Universal Access Transceiver System Description

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Outline

- History
- UAT Description
  - System Overview
  - Some Details
- Spectrum and Standards
- Summary Attributes

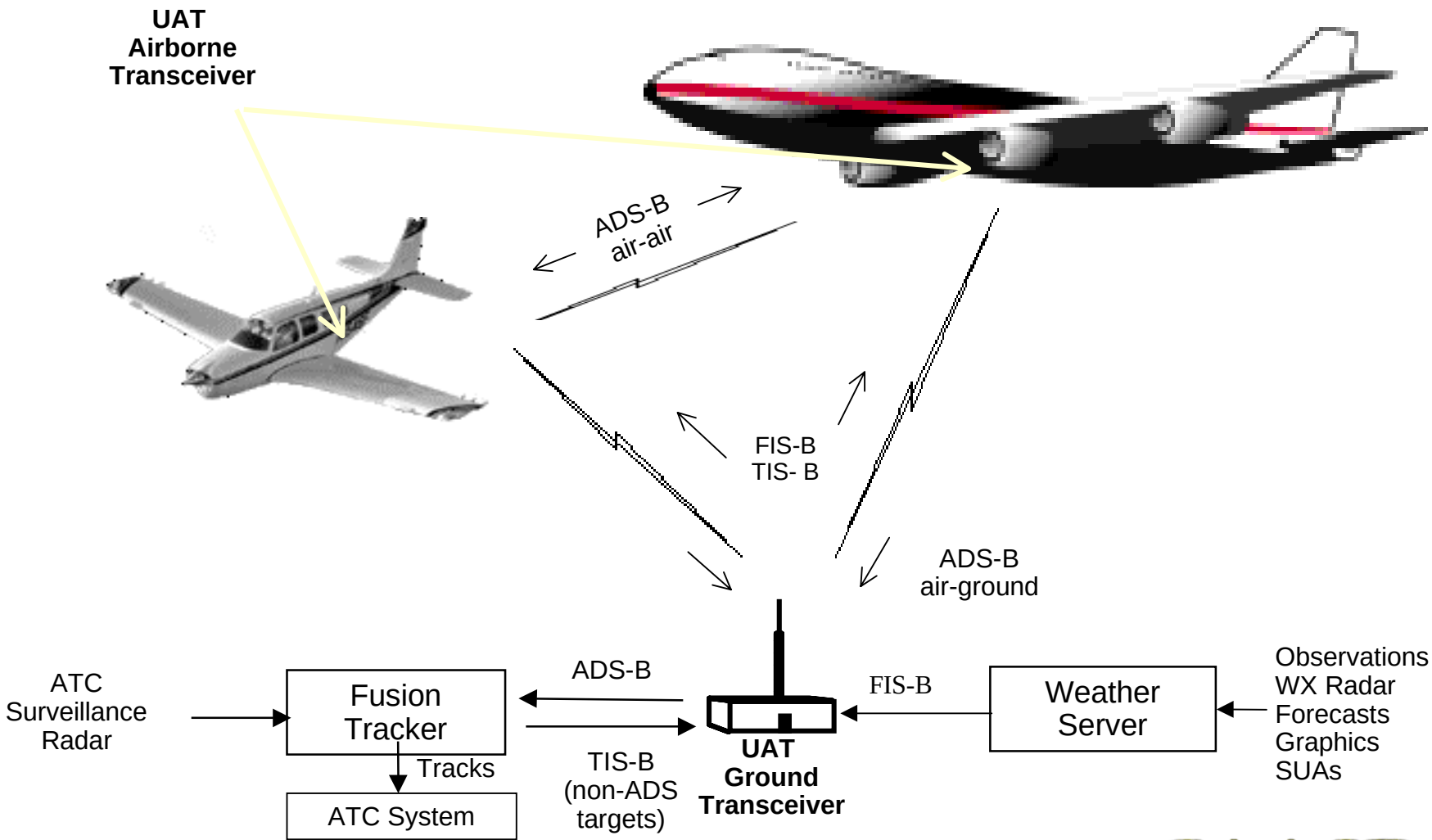
A Brief History of UAT

- **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 Applications and Connectivity



Waveform Selection

- **Requirements**
  - **Good capture effect**
  - **relatively efficient and low cost power amplifier**
  - **simple/robust decoder**

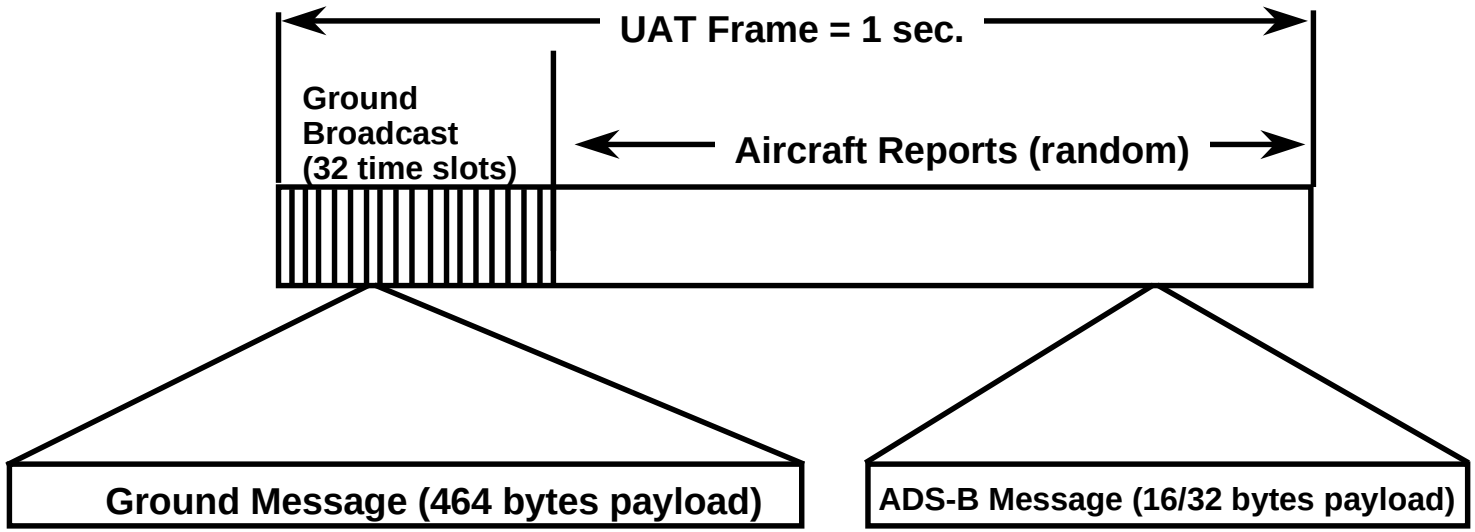
- **Binary FM with high modulation index chosen**

Frequency Band Selection

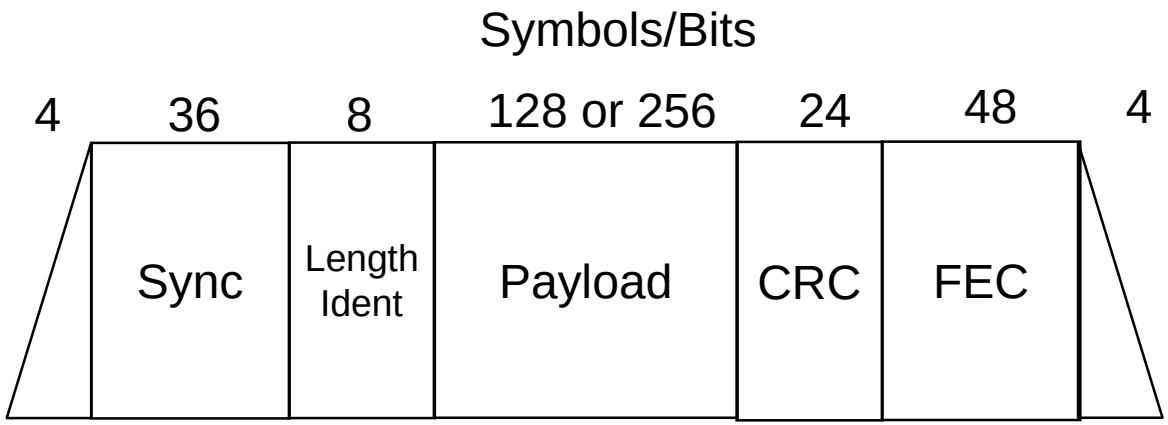
- **ADS-B requires ARNS allocation--3 alternatives:**
  - **VHF: 108-118 MHz**
  - **L-band: 960-1215 MHz**
  - **C-band: 5000-5250 MHz**
- **Extremely difficult to assemble enough contiguous channels at VHF**
- **Propagation loss too high at C band**
- **960-1215 MHz has channelization and current usage 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				**ICAO 24-Bit Aircraft Address**				
2	A1 (MSB)	A2	. . .					
3								(LSB)
4				**Latitude**				
5	(Sign)							
6								(LSB)
7				**Longitude**				
8	(Sign)							
9	(MSB)	**NUC_R**		(LSB)	(MSB)	**NUC_P**		(LSB)
10		**N-S Velocity**				(LSB)	**1 PPS OK**	**H.Pos.OK**
11			(LSB)	(Sign)				
12	(Sign)			**E-W Velocity**				
13				**Pressure Altitude**				(LSB)
14	**Pressure Altitude Rate**			(LSB)	(MSB)			
15	**Air/Ground State**	**Anon.**		**(sign)**				

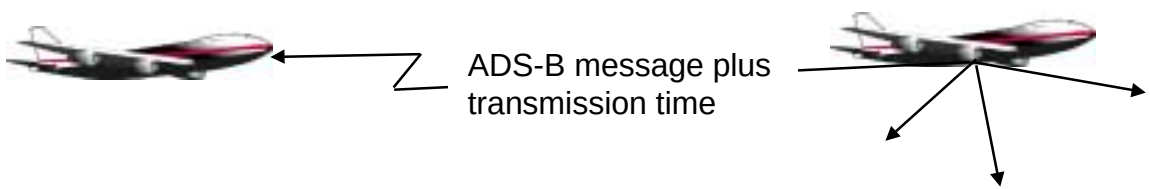
ADS-B Message Set and Transmission Schedule for Full Capability Participant (Assumed for TLAT Evaluation)

- State Vector + Call Sign + Status
- State Vector + TCP + TCP+1
- State Vector + TCP + TCP+1
- State Vector +[*future payload*]

- Four second message epoch

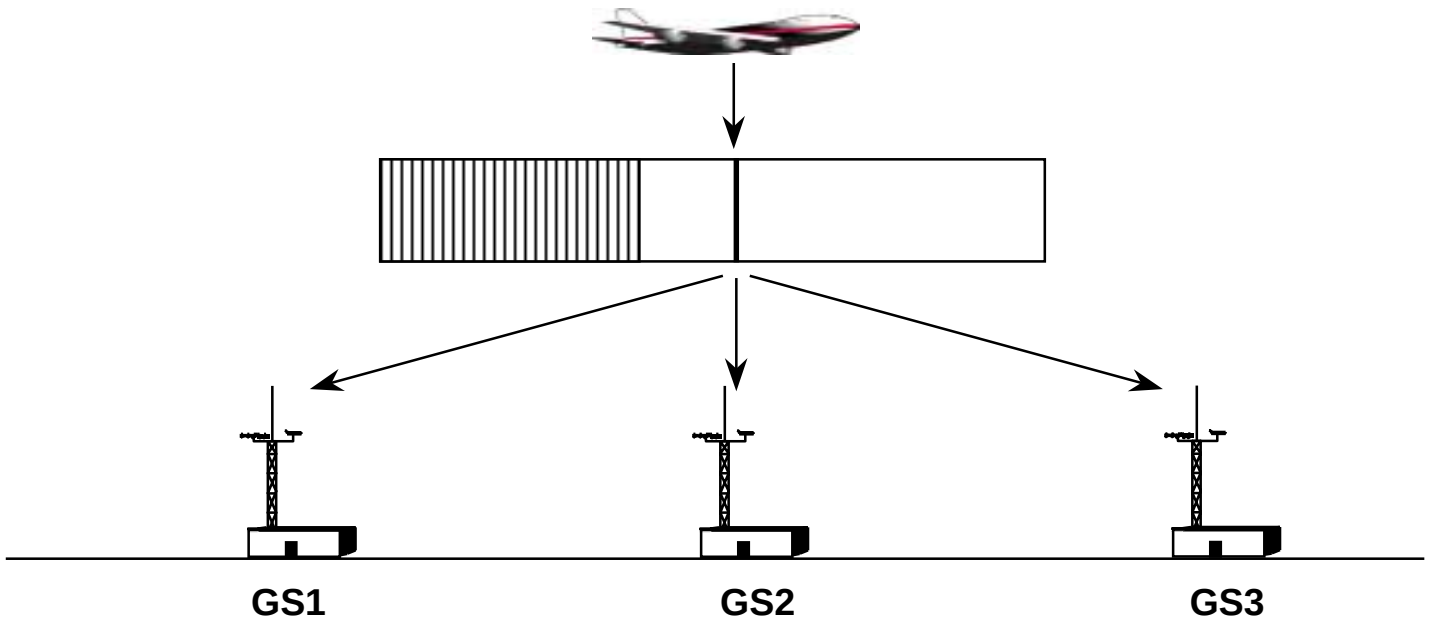
Independent ADS-B Report Validation: Aircraft Perspective

- **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**



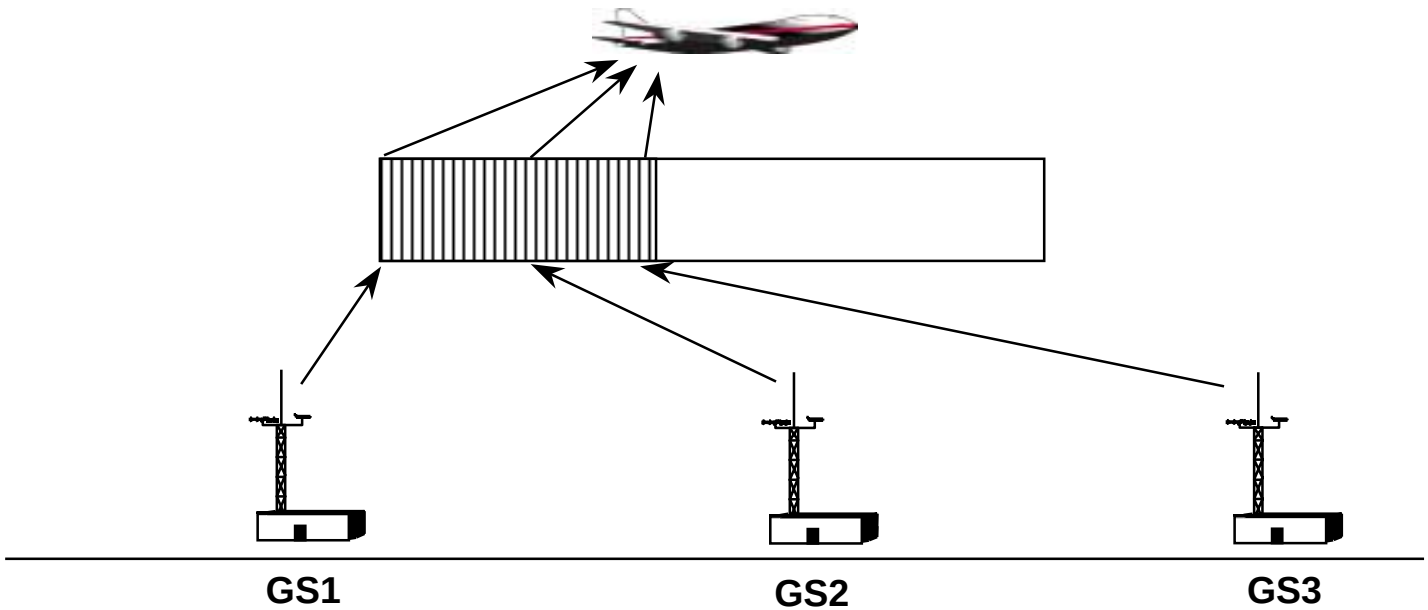
Independent ADS-B Report Validation: Ground ATC Perspective

- **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**

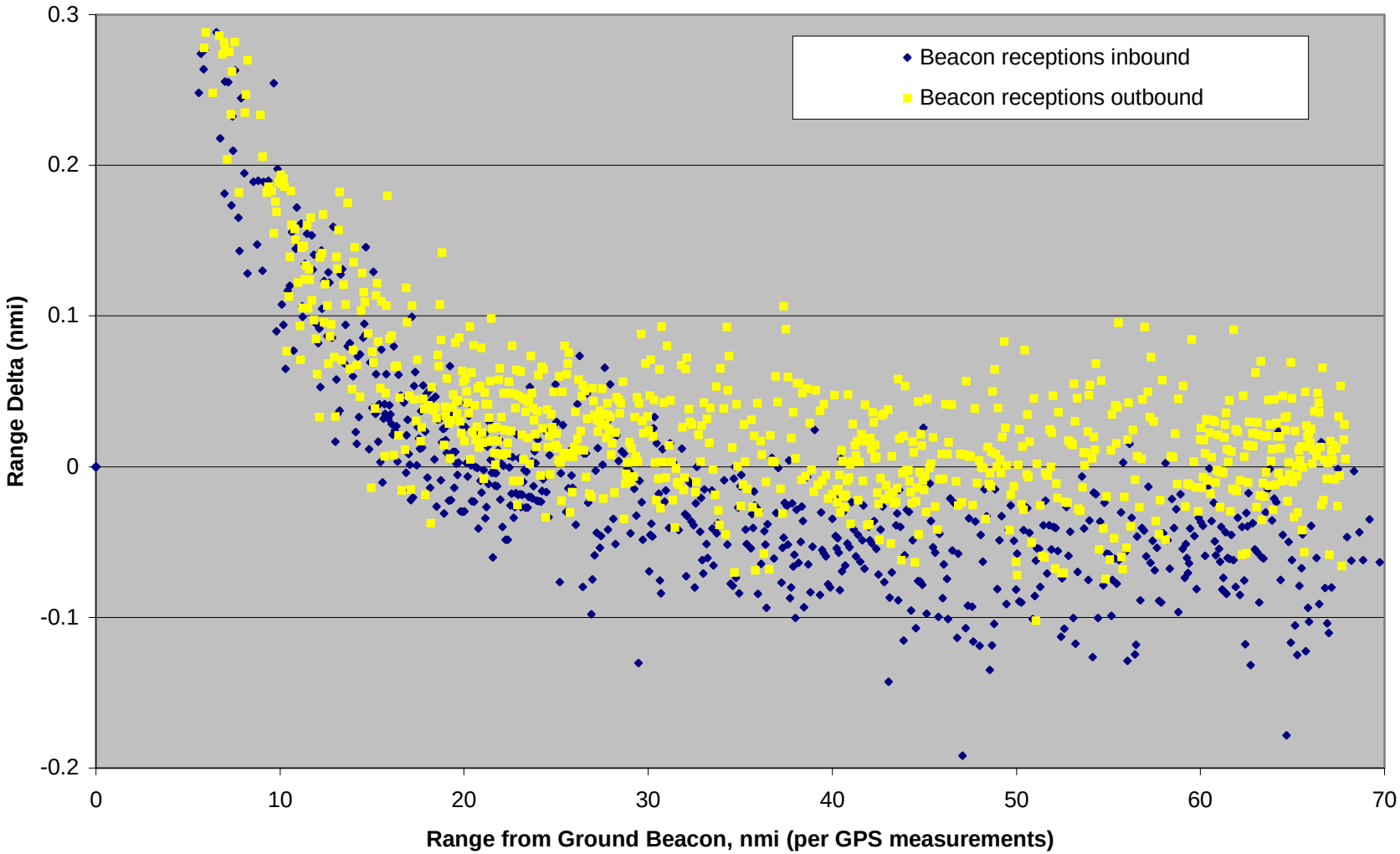


Independent Position Estimate from Ground Messages

- 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



Metroliner to Ground Beacon Range Comparison During Overflight at 14000'
TOR-derived Range minus GPS-derived Range--NO Slant Range Correction Applied



CAASD

Spectrum and Standards

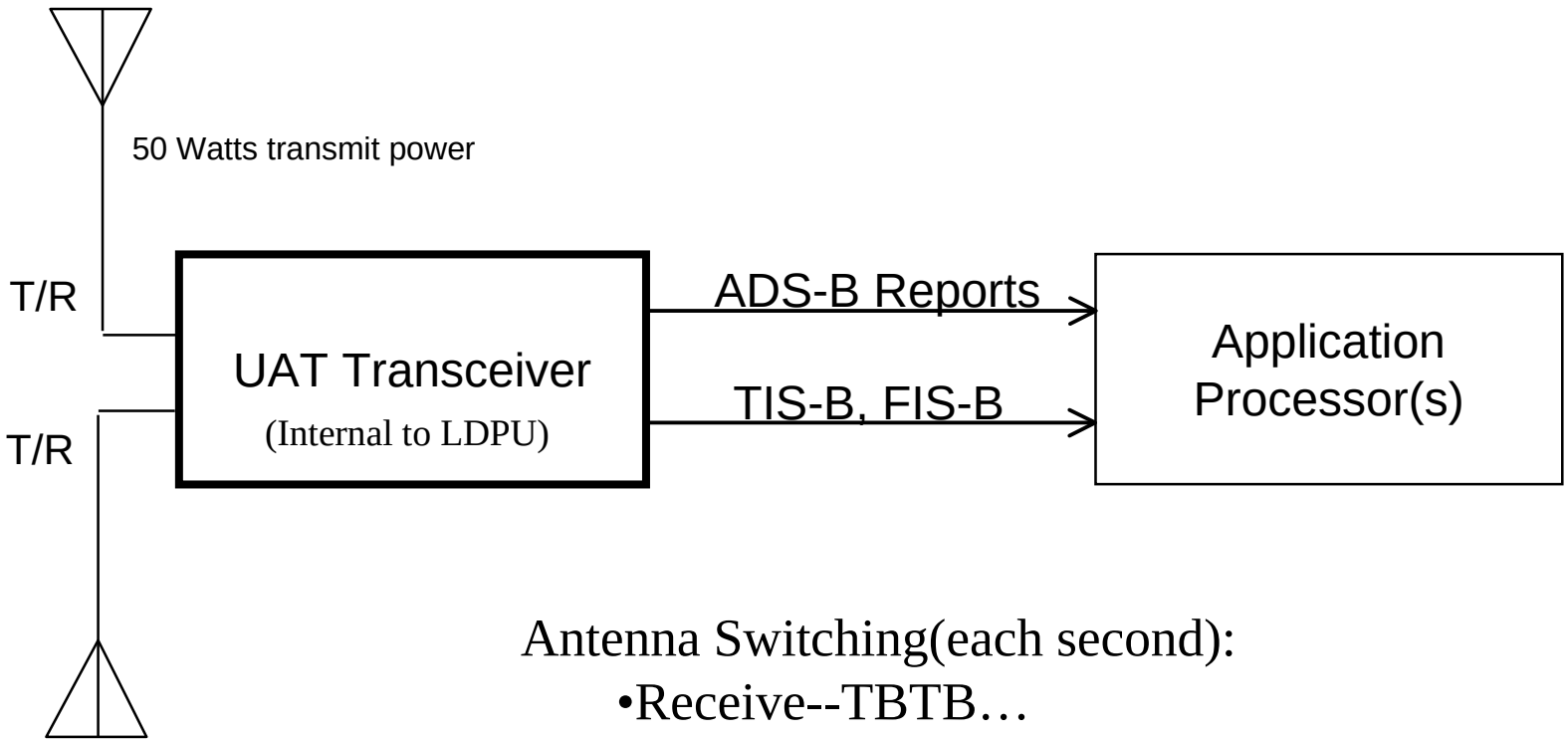
- All experimental assignments to date have been at 966 MHz
- FAA shifting frequency to 981 MHz for future Capstone (for greater international viability)
- RTCA PMC go ahead for MOPS development
- ICAO AMCP WG C to consider SARPs development in their future work program

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

Backup Material

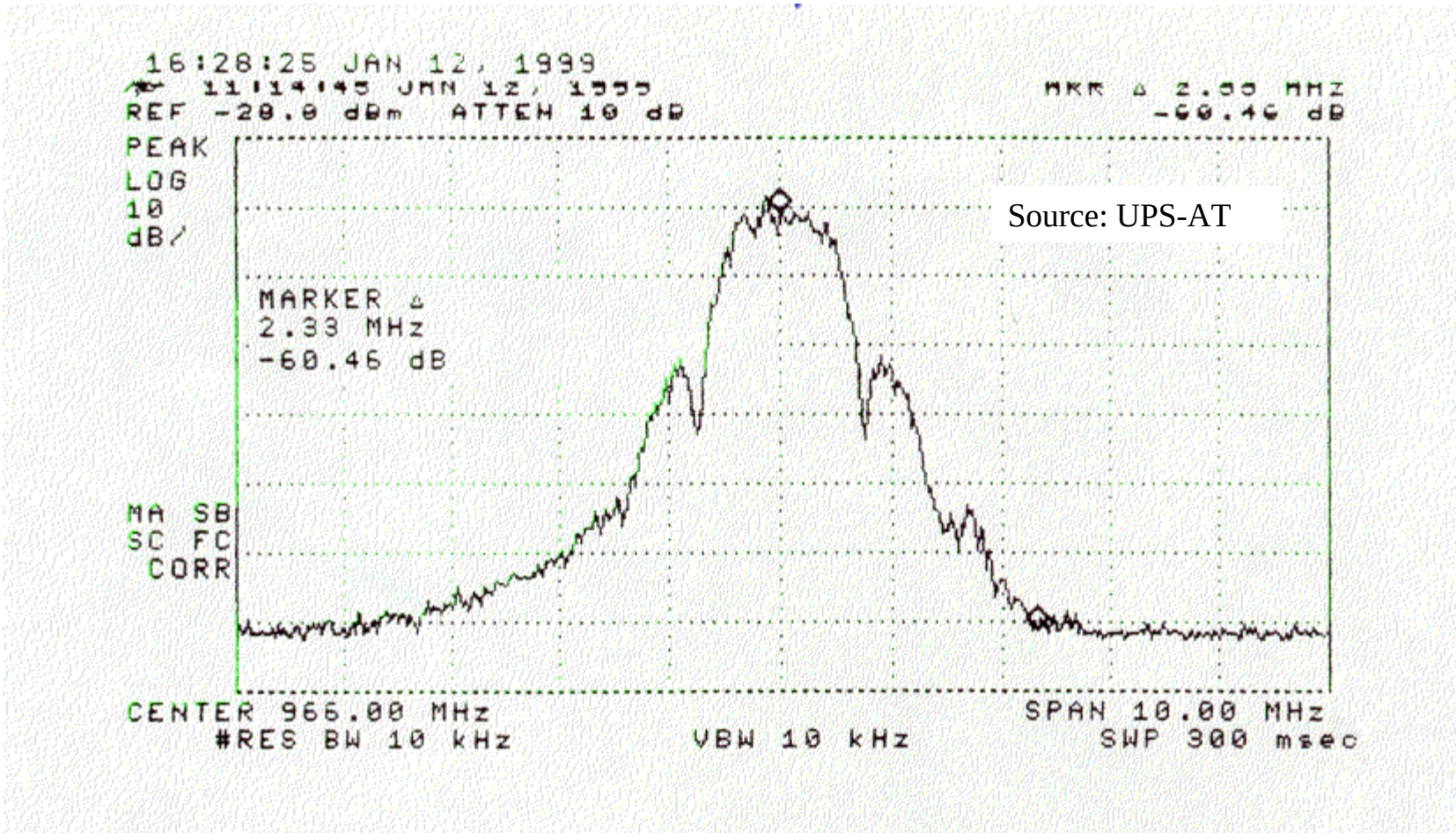
Evaluation Unit Airborne Subsystem



Antenna Switching(each second):

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

UAT Spectrum (Measured)



Source: UPS-AT

Overview of ADS-B Link Technologies