ADS-B - A Boeing Perspective

ICAO ADS-B Seminar/Study & Implementation Task Force/11

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Agenda

- ATS Landscape
- Standards/Certification
- US Activities
- Other Regional Activities
- Boeing Plan – ADS-B Out
- Boeing Plan – ADS-B In
- Airplane Architecture Considerations
- ADS-B In Symbology
- Equipage Levels
- Benefits
- Conclusions

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Air Transportation System Roadmap

Airplane Population

2010 | 2015 | 2020 | 2025 | 2030

19,410

Growing Fleet of Highly Capable Aircraft

Growth (20,120)

Replacement (13,380)

Retained (6,030)

39,530

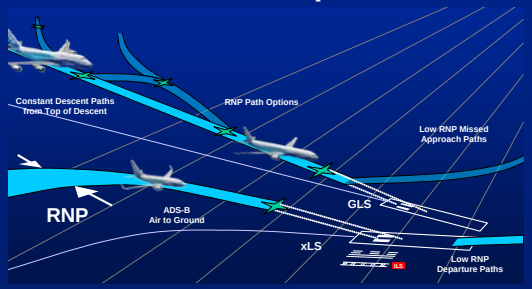
33,500 new

31% Of Today's Fleet Will Be Operating 20 Years From Now

Airspace Operations

Manual ATC Intervention, Control by Radar & Navaid

Pre-Defined Performance Based Airspace



Dynamic Performance Based Airspace

Key Capabilities

ATM Automation

Time-Based Arrivals; TRACON RPI; Extended TBFM; Time-based RNP/RNAV Arrivals; Surface Tool; Departure Tool; 4D Trajectory Negotiation Tool; Arr/Dep/Surf Data Integration; TRACON TBFM; Conflict Detection; Conflict Resolution; 4D Conflict Resolution

Communication

Analog Voice; FANS-1; ACARS; ATN; Link 2000+; FANS-2; Oceanic RCP; Polar SATCOM; Broadband IP; FANS-3; Continental RCP; Digital Voice; Future Subnetworks

Navigation

RNP; Full Profile RTA; GLS Cat I; AMM; RNP AR; GLS Cat III; ORE Indication; Multi Freq / Constellation GNSS; Expanded Windfield; Graphical WX; EVS/SVS; Advanced RTA; Graphical Taxi; ORE Active; Global Cat I from Space; GNSS Backup System

Surveillance

Extended Squitter; ADS-C; Prim / Sec Radar; ACAS 7.1; ADS-B In/CDTI; ADS-B Out DO260B; Spacing; ACAS/ADS-B Integration; SURF IA; Adv ADS-C; Delegated Separation; Self Separation

System Wide Information Management

OLDI; ETMS; AIDC; RADNET; Adv Inter-Facility Coord; Aero/Met Info; Shared Trajectory & Surveillance Info

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Standards Development

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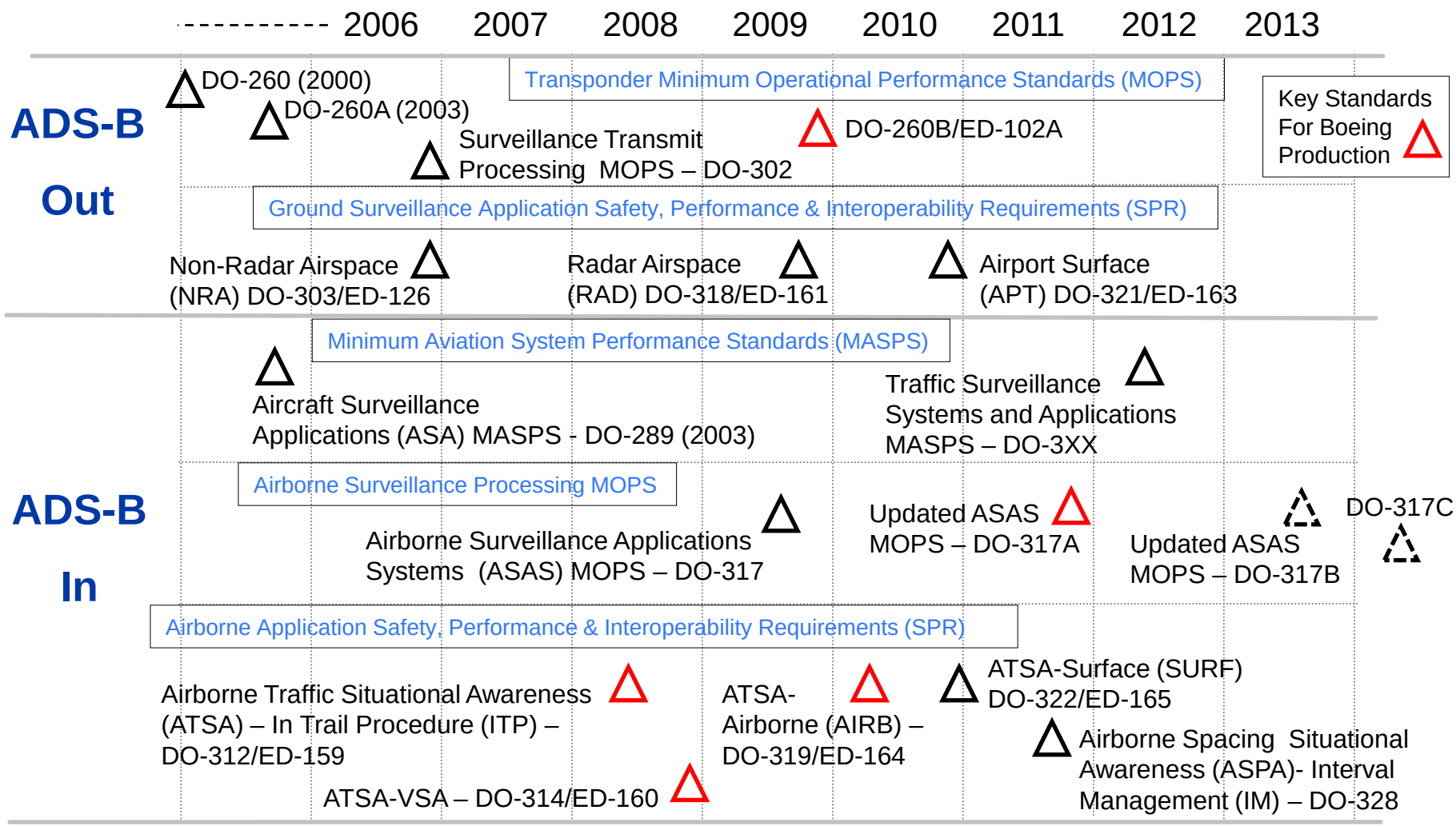

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Certification Documents

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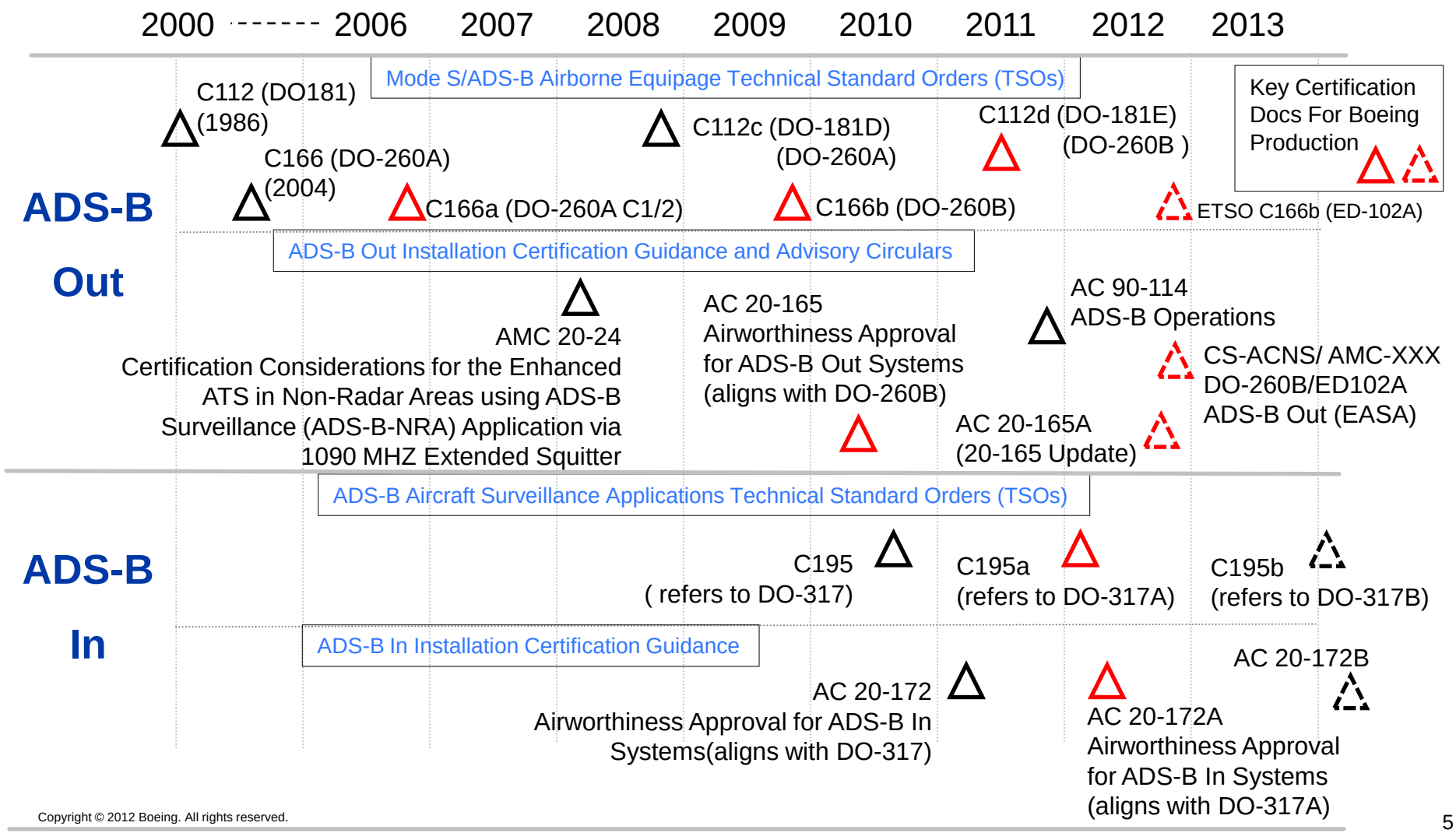

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US/FAA Activities

- **ADS-B Out mandate for Class A, B, C airspace and Class E airspace (≥10Kft MSL) effective 1 Jan 2020 (FAR 91.225/91.227)**
  - Requires new transponder standard (DO-260B)
  - Requires update to GPS sensor with a minimum of SA Aware
  - Future update of AC 90-114 will likely require use of a service availability prediction tool (SAPT) to determine the ability of the positioning source (GNSS) to meet the position accuracy and integrity requirements for flight plan route
- **FAA-sponsored ADS-B In trials**
  - Merging and Spacing (UPS/Louisville - complete)
    - First validation of flight deck based Interval Management using EFB and auxiliary displays
  - Surface with Indications and Alerts (SURF IA - complete)
    - Provided operational performance evaluation on airport surface with final approach/runway occupancy alerting
  - In Trail Procedure (ITP - 2012)
    - Provide operational benefits in non-surveillance airspace
    - Validate operational performance and economic benefits
  - Flight Deck Based Interval Management-Spacing (FIM-S - 2012/13)
    - Reduce fuel burn, noise and emissions while maintaining high throughput
    - Develop and validate flight deck technology to enable FIM-S operations
- **FAA & NASA Interval Management operational evaluations planned (2015/16)**

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Other Regional Activities

- **Nav Canada providing preferential services to ADS-B Out equipped a/c over Hudson Bay between FL350 and FL400 inclusive (initiated Nov 2010)**
  - Current production transponder meets mandate (EASA AMC 20-24 certification basis)
  - Elementary/Enhanced/Extended Squitter (ELS/EHS/ES) surveillance capability with AFM Update
  - Installed on Boeing production airplanes since early 2004
  - Service bulletins available for retrofit of in-production models
  - Starting 20 Oct 2011 non-equipped a/c must file for fixed route
- **European Commission completed an Implementing Regulation on 22 Nov 2011 mandating ADS-B Out in production on 8 Jan 2015 and for entire European airspace (retrofit) on 7 Dec 2017**
  - Requires transponder update to DO-260B standard
  - Need timely publication EASA Certification Specification (CS-ACNS) and AMC/ETSO
  - No requirement for ground systems to use ADS-B Out
- **Australia (CAO 20.18, Amend Order No. 3, dated Dec. 2009)**
  - Mandates ADS-B Out for upper airspace (≥FL290) in Dec 2013
  - Current production transponder meets mandate (AMC 20-24)
  - SA-Aware GNSS receiver mandated in production starting 8 Dec 2016
    - Honeywell RMA-55B Multi-Mode Receiver is not SA-Aware and will not be modified to SA-Aware

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Other Asia Region Activities (known)

- Hong Kong (Airworthiness Notice 102F, Issue 2, 28 Feb 2011)
  - Implement the use of Automatic Dependent Surveillance Broadcast (ADS-B) Out:
    - After 31 Dec 2013 for aircraft flying over PBN routes L642 or M771 between FL290 and FL410
    - After 31 Dec 2014 for aircraft flying within Hong Kong FIR between FL290 and FL410
  - Must meet DO-260 (Version 0) requirements of ICAO Annex 10 and ICAO Doc 9871 Chapter 2, or DO-260A (Version 1) requirements of ICAO Doc 9871 Chapter 3
  - Means of compliance per EASA AMC 20-24 or CASA CAO 20.18 Appendix XI
  - Current Boeing production equipage meets requirements

- Singapore (CAAS AIC 14, 28 Dec. 2010)
  - Implement the use of Automatic Dependent Surveillance Broadcast (ADS-B) Out after 12 Dec 2013 within certain parts of the Singapore FIR (≥FL290)
  - Must meet EASA AMC 20-24 or CASA CAO 20.18 Appendix XI, otherwise must fly at <FL290
  - Current Boeing production equipage meets requirements

- Other Asia Pacific Regulatory Agencies
  - Expected to follow ADS-B Avionics Requirements template per APANPIRG Conclusion 21/39
  - Template states: Must meet EASA AMC 20-24 or CASA CAO 20.18 Appendix XI

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ADS-B Out – Meeting the Mandates

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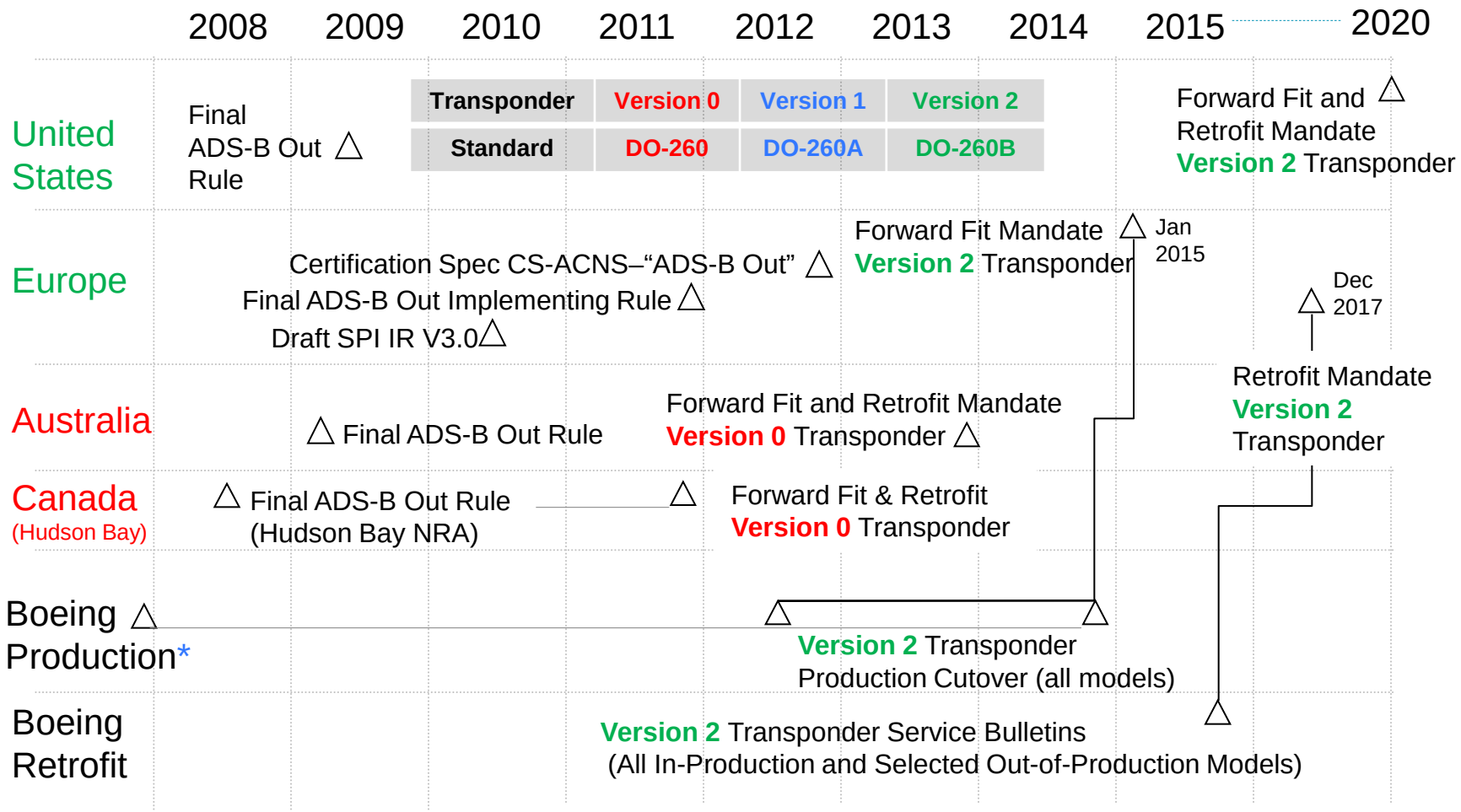

* **787-8 & 747-8** aircraft have **Version 1** transponder and SA-Aware GNSS receiver since Entry into Service (EIS)

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ADS-B Out – Version 2 ATC Transponders

- **Planned Boeing in-production Version 2 (DO-260B) ATC transponder capability**

	737NG	747-8	767	777	787-8
Buyer Furnished Equipment (BFE)	ACSS (update to ATDL XS-950) Honeywell (TRA-100B) RCI (TPR 901)		ACSS (update to ATDL XS-950) Honeywell (TRA-100B) RCI (TPR 901)	ACSS (update to ATDL XS-950) Honeywell (TRA-100B) RCI (TPR 901)	
Supplier Furnished Equipment (SFE)		RCI (1) (TPR 901)			RCI ISS (2)

RCI – Rockwell Collins Inc.

(1) Same unit as Buyer Furnished Equipment

(2) Integrated Surveillance System (ISS) includes ATC Transponder, ADS-B Out, ACAS/ACAS, Terrain Awareness, and Weather Radar

BFE – Equipment selected/provided by buyer
SFE - Equipment basic to airplane

- **All units planned to be certified to TSO C112d/C166b**
- **Interfaces per ARINC 718A Supplement 4 (787 ARINC 768-2)**
- **Installation compliant with requirements of AC 20-165**
- **Need timely publication EASA Certification Specification (CS-ACNS)), AMC, and ETSO**
  - Currently planned for publication in 4Q 2012
  - AMC will be very similar to FAA AC 20-165 to be compliant with CS

DO-260B should be maintained as minimum ADS-B Out standard

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ADS-B Out – Multi-Mode Receivers (MMRs)

- **Boeing in-production Multi-mode receiver (MMR) capability**

	737NG	747-8	767	777	787-8
Buyer Furnished Equipment (BFE)	Honeywell (RMA-55B SA On) Thales (TLS-755 SA Aware) Rockwell (RCI) (GLU-920-001/002 SA On) (GLU-920-004 SA Aware) (GLU-925 SA Aware)		Honeywell (RMA-55B SA On) Thales (TLS-755 SA Aware) Rockwell (RCI) ((GLU-920-001/002 SA On) (GLU-920-004 SA Aware) (GLU-925 SA Aware)	Honeywell (RMA-55B SA On) Thales (TLS-755 SA Aware) Rockwell (RCI) (GLU-920-001/002 SA On) (GLU-920-004 SA Aware) (GLU-925 SA Aware)	
Supplier Furnished Equipment (SFE)		Rockwell(1) (RCI) (GLU-925 SA Aware)			Honeywell INR (2)

- **All units certified to TSO C129a**
- **Interfaces per ARINC 755-3**

(1) Same unit as Buyer Furnished Equipment
(2) Integrated Navigation Radio – SA Aware

BFE – Equipment selected/provided by buyer
SFE - Equipment basic to airplane

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ADS-B In Development Plans

- Standards for some applications still under development
- Operational procedures for ADS-B In applications in trial phase
- Boeing goal to develop equipage architectures with growth capability
- Solution must provide economic/technically sound approach for our customers
- Prototyping ADS-B In/ CDTI displays and guidance in FFOV
- Flight deck human machine interface requirements near completion
  - Symbology and displays
- Research and feasibility studies on-going:
  - Traffic processing requirements in work
  - Targeting initial set of situational awareness applications
  - Retrofit solutions for out-of-production models in review
    - Evaluating auxiliary display solution/certification requirements for retrofit

Plans for ADS-B In/CDTI are in work

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ADS-B In – Traffic Processing

- **Planned Boeing In-Production traffic processing function in ACAS LRU**

	737NG	747-8	767	777	787-8
Buyer Furnished Equipment (BFE)	ACSS (TCAS 3000 SP) Honeywell (TPA -100C) Rockwell (RCI) (TTR-2100)		ACSS (TCAS 3000 SP) Honeywell (TPA -100C) Rockwell (RCI) (TTR-2100)	ACSS (TCAS 3000 SP) Honeywell (TPA -100C) Rockwell (RCI) (TTR-2100)	
Supplier Furnished Equipment (SFE)		RCI (1) (TTR-2100)			RCI ISS (2)

(1) Same unit as Buyer Furnished Equipment
(2) Integrated Surveillance System (ISS) includes ATC Transponder, ADS-B Out, ACAS, Terrain Awareness, and Weather Radar

BFE – Equipment selected/provided by buyer
SFE - Equipment basic to airplane

- **All units will be certified to TSO C195a**
- **Interfaces per ARINC 735B Supplement 1 (787 ARINC 768-2)**
- **Installation compliant with requirements of AC 20-172a**

Plans for ADS-B traffic processing are in work

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Architecture Considerations

Function	737NG	747-8	767	777	787-8
Traffic Computing	Single ACAS LRU	Single ACAS LRU	Single ACAS LRU	Single ACAS LRU	Dual ISS (1)
CDTI	ND	ND	ND	ND	ND
Aircraft Interfaces	FMC/MMR/ ADIRU	FMC/MMR/ ADIRU	FMC/MMR/ ADIRU	FMC/MMR/ ADIRU	FMF/INR
Guidance (speed/dist)	ND	ND	ND	ND	ND
Crew Controls	MCDU/TBD	MCDU/TBD	MCDU/TBD	MCDU/CCD	MKP/CCD

(1) Integrated Surveillance System (ISS) includes ATC Transponder, ADS-B Out, ACAS, Terrain Awareness, and Weather Radar

Plans for ADS-B In Integration are in work

CCD – Cursor Control Device
FMF – Flight Management Function
INR – Integrated Navigation Radio
LRU – Line Replaceable Unit
MCDU - Multi-function Control & Display Unit
MKP – Multi-function Key Pad
ND – Navigation Display

Forward fit of ADS-B In/CDTI targeted for forward field of view display systems

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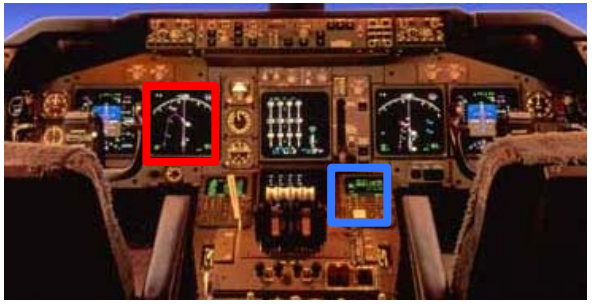
Flight Deck Considerations

737

747



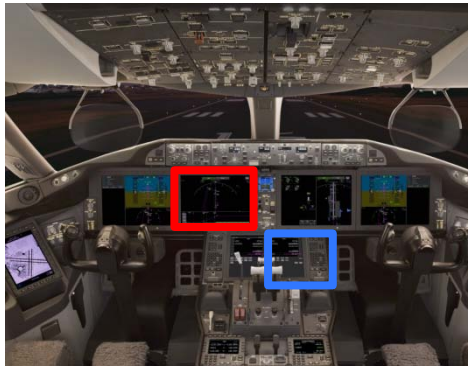
767

Display System upgrade is Required

777

Plans for ADS-B In Integration on the flight deck are in work

787



Display

Control

Forward fit of ADS-B In/CDTI targeted for forward field of view display systems

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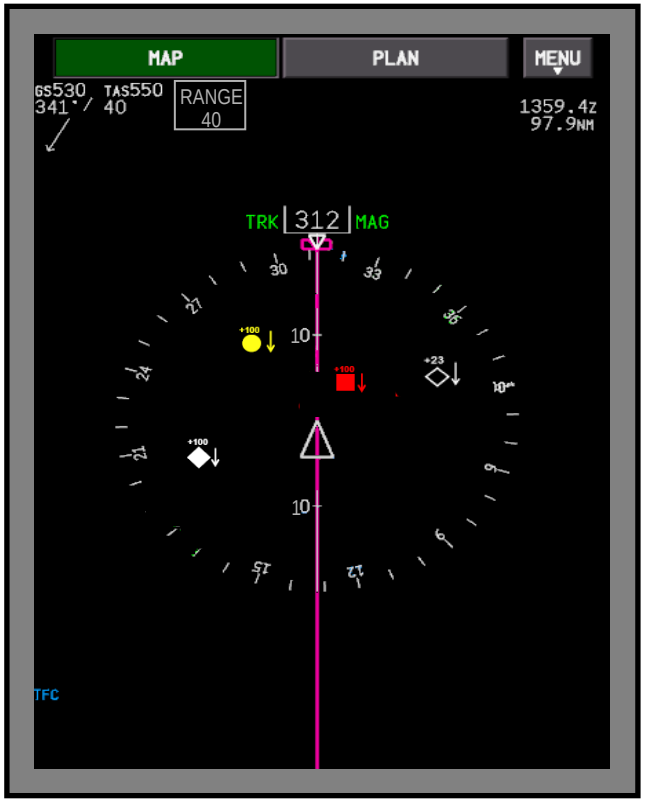
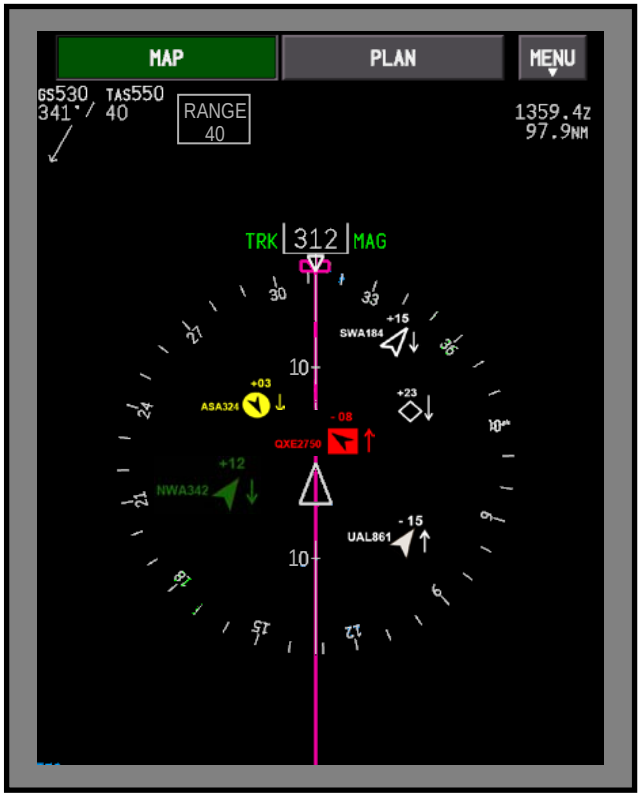
New ADS-B In Symbology

Baseline Design



Legacy ACAS Traffic Symbol Set

Proposed Design Changes



ADS-B Traffic Symbol Set

ADS-B In integration with ACAS in the flight deck required for long term while maintaining underlying independent ACAS collision avoidance function

Plans for ADS-B In symbology are in work

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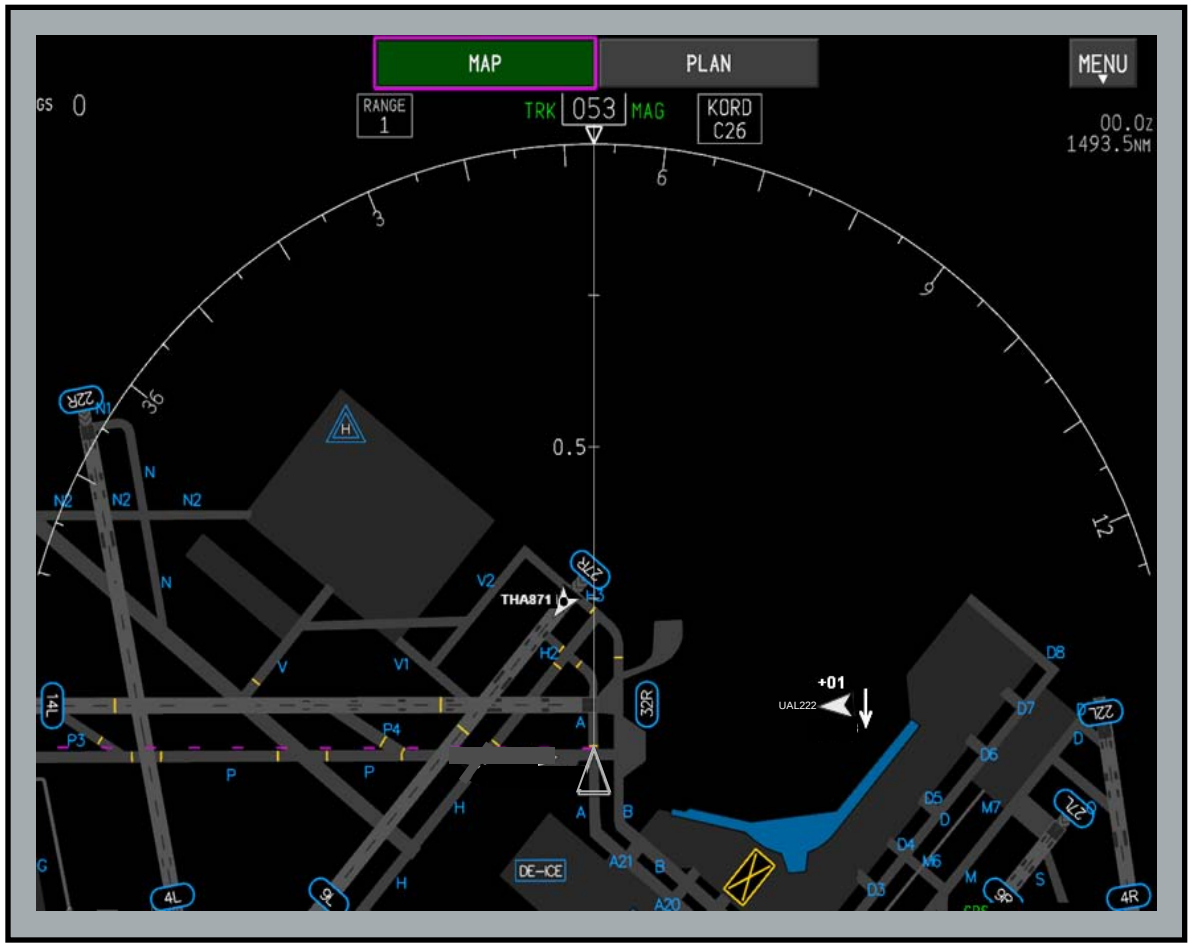
New ADS-B In Symbology

ADS-B Surface Traffic Symbology



Plans for ADS-B In symbology are in work

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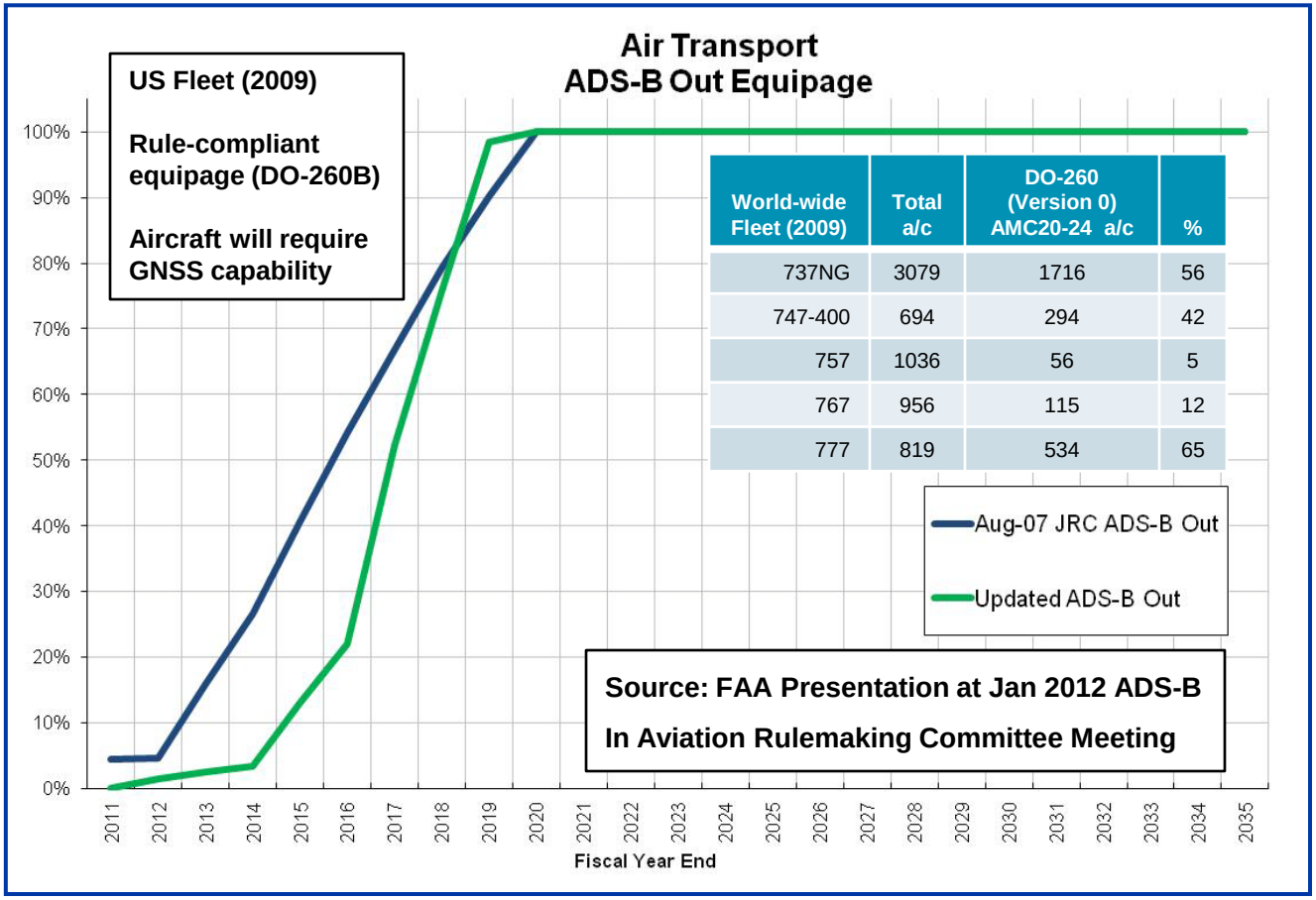
ADS-B Out Equipage Growth



World-wide Fleet (2009)	Total a/c	DO-260 (Version 0) AMC20-24 a/c	%
737NG	3079	1716	56
747-400	694	294	42
757	1036	56	5
767	956	115	12
777	819	534	65

DO-260B equipage for aircraft operating in the US will grow to 100% by 2020

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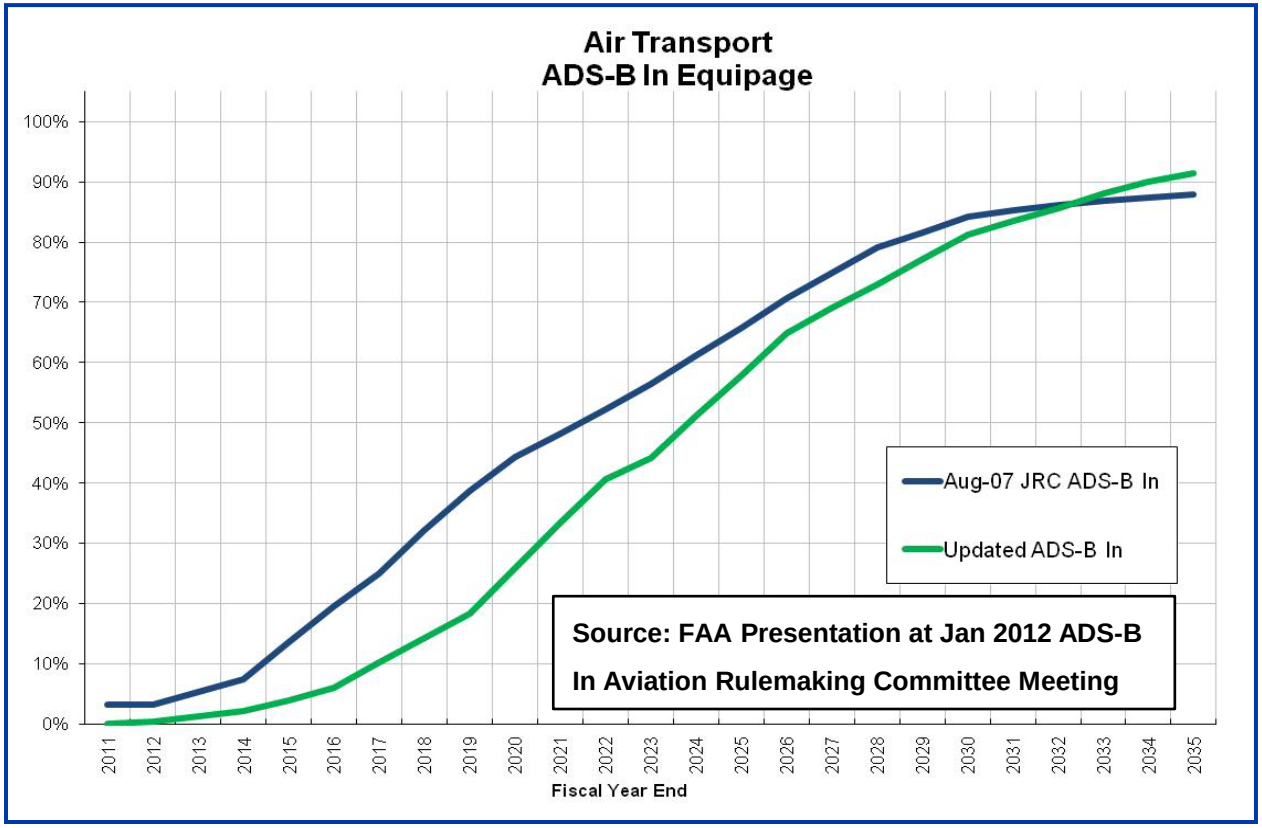
ADS-B In Equipage Growth



Retrofit of the existing fleet for ADS-B In and CDTI is key to gaining high equipage penetration levels required to support significant ADS-B In operational benefits

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Benefits

- **ADS-B Out provides a low cost ground surveillance alternative to radar**
  - Reduced air navigation service provider costs
  - Provides radar-like separation or better
  - Requires new airplane functionality for most aircraft in the existing fleet (Transponder/GNSS receiver)

- **ADS-B In provides increased operational efficiency and capacity**
  - Business case will be demonstrated through operational evaluations
  - Operators need to see reasonable return on investment (~3yr payback period)
  - In Trail Procedure (ITP) and Interval Management applications most likely to provide early benefit
  - Benefits will be required with mixed ADS-B In equipage
    - Retrofit of existing fleet will be key to gaining early benefits
  - Operators will drive need for ADS-B In features on production aircraft
  - Operators desire bundled applications with consistent flight deck interfaces
  - Production a/c architecture must support growth capability for advanced applications

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Conclusions

- Meeting production/retrofit mandates for ADS-B Out
- Developing ADS-B In solutions which maximize value of equipage
  - Conducting forward fit studies targeting primary field of view to ensure cost-effective architectures with growth capability
  - Evaluating retrofit solutions including auxiliary displays
- Coordinating with Air Navigation Service Providers (Canada, Australia, Europe, US, others) to ensure common airborne requirements global harmonization
- Engaging with airlines and industry partners on rulemaking around the world
- Continuing industry standards support
- Boeing Aero Magazine Article on ADS-B:
  - http://www.boeing.com/commercial/aeromagazine/articles/qtr_02_10/2

Boeing is actively engaged in ADS-B development, a key capability for improved airline operations

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Questions

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