



ADS-B - A Boeing Perspective

ICAO ADS-B Seminar / Study and Implementation Task Force

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Avionics/ Air Traffic Management

Agenda

Boeing Commercial Airplanes – Avionics / Air Traffic Management

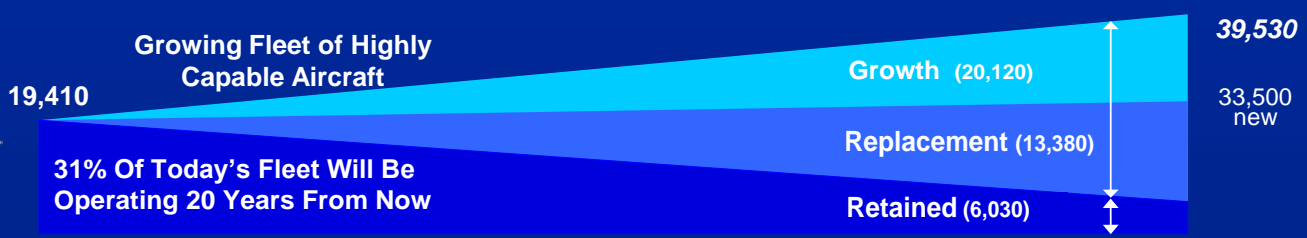
- **ATS Landscape**
- **Standards/Certification**
- **US Activities**
- **Regional Activities**
- **Boeing Plan – ADS-B Out**
- **Boeing Plan – ADS-B In**
- **Airplane Architecture Considerations**
- **ADS-B In Symbology**
- **Benefits**
- **Conclusions**



Air Transportation System Roadmap

2010 2015 2020 2025 2030

Airplane Population

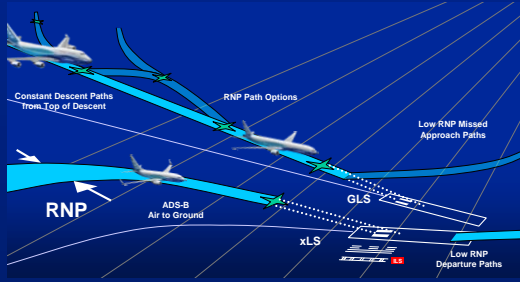


Airspace Operations

Manual ATC Intervention, Control by Radar & Navaid



Pre-Defined Performance Based Airspace



Dynamic Performance Based Airspace

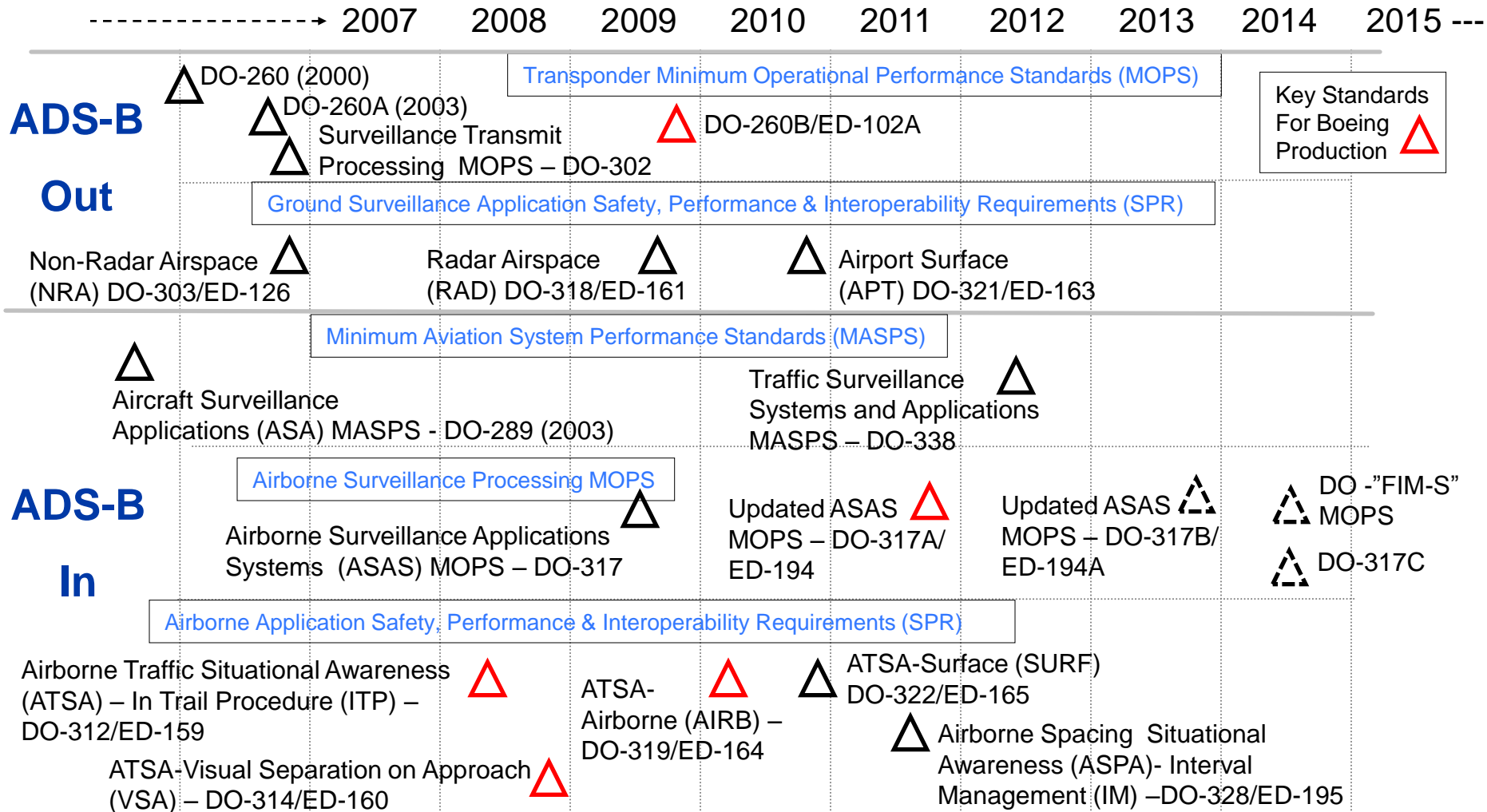


Key Capabilities

ATM Automation	Time-Based Arrivals	TRACON RPI	Extended TBFM				
	Conflict Detection	Arr/Dep/Surf Data Integration	Time-based RNP/RNAV Arrivals	Surface Tool	Departure Tool	4D Trajectory Negotiation Tool	
Communication		Link 2000+		TRACON TBFM			
Analog Voice	FANS-1	FANS-2		FANS-3			
ACARS		Oceanic RCP		Continental RCP			
		Polar SATCOM	Broadband IP	Digital Voice	Future Subnetworks		
Navigation		GLS Cat I	GLS Cat III	Multi Freq / Constellation GNSS		Global Cat I from Space	
	RNP	RNP AR	Expanded Windfield	Advanced RTA			
Full Profile RTA			Graphical WX	Graphical Taxi			
	AMM	ORE Indication	EVS/SVS	ORE Active		GNSS Backup System	
Surveillance	Extended Squitter			ACAS/ADS-B Integration			
	ADS-C	ADS-B In/CDTI	Spacing	SURF IA	Adv ADS-C		Self Separation
Prim / Sec Radar		ADS-B Out DO260B		Delegated Separation			
System Wide Information Management							
OLDI	ETMS	AIDC		Adv Inter-Facility Coord		Shared Trajectory & Surveillance Info	
	RADNET			Aero/Met Info			

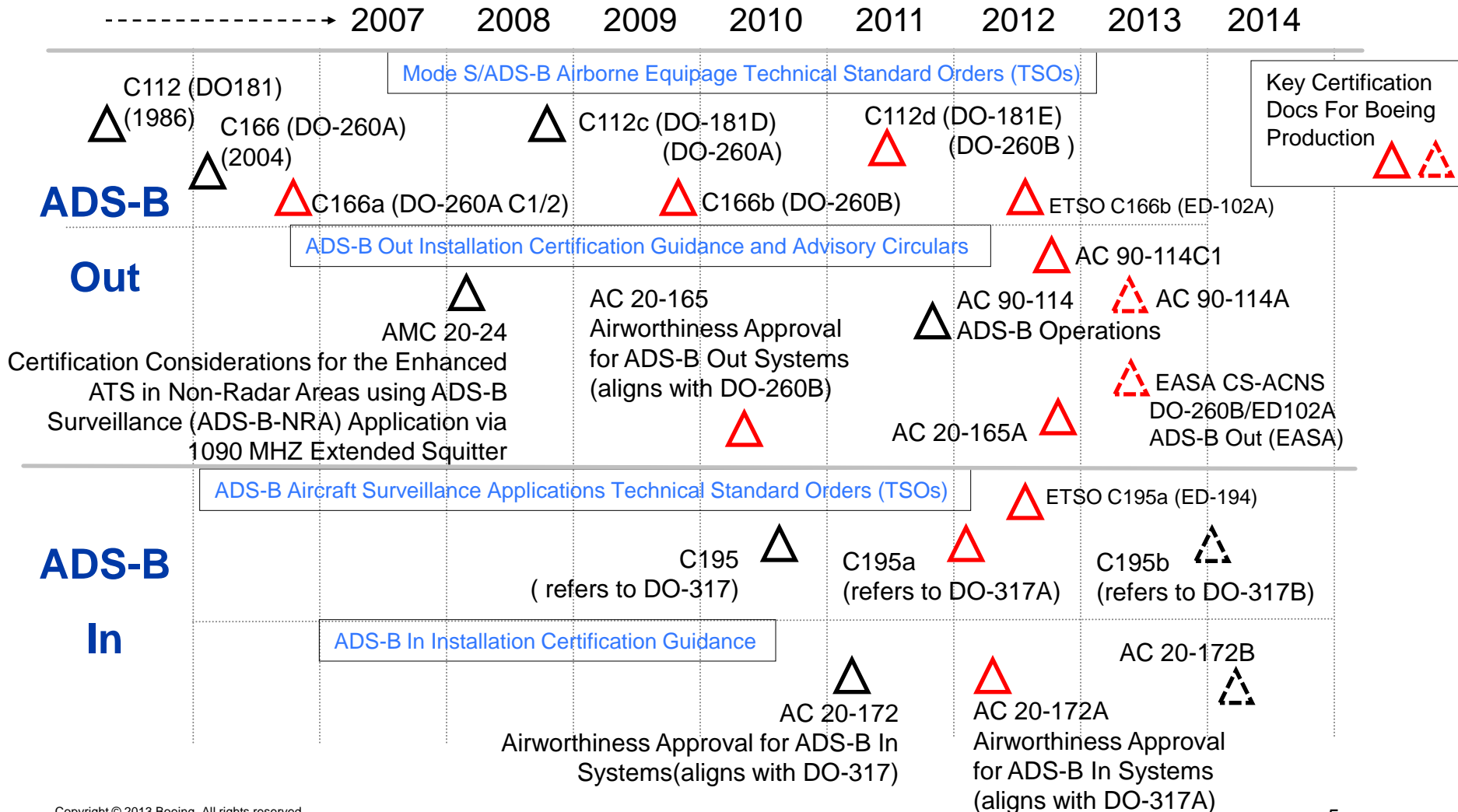
Standards Development

Boeing Commercial Airplanes – Avionics / Air Traffic Management



Certification Documents

Boeing Commercial Airplanes – Avionics / Air Traffic Management



US/FAA Activities

Boeing Commercial Airplanes – Avionics / Air Traffic Management

- **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 1090 MHz ADS-B standard (DO-260B) transponder
 - AC 90-114A will likely require use of a service availability prediction tool (SAPT) to determine ability to dispatch
 - SAPT will take into account: Time and route of the planned flight, GPS constellation and satellite outage information, WAAS status, Operational status of SSRs (radar) and WAM along route, GPS Jamming and Interference (NOTAM), and the GNSS receiver capability (Selective Availability (SA), Barometric Aiding, and Mask Angle)
- **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
 - SURF IA development on hold
 - In Trail Procedure (ITP – 2012/13)
 - Provide operational benefits in non-surveillance airspace
 - Validate operational performance and economic benefits
 - Flight Deck Based Interval Management-Spacing (FIM-S – 2013/14)
 - Reduce fuel burn, noise and emissions while maintaining high throughput
 - Develop and validate flight deck technology to enable FIM-S operations
- **FAA & NASA Flight deck-based Interval Management – Spacing (FIM-S) operational evaluations planned (2016)**

Regional Activities

Boeing Commercial Airplanes – Avionics / Air Traffic Management

- **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(started 2004) meets mandate (EASA AMC 20-24 certification basis)
 - Elementary/Enhanced/Extended Squitter (ELS/EHS/ES) surveillance capability with AFM Update
 - Service bulletins available for retrofit of in-production models
 - Starting 20 Oct 2011 non-equipped a/c must file for fixed route
 - Planning change from “approved/white list” to “black list”
- **European Commission completed 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
 - Draft CS-ACNS/AMC released Nov 2012
 - Need timely publication of EASA Certification Specification and AMC (CS-ACNS)
 - 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 (\geq 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
 - Changed from “approved/white list” to “black list” in Aug 2012

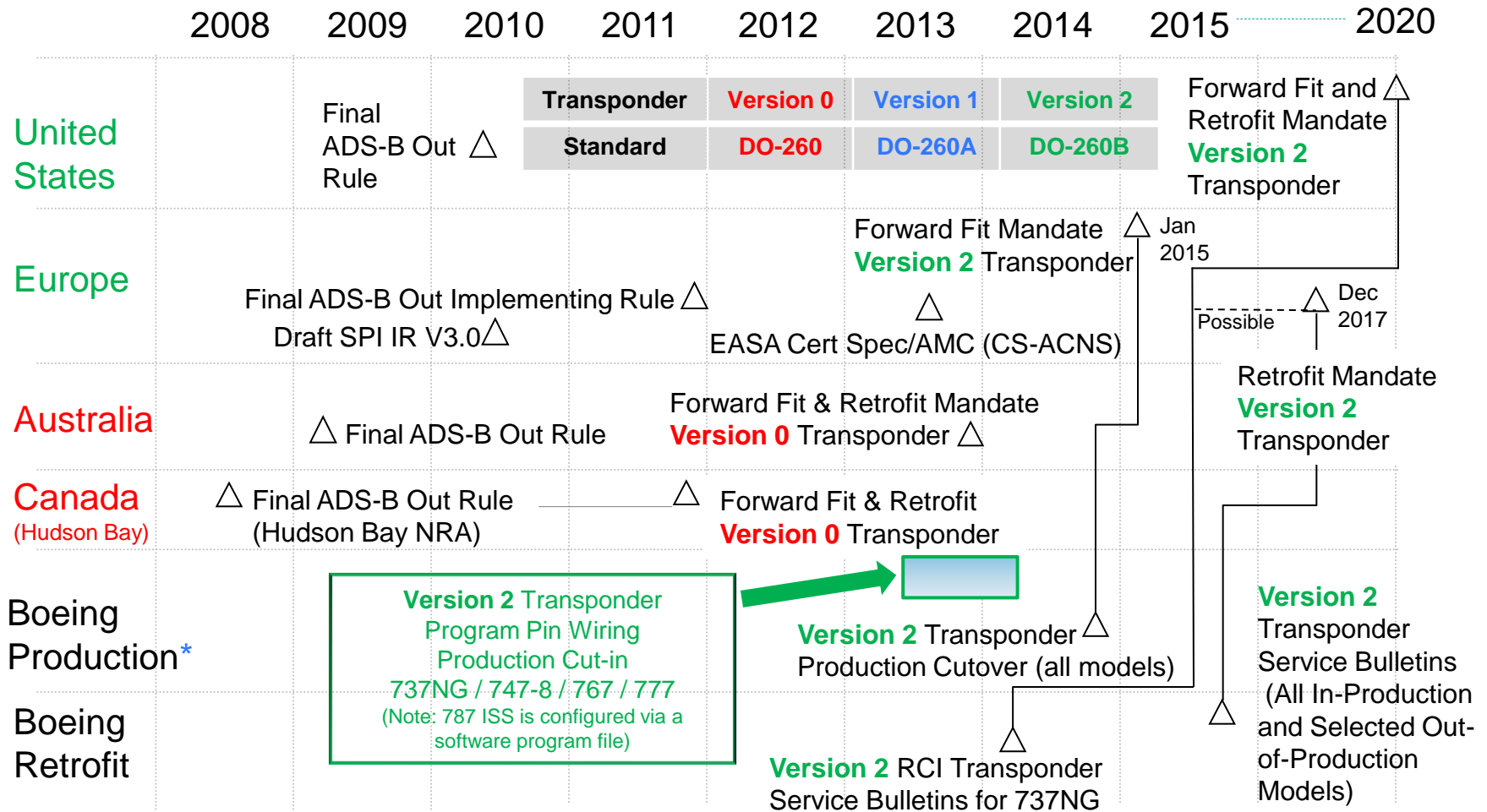
Regional Activities (Cont)

Boeing Commercial Airplanes – Avionics / Air Traffic Management

- **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 (\geq 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

ADS-B Out – Meeting the Mandates

Boeing Commercial Airplanes – Avionics / Air Traffic Management



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

ADS-B Out – Version 2 ATC Transponders

Boeing Commercial Airplanes – Avionics / Air Traffic Management

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

	737NG/MAX	747-8	767	777	787
Buyer Furnished Equipment (BFE)	ACSS (NXT-800) Honeywell (TRA-100B) RCI (TPR 901-205)		ACSS (NXT-800) Honeywell (TRA-100B) RCI (TPR 901-205)	ACSS (NXT-800) Honeywell (TRA-100B) RCI (TPR 901-205)	
Supplier Furnished Equipment (SFE)		RCI ⁽¹⁾ (TPR 901-205)			RCI ISS- 2100 ⁽²⁾

(1) Same unit as Buyer Furnished Equipment

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

RCI – Rockwell Collins Inc.

- 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 20-165A
- Need timely publication of EASA Certification Specification and AMC (CS-ACNS)
 - Currently planned for publication in 2Q 2013
 - Draft Acceptable Means of Compliance (AMC) similar to FAA AC 20-165A

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

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

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

Boeing Commercial Airplanes – Avionics / Air Traffic Management

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

	737NG/MAX	747-8	767	777	787
Buyer Furnished Equipment (BFE)	Honeywell (RMA-55B SA On)		Honeywell (RMA-55B SA On)	Honeywell (RMA-55B SA On)	
	Offerability of SA-On MMRs with Version 2 Transponders under evaluation				
	Thales (TLS-755 SA Aware)		Thales (TLS-755 SA Aware)	Thales (TLS-755 SA Aware)	
	Rockwell (RCI) (GLU-920-001/002 SA On) (GLU-920-004 SA Aware) (GLU-925 SA Aware)		Rockwell (RCI) ((GLU-920-001/002 SA On) (GLU-920-004 SA Aware) (GLU-925 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⁾ (SA-Aware)

- 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

To Maximize Dispatch Availability Boeing Recommends SA-Aware MMRs

ADS-B-Out Operational Benefits Validation

Boeing Commercial Airplanes – Avionics / Air Traffic Management



**Federal Aviation
Administration**



ADS-B-Out Operational Benefits Validation

Boeing Commercial Airplanes – Avionics / Air Traffic Management

- **FAA is sponsoring an Operational Benefits Validation (OBV) project which will provide accelerated equipage of at least 110 United Airlines 737-NG's with FAA-rule-compliant ADS-B Out.**
 - Rockwell Collins will initiate and conduct a TSO-C166b transponder certification project on an accelerated schedule
 - Boeing will provide wiring instructions and activation Service Bulletins for 246 UAL 737-NGs with Rockwell Collins transponders and MMRs
 - UAL will accelerate the retrofit of 110 737-NG aircraft and operate these aircraft in revenue service, and will endeavor to accelerate the equipage of the remaining 136 aircraft prior to the 2020 FAA ADS-B Out rule compliance date
 - FAA will provide integrated project management, funding, perform data collection & benefits' analysis, and coordinate within the FAA to enable ADS-B Out operational advantages in selected airspace

ADS-B Out OBV Schedule Summary

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Milestone	Date
Boeing SB for all associated wiring modifications for in-service aircraft	May 2013
RCI TSO submittal to FAA	January 2014
Boeing SB installation and activation of rule-compliant transponder	April 2014
Transponder Retrofit of 110 UAL aircraft	April 2014 – Dec 2018
OBV operational flights occur	2014 - 2016
OBV operational benefits report	2016

ADS-B In Development Plans

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- 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

ADS-B In – Traffic Processing

Boeing Commercial Airplanes – Avionics / Air Traffic Management

- Planned Boeing In-Production traffic processing function in TCAS/ACAS LRU

	737NG/MAX	747-8	767	777	787
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-2100 ⁽²⁾

(1) Same unit as Buyer Furnished Equipment

(2) Integrated Surveillance System (ISS) includes ATC Transponder, ADS-B Out, TCAS/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

Architecture Considerations

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Function	737NG/MAX	747-8	767 (Display System Upgrade Required)	777	787
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

ADIRU – Air Data Inertial Ref. Unit
 CCD – Cursor Control Device
 FMC – Flight Management Computer
 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

Flight Deck Considerations

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737



747



757/767

(Large Display System Upgrade Required)

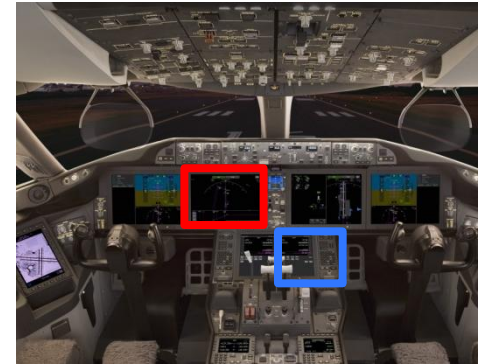


777



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

787



Display

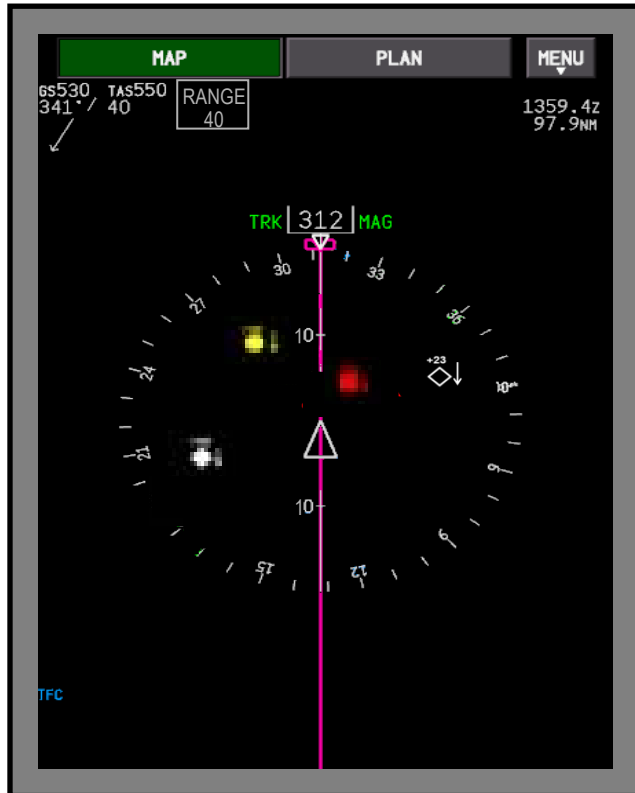
Control

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

New ADS-B In Symbology

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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 while maintaining underlying independent ACAS collision avoidance function

Plans for ADS-B In symbology are in work

New ADS-B In Symbology

Boeing Commercial Airplanes – Avionics / Air Traffic Management

ADS-B Surface Traffic Symbology



Plans for ADS-B In symbology are in work

Benefits

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- **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)
 - Operational benefits will be validated by United 737NG operational evaluations

- **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

Conclusions

Boeing Commercial Airplanes – Avionics / Air Traffic Management

- Meeting production/retrofit mandates for ADS-B Out
- Participating in FAA ADS-B Out Operational Benefits Validation
- 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**

Questions

