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# **Universal Access Transceiver System Description**

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October 2000**

# Outline

- **History**
- **UAT Description**
  - **System Overview**
  - **Some Details**
- **UAT Role in CNS Architecture and Transition**
- **Spectrum and Standards**
- **Summary Attributes**

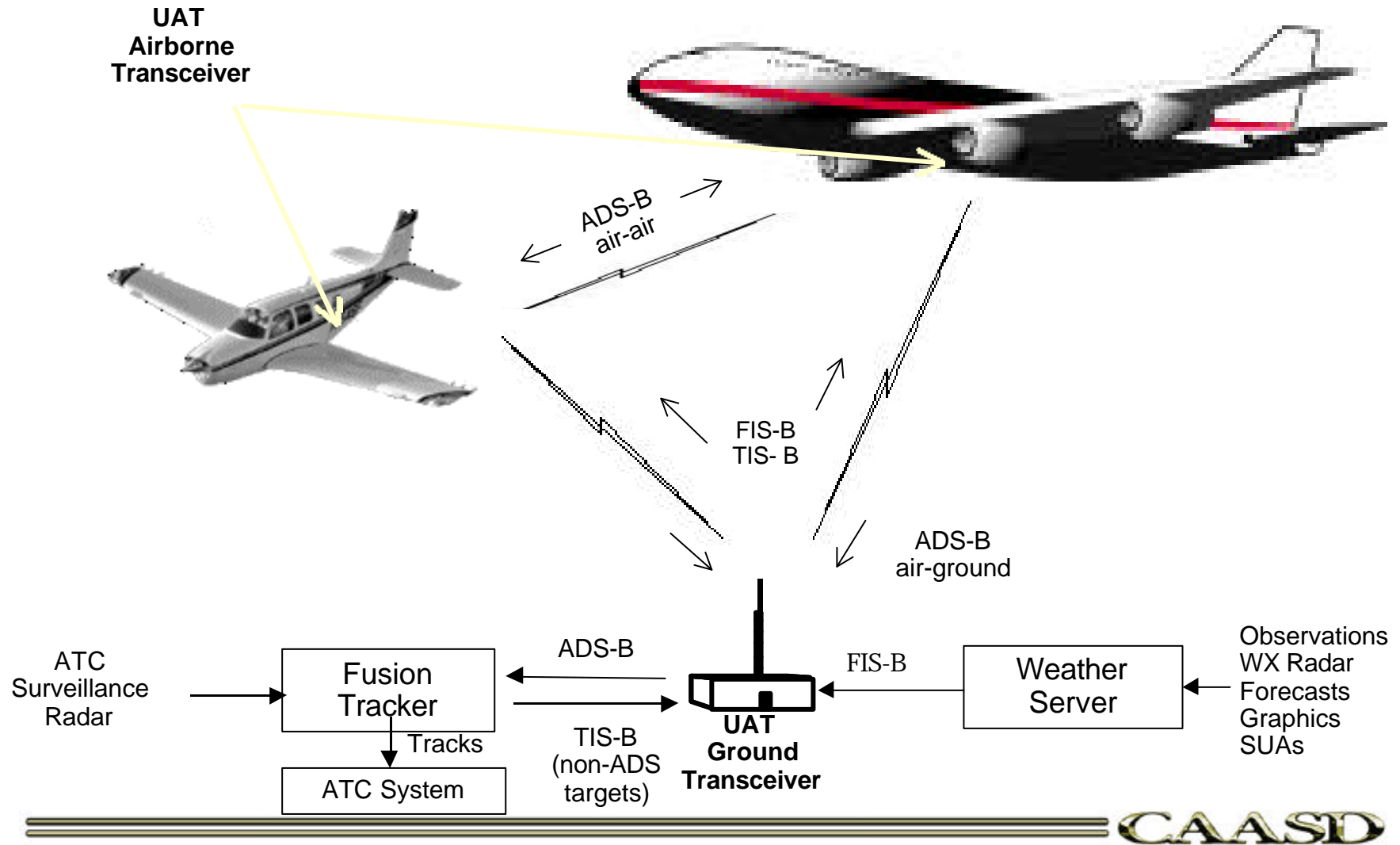
## **A Brief History of UAT**

- **Began around 1995 as part of larger CAASD IR&D initiative on broadcast data link**
  - 6 prototype systems flown on small aircraft
  - ADS-B, TIS-B, and Wx uplink demonstrated
- **Cargo Airlines incorporate UAT in their evaluation--UPS-AT develops UAT**
- **UAT becomes part of SF-21 Link Evaluation study**
- **UAT part of winning bid for FAA's Capstone program**
- **RTCA PMC approves establishment of UAT MOPS working group**

# UAT Overview

- **Designed specifically for ADS-B with no constraints from legacy systems**
- **Simplicity and robustness were paramount design objectives**
- **Operates on a single common wideband channel**
- **1 Mbps channel rate**
- **Capable of supporting multiple broadcast applications to foster early equipage**

# UAT: Broadcast Data Link Supporting ADS-B, TIS-B & FIS-B



# Waveform Selection

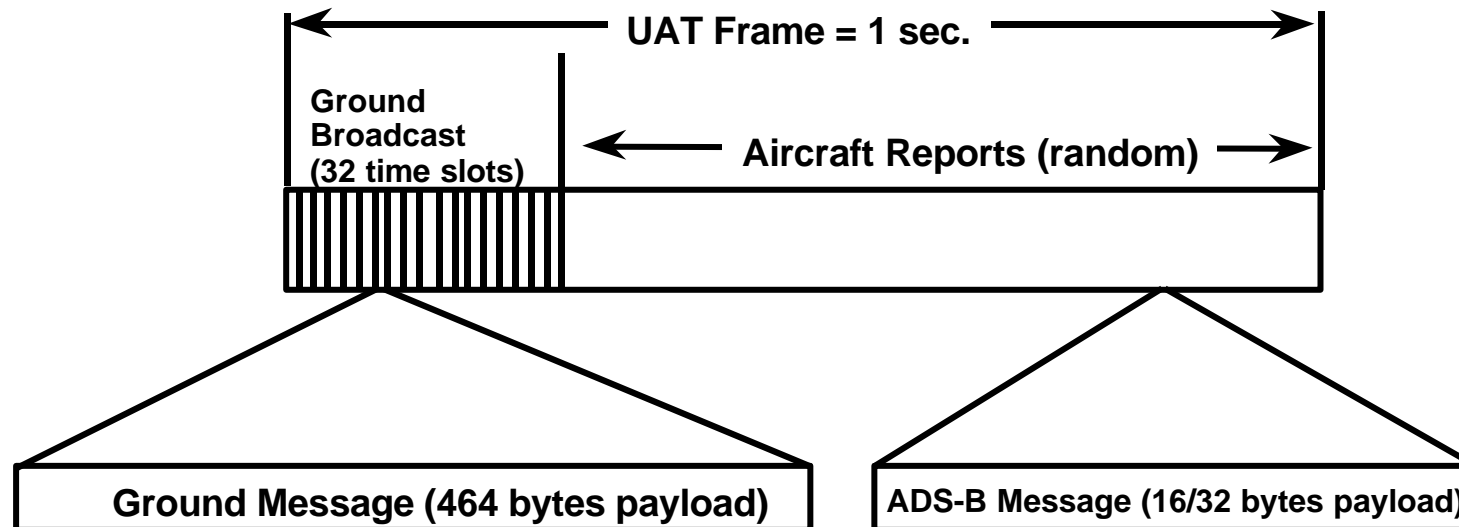
- **Requirements**
  - **Good capture effect**
  - **relatively efficient and low cost power amplifier**
  - **simple/robust decoder**
- **Binary FM with high modulation index chosen**

# Frequency Band Selection

- **ADS-B requires ARNS allocation--3 alternatives:**
  - VHF: 108-118 MHz
  - L-band: 960-1215 MHz
  - C-band: 5000-5250 MHz
- **Extremely difficult to assemble enough contiguous channels at VHF**
- **Propagation loss too high at C band**
- **960-1215 MHz has channelization and current usage most compatible with UAT operation**

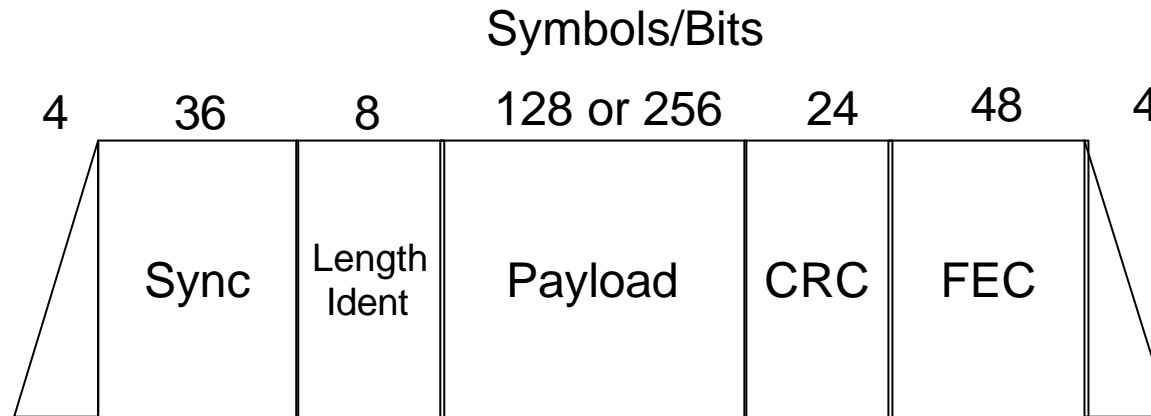
# UAT Media Access Approach

- Requirement: Simple and Robust logic for aircraft media access
- ADS-B transmissions occur based on pseudorandom selection of one of 3200 Message Start Opportunities (MSO)





# ADS-B Message Format



- **Each aircraft transmits exactly one message each second**
- **Standard Forward Error Correction (FEC) increases message robustness to noise and interference**
- **FEC plus Error Checking (CRC) combine for an extremely low undetected message error rate  $<10^{-10}$**

# State Vector Component of Every ADS-B Message

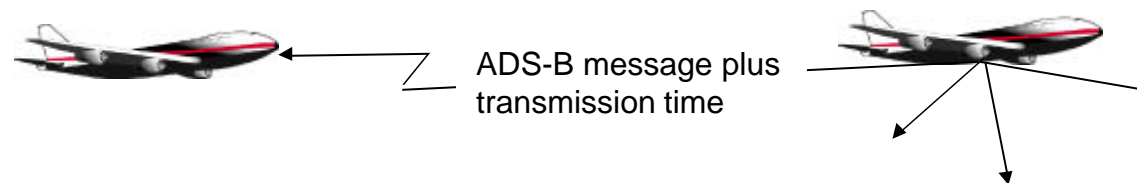
Byte #	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	
0	...						A23	A24 (LSB)	
1	<b>ICAO 24-Bit Aircraft Address</b>								
2	A1 (MSB)	A2	...						
3	(LSB)								
4	<b>Latitude</b>								
5	(Sign)								
6	(LSB)								
7	<b>Longitude</b>								
8	(Sign)								
9	(MSB)	<b>NUC<sub>R</sub></b>			(LSB)	(MSB)	<b>NUC<sub>P</sub></b>		(LSB)
10	<b>N-S Velocity</b>					(LSB)	<b>1 PPS OK</b>	<b>H.Pos.OK</b>	
11	(LSB)			(Sign)					
12	<b>E-W Velocity</b>								
13	(LSB)								
14	<b>Pressure Altitude Rate</b>				(LSB)	(MSB)			
15	<b>Air/Ground State</b>		<b>Anon.</b>		(sign)				

# ADS-B Message Set and Transmission Schedule for Full Capability Participant

- **State Vector + Call Sign**
  - **State Vector + TCP + TCP+1**
  - **State Vector + TCP + TCP+1**
  - **State Vector + [*future payload*]**
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- **One transmitted message every second--4 second message rotation**

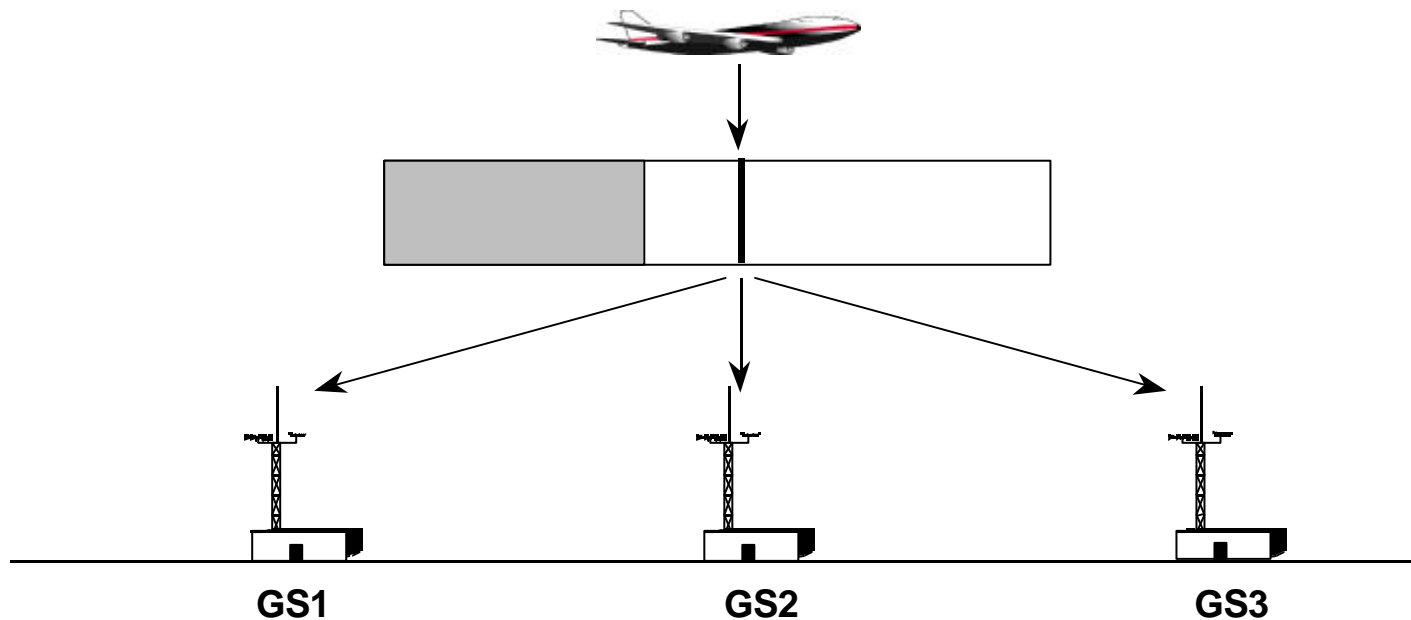
# Independent ADS-B Report Validation: Aircraft Perspective

- **ADS-B message payload includes the precise transmission time (MSO)**
- **Receiving aircraft UAT reports precise time of reception with decoded message payload**
- **Application can perform passive range verification of ADS-B reported position**
- **Preliminary UPSAT flight test data showed time-based slant range estimates to be within 0.2 nmi of that indicated by ADS-B**



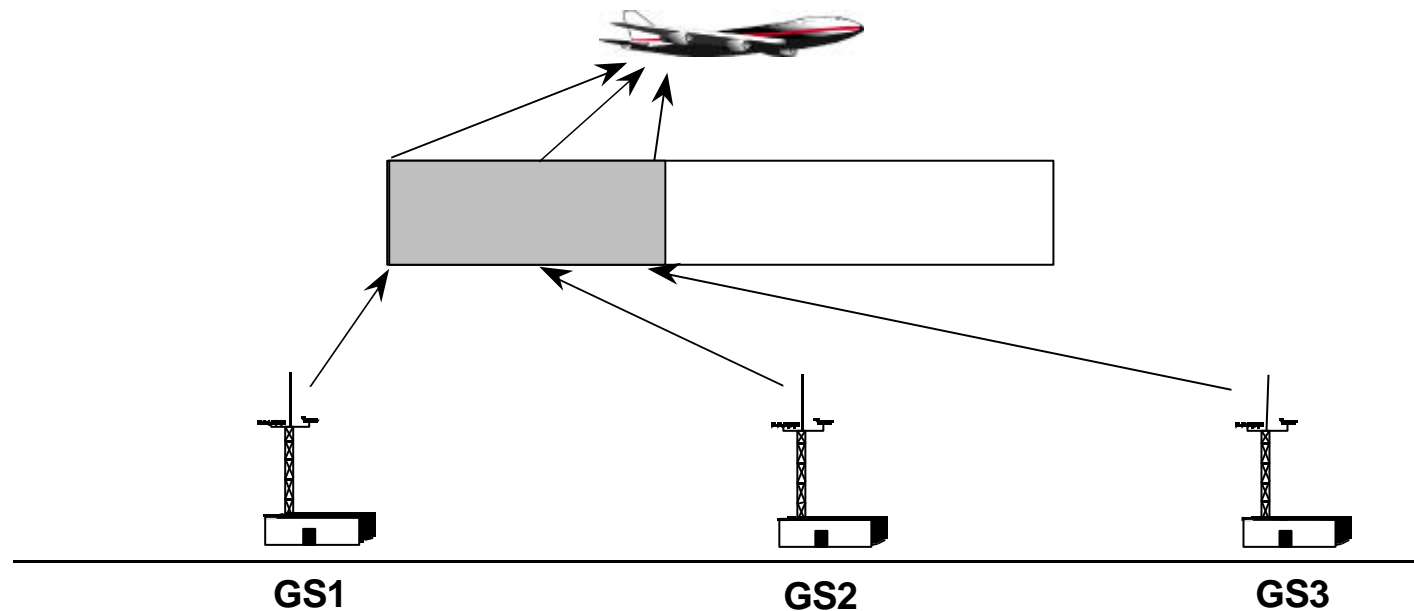
# Independent ADS-B Report Validation: Ground ATC Perspective

- **Single ground site can perform same range validation as aircraft**
- **Multiple networked sites allows position estimate based on differential burst arrival times at ground stations**



# Independent Position Estimate from Ground Messages

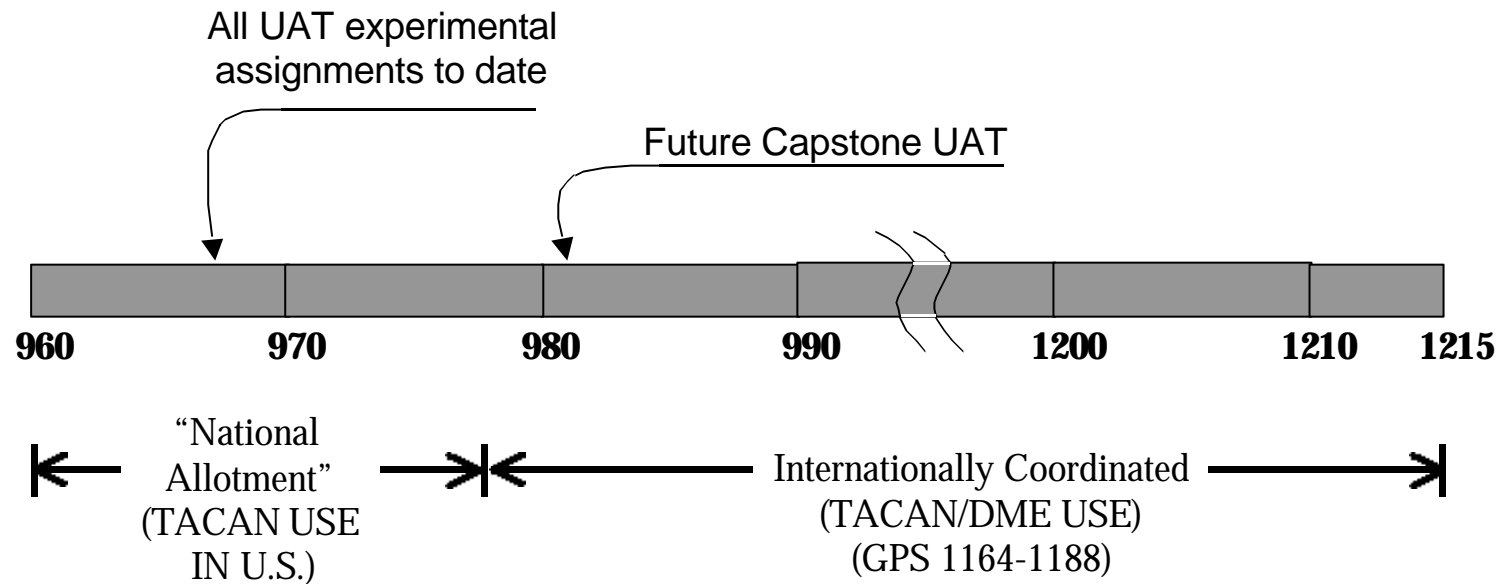
- Time slot and ground station location provided in each uplink message header
- Allows aircraft to derive independent position estimate
- Absolute time not required on aircraft
- Absolute time required at ground stations



# Spectrum and Standards

- **All experimental assignments to date have been at 966 MHz**
- **FAA shifting frequency to 981 MHz for future Capstone (for greater international viability)**
- **RTCA PMC go ahead for MOPS development**
- **ICAO AMCP WG C to consider SARPs development in their future work program**

# 960-1215 MHz ARNS Band





# Summary

- **Intended for a dedicated channel--so capacity and performance limited mainly by system self interference**
- **Every ADS-B message has a complete State Vector**
  - no tracking or message assembly required
  - no lat/lon decompression or ambiguity resolution required
  - no need to burden application with detection of transmission errors
- **Full resolution position reporting**
- **Consistent operation in all flight domains**
- **No channel sensing required for tx--minimal tx-only implementations are viable**
- **No tuning procedures required to access full suite of broadcast services**
- **Simple, proven frequency modulation technique**



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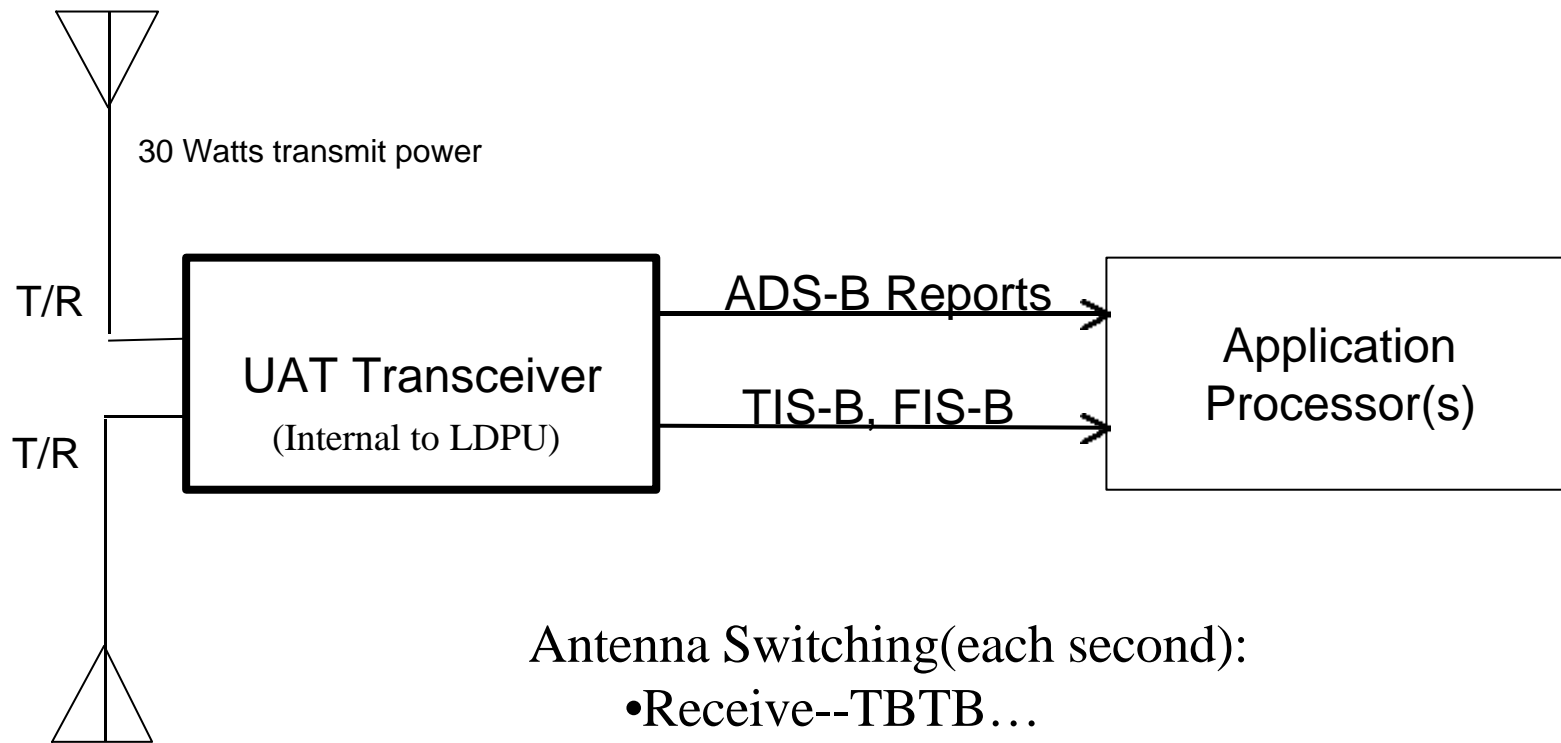
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# Backup Material

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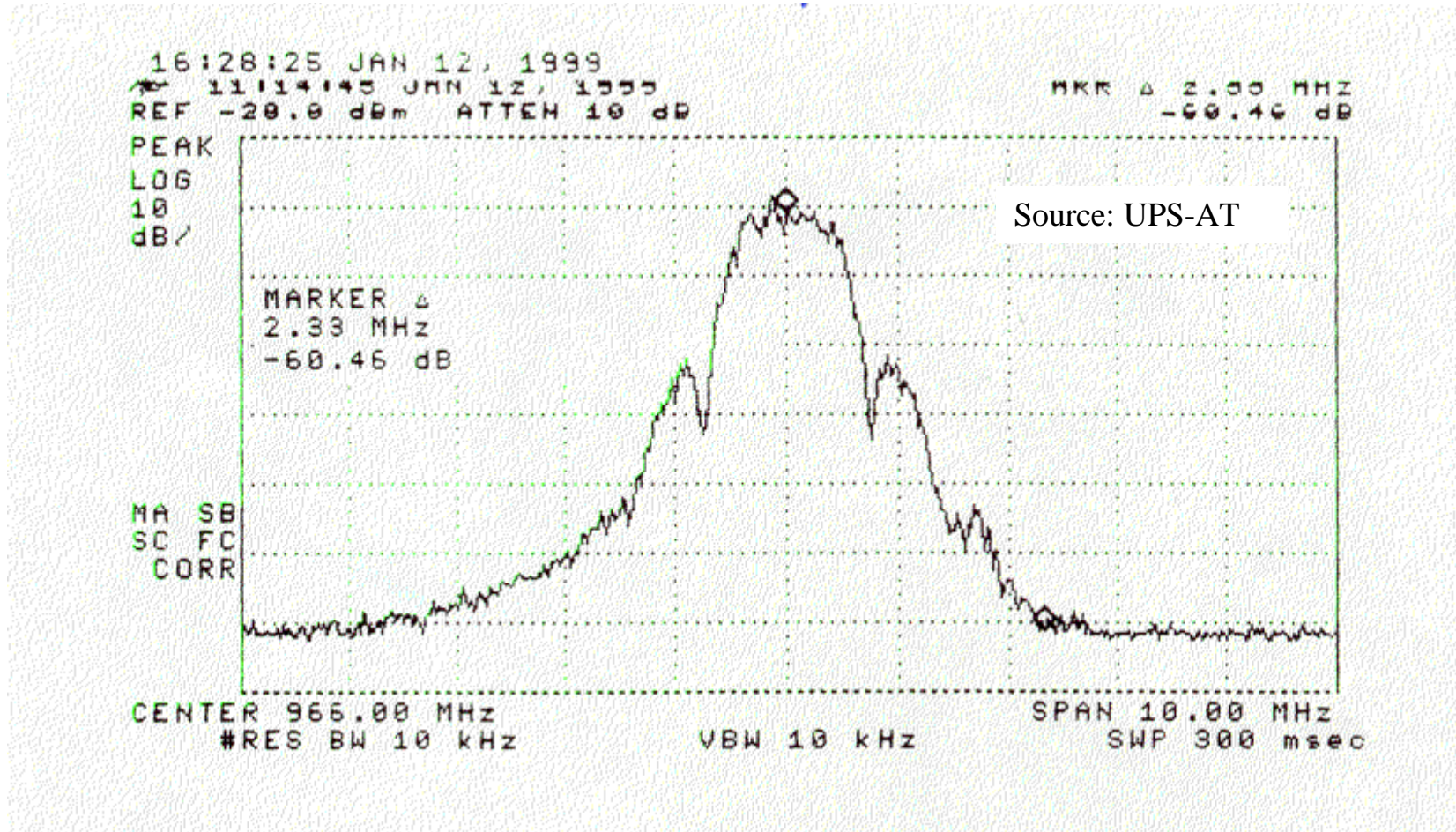
# Evaluation Unit Airborne Subsystem



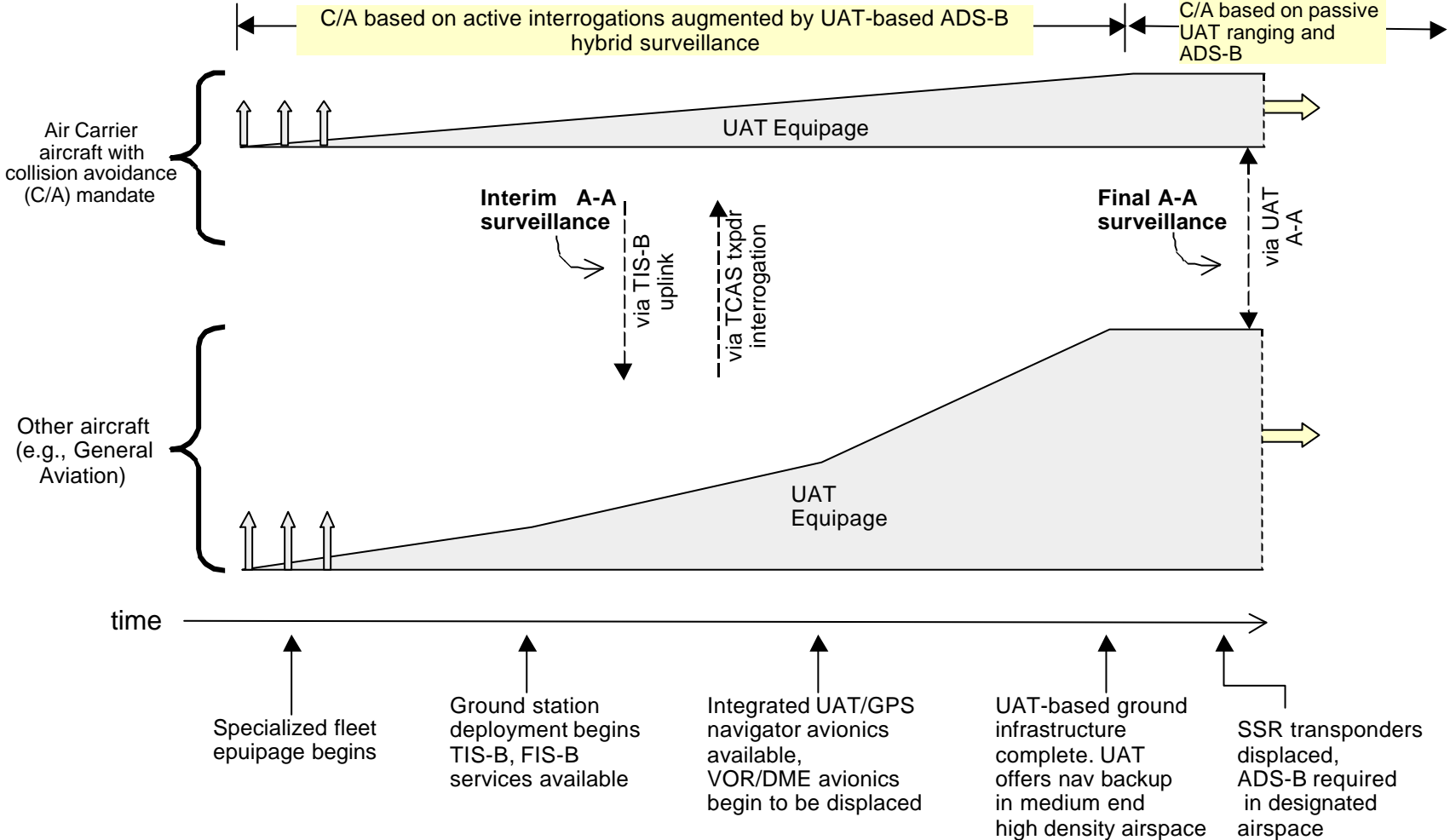
Antenna Switching(each second):

- Receive--TBTB...
- Transmit--TTBBTTBB...

# UAT Spectrum (Measured)

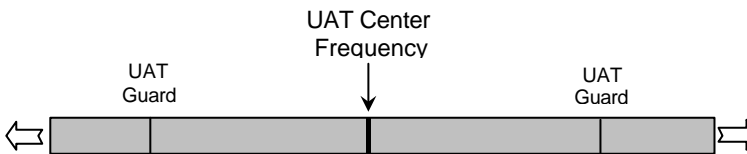


# Possible UAT Transition and Role in CNS Architecture



# Considerations in Choosing UAT Frequency

- Frequency should be below 1025 OR above 1150
  - minimize cosite effects from airborne DME interrogators
  - avoid UAT interaction with ground DME transponders
- Avoid proximity to 1030 (TCAS) and L5 also for airborne cosite
- Minimize displacement of LOC assignments (more limited than VOR)
- Low end of band preferable for best ADS-B air-air propagation



The diagram shows a frequency band structure with three main sections: UAT Guard, UAT Center Frequency, and UAT Guard. The UAT Center Frequency is indicated by a downward arrow pointing to a vertical line in the center of the band. The UAT Guard sections are indicated by double-headed arrows pointing outwards from the center. Below the diagram is a table with three columns corresponding to the frequencies 980, 981, and 982.

DME Ground Reply Frequency	980	981	982
VHF Nav Pairing	108.2 (VOR)	108.3 (LOC)	108.4 (VOR)
# U.S. Assignments that Include DME	25	8	20