new technology transition**



Note: Services in upper case are primary services

- DME shares with JTIDS/MIDS, GNSS L5/E5/G3 and SUR
- Sharing optimized as far as possible given current systems?
  - There are also NO metrics for sharing efficiency
- Freeing up DME spectrum to facilitate additional sharing with aviation systems (such as LDACS) is challenging

Conclusions

- Evolution of CNS is complex
  - **Mix of diverse analogue and digital technologies**
  - **Space based technologies still require terrestrial back-ups**
  - **Need to work within existing allocations**
  - **Aviation is a mature industry, no effective innovation drivers**
  - **Aviation is global while driven by individual stakeholder business decisions**
- CNS triangle is becoming more inter-dependent
  - **Common mode vulnerabilities vs. common mode strengths**
  - **Aviation must stop taking spectrum for granted: 150 vs. 3 Billion Euros…**
  - **Interference free spectrum must be efficient to be future-proof**
  - **Full cooperation required: CNS, RPAS, Security, MIL**