ADS-B - A Boeing Perspective

Surveillance Seminar & Surveillance Implementation Coordination Group (SURICG/2)

Ulaanbaatar, Mongolia

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Avionics/ Air Traffic Management

Agenda

- Air Transportation System Landscape
- Standards/Certification
- Regional Activities
- Boeing Plan – ADS-B Out
- ADS-B Out Position Sources
- ADS-B In for 787
- Interval Management Trial
- Summary

Air Transportation System Roadmap

BOEING

Airplane Population

2015 | 2020 | 2025 | 2030 | 2035

22,510

Growing Fleet of Highly Capable Aircraft

45,240

Growth (22,730)

39,620 new

Replacement (16,890)

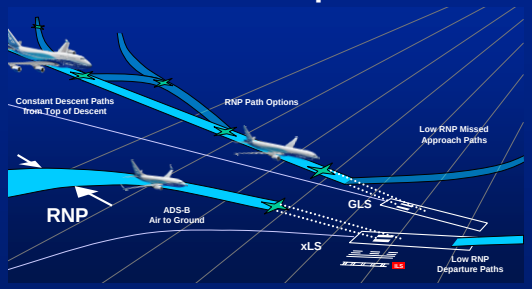
Retained (5,620)

25% of today's fleet will be operating 20 years from now.

Airspace Operations

Manual ATC Intervention, Control by Radar

Pre-Defined Performance Based Airspace



Dynamic Performance Based Airspace

Key Capabilities

ATM Automation
Conflict Detection
Time-based Arrivals
Airspace Flow Program
CTOP
PDRR
Surf Schedule
IDAC
GIM-S
TFM Reroutes
TBM in Terminal
VCV
TBM w/Path
TFDM Datalink Taxi
Conflict Res.
IM-S
4D Conflict Resolution
4D Negotiation
DRNP Enroute
DRNP Terminal

Communication
Analog Voice
FANS-1 ACARS
ATN
Polar SATCOM
Oceanic RCP
FANS-2 Link 2000+ (B1)
Continental RCP
Broadband IP
Future Subnetworks
FANS-3 (B2)
IPS
Dual SATCOM LRCS
PTT SATVOICE

Navigation
RNP
RNP AR
Full Profile RTA
GLS CAT I
Airport Moving Map
GLS CAT III
Expanded Wind Field
Temp Comp
SBAS LPV
Multi Const GNSS
Global CAT I
Adv RTA
Graphical Taxi
GNSS Backup
DRNP

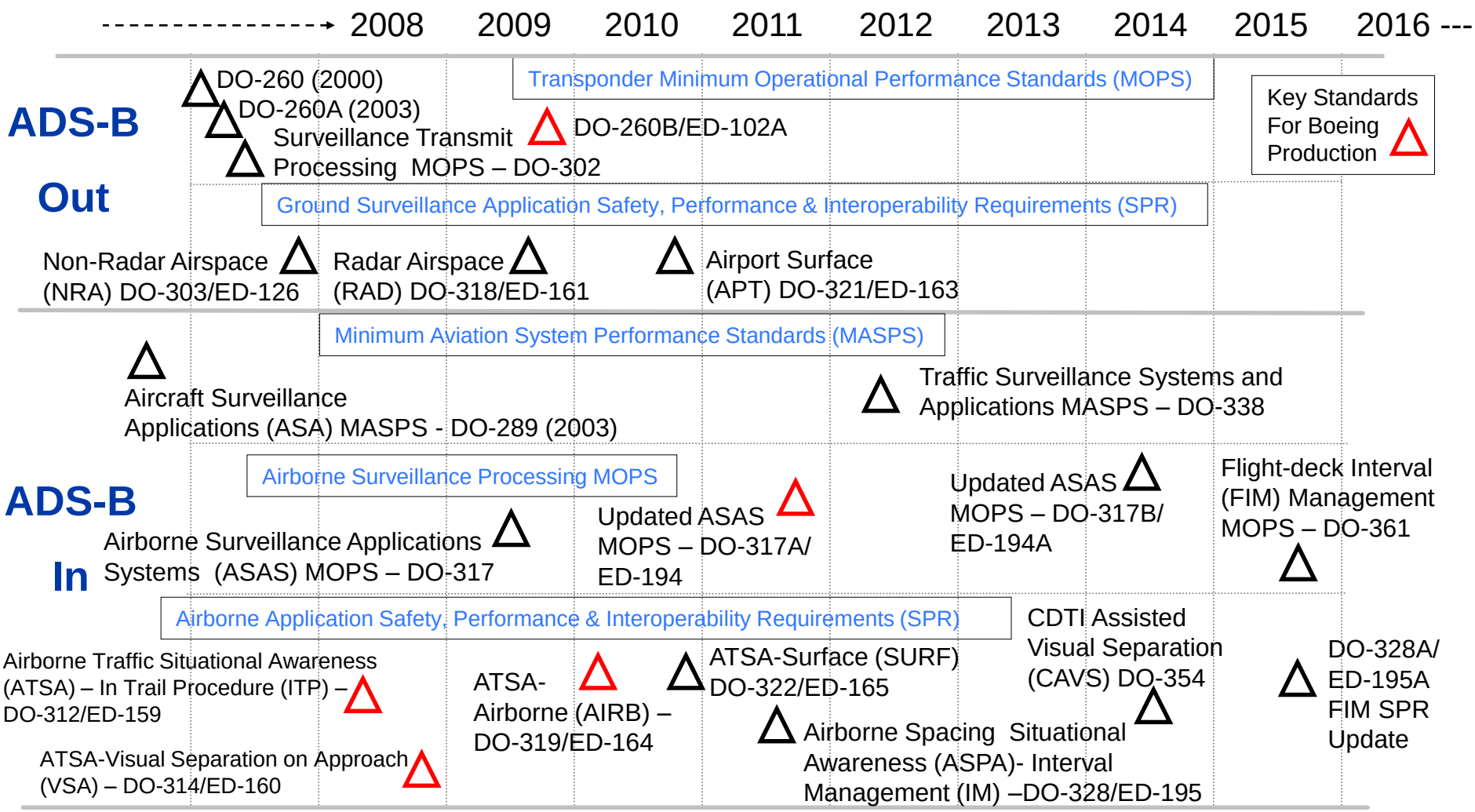
Surveillance
ADS-C
Radar
Wx Radar
Ext. Squitter
ADS-B DO260
ACAS 7.1
ADS-B Out DO260B
ADS-B In/CDTI
SURF SA
Distress Tracking
ACAS-X
SURF IA
Adv Interval Management
Adv ADS-C
ADS-B In w/CD&R

System Wide Information Management
OLDI
RADNET
AIDC
ETMS
FIXM
Aero/Met Info
Adv Inter-Facility Coord
Shared Trajectory & Surveillance Info

R10.1

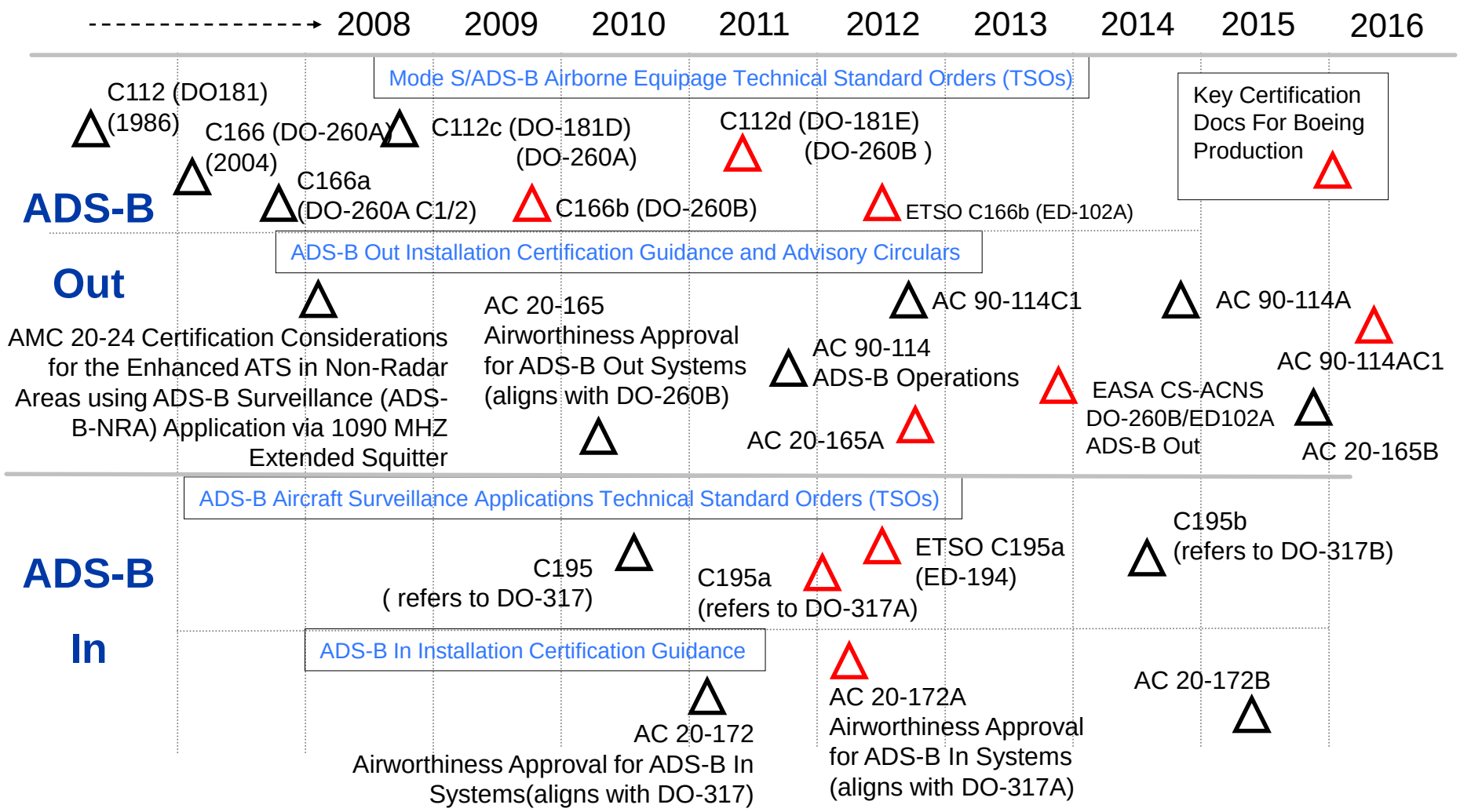
Standards Development

Boeing Commercial Airplanes – Avionics / Air Traffic Management



Certification Documents

Boeing Commercial Airplanes – Avionics / Air Traffic Management

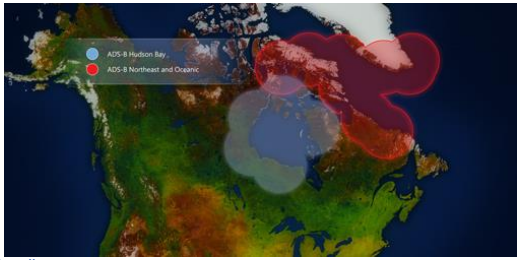


US/FAA Activities

- **ADS-B Out mandate for Class A, B, C airspace and Class E airspace (≥10Kft MSL) effective 1 Jan 2020 (14 CFR 91.225/91.227)**
  - Requires new 1090 MHz ADS-B standard (DO-260B) transponder
  - Requires GNSS position source NIC (Integrity) ≥ 7 (0.2nm) and NAC (Accuracy) ≥ 8 (0.05nm)
  - SA-On & SA-Aware receivers requires preflight availability prediction – No prediction required for SBAS receivers
  - Exemption 12555 available for continued use of SA-Aware receivers without prediction until 2025
- **Current United States ADS-B Projects/Trials**
  - In Trail Procedure (ITP) operational at all 3 oceanic centers (Oakland/Anchorage/New York) in 2017
  - Deploying Ground-based Interval Management - Spacing (GIM-S) throughout domestic airspace
  - Conducted Jan/Feb 2017 trial of Version 0 Flightdeck-based Interval Management – Spacing (FIM-S)
  - Possible FIM-S Paired Approach demonstration in 2018/2019
  - Pursuing deployment of Advanced – Interval Management (A-IM) after 2020

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)**
  - Version 0 DO-260 EASA AMC 20-24 certification
  - Starting 20 Oct 2011 non-equipped a/c must file for fixed route
  - Coverage over Hudson Bay and expanded to Northeast and Oceanic
  - Operational approval no longer required Nov 2014 (ENR 1.6.3) /
    - Changed from “approved/white list” to “black list”

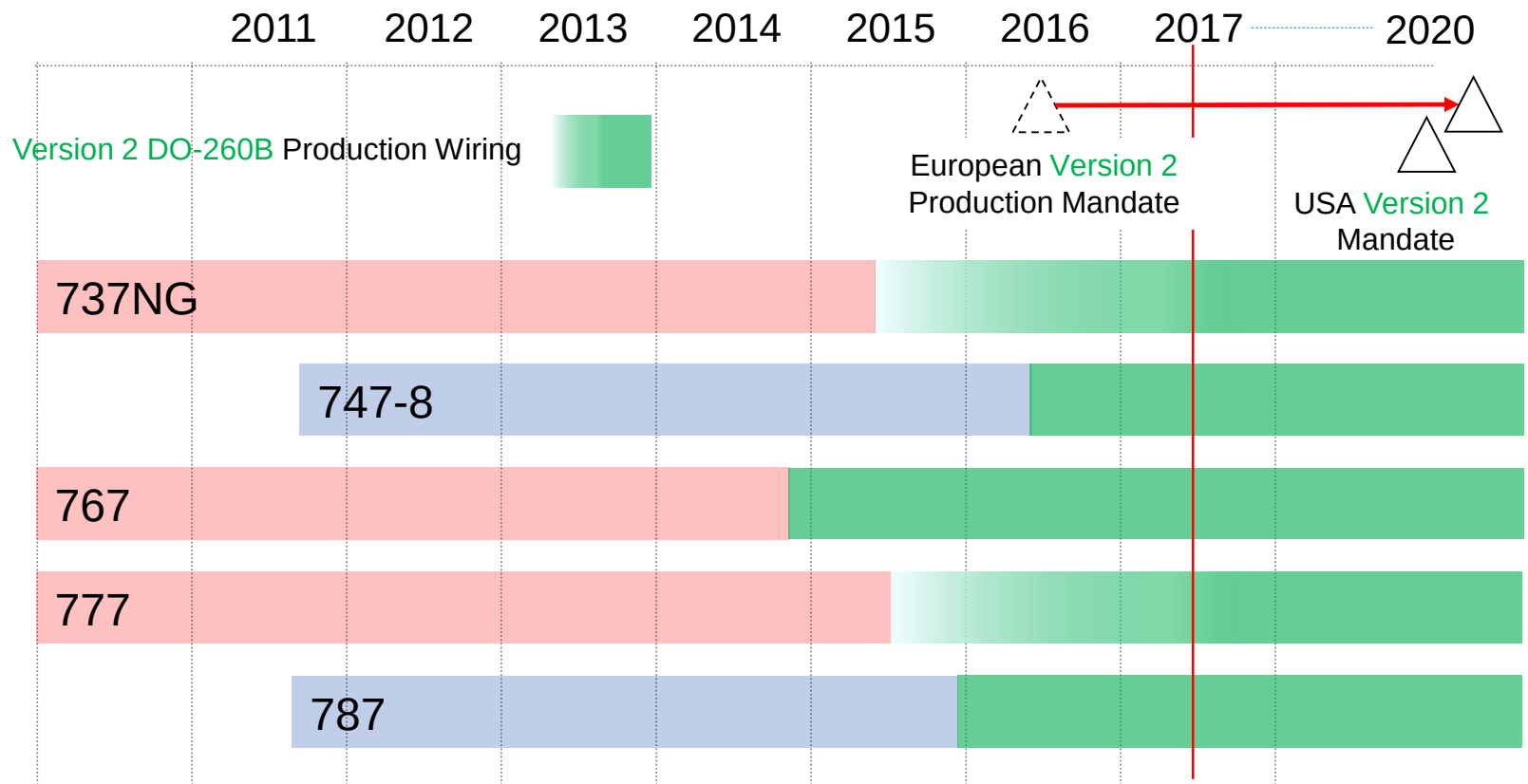


http://www.navcanada.ca/EN/products-and-services/Pages/on-board-operational-initiatives-ads-b.aspx

- **European Commission released EU 2017/386 amending Implementing Regulation EU 1207/2011 ADS-B Out mandate to 7 June 2020 for both production and retrofit**
  - Initial mandate (EU 1207/2011) dates were 8 January 2015 in production and 7 December 2017 for retrofit
  - Version 2 DO-260B FAA AC 20-165() certification
  - Final CS-ACNS/AMC released Dec 2013
  - EASA conducting rulemaking task for comprehensive assessment of applicability to General Aviation, ANSP obligations, exemptions, and timing

- **Australia (CAO 20.18, Amend Order No. 3, dated Dec. 2009)**
  - Mandated ADS-B Out for upper airspace (≥FL290) in Dec 2013
  - Exemption for certain operators in oceanic and continental airspace until 6 June 2020
  - Version 0 DO-260 EASA AMC 20-24 certification
  - SA-Aware GNSS receiver mandated in production starting 8 Dec 2016
    - Honeywell RMA-55B Multi-Mode Receiver is <u>not</u> SA-Aware and will <u>not</u> be modified to SA-Aware

ADS-B Out – Production Airplanes



737MAX & 777X Version 2 DO-260B capable at Entry Into Service

ADS-B Out Standard	Version Number
DO-260	0
DO-260A	1
DO-260B	2

Boeing Compliant with US & European DO-260B Production Mandate

ADS-B Out – Version 2 ATC Transponders

- **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

- **All units planned to be certified to TSO-C112d/C166b**
- **Interfaces per ARINC 718A Supplement 4 (787 ARINC 768-2)**
- **Installation compliant with published regulatory requirements**
  - FAA AC 20-165A
  - EASA Certification Specification/AMC (CS-ACNS)

BFE – Equipment selected/provided by buyer
SFE - Equipment basic to airplane
RCI – Rockwell Collins Inc.

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

ADS-B Out Version 2 ATC Transponders Production Certification Schedule (by Model)

Boeing Commercial Airplanes – Avionics / Air Traffic Management

	737NG		747-8	767		777		787
BFE	ACSS	April 2015 L/N 5389	N/A	ACSS	December 2014 L/N 1072	ACSS	May 2015 L/N 1309	N/A
	Honeywell	2017		Honeywell	No Customer	Honeywell	2017	
	Rockwell	Nov 2015 L/N 5673		Rockwell	No Customer	Rockwell	Jan 2016 L/N 1365	
SFE	N/A		Rockwell May 2016 L/N 1531	N/A		N/A		RCI ISS 2100 (2) Dec 2015 L/N 369, 371 and on

(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
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Supplier	Model	Part No.
ACSS	NXT 800	9008000-10000
Honeywell	TRA 100B	066-01212-0301
Rockwell Collins	TPR 901-205	822-1338-205
Rockwell Collins	ISS 2100	822-2120-101 or -102*

Available Today

*** Supports ADS-B In**

Boeing Service Bulletins available for all production configurations

787 ADS-B Software Update / Service Bulletin

- **In Service Issue**
  - ADS-B Out position reports begin “coasting” at constant track angle
  - Two unique root causes
- **Root Causes**
  - Root Cause #1 - Lat/Long from Nav Radio contained within different network packets
  - Root Cause #2 – Internal timing issue between 2 software elements (Sys I/O and Traffic)
- **Resolution**
  - Software resolving both issues first installed on 787 L/N 544 and on (for new aircraft) on 23 Mar 2017
  - Software service bulletin is scheduled to be released in June of 2017
  - Implement Boeing Service Bulletin B787-81205-SB340036-00
  - Boeing recommends service bulletin install within 12 months from release
  - Upgrade has 2 software parts loaded into Integrated Surveillance System (ISS) unit
  - Available at no cost on MyBoeingFleet / ~1-hour for both ISS units (SB conservatively estimates 3 hrs)
  - Software compliant with US/European DO-260B mandates
  - Do not confuse with Boeing Service Bulletin B787-81205-SB340025-00
    - Updates ISS Hardware for ADS-B In capability (ISS Hardware Part No. 822-2120-102)

Recommend Implementation of No Cost Software Upgrade As Soon As Possible

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

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

	737NG	747-8	767	777	787
Buyer Furnished Equipment (BFE)	Honeywell (RMA-55B SA On) ACSS Transponder Certified with Honeywell SA On MMR 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) ACSS Transponder will be Certified with Honeywell SA On MMR Thales (TLS-755 SA Aware) Rockwell (RCI) (GLU-920-001/002 SA On) (GLU-920-004 SA Aware) (GLU-925 SA Aware)	**Stopped production in 2015**
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

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

To Maximize Dispatch Availability Boeing Recommends SA-Aware/SBAS MMRs

ADS-B Out – SBAS Receivers (MMRs)

- **Boeing in-production SBAS capability**
  - 737MAX

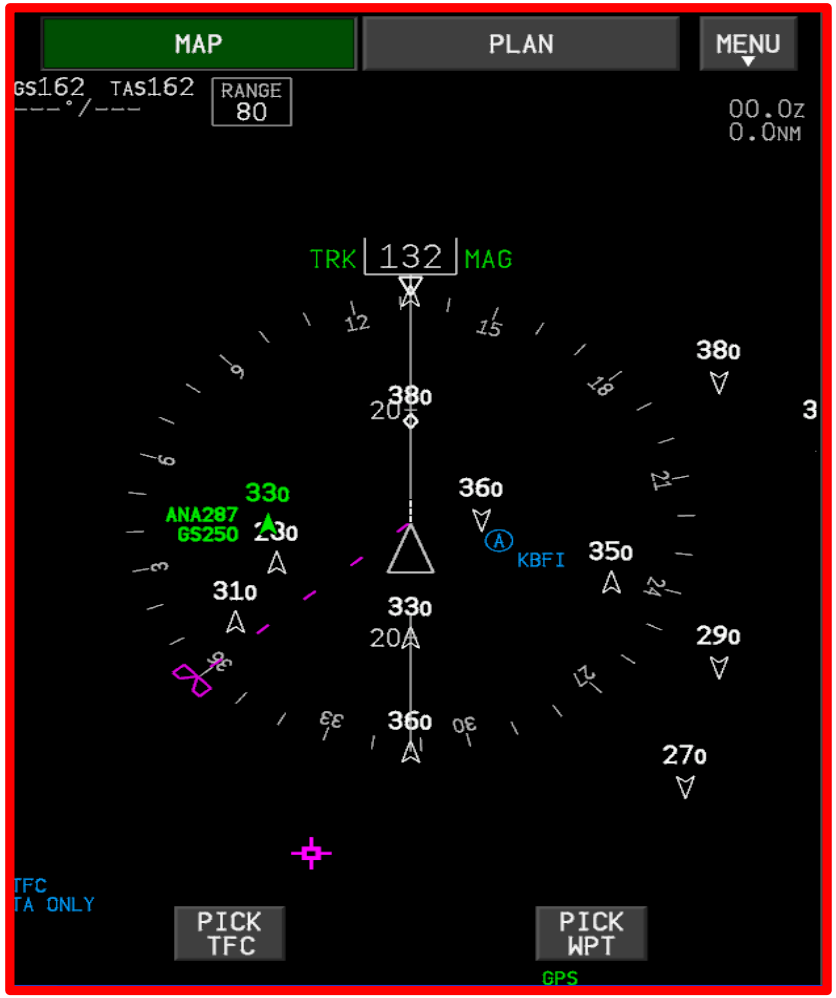
	3GMMR	
	Honeywell	Rockwell
Model Name	IMMR	GLU-2100
Initial Capability	SBAS (WAAS)	SBAS (WAAS)
Projected Production Availability	1Q2017	1Q2018
Cutover	737-8MAX (After Entry Into Service)	737-9MAX (Entry Into Service)
Wiring Provisions	At Entry Into Service	At Entry Into Service

- 737NG – Available after introduction on 737MAX (with CAT I GLS option)
- 777 - Available after introduction on 737MAX (without GLS)
- 777X – Available at entry into service

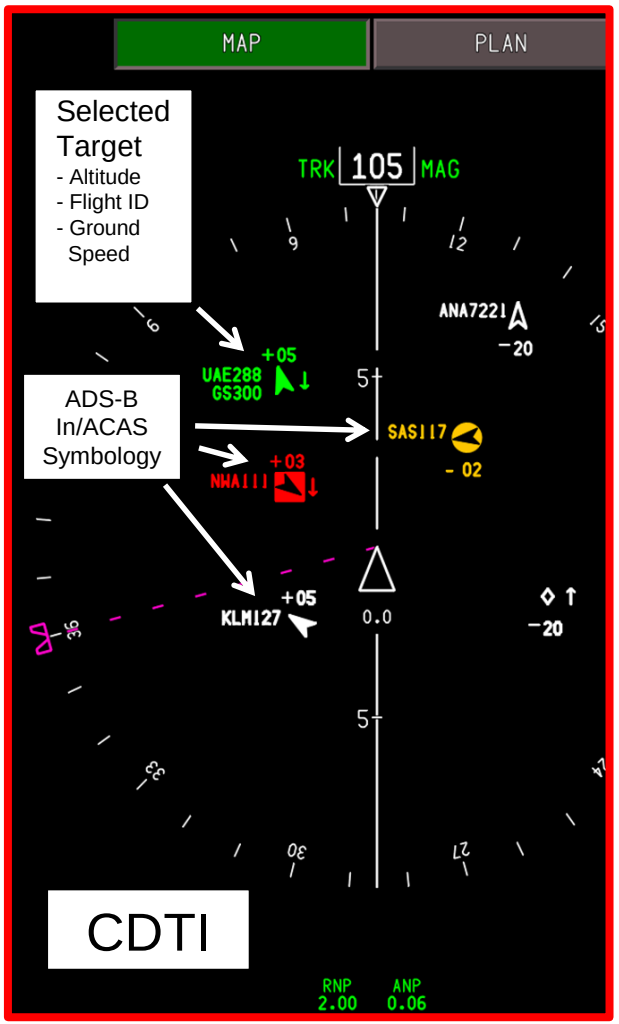
SBAS Plans for 747-8/767/787 Under Review

787 ADS-B In

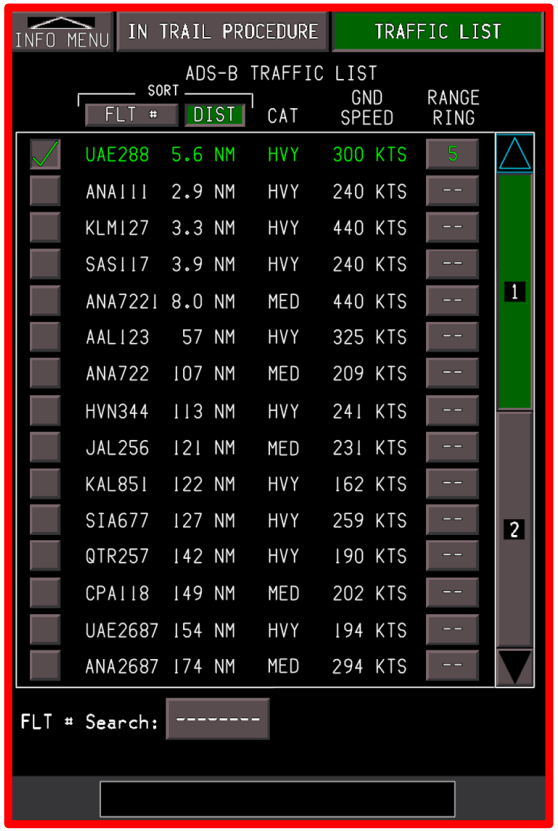
- **Provides suite of situational awareness applications**
  - Airborne Traffic Display (AIRB)
  - Visual Separation on Approach (VSA)
  - In Trail Procedure (ITP)
- **Offerable starting June 2013**
  - 787 Catalog Rev W
- **1st install was end of 2015**

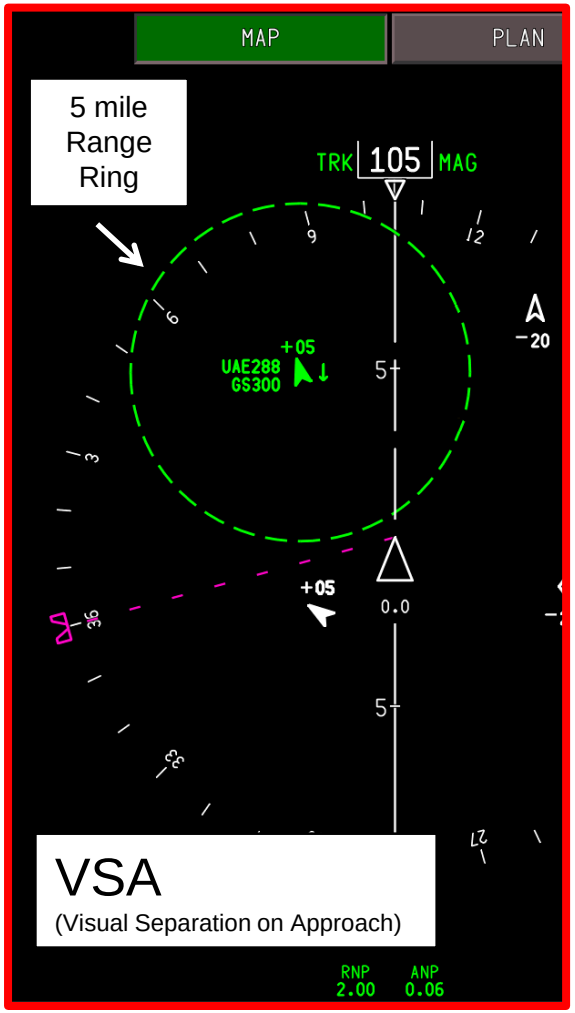


787 CDTI & VSA

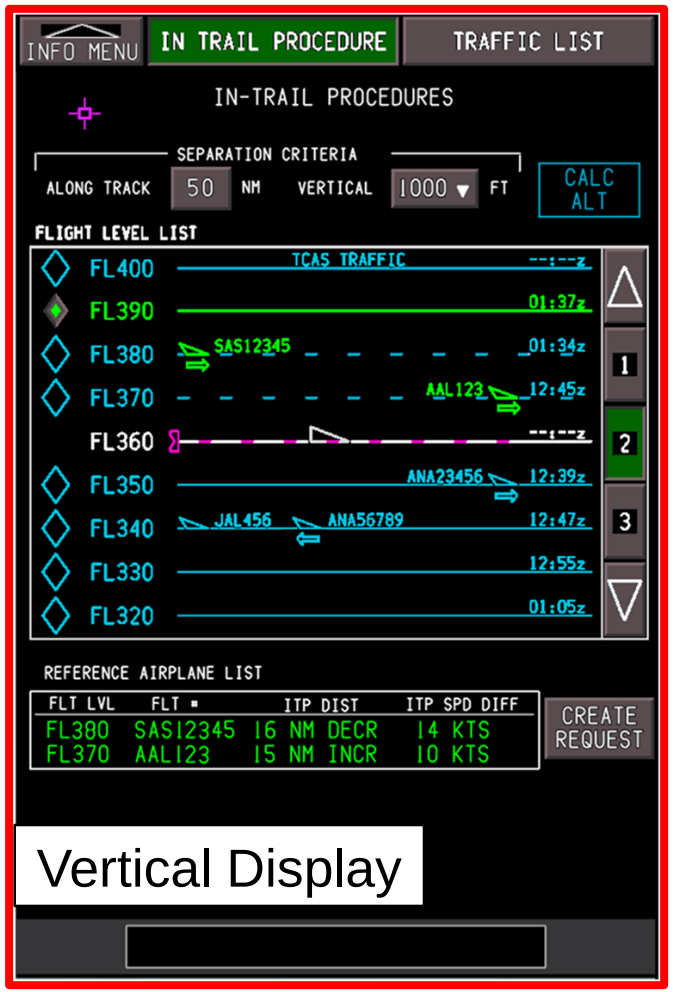


Traffic List



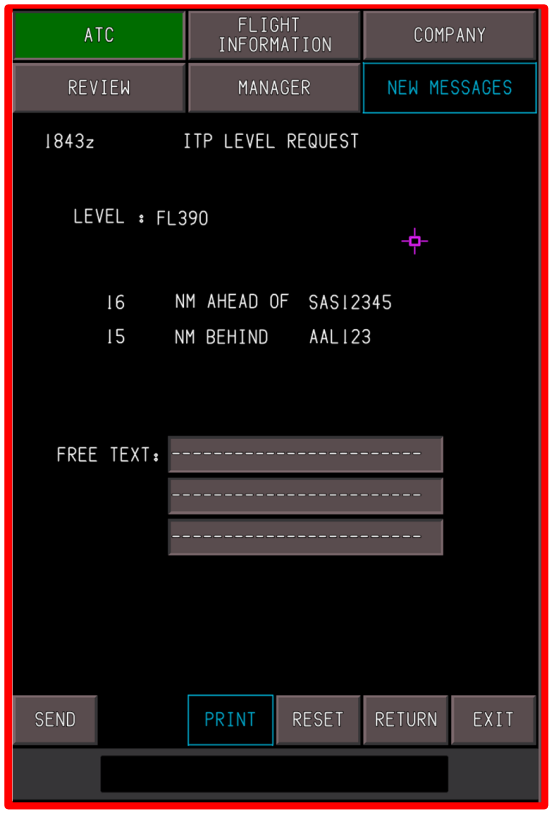


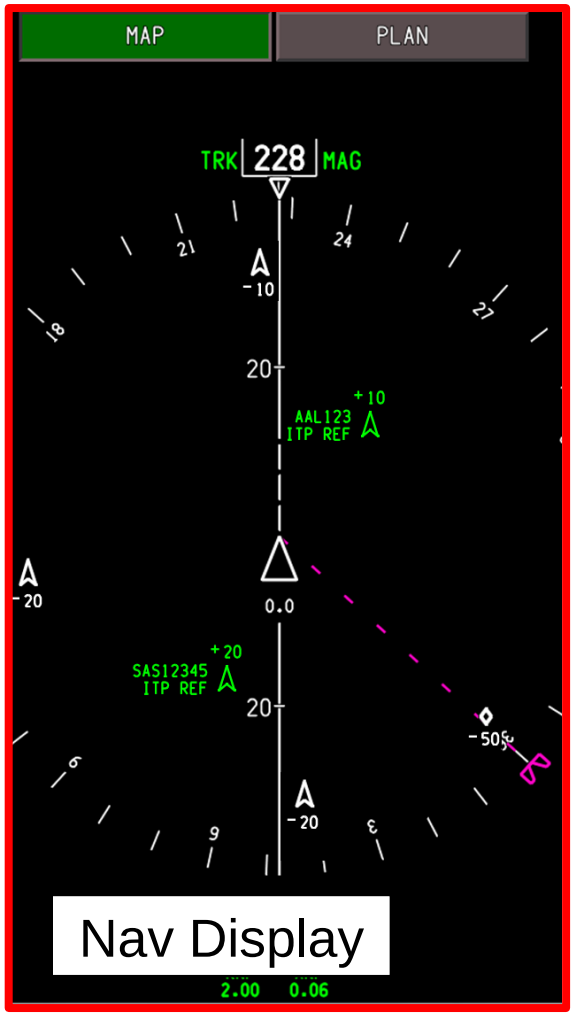
787 In Trail Procedure (ITP)



Vertical Display

Comm Page





Nav Display

Interval Management (IM) Trial (Feb 2017)

Honeywell Dassault Falcon 900 N889H

- Equipped with ADS-B Out technology
- IFR capable, GNSS equipped, LNAV/VNAV and AR capable

Honeywell Boeing 757 N757HW

- Equipped with ADS-B Out & In technology, FIM Avionics
- Test aircraft; modified to meet data-gathering requirements

United Airlines B-737 UAL2197

- Equipped with ADS-B Out & In technology, FIM Avionics
- Standard 'NG' production aircraft
- Data-gathering in FIM avionics, engineering work station, and DFDR

Rules and regulations:

- All aircraft will operate under Part 91 rules
- 737 and 757 will have Experimental certificate (FIM equipment)
- Operated by own company flight crews (qualifications, currency, etc.)
- Either two or three aircraft airborne at one time

Boeing/NASA Partnership : Flight-deck Interval Management Research

Uses

- ATC-generated spacing targets
- ADS-B traffic-aware speed “bug
- On-board automation/guidance

Results in

- Highly accurate approach spaci
- Improved airport capacity

In-flight Photo : NASA and Boeing researchers testing FIM, KMWH Feb 2017

Summary

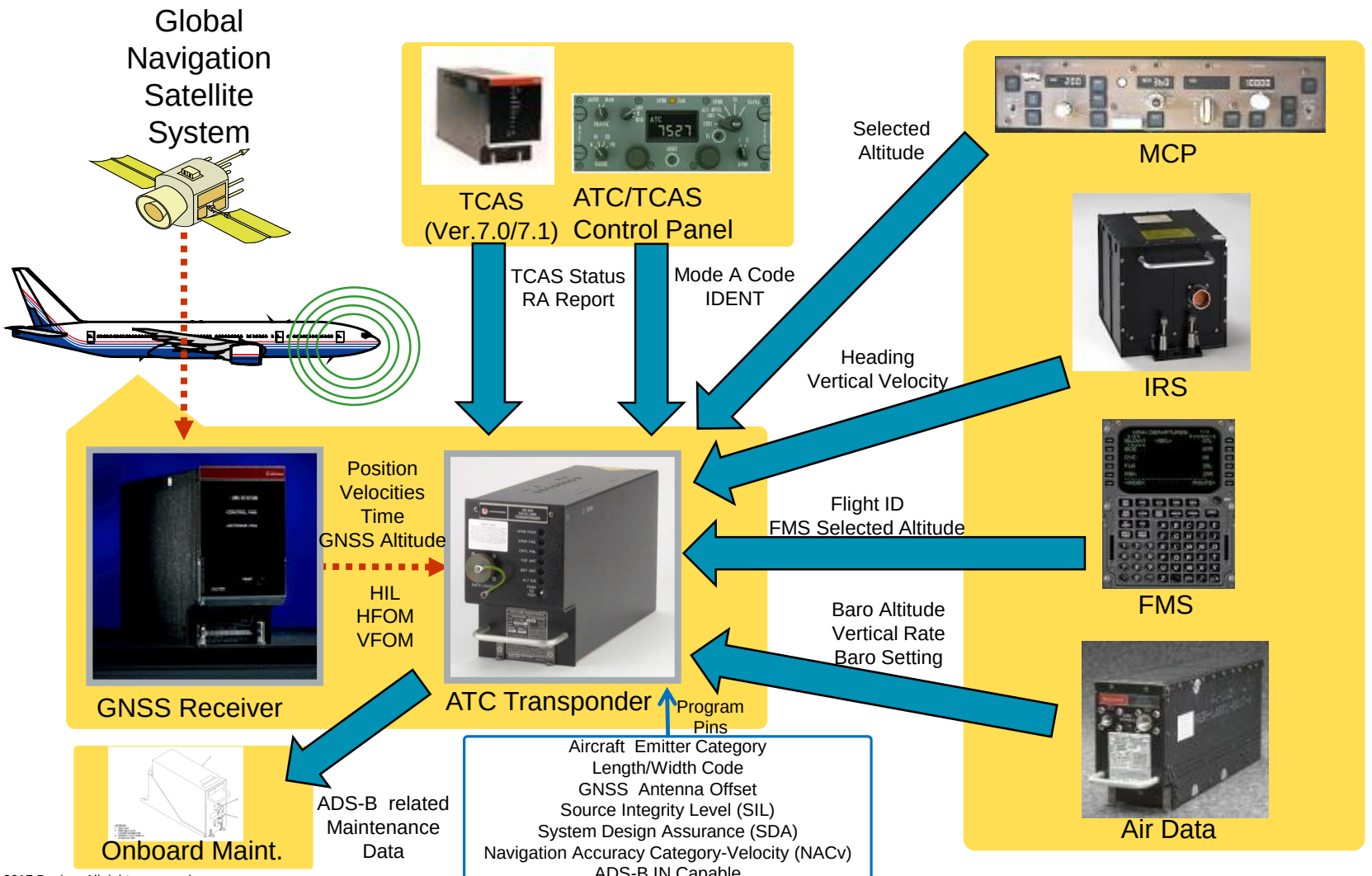
- Meeting production/retrofit mandates for ADS-B Out
- Working with Air Navigation Service Providers to ensure common airborne requirements and global harmonization
- Developing ADS-B In solutions which maximize value of equipage
  - Conducting forward fit studies targeting primary field of view to ensure cost-effective architectures with growth capability
  - Evaluating retrofit solutions including auxiliary displays
- Participating in ADS-B In trials and demonstrations
- Engaging with airlines and industry partners on rulemaking around the world
- Continuing industry standards support

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

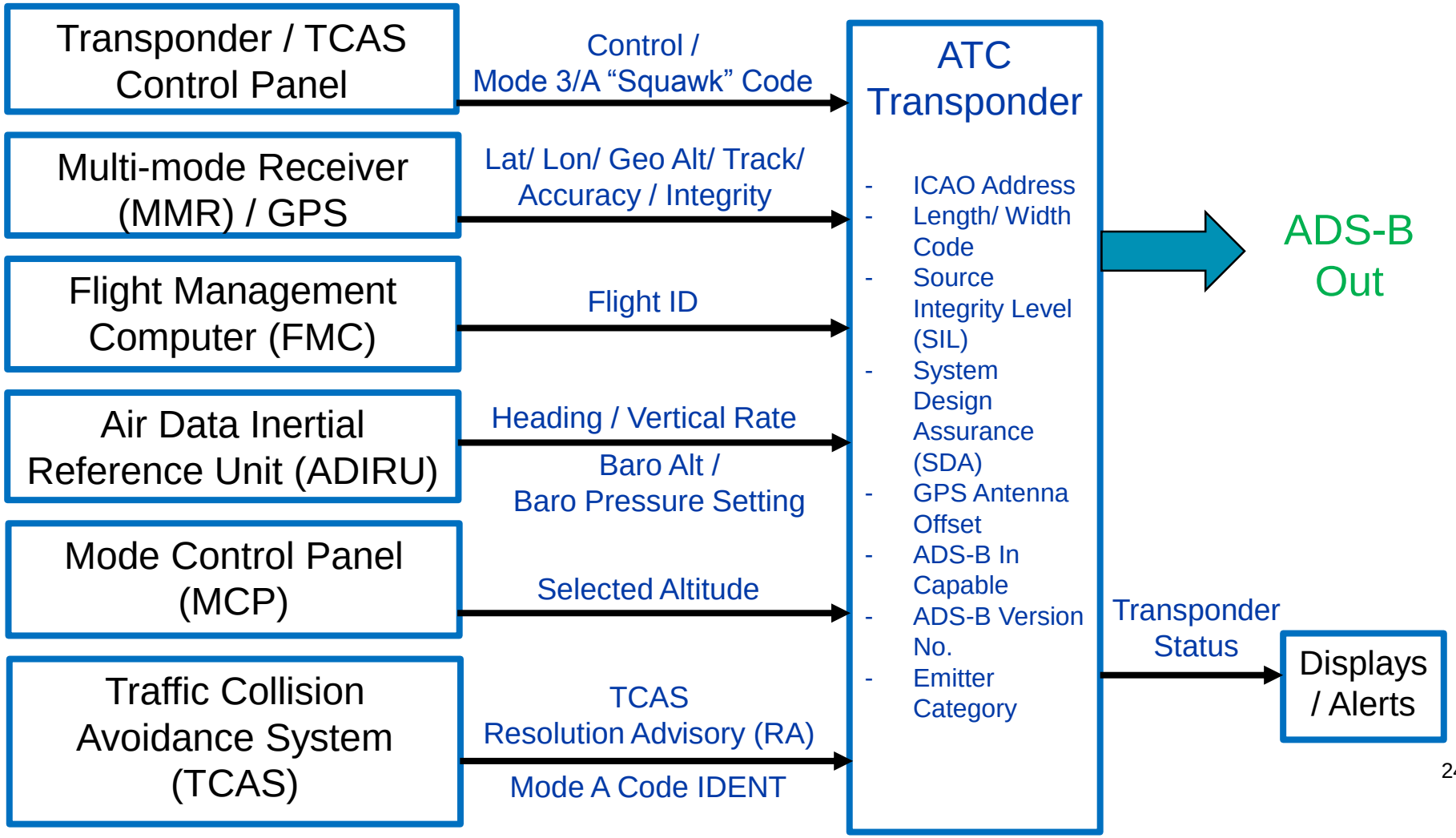
Questions

Backup Charts

What is required for ADS-B Out?



Simplified Airborne ADS-B "System" Diagram



Production ADS-B Out Capability

Boeing Commercial Airplanes – Avionics / Air Traffic Management

Functionality	737NG	737MAX	747-8	767	777	777X	787	All Models Ready
SA-On GPS	HI RMA 55B 1998	HI RMA 55B	N/A	No customer	HI RMA 55B 1998	N/A	N/A	1998
SA-Aware MMR	RCI GLU-925 2005	RCI GLU-925	RCI GLU-925 At Entry Into Service	RCI GLU-925 2005	RCI GLU-925 2005	N/A	HI INR At Entry Intro Service	2005
3GMMR (SBAS/WAAS)	HI I-MMR (2017) RCI GLU-2100 (2018)	HI I-MMR (2017) RCI GLU-2100 (2018)	TBD	TBD	HI I-MMR (2017) RCI GLU-2100 (2018)	At Entry Into Service	TBD	TBD
4GMMR (Multi-Frequency / Multi-Constellation)	Not before 2025	Not before 2025	Not before 2025	Not before 2025	Not before 2025	Not before 2025	Not before 2025	Not before 2025
ADS-B Out Airplane Interface Wiring	2003 L/N 1394	At Entry Into Service	From Entry Into Service	2003 L/N 903	2003 L/N 455	At Entry Into Service	Not Required (on Common Data Network)	2003
Transponder Program Pin Wiring	6/3/13 L/N 4522	At Entry Into Service	10/7/13 L/N 1490	10/10/13 L/N 1063	8/1/13 L/N 1132	At Entry Into Service	Not Required (Option Selection Software)	Oct 2013
DO-260B (V2) Transponders	ACSS 4/15 (L/N 5389) HWI 2Q2017 RCI 11/15 (L/N 5673)	At Entry Into Service	RCI 5/16 L/N 1531	ACSS 12/14 (L/N 1072) HWI/RCI (No Customer)	ACSS 5/15 (L/N 1309) HWI 2Q2017 RCI 1/16 (L/N 1365)	At Entry Into Service	RCI 12/15 (L/N 369, 371 and on)	May 2016 (all suppliers ready 2Q2017)
Alerts	XPDR Control Panel	XPDR Control Panel	XPDR EICAS Msg and Pilot Procedure	XPDR EICAS Msg and Pilot Procedure	ADS-B Out EICAS Msg (AIMS V16 or later)	ADS-B Out EICAS Msg	ADS-B Out EICAS Msg	Part of ADS-B Function

Retrofit ADS-B Out Capability

Boeing Commercial Airplanes – Avionics / Air Traffic Management

	In-Production Models					Out-of-Production Models					
Functionality	**737NG**	**747-8**	**767**	**777**	**787**	**717**	**737-300/ 400/ 500**	**747-400**	**757**	**MD 10/11**	**MD 80/90**
SA-On GPS	SB Avail	N/A	SB Avail	SB Avail	N/A	HI in Prod	SB Avail (Analog MMR)	SB Avail	SB Avail	SB Avail for MD-11	SB Avail (Analog MMR)
SA-Aware MMR	SB Avail	No SB Required (SA-Aware in Prod)	SB Avail	No SB (Avail for Purchase)	No SB Required (SA-Aware in Prod)	No SB (Avail for Purchase)	GPSSU SB Avail -300/-400 in 2015 (Avail for Purchase on -500)	No SB for GLU-925-002 (Avail for Purchase)	SB Avail	No SB (Avail for Purchase)	No SB
3GMMR (SBAS/WAAS)	SB 6 months after Prod Cert	TBD	TBD	SB 6 months after Prod Cert	TBD	No SB	No SB	No SB	No SB	No SB	No SB
4GMMR (Multi-Frequency / Multi-Constellation)	Not before 2025	Not before 2025	Not before 2025	Not before 2025	Not before 2025	No SB	No SB	No SB	No SB	No SB	No SB
ADS-B Out Airplane Interface Wiring	SB Avail	No SB Required	SB Avail	SB Avail w/ SA-On GPS	No SB Required	In Production 2005 SB Avail	SB Avail with RCI Analog MMR	In Production 2003 L/N 1336 SB Avail	SB Avail	SB Avail for MD-11	No SB
DO-260B Transponder Program Pin Wiring	SB Avail	SB Avail	SB Avail	SB Avail	N/A	No SB (Avail for Purchase)	No SB (Avail for Purchase)	No SB (Avail for Purchase)	No SB (Avail for Purchase)	No SB (Avail for Purchase)	No SB
DO-260B (V2) Transponders	SB 6 months after Prod Cert	SB 6 months after Prod Cert	SB 6 months after Prod Cert	SB 6 months after Prod Cert	SB 6 months after Prod Cert	No SB (Avail for Purchase)	No SB (Avail for Purchase)	No SB (Avail for Purchase)	No SB (Avail for Purchase)	No SB (Avail for Purchase)	No SB
Alerts	XPDR Control Panel	XPDR EICAS Msg and Pilot Procedure	XPDR EICAS Msg and Pilot Procedure	ADS-B Out EICAS Msg (AIMS V16 or later)	ADS-B Out EICAS Msg (DCA Common Block Point 2 (CBP2))	XPDR EAD Msg and Pilot Procedure	XPDR Control Panel and Pilot Procedure	XPDR EICAS Msg and Pilot Procedure	XPDR EICAS Msg and Pilot Procedure	XPDR EAD Msg and Pilot Procedure	XPDR Control Panel or MWCC or EOAP and Pilot Procedure