



ITT

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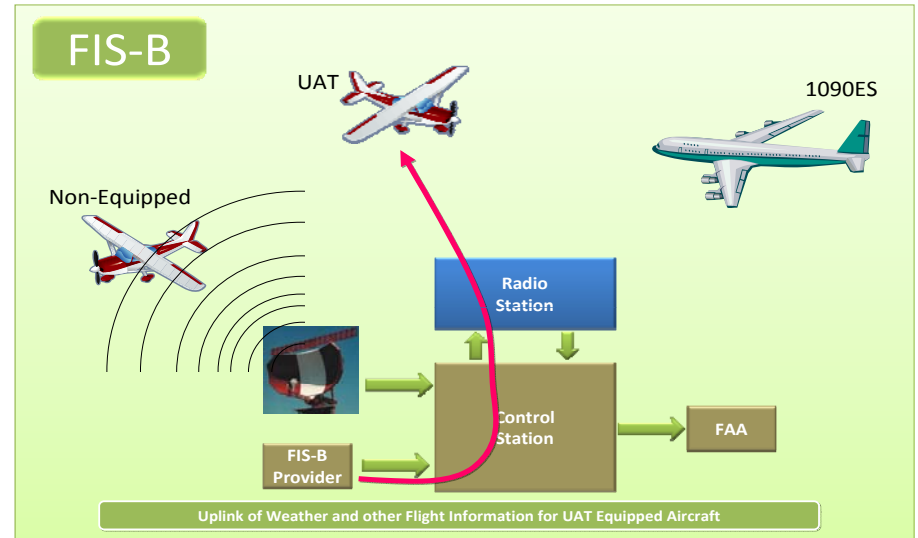
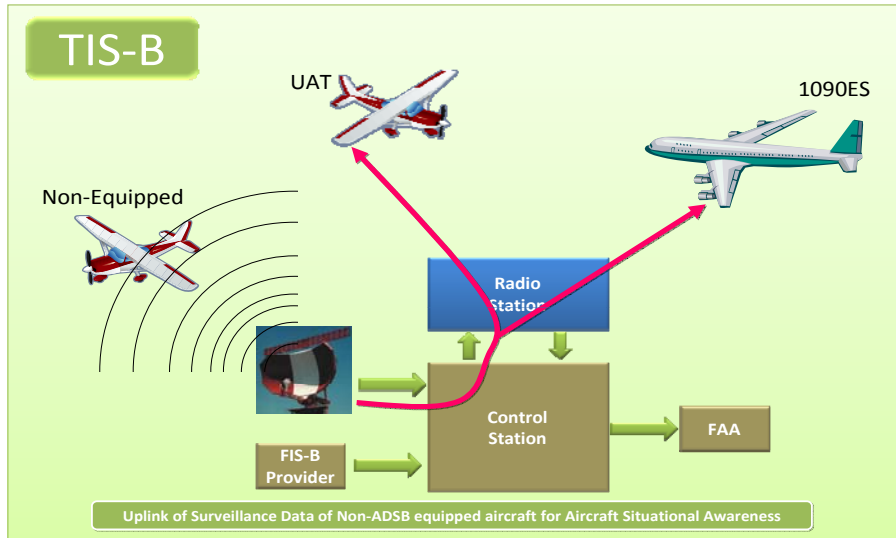
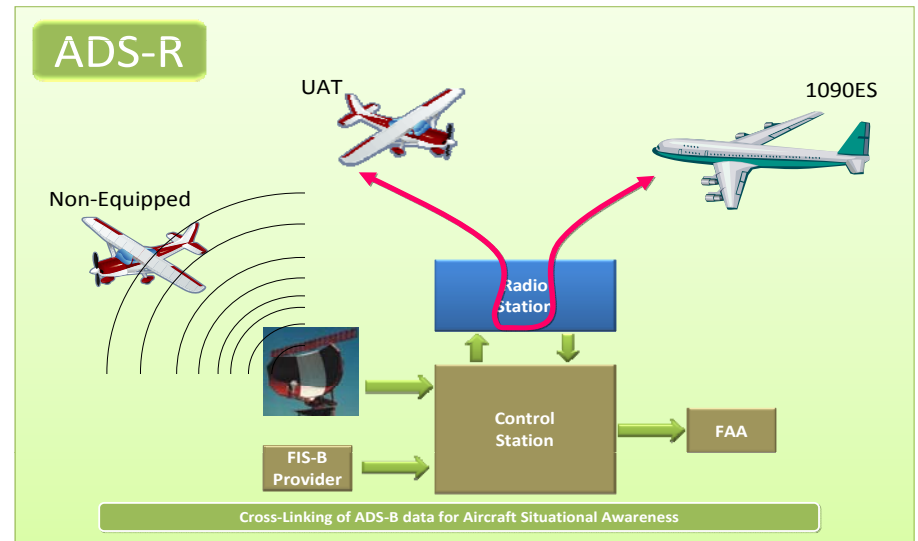
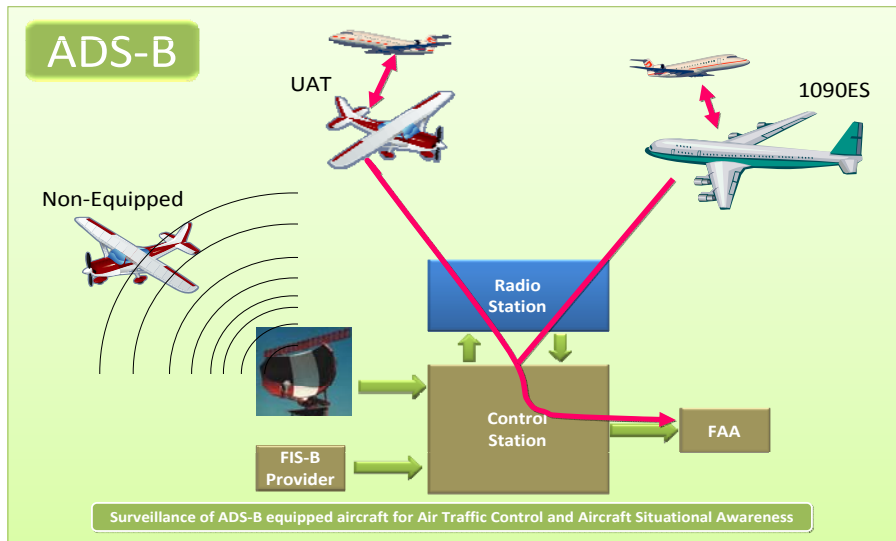
Surveillance and Broadcast Services System – Nationwide Deployment

May 15, 2009

Background

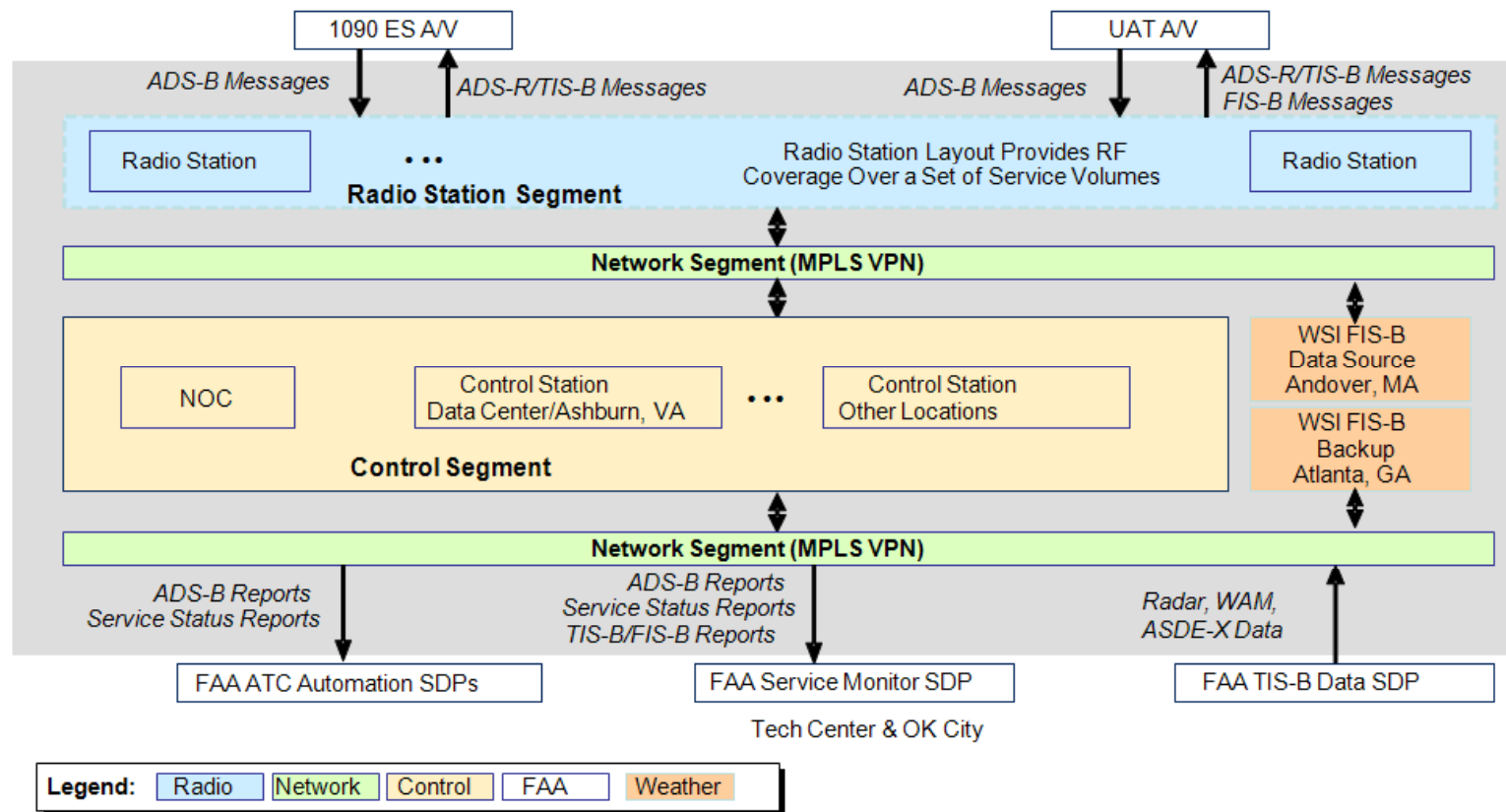
- Surveillance and Broadcast Services (SBS) Program
 - FAA program office created in 2005 to manage a program that will enable the ATC system to migrate from one that relies on radar technology to a system that uses precise location data from the global positioning satellite network
 - Enabler of this evolution is the ADS-B technology
 - With this technology, both controllers and pilots will see radar-like displays of highly accurate traffic data.
 - SBS will also provide pilots access to weather services, terrain maps, and flight information services

SBS Services



Surveillance and Broadcast Services System (SBSS)

- SBSS is the ground infrastructure including radio stations, central processing facilities, radar/sensor data pickup, weather and aeronautical data pickup and data delivery capabilities



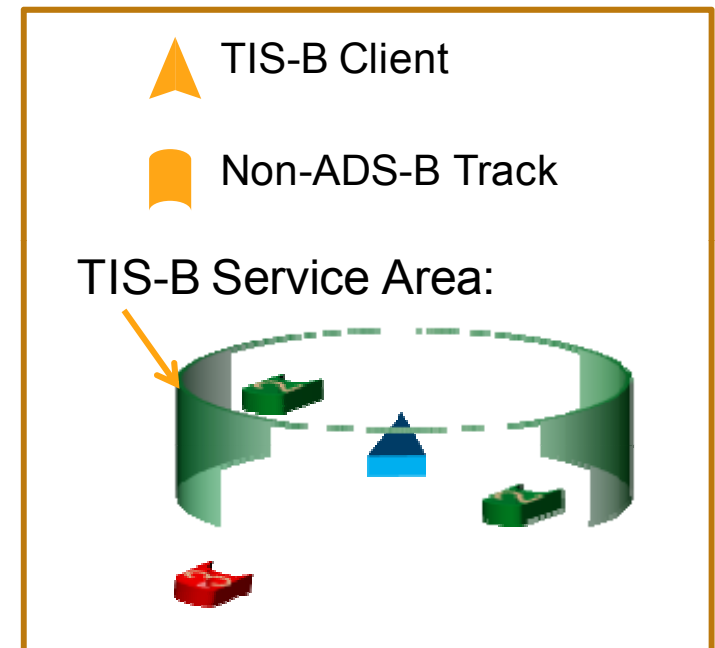
TIS-B Service

- Overview

- TIS-B Service is the broadcast of traffic information to ADS-B equipped aircraft from the SBSS
- Source of the traffic information is derived from ATC surveillance radars and sensors
- TIS-B is an advisory-only application intended to provide ADS-B equipped aircraft with a more complete view of near-by traffic where not all nearby aircraft may be ADS-B equipped.
 - To receive TIS-B services, an aircraft must be equipped with an ADS-B transceiver and a cockpit display of traffic information (CDTI)

TIS-B Design and Deployment

- TIS-B is deployed as a client-oriented service
 - Provides near-by traffic information to ADS-B equipped aircraft
 - TIS-B service area is a cylinder centered on the client
- TIS-B clients are determined based on the set of ADS-B reports received by the SBSS Radio Stations
 - These reports are filtered as follows:
 - Geographically
 - ADS-B 1090ES Report Type
 - 1090ES Version 0 aircraft are not TIS-B clients
 - ADS-B Report Quality & Reasonableness Test
 - Filter when received signal level is very low
 - Filter reported position for a “position outlier”



TIS-B Client Service Area

TIS-B Transmission Scheduling

- TIS-B processor within the SBSS looks at candidate “target” reports to transmit
- Logic is applied to determine if a target should be transmitted
 - Target must be within cylindrical service area around a client
 - TIS-B truth table criteria
- For the set of targets to be broadcast, TIS-B processor identifies one or more radios for scheduling transmissions

TIS-B Transmission Truth Table

TARGET ATTRIBUTE	CLIENT ATTRIBUTE		
	1090 (E/E+C)	UAT (E/E+C)	Both (E/E+C)
	TARGET PROVIDED TO CLIENT via TIS-B?		
Radar Only	Y/Y	Y/Y	Y/Y
1090 & UAT	N/N	N/N	N/N
<i>1090 (v0)</i>	<i>N/N</i>	<i>Y/Y</i>	<i>N/N</i>
1090 (v1)	N/N	Y/N*	N/N
UAT	Y/N*	N/N	N/N

N* indicates that ADS-R provides the Target so that TIS-B suppresses

FIS-B Service

- Overview

- FIS-B service is a ground-to-air broadcast of meteorological and aeronautical information including both textual and graphical products
- Broadcast Products include:
 - Weather Products
 - Routine weather reports (METARs)
 - Textual aviation special weather reports (SPECIs)
 - Textual terminal aerodrome forecasts (TAFs)
 - Graphical weather products including radar composite and mosaic images
 - Aeronautical Products
 - Temporary flight restricted airspace
 - Other notices to airmen (NOTAMs)

FIS-B Products & Update Intervals

FIS-B Product	Source product update interval	Rate received from FIS-B Product Provider	SBSS-Required Update Interval	SBSS-Required Transmission Interval	
AIRMET	6 hours, plus as needed	30 min & upon change	As Available	5 minutes	
SIGMET (& Convective SIGMET)	As needed		As Available, then at 15 minute intervals for 1 hour		
METAR	1 hour	Upon arrival	1 minute (where available), As Available otherwise		
SPECI	As needed				
CONUS NEXRAD	6-10 minutes at each radar site depending on selected VCP	5 min	5 minutes (10 minutes for clear air mode)		15 minutes
Regional NEXRAD				2.5 minutes	
NOTAM-D & NOTAM-FDC	28 days, others issued as needed	Upon arrival	As Available	10 minutes	
TFR	As needed	30 min & upon change			
PIREP	As filed by pilots	Upon arrival			
SUA Status	Published yearly, updated as needed	10 min			
TAF	6 hours	Upon arrival			8 Hours
AMEND	As needed				
Winds & Temperatures Aloft	6 hours	Upon arrival: forecast runs 4 times daily			12 Hours

FIS-B Design and Deployment

- FIS-B transmissions are made using 32 ground uplink channels of the UAT system
 - FIS-B data set may require more than a single UAT channel throughput
- FIS-B Data Channel Blocks (DCBs)
 - The 32 FIS-B UAT data channels have been mapped to logical groups: DCBs*
 - Each DCB is treated as a single virtual FIS-B channel
 - Radio Station utilizes all of the available bandwidth of one or more of the UAT channels associated with the DCB for FIS-B transmission.
 - FAA SBS team is planning to issue an interface control document avionics vendors
 - If avionics see all UAT ground channels as independent and uncorrelated, and if they 'train' on a mix of slots from different Radio Stations and do not receive and process all slots from a single Radio Station, the avionics may not receive the full FIS-B program

ITT Data Channel Block (DCB)	FIS Channel List Assigned			
A	1	9	17	25
B	2	10	18	26
C	3	11	19	27
D	4	12	20	28
a	13	21	29	
b	6	22	30	
1	7	15	31	
2	8	16	24	
x	14	23	32	
y	5			

* Gheorghisor, Dr. Izabela L; Wilson, Dr. Warren J; Moody, Jr, J. Chris, "UAT Tool Suite User's Manual", MP080162, September 2008

FIS-B Product Outage and Optional Products

- Product Outage
 - When one or more of the FIS-B products is unavailable for any reason, the SBSS generates and sends a FIS-B Outage message
 - FIS-B Product ID = 8 (same as used for NOTAMs)
 - Syntax: [report_year]/[report_number] FIS-B SERVICE OUTAGE [start_time] [geographic_scope] [product(s)_affected] UNAVAILABLE
- Optional Products
 - Echo Tops (the radar indicated top of an area of precipitation) (graphical product)
 - Lightning Strikes (graphical product)
 - Severe Weather Forecast Alert (AWW) and Severe Weather Watch (graphical product)
 - Ceilings
 - Digital Automatic Terminal Information Service (D-ATIS) (textual product)
 - Icing: Current Icing Product (CIP) & Forecast Icing Potential (FIP) (graphical product)
 - Terminal Weather Information for Pilots (TWIP) (graphical product)
 - Turbulence (graphical product)

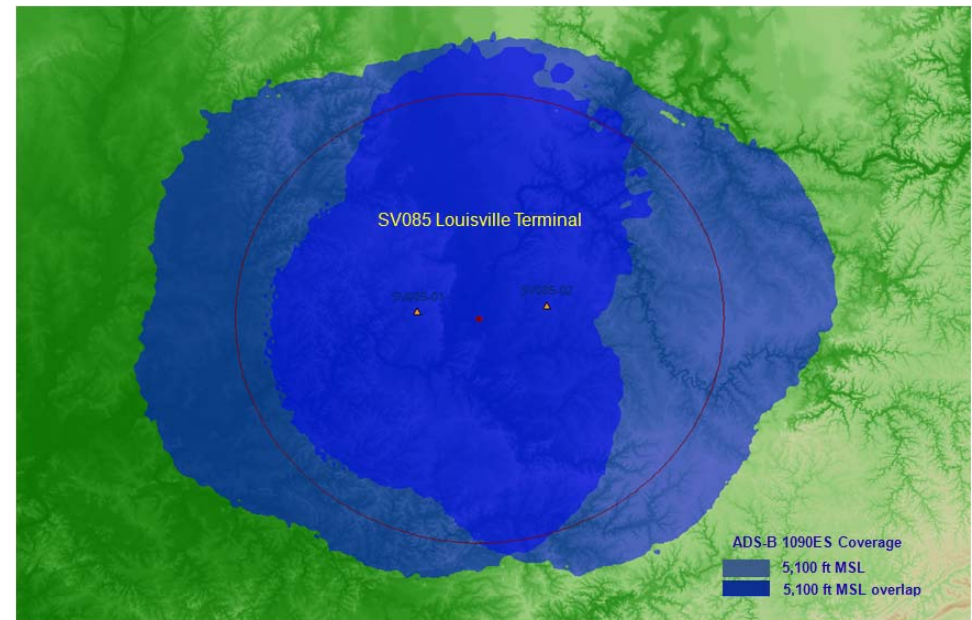
ADS-B Service

- Overview

- ADS-B service provides a surveillance capability that can enhance existing radar by provided target data with higher update rates and accuracy and provide service in areas without radars
- ADS-B equipped aircraft (and vehicles) broadcast their state vector (horizontal and vertical position; and horizontal and vertical velocity) and other information over a NAS-approved ADS-B link technology
 - 1090ES
 - UAT data link
- ADS-B message broadcasts may be received directly by other ADS-B equipped aircraft (air-to-air ADS-B)
- These ADS-B messages on both link technologies are received and processed by the SBSS
 - SBSS filters, formats and validates the received Messages for delivery to ATC for use in separation assurance and other services

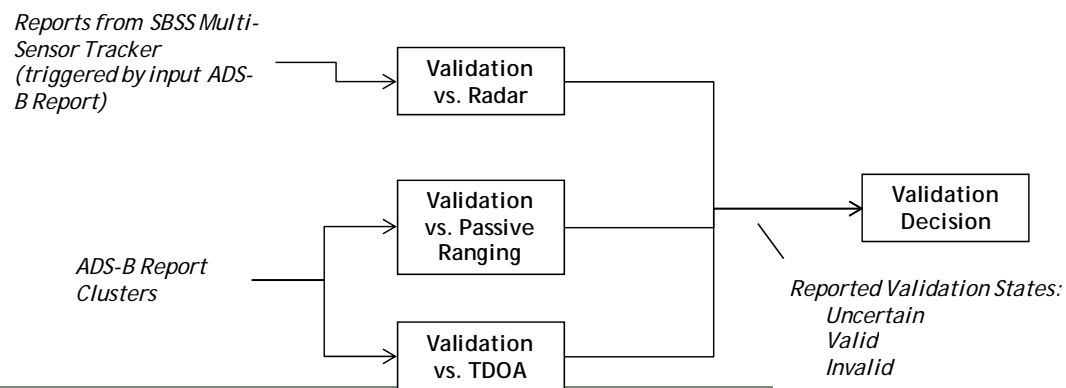
ADS-B Design and Deployment

- SBSS provides ADS-B Service utilizing 2 major SBSS subsystems
 - Radio Stations
 - ADS-B processors in a centralized SBSS processing (called “Control”) Stations
- ADS-B Message Processing
 - Grouping and filtering functionality
 - Clustering of multiple ADS-B report copies (resulting from overlapping SBSS Radio Station coverage)
 - Filtering (e.g. geographic; by configured ICAO addresses)
 - Test for outliers and duplicates
 - Validation



ADS-B Report Validation

- The SBSS can perform independent validation of ADS-B Messages
- Validation is a state of an incoming ADS-B Message stream, not a message -by-message determination
 - A history of metrics is maintained by each independent validation engine
- The SBSS ADS-B processor applies three independent validation methods, in accordance with the following priority logic
 - (1) Radar validation (using primary radar, secondary radar or both if available)
 - (2) Passive ranging (if target report is based on a UAT ADS-B Message)
 - (3) Time-difference of message arrival



ADS-R Service

- Overview
 - Two data link technologies are approved for ADS-B Service in the NAS, 1090ES and UAT
 - Aircraft and vehicles that are equipped with only one technology will not receive direct air-to-air broadcasts of ADS-B from targets utilizing the opposite technology
 - The ADS-R Service defines a capability for the SBSS to rebroadcast ADS-B data from one data link to the other in defined service areas
 - This capability supports enhanced situational awareness and eventually additional applications

ADS-R Design and Deployment

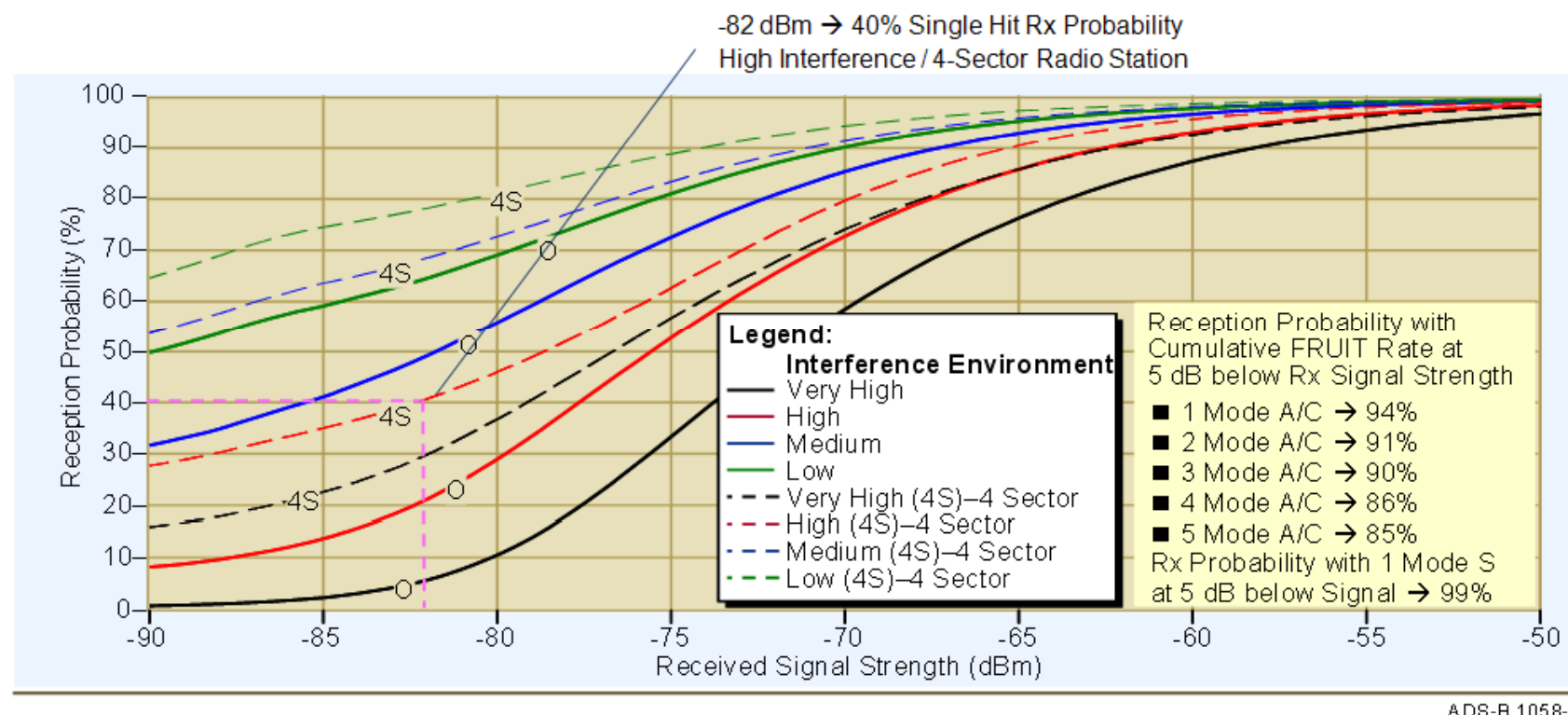
- ADS-R Service is deployed as a client oriented service (similar to TIS-B service)
 - Provides ADS-B data link translation for near-by aircraft to ADS-B equipped aircraft
- ADS-R Transmission Scheduling
 - ADS-R processor within the SBSS looks at candidate “target” reports to transmit
 - Logic is applied to determine if a target should be transmitted
 - Target must be within the cylindrical ADS-R service area around a client
 - ADS-R truth table criteria
 - Re-broadcast schedule provided to SBSS Radio Stations

ADS-R Transmission Truth Table

TARGET ATTRIBUTE	CLIENT ATTRIBUTE		
	1090ES	UAT	Both
	Provide Target to client via ADS-R?		
1090ES & UAT	N	N	N
<i>1090ES (v0)</i>	<i>N</i>	<i>N</i>	<i>N</i>
1090ES (v1)	N	Y	N
UAT	Y	N	N

ADS-R Update Interval

- ADS-R 1090 transmission environment includes ATC SSR replies and 1090ES ADS-B Messages from aircraft as interfering messages at an aircraft Radio
 - Aircraft radios are designed for this environment, but their reception performance is necessarily probabilistic



Probabilistic behavior of 1090 Receiver in different Interference Environments and different Radio Station configurations (Omni vs. 4-Sector)

Meeting ADS-R Target Update Interval (UI)

- Approach

- ADS-B System meets a required Target Update Interval by relying on multiple 'trials' within an Update Interval to receive an ADS-B Message
 - Each such transmission by an aircraft is a 'trial'
 - One message in the multiple trials needs to be received in the applicable Update Interval (1,3, or 6 seconds) 95% of the time

ADS-R Update Interval Methodology

Terminal Domain Example: Assume ADS-B UAT provides worst case UI (3s). SBS sends 3 1090 messages on each Update → 1/sec

<i>UAT → 1090</i>	<i>Surface</i>	<i>Terminal</i>	<i>En Route</i>	<i>1090 → UAT</i>	<i>Surface</i>	<i>Terminal</i>	<i>En Route</i>
Required Rx UI at 1090 Aircraft (95%)	2 sec	5 sec	10 sec	Required Rx UI at UAT Aircraft (95%)	2 sec	5 sec	10 sec
ADS-R Tx Messages Each Update Interval 1	4	5	10	ADS-R Tx Single Hit Messages Each Update Interval 1	2	5/3	5/3
Goal for ADS-R Single Hit Message Rx Probability 2	53%	45%	26%	Goal for Message Rx Probability 3	90%	90%	90%
Required Rx Power at Probability Goal (dBm) 4	-72 (H) -77 (M) -79 (L)	-73 (H) -76 (M) -79 (L)	-76 (H) -79 (M) -79 (L)	Required Rx Power at Probability Goal (dBm) 5	-93	-93	-93

- Aircraft needs to receive at least one of these ADS-R messages in the required Update Interval with 95% probability; for the 1090 Terminal, this is met by transmitting an even position, odd position, and velocity at the ADS-B Update Interval (every three seconds).
- Probability Goal ensures that at least one of the message opportunities will be received in the required Update Interval.
- UAT slotted ALOHA allows 95% probability of reception for UAT Targets <100; for a maximum of 250 UAT Targets, 90% reception is achievable.
- Required power in High/Medium/Low (Traffic Density and Interference) Environments to receive a message at Probability Goal per MOPS 1090 A1 Rx performance. Transmit power is controlled to meet or exceed this goal.
- Required power at Probability Goal is MOPS UAT 90%Rx performance. Transmit power is controlled to meet or exceed this goal.

Relationship between Reception Probability after N 'trials' (P_N) to the 'single hit' Reception Probability (P_1)

ADS-B 1075-5

$$P_N = 1 - (1 - P_1)^N$$

Deployment Status

- The South Florida implementation of TIS-B and FIS-B Essential Services has been evaluated by ITT and the FAA and supported the FAA In-Service Decision (ISD) by the FAA in the 4th quarter of 2008
 - TIS-B and FIS-B are now operational in South Florida, and ITT is proceeding with the rollout of Essential Services in the NAS
- Currently ADS-B and ADS-R Critical Services are under test in Surface and Terminal domains of Louisville, KY
 - Implementation and test in Philadelphia, PA terminal and surface airspaces, as well as en route airspaces in the Gulf of Mexico and Juneau, AK are scheduled
 - The above four implementations of Critical Services will be evaluated by ITT and the FAA in support of a Critical Services ISD in 2010; Following this ISD, ITT will commence the rollout of Critical Services in the NAS

Summary

- ITT has designed the SBSS to meet the ground infrastructure requirements for the Surveillance and Broadcast Services
 - ADS-B, ADS-R, TIS-B and FIS-B
- This rollout of SBS supporting infrastructure supports the overall phased deployment of SBS
 - Segment 1 FY 2007 - 2010: ADS-B, ADS-R, TIS-B, and FIS-B provided in limited areas that can obtain benefits from early avionics equipage; some aircraft equip with advanced avionics to support airborne situational awareness
 - Segment 2 FY2009 – 2013: Ground ADS-B service infrastructure is deployed on a NAS-wide scale while avionics equipage continues
 - Segment 3 FY2015 – 2020: All aircraft become equipped and the services are available NAS-wide. At this time, legacy infrastructure removal can begin to eliminate unnecessary redundant surveillance coverage
 - Segment 4 FY2020 – 2025: This longer-term segment includes the implementation of more complex aircraft/vehicle based applications and eventual removal of TIS-B services as full avionics equipage is realized