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ADS-B Implementation: Avionics and Ground

Presented to: NAM/CAR/SAM Workshop on the Development of the regulation for the implementation of ADS-B

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Date: July 2023

Federal Aviation Administration

Agenda

- ADS-B Implementation Overview
- Infrastructure
- Aircraft Avionics

- Case Study: US ADS-B Program

ADS-B Implementation Overview

- As part of the regulatory process, questions may arise from stakeholders related to how prepared the Civil Aviation Authority (CAA) and Air Navigation Service Provider (ANSP) will be to utilize ADS-B.
- There are two key parts that need to be considered:
  - Infrastructure
  - Aircraft Avionics
- It is critical to have an implementation strategy/plan to help assist the regulatory process.
  - Reduces push-back and helps in discussions on regulatory effectivity dates.

Infrastructure

- The type of infrastructure to be implemented can depend on different factors (e.g., Terrain, operational requirements, coverage requirements, avionics compatibility, etc.)
- To address these factors, the ICAO Member State needs to perform an analysis to determine what systems are needed to provide the necessary services while maintaining or enhancing airspace safety.
  - Ground based, Space-Based, or Combination
  - Aircraft equipage (Top/Bottom vs Bottom-only antenna)
  - Performance availability (i.e., NIC and NAC)
- A decision must also be made on how a Member State will obtain ADS-B information (i.e., via equipment purchase, performance-based contract, or some other means).

Aircraft Avionics

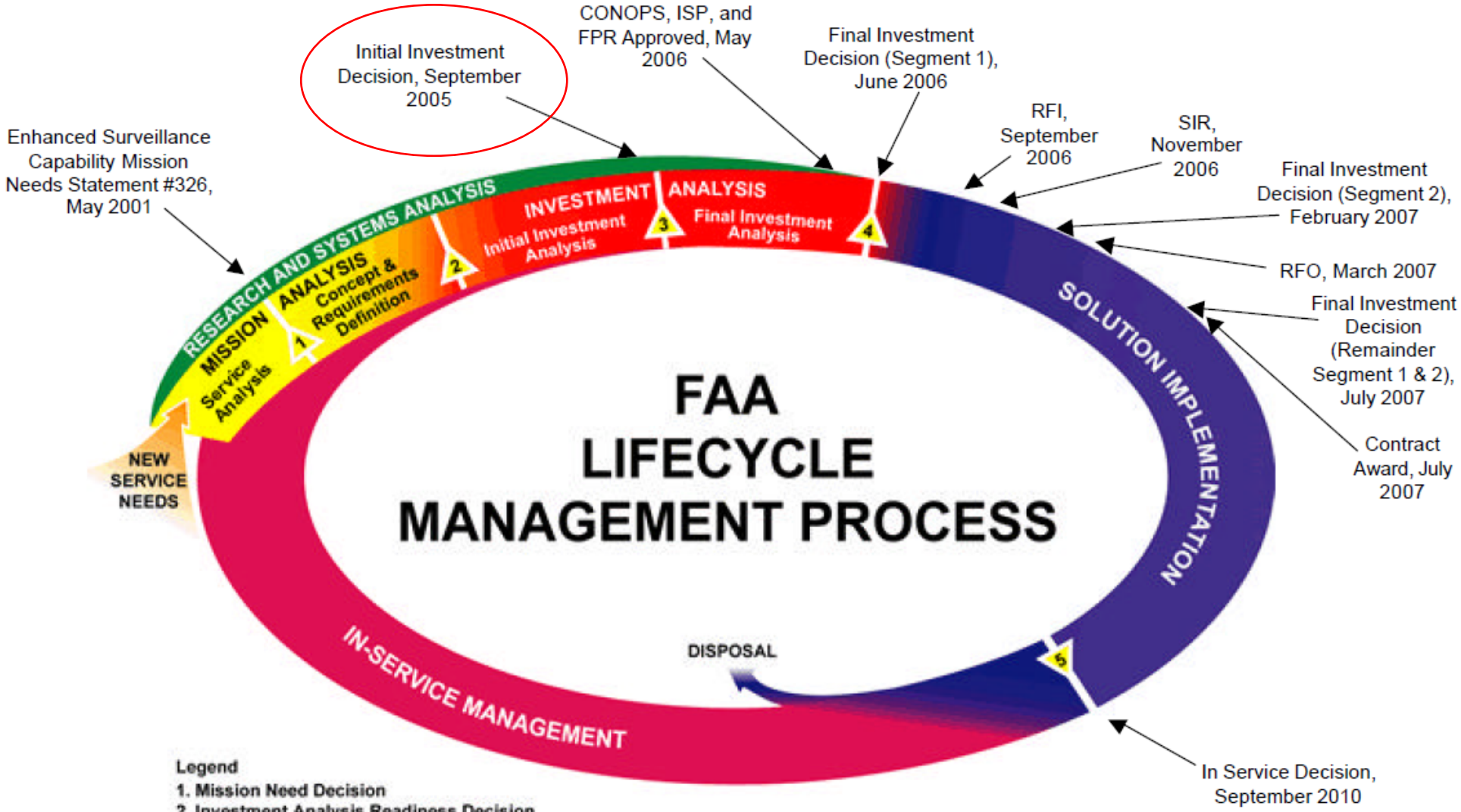
- The regulatory process may drive the performance that is required from the aircraft avionics.
  - Dependent on the ANSPs desired operational requirements
- Understanding what is available or how long development of the avionics equipment will take is one piece for ensuring regulatory compliance.
- A second piece is the certifications available to install the equipment on the aircraft.
  - Existing certifications within governing State
  - Reciprocity to accept certification from another governing State
- Compatibility between the avionics requirements and the infrastructure.

Operational Considerations

- An additional aspect that should be considered is the operational requirements necessary to be met for the ANSP to provide the desired service.
- Operational areas that should be considered are:
  - Desired separation services
  - Controller training (if necessary)
  - Future airspace plans
- Particularly, the ANSP should have an understanding of how ADS-B will be used to meet the existing level of safety while provisioning for future expansion.
- This should be taken into account as part of your implementation analysis and decisions.

Case Study: US ADS-B Program Infrastructure

Federal Aviation Administration



CONOPS = Concept of Operations; ISP = Integrated Safety Plan; FPR = Final Program Requirements; RFI = Request for Information; SIR = Screening Information Request; RFO = Request for Offer

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Case Study: US ADS-B Program Infrastructure

Federal Aviation Administration

- Prior to initiating any acquisition work, there is a need to obtain the necessary funding.
- As part of its Acquisition Management System (AMS) process, the Joint Resource Council (JRC) is given the responsibility to approve all acquisition programs.
  - JRC is made up of Senior Level representatives from various FAA organizations.
- In September 2005, the JRC approved the initial investment to establish the Surveillance and Broadcast Services (SBS) group responsible for performing the implementation of ADS-B.

Case Study: US ADS-B Program Infrastructure

- To obtain this approval, there was a need to develop a clear definition of the desired program.
  - Description of the desired implementation and associated applications (e.g., CONOPS)
  - Business and Safety case
  - Schedule
  - Understanding of the functional architecture, performance requirements, and key requirements.
- After performing the necessary alternatives analysis and business case, the FAA decided to pursue a performance based service contract.

Case Study: US ADS-B Program Infrastructure

- Based on prior experience, the SBS group held an industry day in June 2006 with a focus on providing interested vendors with potential information and timelines associated with this program.
- The information provided an overview of:
  - Definition of different Segments of the contract
  - Desired approach for equipment ownership, communication protocols, data ownership, and performance requirements.
  - Implementation Strategy and Schedule
  - Acquisition Strategy
- The following slides show an example of the information that was developed and shared during the Industry Day event.

Case Study: US ADS-B Program
Infrastructure – Segment Definition

Federal Aviation Administration

Services / Applications:	Segment:
Surveillance Broadcast Services (En Route, Terminal, Surface)	Segment 1 & 2
Traffic / Flight Information Broadcast Services	Segment 1 & 2
Enhanced Visual Acquisition	Segment 1 & 2
Enhanced Visual Approaches (1)	Segment 1 & 2
Final Approach and Runway Occupancy Awareness	Segment 1, 2 & 3
Airport Surface Situational Awareness	Segment 1, 2 & 3
Conflict Detection	Segment 1, 2 & 3

(1) Merging and Spacing and Cockpit Display of Traffic Information (CDTI) Assisted Visual Separation (CAVS) are a part of the Enhanced Visual Approaches Application

Case Study: US ADS-B Program
Infrastructure – Segment Definition

Federal Aviation Administration

Milestone	Projected Completion Date
Segment 1 JRC	June 2006
Screening Information Request (SIR) Issued	November 2006
Segment 2 JRC	February 2007
Request for Offer Released	March 2007
Contract Award	July 2007
NPRM Issued	September 2007
Preliminary Design Review (PDR)	October 2007
Critical Design Review (CDR)	January 2008
Key Site Initial Operating Capability (IOC) of Broadcast Services	July 2008
In-Service Decision (ISD) of Broadcast Services	November 2008
Final Rule Published	April 2009
Gulf of Mexico Comm. and Weather IOC	September 2009
Louisville IOC of Surveillance and Broadcast Services	October 2009
Gulf of Mexico IOC of Surveillance and Broadcast Services	December 2009
Philadelphia IOC of Surveillance and Broadcast Services	February 2010
Juneau IOC of Surveillance and Broadcast Services	April 2010
Surveillance and Broadcast Services ISD for ADS-B	September 2010

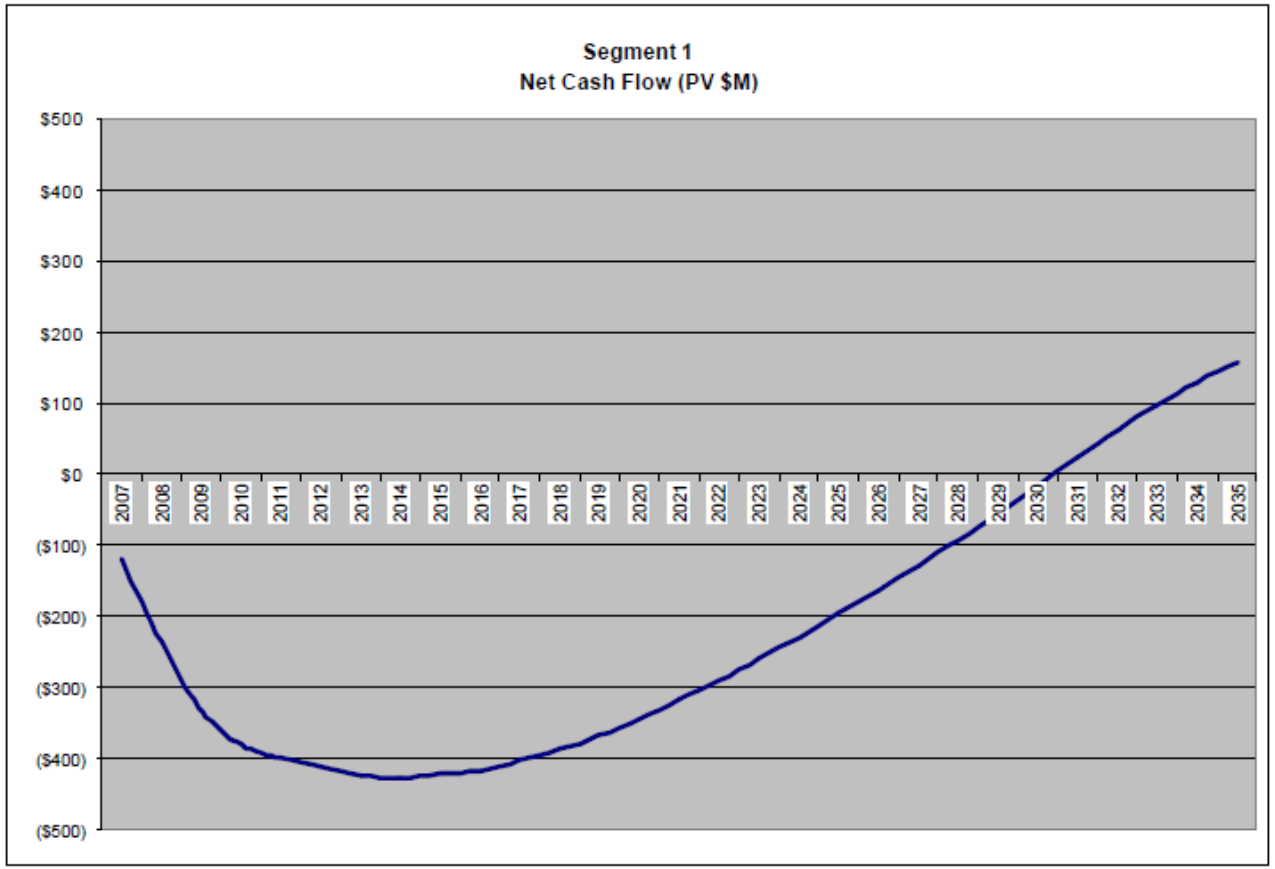
Case Study: US ADS-B Program
Infrastructure – Segment Definition

- **Segment 2 (2009 – 2014):**
  - ADS-B "Out" Final Rule Published: FY 2009
  - Continue Initial Aircraft to Aircraft Application Deployment: FY 2010 – FY 2014
  - Additional Aircraft to Aircraft Application Deployment: FY 2010 – FY 2014
  - Additional Aircraft to Aircraft Requirements Definition: FY 2010 – FY 2014
  - Continue / Complete TIS-B / FIS-B Deployment: FY 2009 – FY 2012
  - Continue / Complete ADS-B NAS Wide Infrastructure Deployment: FY 2010 – FY 2013
  - Complete 40% Avionics: FY 2014
- **Segment 3 (2015 – 2020):**
  - Additional Aircraft to Aircraft Requirements Definition: FY 2015 – FY 2020
  - Additional Aircraft to Aircraft Application Deployment: FY 2015 – FY 2020
  - Targeted Removal of Legacy Surveillance: FY 2018 – FY 2020
  - Complete 100% Avionics: FY 2020
  - Complete Initial Aircraft to Aircraft Application Deployment: FY 2020
- **Segment 4 (2021 – 2025):**
  - Complete Removal of Targeted Legacy Surveillance: FY 2023
  - Complete Targeted Removal of TIS-B: FY 2025
  - Complete Additional Aircraft to Aircraft Application Deployment: FY 2025

Case Study: US ADS-B Program
Infrastructure – Cost/Benefit

Federal Aviation Administration

High Confidence Results	Segment 1
Net Present Value ($M)	$158.0
B/C Ratio	1.3
Payback Year	2031
Internal Rate of Return	9%



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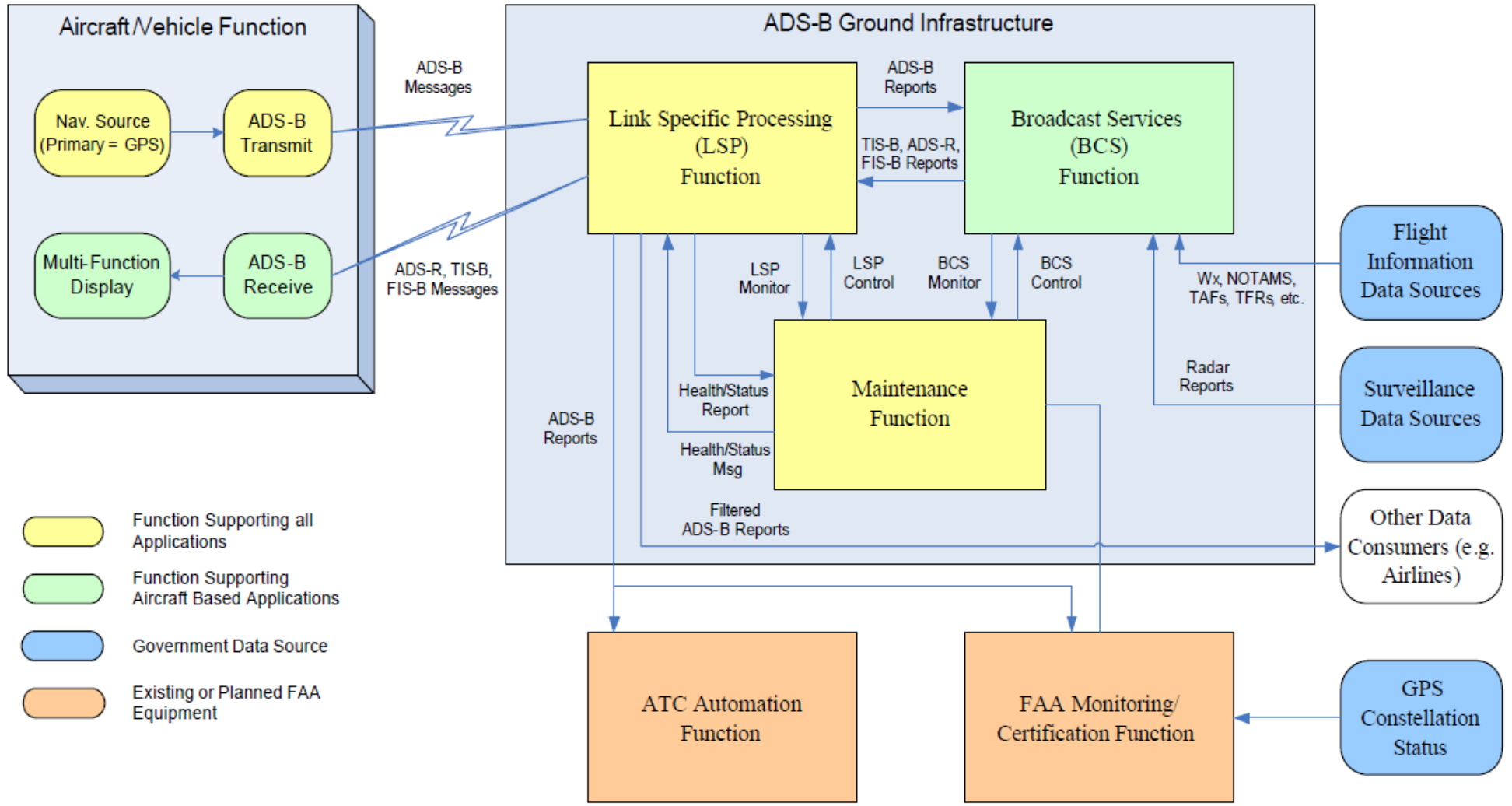
Case Study: US ADS-B Program Infrastructure

Federal Aviation Administration



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Case Study: US ADS-B Program Infrastructure

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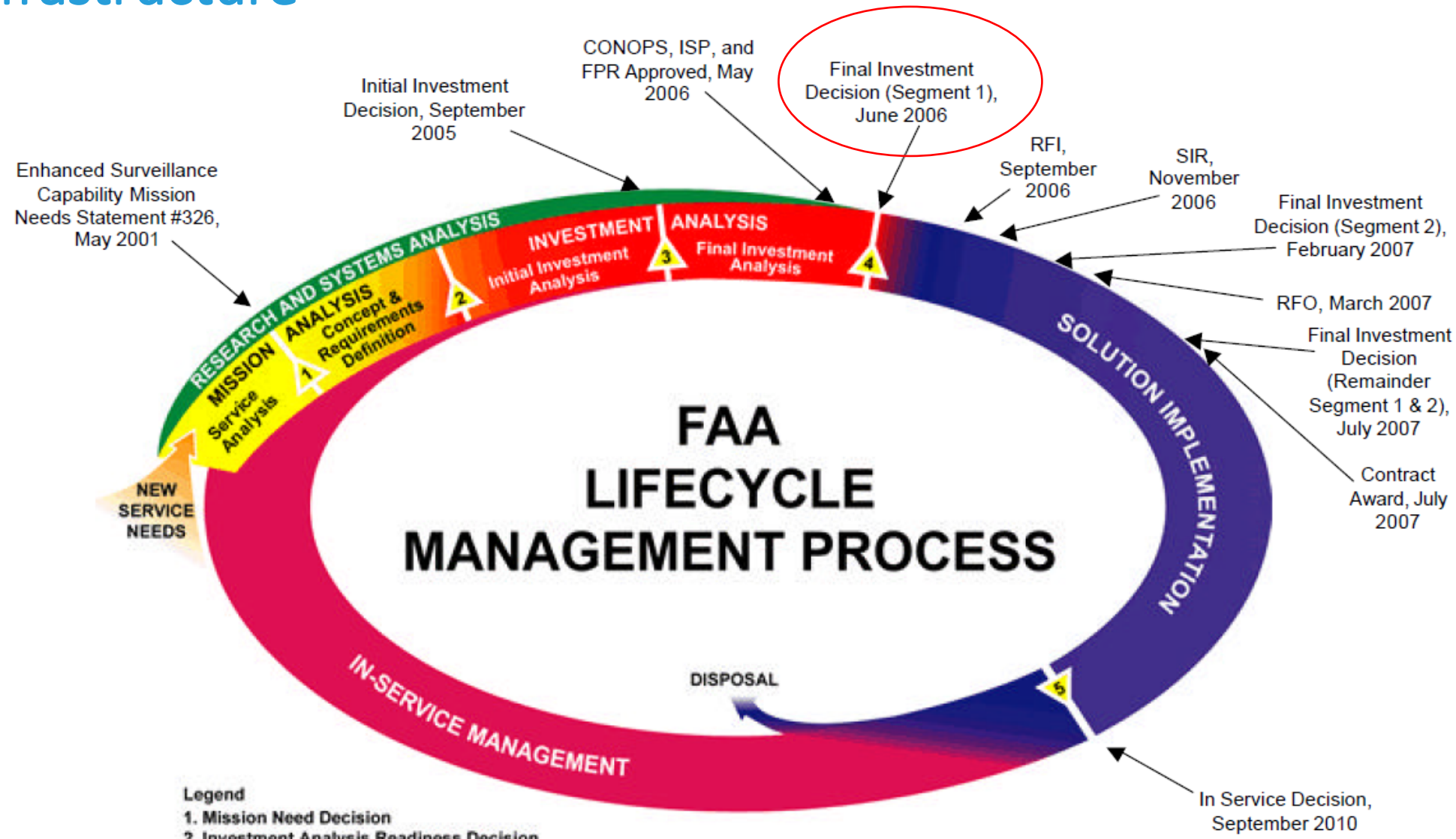

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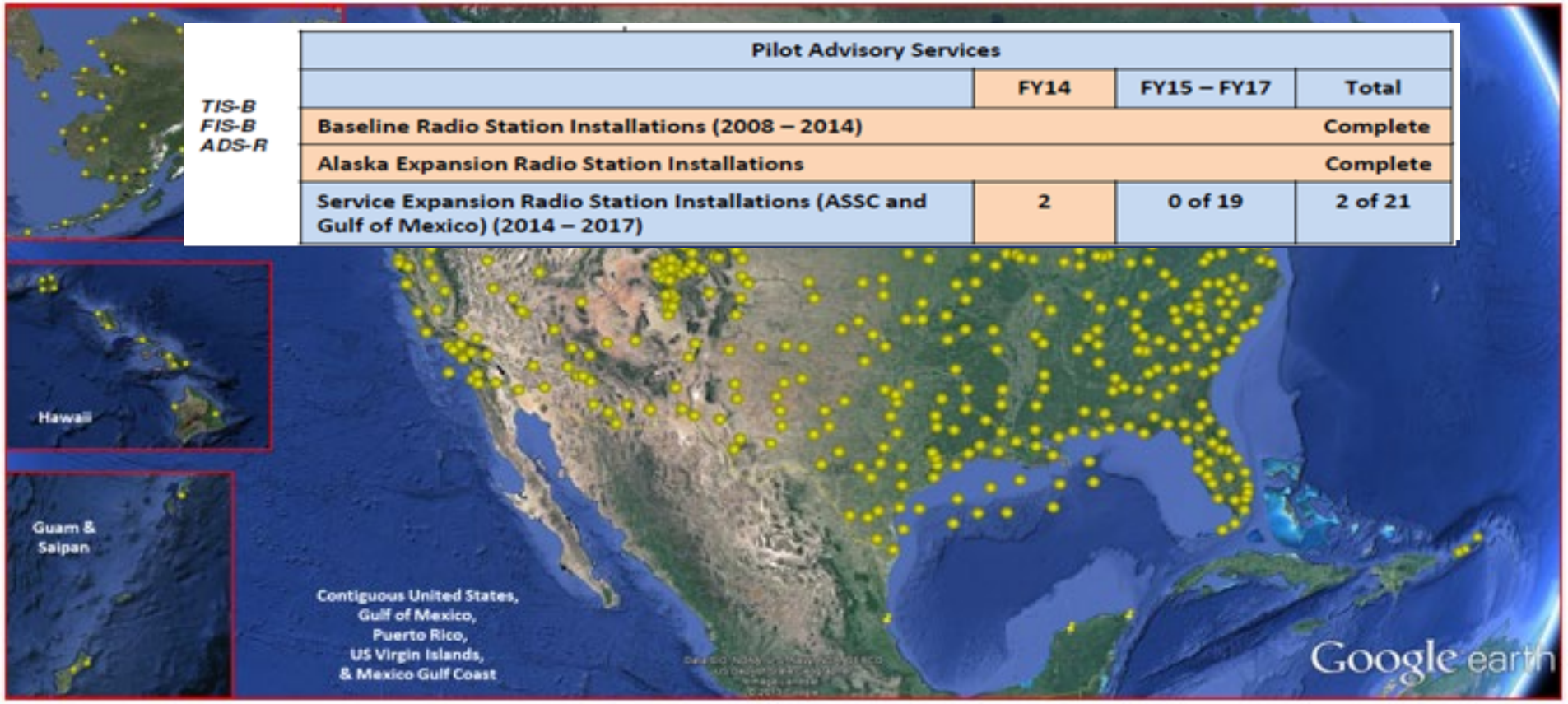
Case Study: US ADS-B Program Infrastructure

- Leveraging feedback received through engagement with industry, the SBS team received final approval for Segment 1 from the JRC in July 2006.
- This final approval allowed the team to continue working on issuing the Request for Information (RFI) and Screening Information Request (SIR).
- The AMS steps were followed until the final performance based service contract was awarded in July 2007.
- The FAA began working with the selected service contractor to initiate deployment of the ground infrastructure in 2008.
  - Initiation of this work provided a message that the FAA would be ready, as promised in the rulemaking process, to utilize ADS-B on the effectivity date of the regulation.

Case Study: US ADS-B Program Infrastructure – Deployment

Federal Aviation Administration



Pilot Advisory Services			
	FY14	FY15 – FY17	Total
Baseline Radio Station Installations (2008 – 2014)			Complete
Alaska Expansion Radio Station Installations			Complete
Service Expansion Radio Station Installations (ASSC and Gulf of Mexico) (2014 – 2017)	2	0 of 19	2 of 21

- Baseline installations took place from 2008 – 2014.
- Service expansion radios (Gulf of Mexico and ASSC) took place from 2014 – 2017.
  - Work in Gulf of Mexico added add'l stations to extend coverage to FIR boundary

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Case Study: US ADS-B Program Infrastructure

- As previously shown, the FAA incorporated ADS-B In services as part of its desired plans for the future of the airspace.
- ADS-B In services are provided through the implemented ADS-B ground stations up to an aircraft that is properly performing ADS-B Out system with a capability of receiving ADS-B In.
  - ADS-B In reception capability is included as part of the ADS-B Out message.
- The following slides illustrate the different ADS-B In services provided.

Case Study: US ADS-B Program
Infrastructure – ADS-R

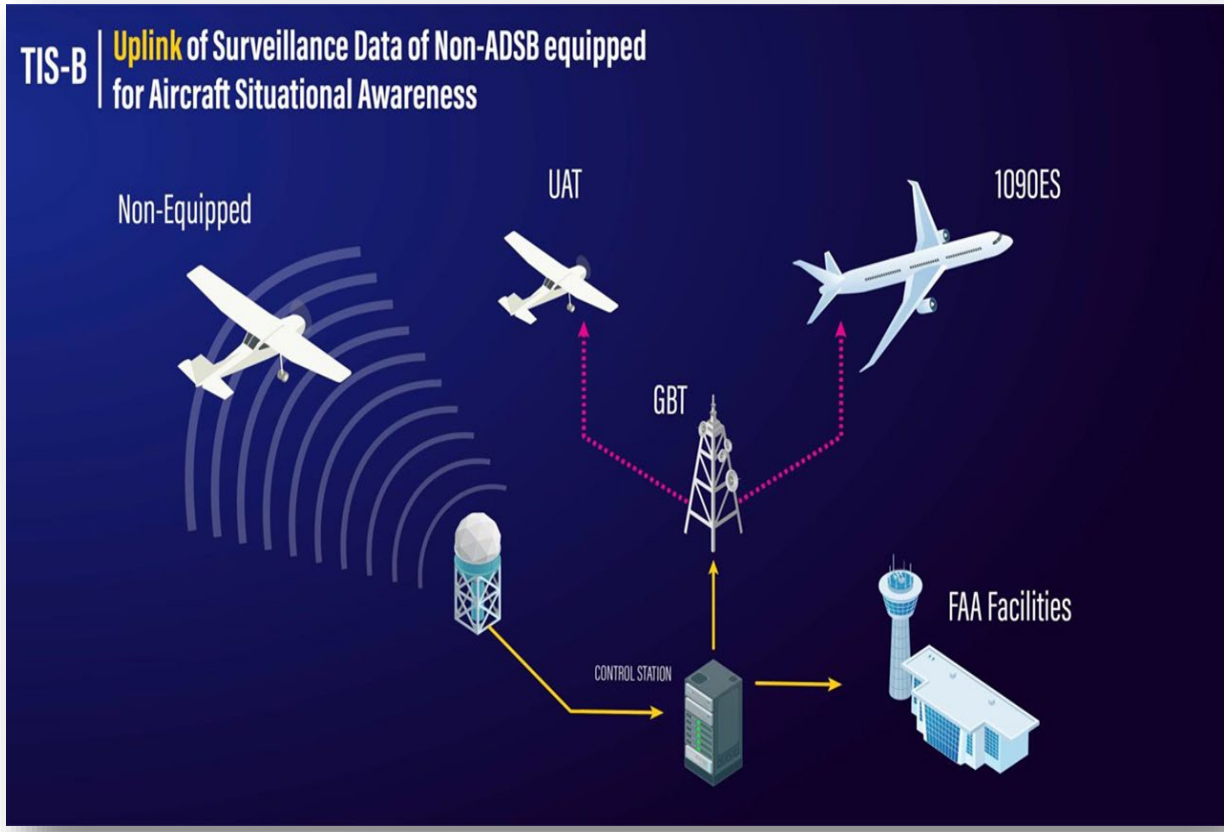
- **Service Description**
  - Client-based service
  - Relays ADS-B information transmitted by an aircraft equipped with an ADS-B Out system broadcasting on one link (1090 or 978 MHz)…
  - …to an aircraft equipped with ADS-B In on the other link.
- **Features**
  - The information for an aircraft equipped with a 1090 MHz ADS-B Out system will be re-broadcasted to an aircraft equipped with ADS-B In on the Universal Access Transceiver (UAT) frequency (i.e., 978 MHz), and vice versa.
  - Improves safety by providing pilots with real-time situational awareness of the aircraft flying within a 15-nautical mile radius and up to 3,500 feet above or below (aka "Hockey Puck")

NOTE: Allowing UAT adds significant complexity to the ground system.

The yellow arrows show ground-based data flow from the receiver about non-ADS-B equipped aircraft to the control station, then the ground-based towers (GBT). The pink arrows show the transmitted data flow to ADS-B equipped aircraft.

Case Study: US ADS-B Program
Infrastructure – TIS-B

- **Service Description**
  - Client-based service
  - Provides Surveillance information about aircraft (i.e., TIS-B targets) that <u>are not</u> **ADS-B Out**-equipped…
  - …to **ADS-B Out/In** equipped aircraft.
- **Features**
  - **GBT** – Ground Based Transceivers (GBT) transmit the information
  - To qualify as a TIS-B target, an aircraft must be equipped with a transponder, and be within radar coverage.
  - Improves safety by providing pilots with real-time situational awareness of the aircraft flying within a 15-nautical mile radius and up to 3,500 feet above or below (aka “Hockey Puck”)



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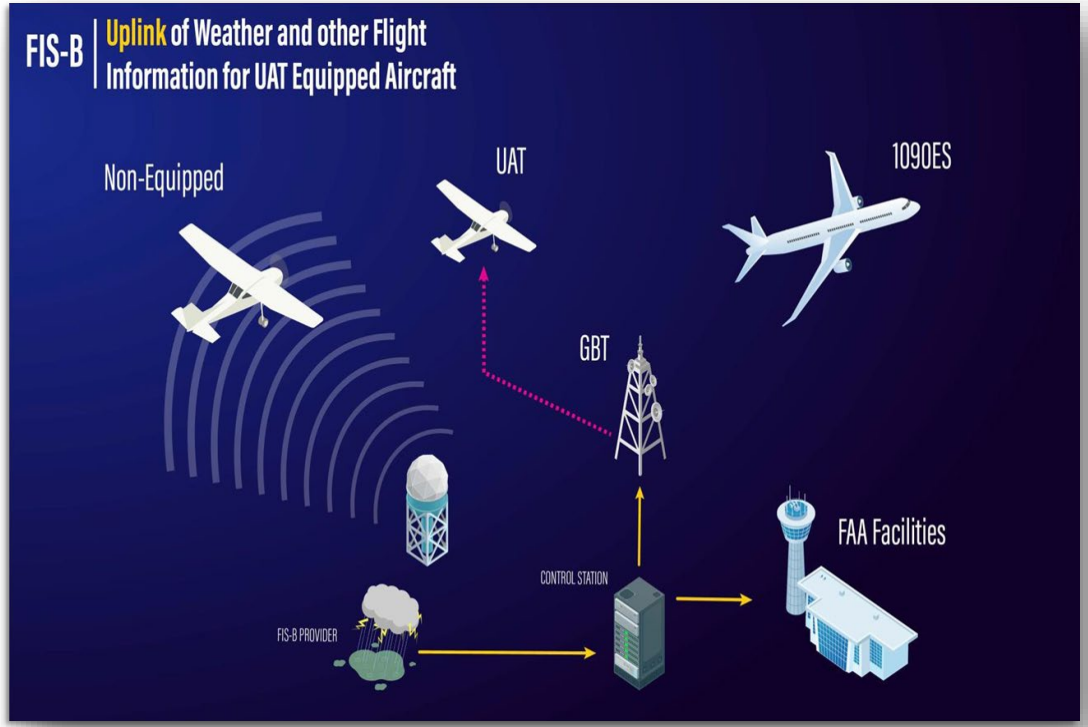
Case Study: US ADS-B Program
Infrastructure – FIS-B

- **Description**
  - Provides the meteorological and aeronautical data to the cockpit
  - Always broadcast into the airspace on the **UAT frequency** only.
- Some of the currently available FIS-B products:

- Airmen's Meteorological Information (AIRMET)
- Significant Meteorological Information (SIGMET)
- Convective SIGMET
- Meteorological Aerodrome Reports (METAR)
- CONUS NEXRAD
- Regional NEXRAD
- Turbulence (low and high altitude)
- Notice to Airmen (NOTAMs)
- Pilot Reports (PIREPs)
- Special Use Airspace (SUA) Status
- Terminal Aerodrome Forecast (TAF)
- Winds & Temperatures Aloft
- TIS-B Service Status
- Center Weather Advisory
- Cloud Tops
- Lightning
- Icing (low and high altitude)

NOTE: Products listed are generated from external data sources. Need to consider where the data will come from.



The yellow arrows show ground-based data flow from the Flight Planning systems to the control station, then the ground-based towers (GBT). The pink arrows show the transmitted data flow to UAT equipped aircraft.

Case Study: US ADS-B Program
Avionics

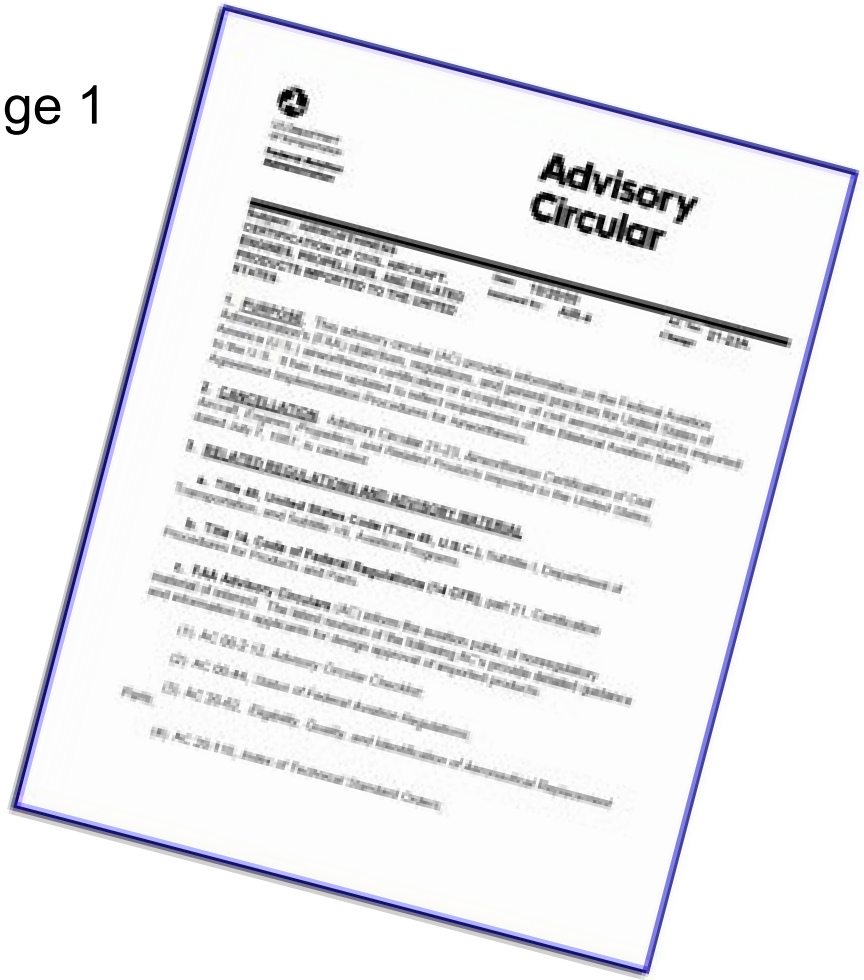
- Two out of three key aspects of ADS-B have already been discussed:
  - Regulation (see Presentation on ADS-B Regulation Development)
  - Infrastructure
- A third important component is the aircraft avionics.
- In collaboration with industry through the joint RTCA/EUROCAE working groups, the ADS-B Version 2 Minimum Operating Performance Standards (MOPS) were completed.
  - RTCA DO-260B/ED-102A
  - RTCA DO-282B

Case Study: US ADS-B Program
Avionics

- As part of the rulemaking process, the FAA developed the applicable Technical Standard Orders (TSOs) to allow manufacturers to develop and certify ADS-B Out equipment to these new standards.
  - TSO-C166b for 1090ES ADS-B Out systems
  - TSO-C154c for UAT ADS-B Out systems
- Additionally, the FAA developed guidance to assist aircraft and equipment manufacturers with installation and testing that should be conducted as part of the aircraft certification process (i.e., Type Certificate/Supplemental Type Certificate/Amended Type Certificate).

Case Study: US ADS-B Program Avionics

- **RTCA documents**
  - RTCA DO-260B, DO-260C as modified by Change 1
  - RTCA DO-282B, DO-282C
- **TSO**
  - TSO-C166b, TSO-C166c
  - TSO-C154c, TSO-C154d
- **Advisory Circular**
  - AC 20-165B
  - AC 90-114B Change 1
- **ADS-B documents can be found at:**
  - RTCA documents - www.rtca.org
  - FAA documents - http://drs.faa.gov



Case Study: US ADS-B Program
Avionics

- To encourage development of avionics and aircraft certifications, the FAA collaborated with industry to fund several avionics and aircraft certifications.

  - Assisted in providing aviation users with options for equipping their aircraft with rule-compliant ADS-B systems.

- In parallel, the FAA was working with industry to develop guidance and streamline the certification and installation process.

- The installation of the ADS-B equipment was identified as a potential barrier for aviation users, especially the GA community, to meet the 01 January 2020 mandate.

Case Study: US ADS-B Program Avionics

jetBlue HAPPY JETTING

- ADS-B Out
- Aircraft: 35 A320
- STC approved July 2012
- **All 35 modifications complete**

- ADS-B Out and In
- Aircraft: 12 747
- STC approved June 2011
- **12 ADS-B In equipped**

BOEING Rockwell Collins UNITED

- ADS-B Out
- Aircraft: 110 737NG
- Boeing Service Bulletin 01 delivered May 2013 and Rockwell Collins Black Label Equivalent delivered December 2013
- United retrofit begins June 2014
- Upgrades to DO-260B complete by December 2017

- ADS-B Out
- Aircraft: 164
  - 13 B747
  - 59 B767
  - 52 A300
  - 38 MD11
  - 2 B757
- STC for 767, 747/767 AML, MD11/A300 AML approved (December 2011, January 2012, and February 2013 respectively)
- **145 installs complete to date**
- Upgrades complete by June 2014

U·S AIRWAYS

- ADS-B Out and In
- Aircraft: 20 A330-300/200
- STC for ADS-B Out approved August 2012; STC for Merging & Spacing approved January 2013
- **16 ADS-B Out and 13 In installs complete**
- Upgrades (Out and In) complete by March 2014

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Case Study: US ADS-B Program Avionics

- ADS-B Out and In [Multi-function Display (MFD) and Portable Electronic Device (PED)]
- Aircraft: 2 Bell 206 helicopters
- STC issued January 2014
- Upgrades complete by February 2014



- ADS-B Out
- Aircraft: 54 helicopters
  - **9 AW-139 Chevron: Completed February 2013**
  - 47 PHI: Upgrades complete by 2015
- STC for AW-139 282B issued June 2012
- STC for S-92 260B expected May 2014
- STC for S-76 260B expected June 2014
- Upgrades complete by 2016


- ADS-B Out
- Aircraft: 1 Cessna 150
- AML STC for Cessna 150/172/182 issued December 2012
- **Upgrade completed December 2012**


- ADS-B Out
- Aircraft: 400 legacy Capstone aircraft
- Contract awarded to FreeFlight Systems on April 30, 2013
- AML STC for fixed wing expected February 2014 and AML STC to include AS-350 and Bell 412 expected March 2014
- Upgrades complete by February 2015

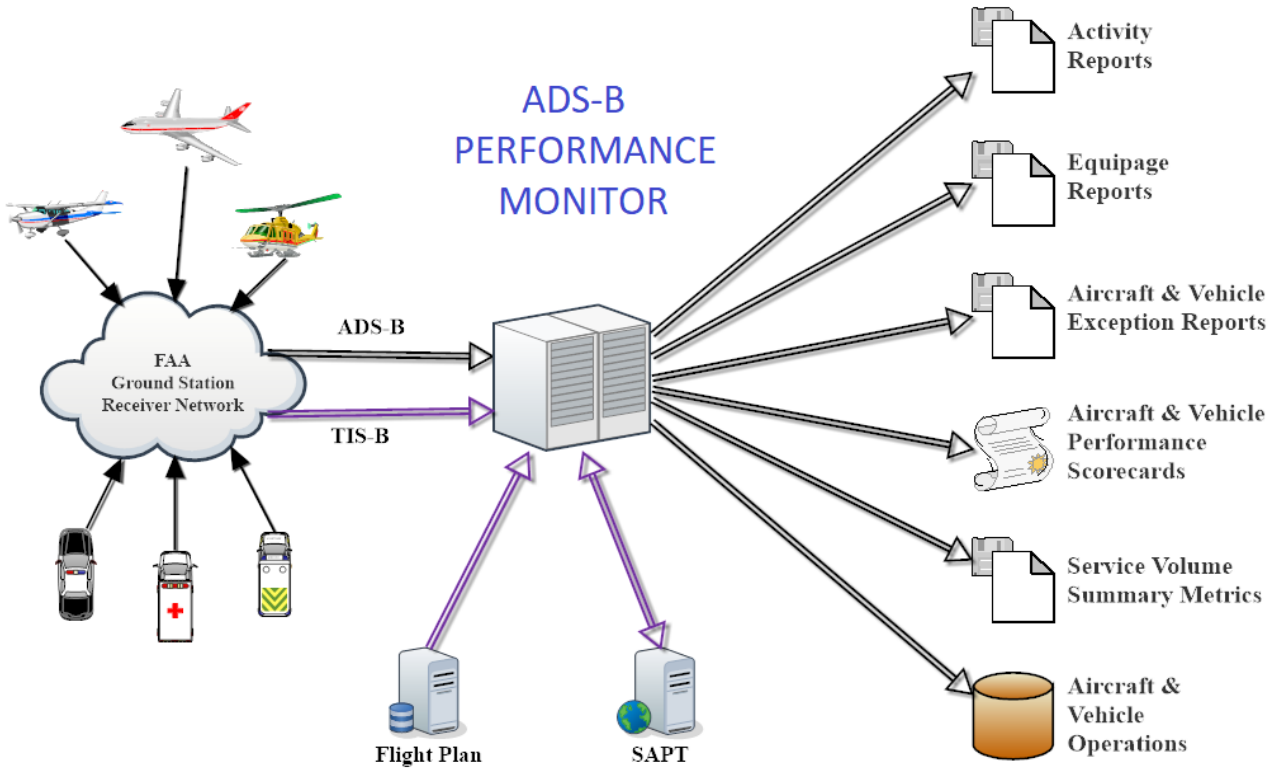
Case Study: US ADS-B Program
Avionics

- To address industry-identified barriers, the FAA published a new Installation Policy Memorandum and an associated technical paper
  - https://drs.faa.gov/browse/excelExternalWindow/1FDEA629CD029A7C86257F7900601653.0001
  - https://www.faa.gov/air_traffic/technology/equipadsb/resources/media/ADS-B_Out-In_Installation_Tech_Paper(9-25-17).pdf

- This policy allowed the use of an existing STC (with permission from the STC holder) as a basis for installation on a similar aircraft not currently covered under the certification
  - Example would be using the STC for a Cessna 172 on a Cessna 152.

Case Study: US ADS-B Program Avionics

- Since ADS-B was the basic building block for the future of surveillance, there was a need to continuously monitor ADS-B performance rather than relying on the 2-year transponder check.
- The FAA decided to develop the ADS-B Performance Monitor (APM) to accomplish this task.

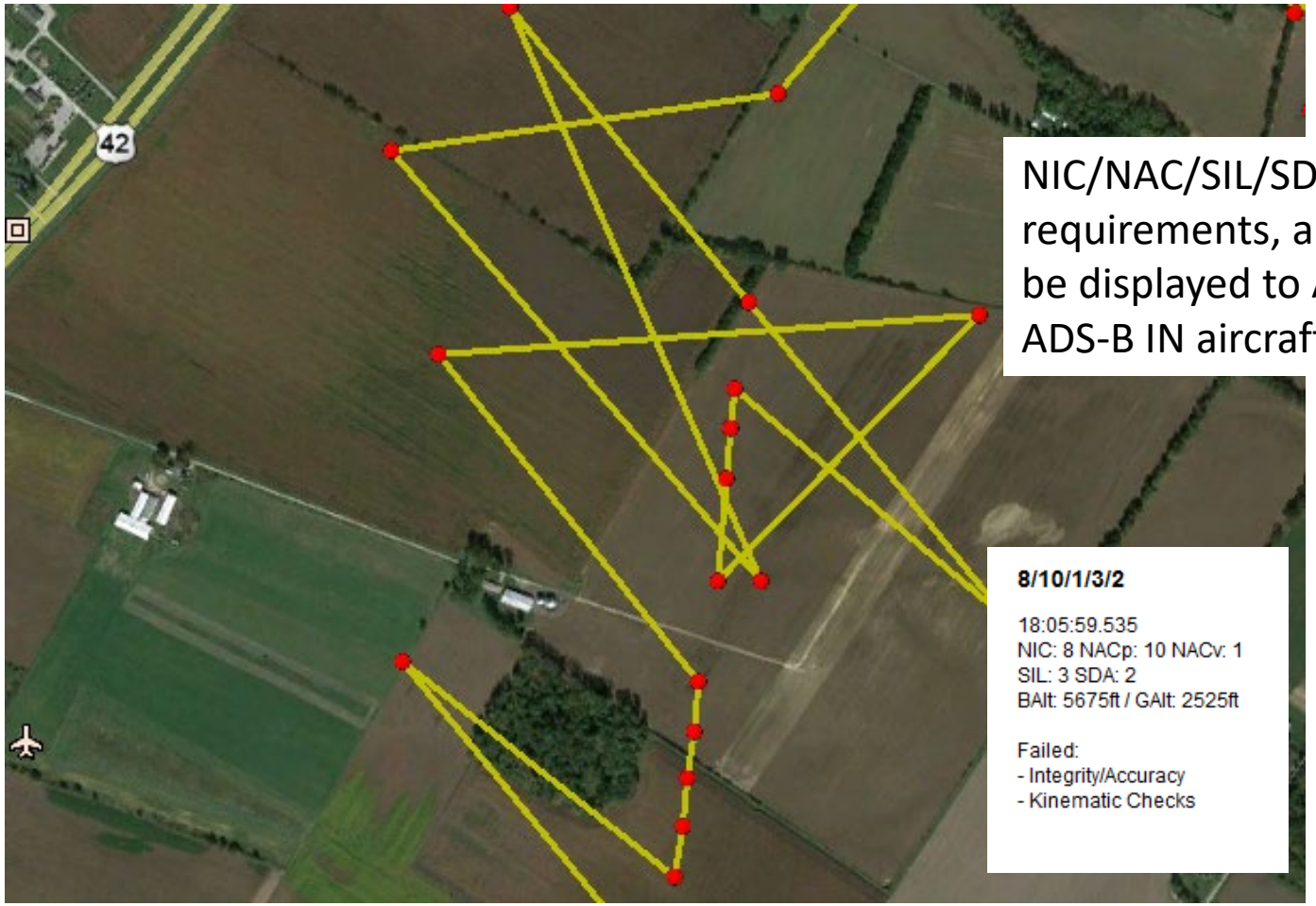


Case Study: US ADS-B Program
Avionics

- Having a monitoring system ensures equipment is meeting the performance required to provide the desired services.
- Additionally, it will assist in identifying and correcting installation issues. Example of such issues are:
  - Incompatible GPS or Software
  - Improper configuration of 24-bit ICAO address
  - Mode A mismatch (applicable for UAT installations)
- Because of the APM, the FAA modified installation guidance to:
  - Provide guidance for showing compatibility of the ADS-B/GPS pairing.
  - Reiterate the requirement outlined in 14 CFR 91.217(b) to ensure the same altitude encoder is used for both the ADS-B Out system and Transponder (applicable for UAT installations)

Case Study: US ADS-B Program
Avionics

Federal Aviation Administration



NIC/NAC/SIL/SDA meet rule requirements, aircraft may be displayed to ATC & other ADS-B IN aircraft.

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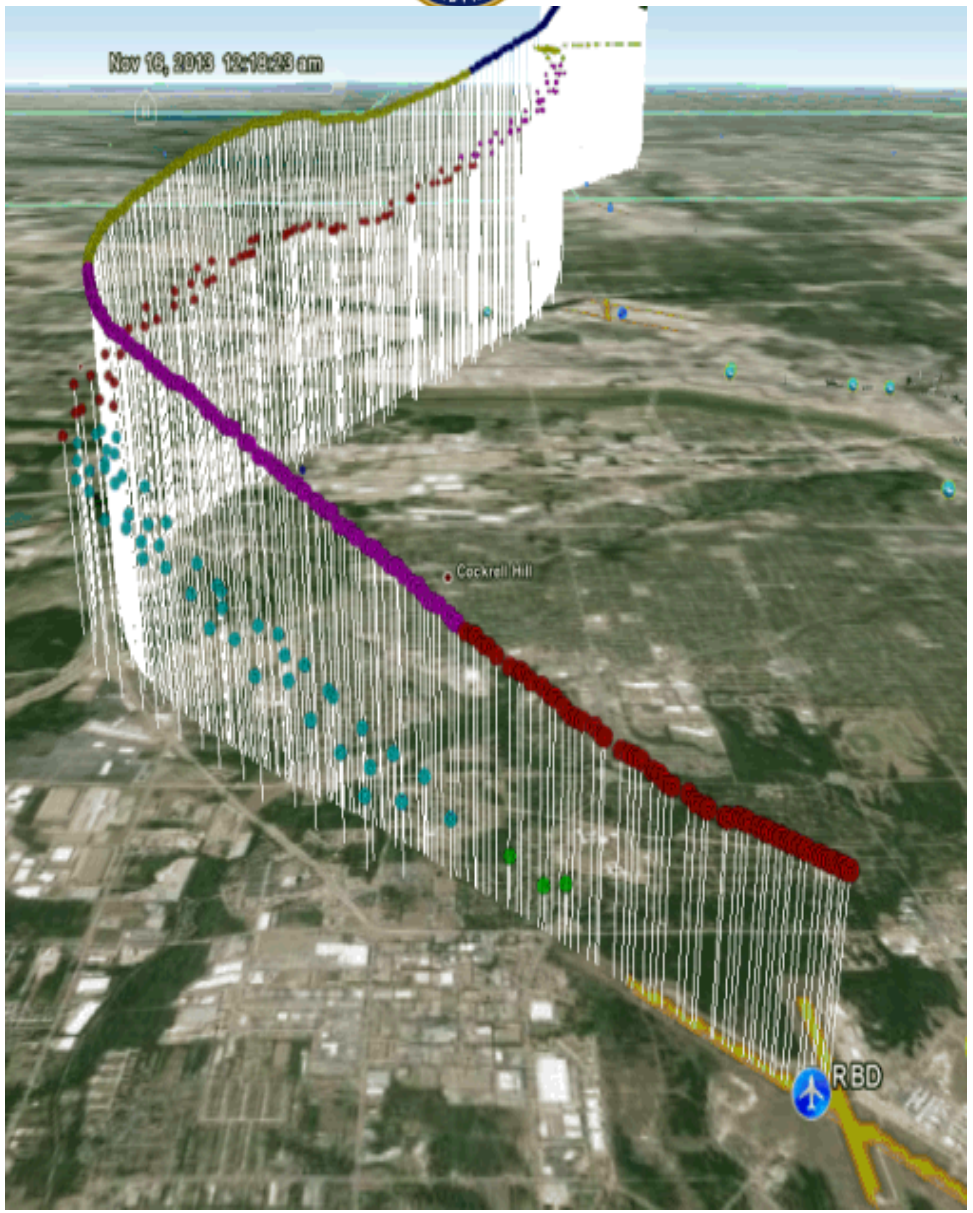
Case Study: US ADS-B Program Avionics

Federal Aviation Administration

- Differing Mode C and UAT Pressure Altitude
- Aircraft is equipped with both a Mode S transponder without 1090ES capability and a Version 2 UAT transceiver
- The UAT baro altitude reports are indicating differences of ~1200ft above the Transponder reported altitude



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CONCLUSION

- In summary, there is a need to work through the appropriate processes to ensure all safety and operational requirements are being addressed and met.

  - This includes development of any guidance or training material that may be needed for the Air Traffic Controllers.

- Do not wait until the publication of your regulation to begin working on implementation and deployment of ADS-B infrastructure (if applicable) and addressing avionics certification or aircraft installation barriers.

  - Both of these items **will** come up as part of your industry engagement.

- UAT for ADS-B Out adds additional complexity to your implementation.

- Consider the need for developing a monitoring tool.

Thank You!

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