The ADS-B Webinar

ICAO
MID & EUR/NAT

Spectrum Considerations

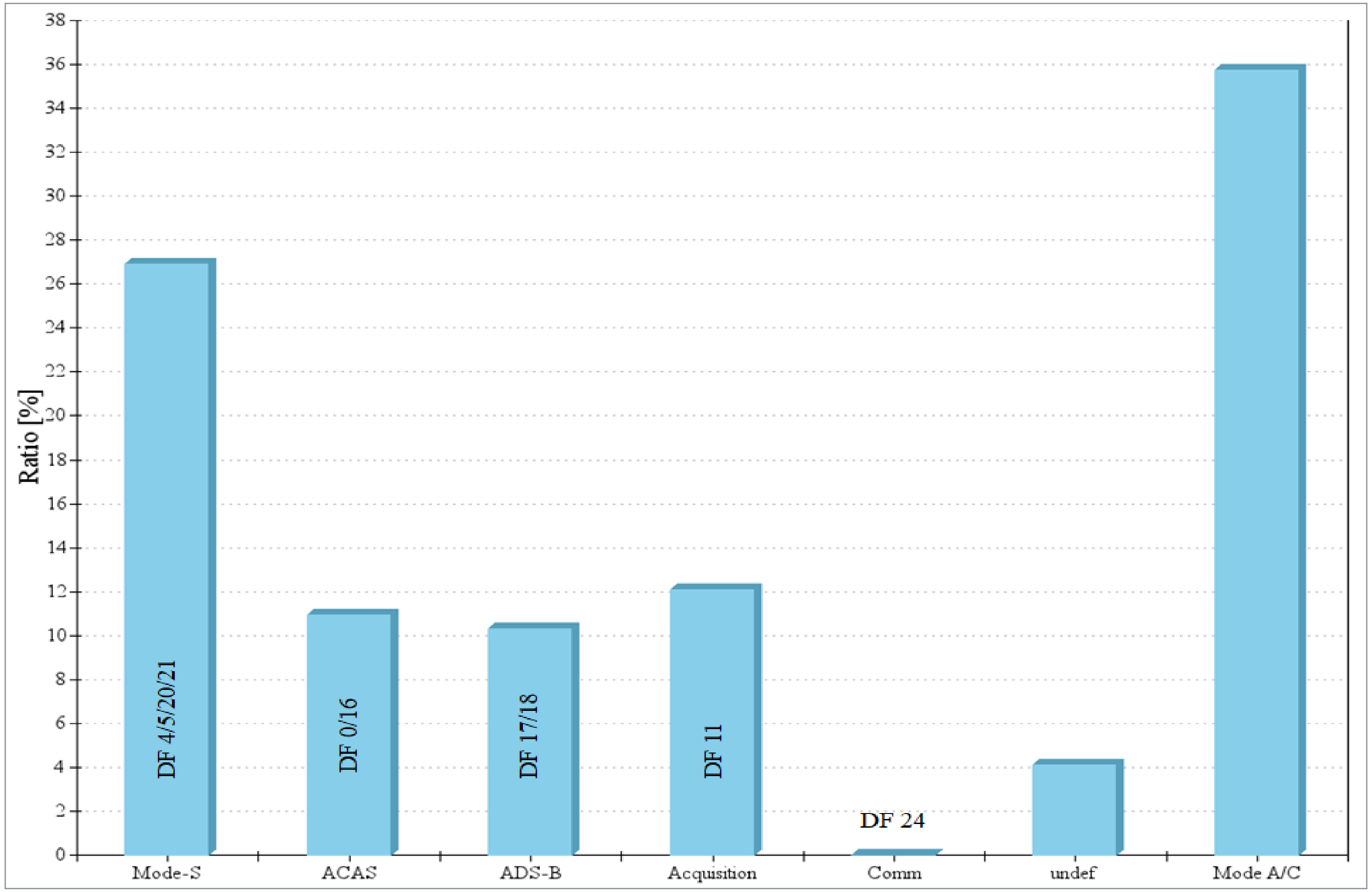
Doug Arbuckle

Federal Aviation Administration
Chair, ICAO Surveillance Panel

1090 MHz Congestion Sources

- SSR/MLAT replies
- TCAS/ACAS replies
- Squitters
  - Acquisition Squitter (Mode S)
  - Extended Squitter (ADS-B OUT)

Source Contributions example



Major Points to Consider

- 1090ES (ADS-B) utilization of 1090 MHz grows linearly with equipped aircraft in a given airspace volume but is typically not the biggest user
- TCAS/ACAS utilization of 1090 MHz grows by <u>more than the square</u> of equipped aircraft in a given airspace volume
  => mitigation is Extended Hybrid Surveillance, which is required in ACAS Xa
- 1090 MHz activity results from both ATCRBS and Mode S type interrogators
- ATCRBS SSR operation is less spectrum efficient than Mode S SSR
- Managing interrogations in heavily surveilled airspace is very important
  - SSRs sharing surveillance data via networking (aka, "clustering"), thereby eliminating redundant surveillance coverage in overlapping geographic regions
  - Use of Passive Acquisition by SSRs and Wide-Area Multilateration
- Mode S Downlink of Aircraft Parameters (DAPs) adds to 1090 MHz utilization – use with caution
- An ongoing 1090 MHz RF monitoring effort may be warranted

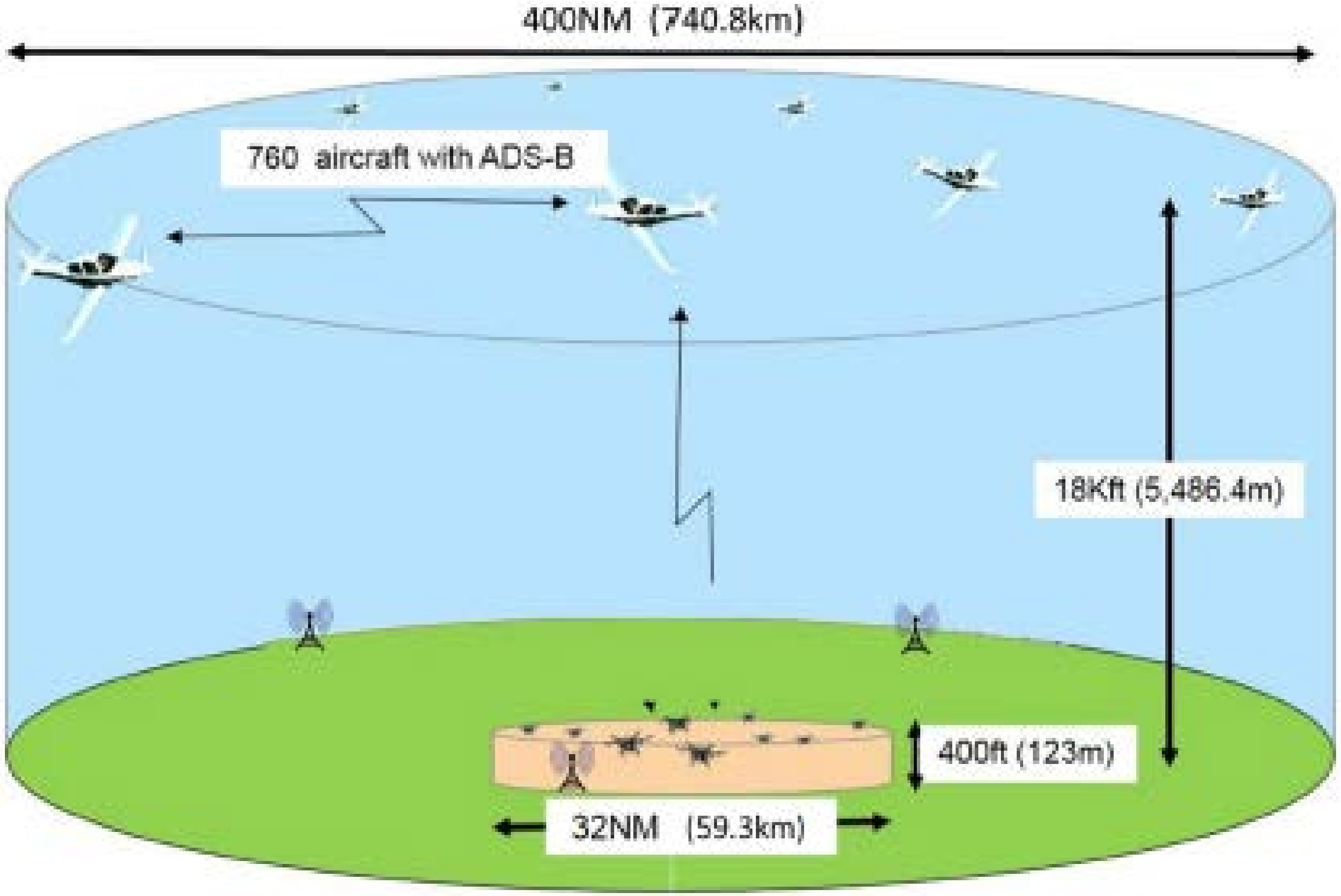
U.S. RPAS Spectrum Analysis

MITRE Study for FAA

- Analyzed UAT (978 MHz) performance assuming equipage by many RPAS at low altitudes
- Purpose was to examine various operational scenarios and estimate UAT's ability to support existing air traffic management air-to-air and air-to-ground applications
- Analysis indicated key parameters are RPAS ADS-B transmission power and RPAS traffic density

Note: NASA performed an independent analysis using a NASA model and produced similar results

Modeled Airspace Environment



Estimated Air-to-Ground Decode Probability (MITRE)

A 16 nm radius circle encompassesjust over 804 square nautical miles

RPAS density per km^2 / RPAS w/in 16 NM radius	RPAS Transmit Power (ERP)			
	1 W	**0.1 W**	**0.05 W**	**0.01 W**
5 / 14000	<0.25	<0.35	<0.10	0.38
3 / 8500	<0.25	<0.35	0.10	**0.58**
1 / 2800	0.25	0.35	0.50	**0.82**
0.5 / 1400	0.50	**0.60**	**0.70**	**>0.82**

Cell phone power levels

U.S. RPAS Analyses Summary

- MITRE and NASA analyses are based on models and do not include real world interference that FAA has observed on both 978 MHz and 1090 MHz at numerous ground station locations
  - MITRE and NASA results are likely optimistic relative to what would be observed in real systems
- 1090 MHz is more congested in the U.S. than 978 MHz, since 1090 MHz is also used by ATCRBS and Mode S systems (TCAS, SSRs and multilateration systems)
  - Impacts on 1090 MHz from RPAS ADS-B transmissions are expected to be significantly worse than those calculated for 978 MHz
- Even at RF transmit power levels which are equivalent to cell phones (1W), RPAS operating in a typical large urban area at airspace densities of one vehicle per 2 km^2 and equipped with ADS-B Out would be expected to cripple any ICAO-compliant surveillance system operating on 978 or 1090 MHz
- Widespread ADS-B Out equipage (as defined in RTCA/EUROCAE MOPS and ICAO documents) by RPAS does not appear to be a feasible alternative

Relevant PfAs and Guidance materials developed by Surveillance Panel

PfAs to Annex 10 Volume IV

- New collision avoidance system (ACAS Xa/Xo) – approved by 3rd meeting of Surveillance Panel
  GANP ASBU Element ACAS-B2/1
- Evolution of ADS-B and Mode S and further ACAS X variants - ***Under development***
  See RTCA DO-260C/DO-181F, EUROCAE ED-102B/ED-73F and RTCA DO-386/EUROCAE ED-275
  GANP ASBU Elements ASUR-B2/1 and ACAS-B2/2

Guidance material (Doc 9924)

- Appendix M - Interference considerations
- Appendix S - Guidance on 1 090 MHz spectrum issues and proper management of 24-bit aircraft addresses associated with unmanned aircraft (UA)
- Guidance for Reduced Performance Devices on 1090 MHz – ***Under development***

THANK YOU