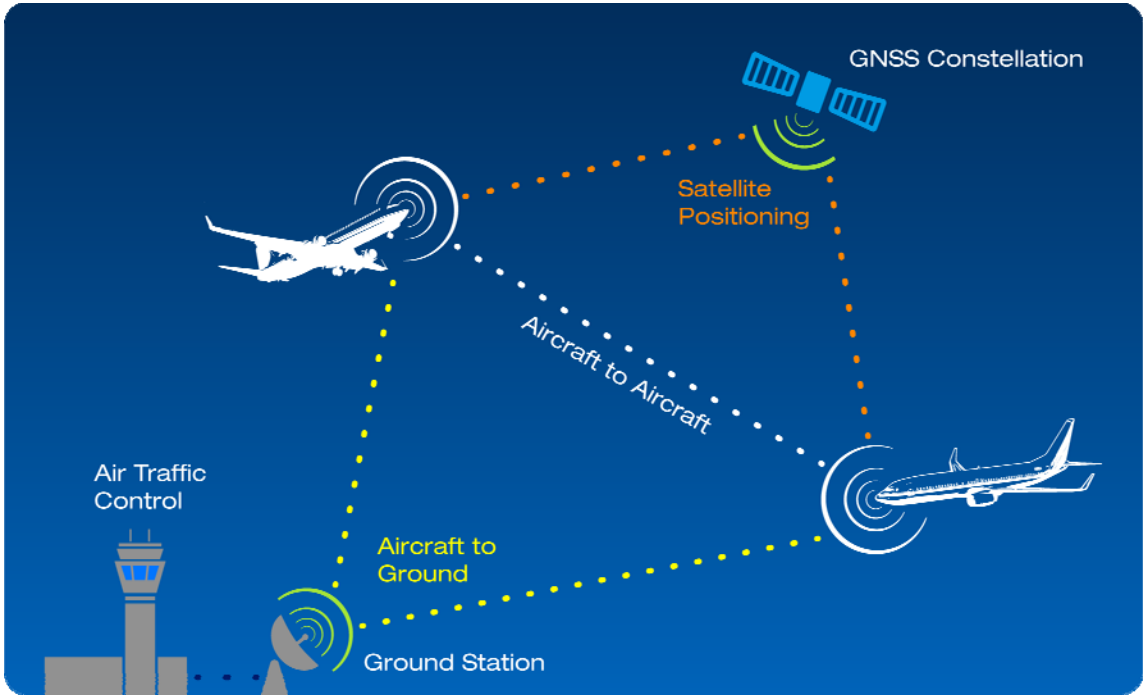
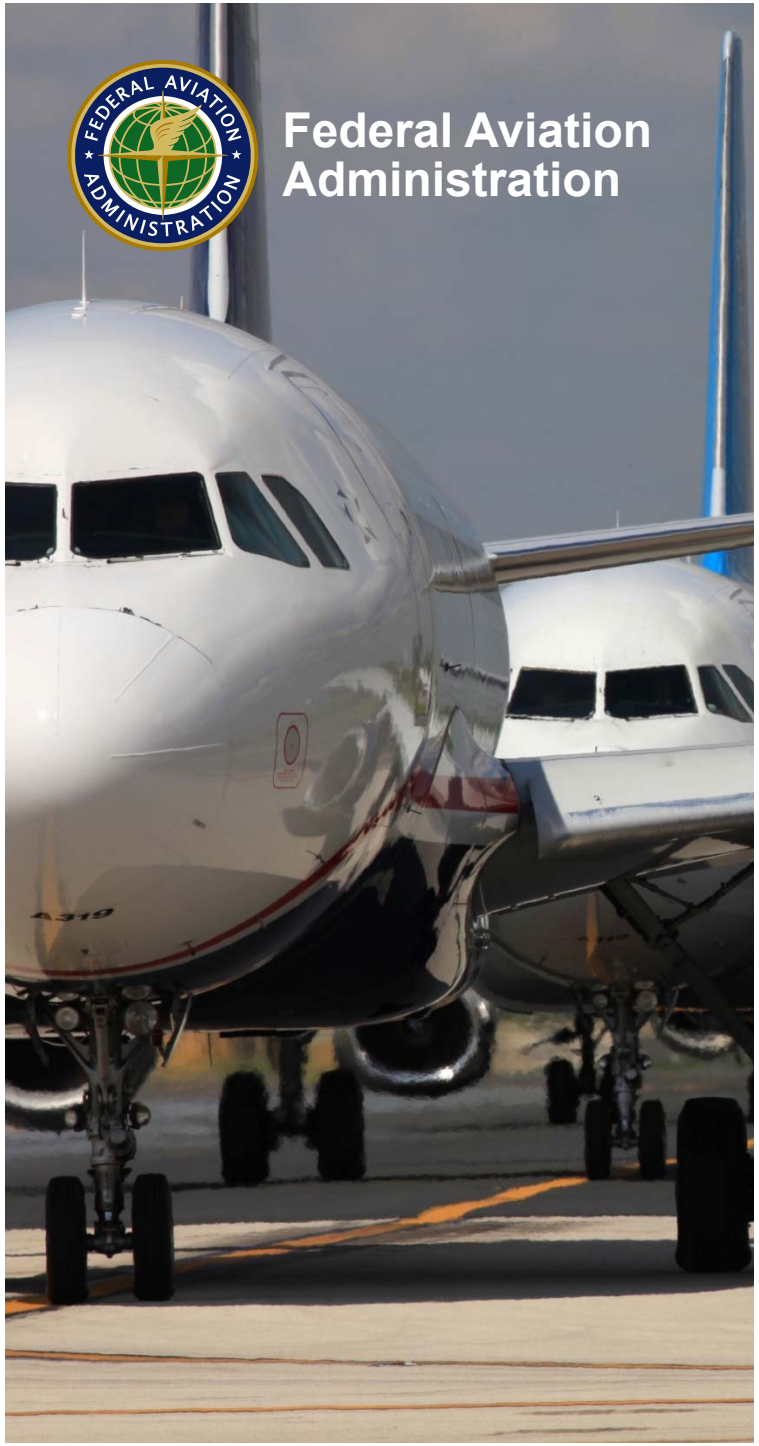
ATO Program Management Organization

ADS-B Program Status



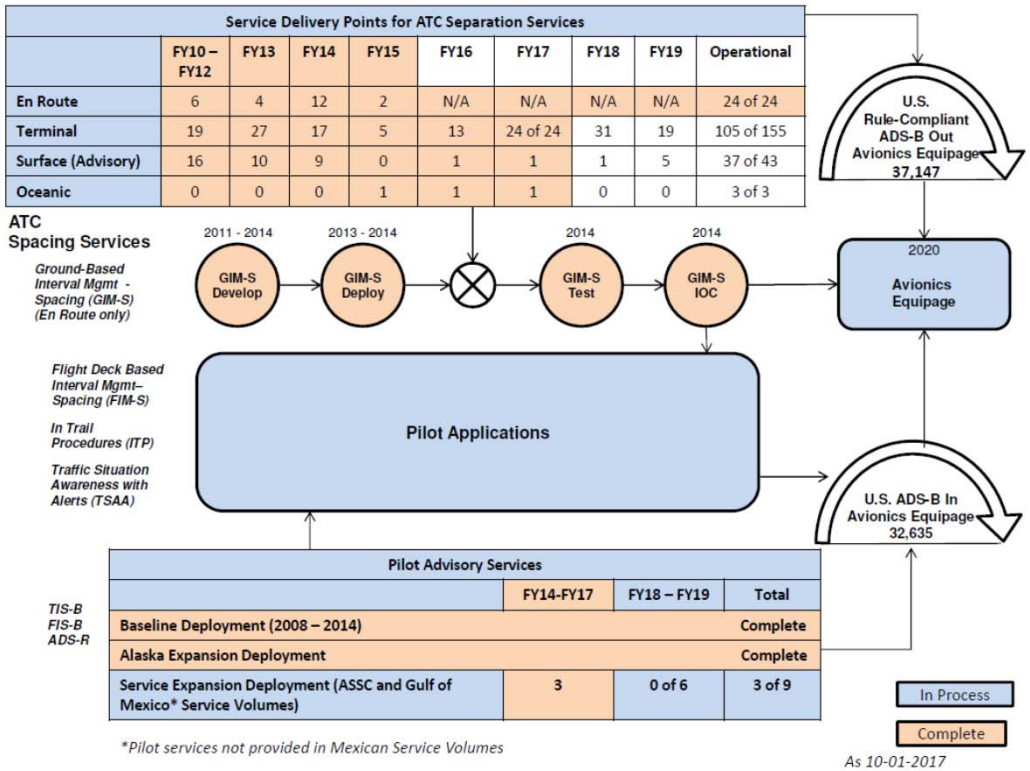


ICAO NAM/CAR/SAM ADS-B
Presented to: Implementation Meeting & Workshop

By: Doug Arbuckle

Date: November 2017

Service Delivery Points for ATC Separation Services									
	FY10 – FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	Operational
En Route	6	4	12	2	N/A	N/A	N/A	N/A	24 of 24
Terminal	19	27	17	5	13	24 of 24	31	19	105 of 155
Surface (Advisory)	16	10	9	0	1	1	1	5	37 of 43
Oceanic	0	0	0	1	1	1	0	0	3 of 3

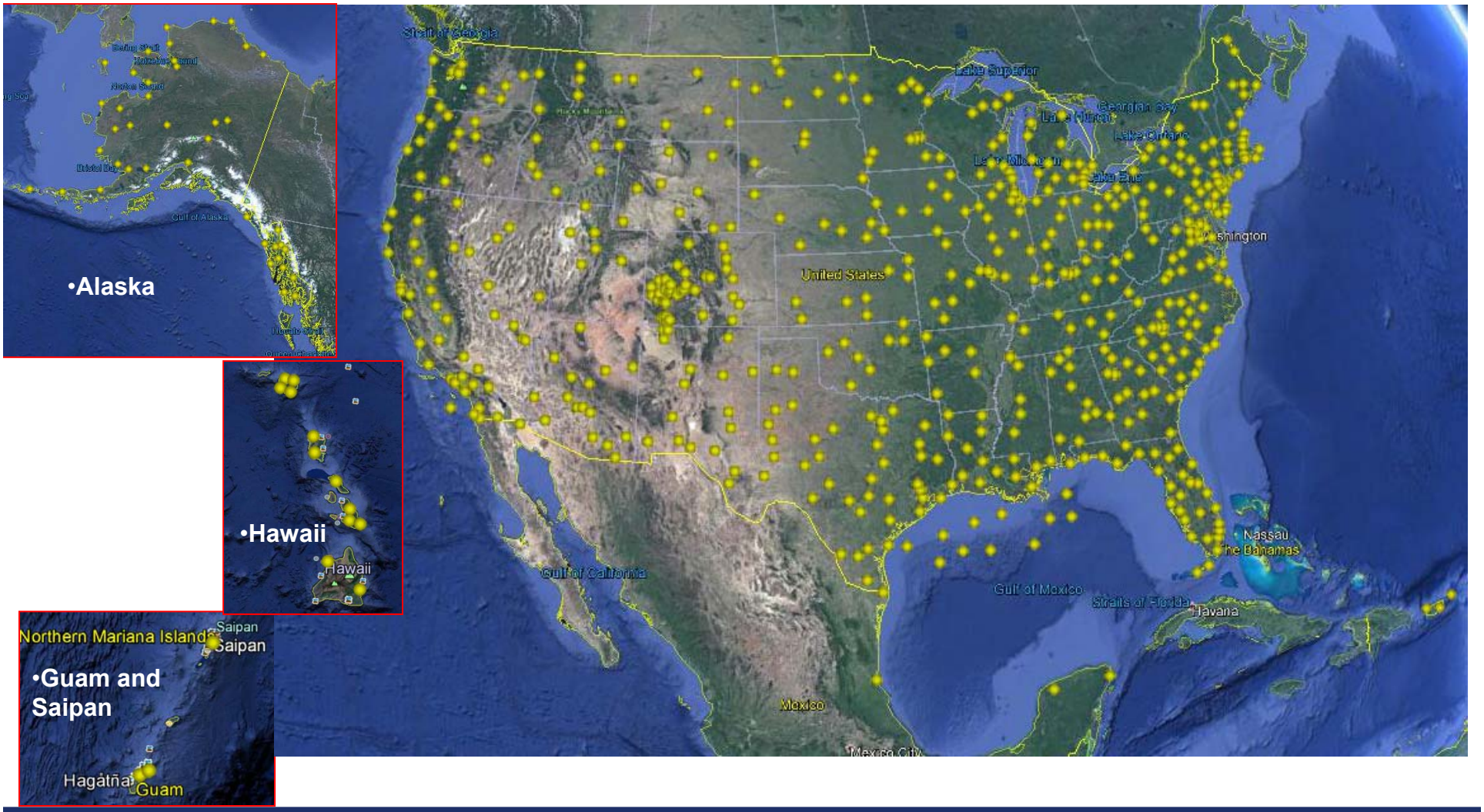


Pilot Advisory Services			
	FY14-FY17	FY18 – FY19	Total
Baseline Deployment (2008 – 2014)			Complete
Alaska Expansion Deployment			Complete
Service Expansion Deployment (ASSC and Gulf of Mexico* Service Volumes)	3	0 of 6	3 of 9

*Pilot services not provided in Mexican Service Volumes

As 10-01-2017

ADS-B Ground Infrastructure



FAA Avionics Upgrades in Progress

BOEING
Rockwell Collins
UNITED

- ADS-B Out
- Aircraft: 110 737NG
- TSO for Rockwell TPR-901 version 2 variants approved 3-Sep-2015
- Boeing wiring Service Bulletin installs underway, 103 of 110 aircraft wired
- Boeing activation Service Bulletin and AFM update approved 18-Jan-2016
- United transponder retrofit began March 2016
- Upgrades to DO-260B complete by December 2017
    - **To date, 102 of 110 upgrades completed**

- ADS-B Out
- Aircraft: 315 legacy Capstone aircraft
- Contract awarded to FreeFlight Systems on April 30, 2013
- AML STC for fixed wing issued March 2014; AML STC to include AS-350/B206 delivered in February 2016; Rotorcraft AML ATC issued March 2016; field approval for Bell 412 completed 2016.
- The UATs aircraft upgrades program extends until December 2017
- 1090 aircraft upgrades will be completed by December 2018
    - **To date, 297 of 315 upgrades completed**

As 10-01-2017

October 2017 Equipage

V2 ADS-B Out equipped aircraft with compliant performance detected by FAA network

Category	As of 1-Sep 2017 (ATAT)	As of 1-Oct 2017 (ATAT)	Monthly Increase		% of estimated fleet equipped^, as of 1-Oct-2017
All Link Version 2	35,599	37,147	1,548	4.35%	
1090ES	29,278	30,805	1,527	5.22%	
UAT	5,515	5,529	14	0.25%	
Dual	806	813	7	0.87%	
US General Aviation	**29,696**	**30,989**	**1,293**	**4.35%**	**19.4% - 31.0%**
US Air Carrier	**1,247**	**1,329**	**82**	**6.58%**	**22.2.% - 26.6%**
Intl General Aviation*	2,138	2,226	88	4.12%	
Intl Air Carrier	769	793	24	3.12%	
U.S. Military & U.S. Special Use	35	31	-4	-11.43%	

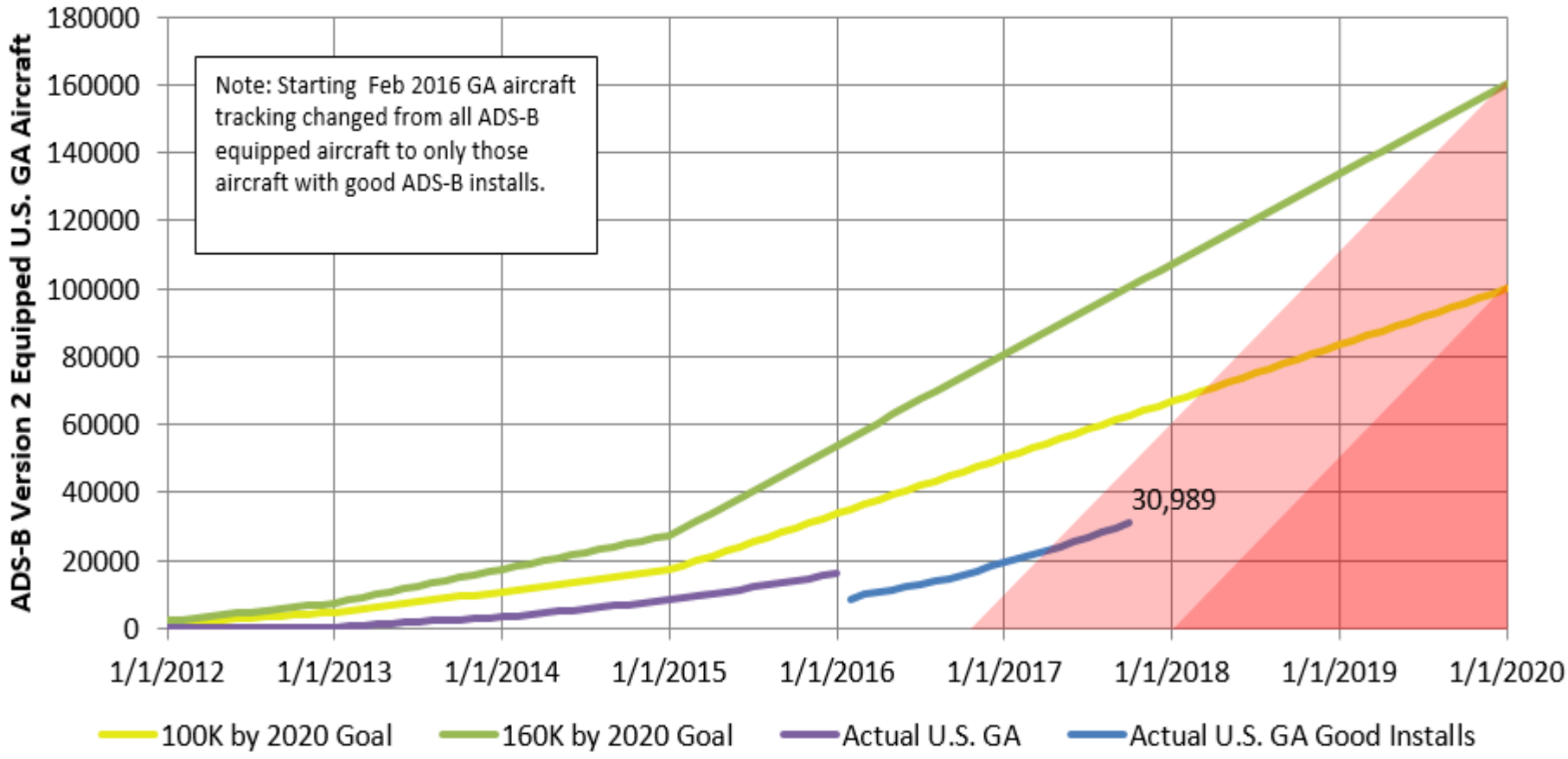
http://www.faa.gov/nextgen/equipadsb/equipment/monitoring/

*Aircraft incorrectly reporting outside US ICAO block are included in Intl GA count.

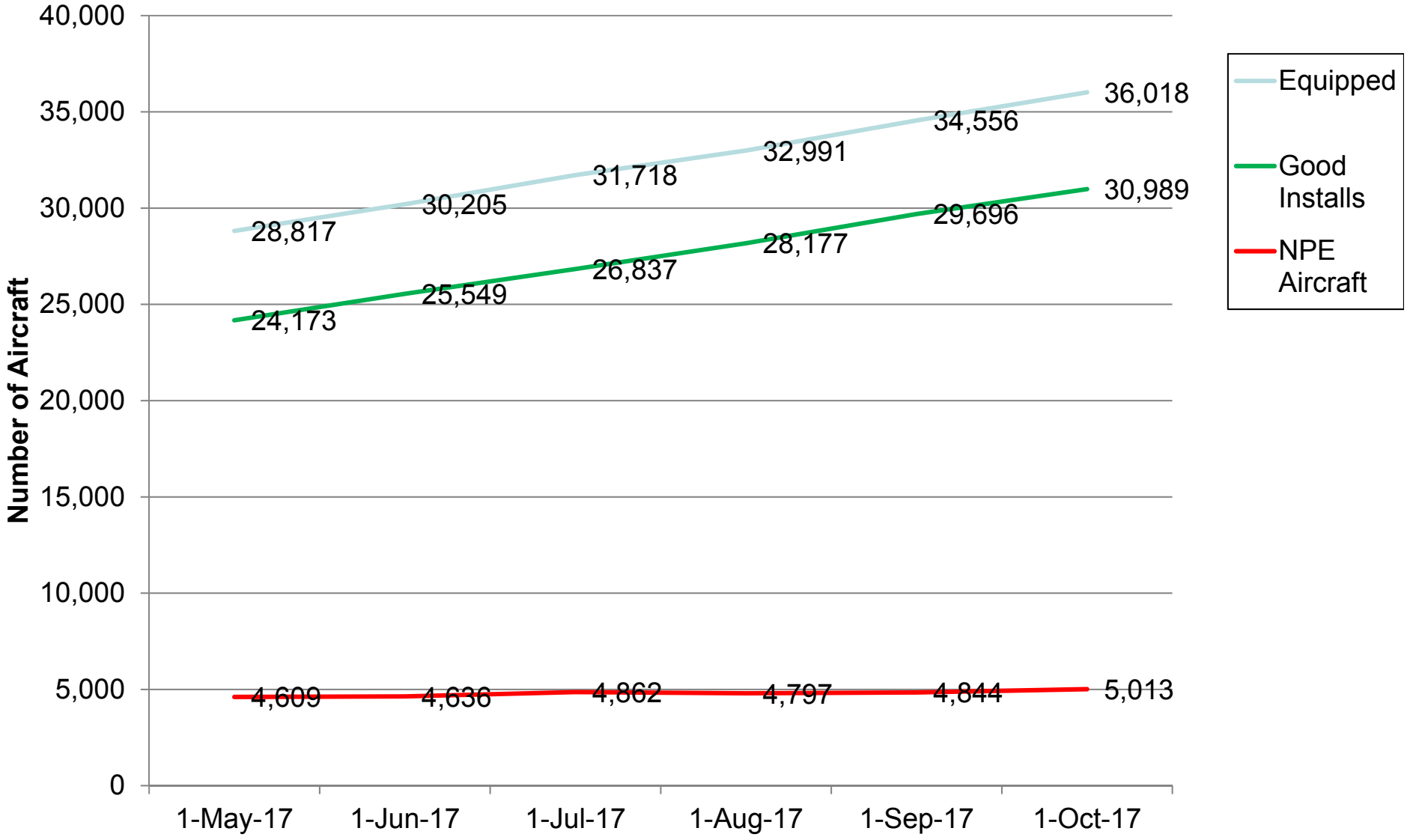
^percentage range based on estimates of 5,000-6,000 US air carrier aircraft and 100K-160K US general aviation aircraft

ATAT – The ATAT was used to generate these numbers starting on June 1, 2016

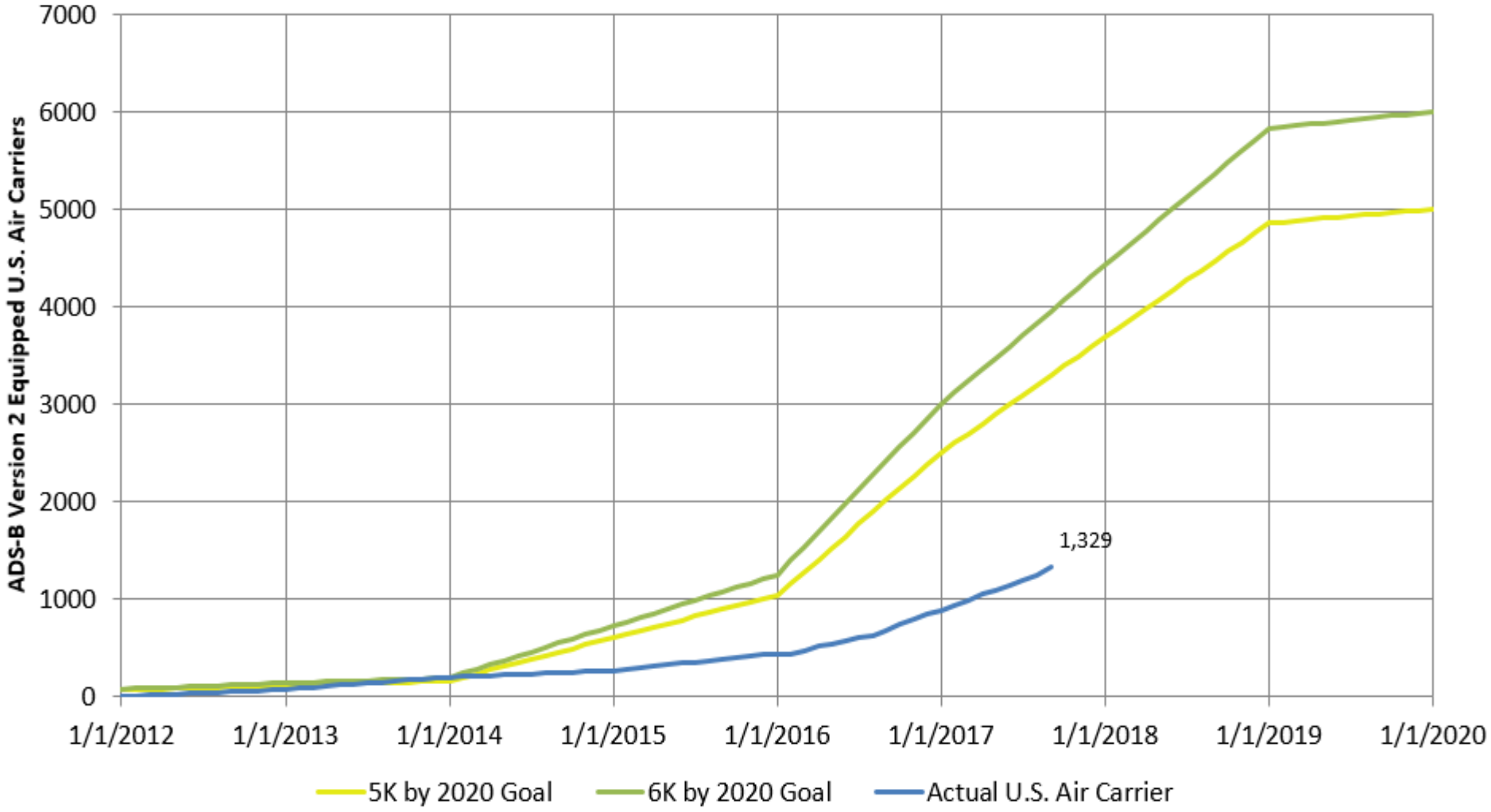
ADS-B Out Version 2 Equipage U.S. General Aviation (good installs) (including Exp & LSA aircraft) Actuals vs 100K and 160K by 2020 Goals



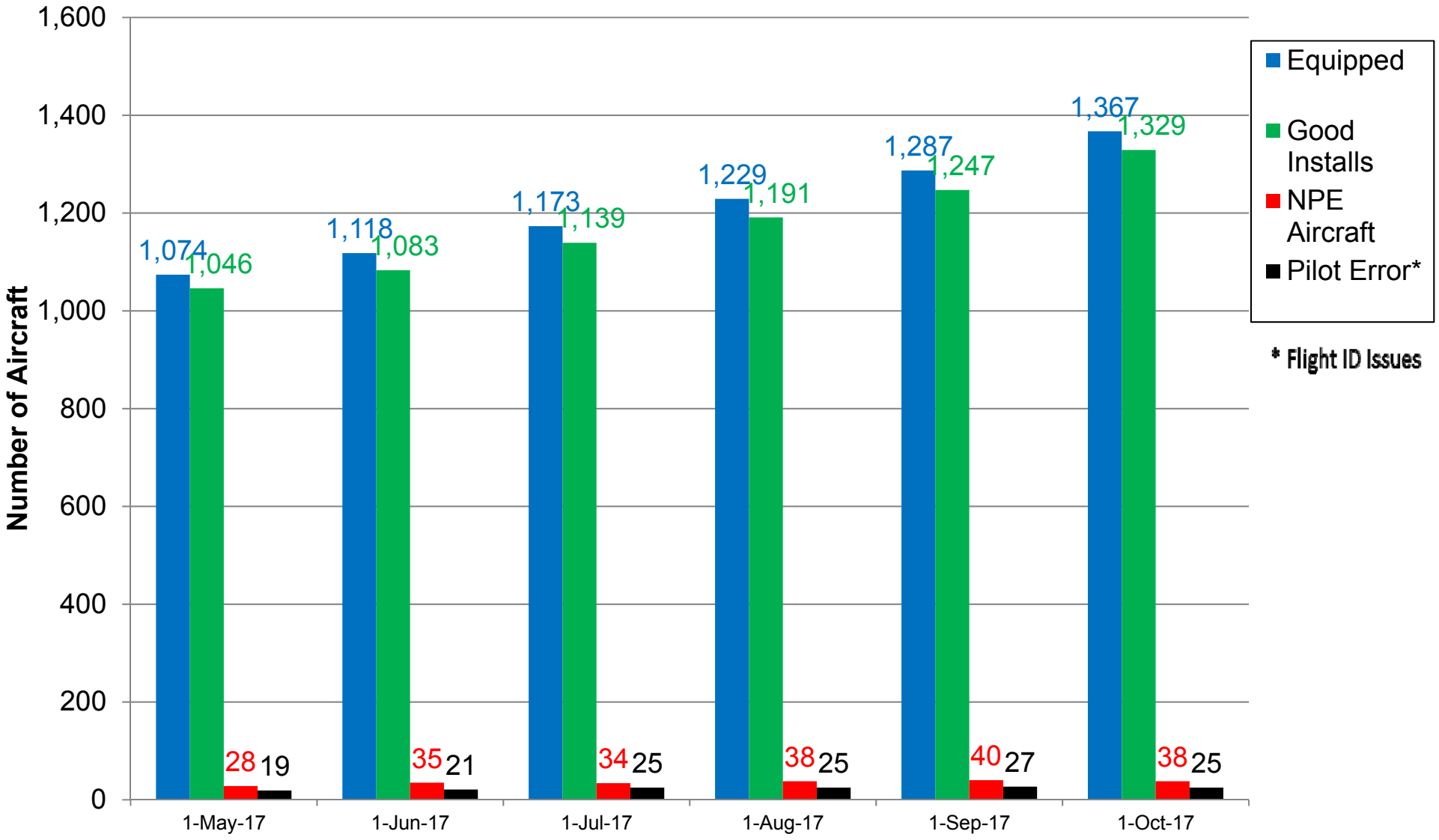
USA GA Aircraft Equipage and Avionics Performance



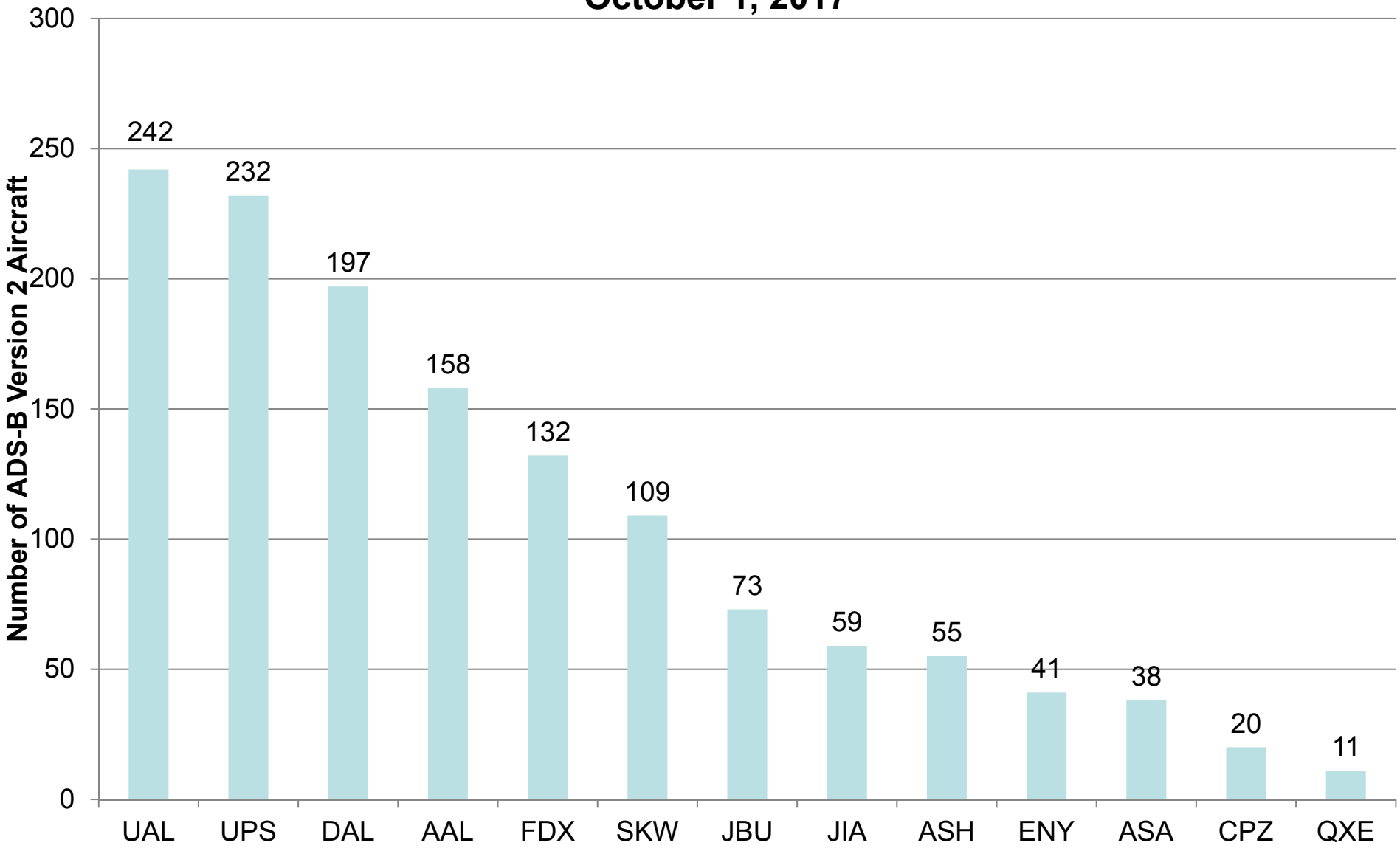
ADS-B Out Version 2 Equipage (good installs) U.S. Air Carriers
Actuals vs 5K and 6K by 2020 Goals



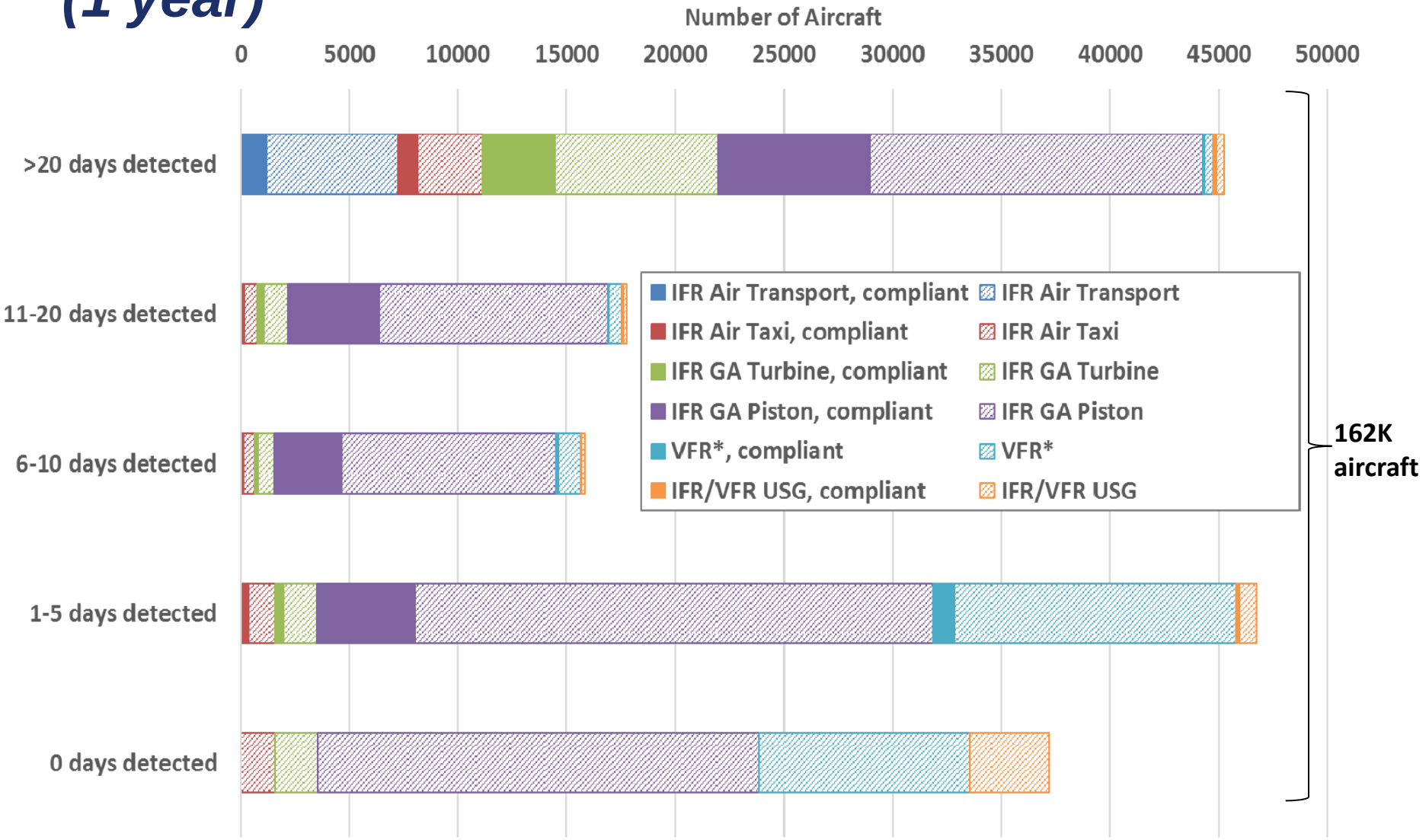
US Air Carrier Equipage & Avionics Performance



Equipage Status - U.S. Air Carriers (>10 aircraft equipped)
October 1, 2017



Aircraft Expected to Equip for ADS-B Out Rule
Grouped by Days Detected in Rule Airspace (1 year)



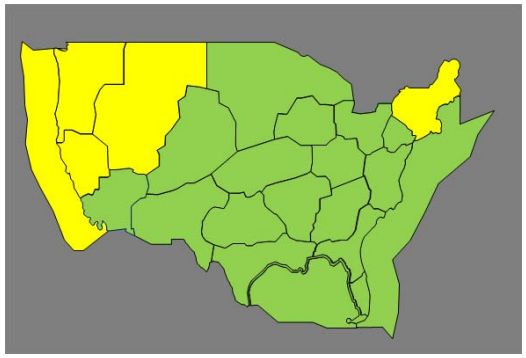
**VFR aircraft based at Class B or C airport, or flew through ADS-B rule airspace*

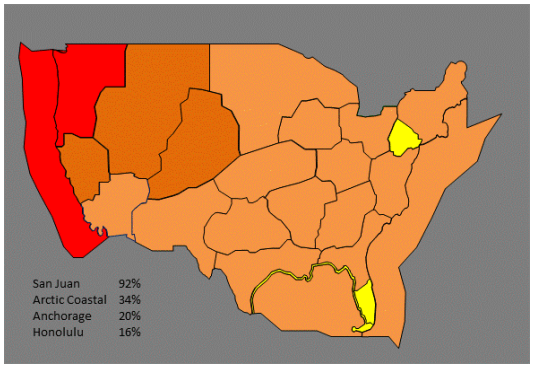
Equipped Operations – Heat Maps

Percent ADS-B Out V2 July 2016 to June 2017

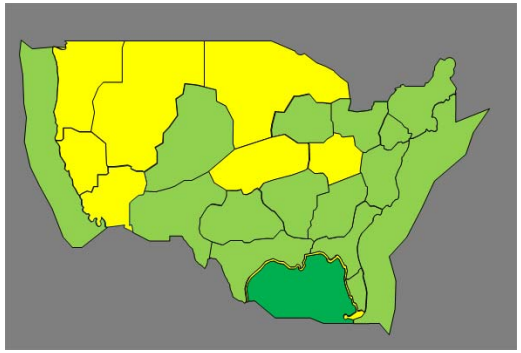
Percent Equipped
25+
20-24
15-19
10-14
5-9
0-4

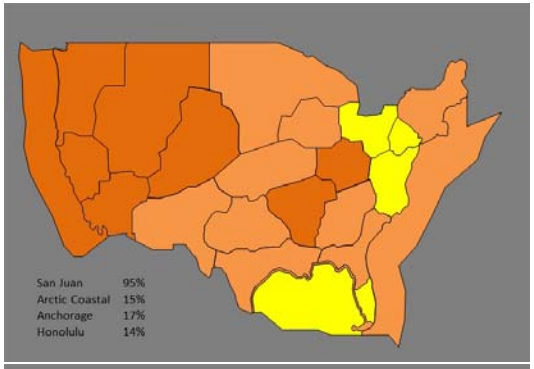
Class A



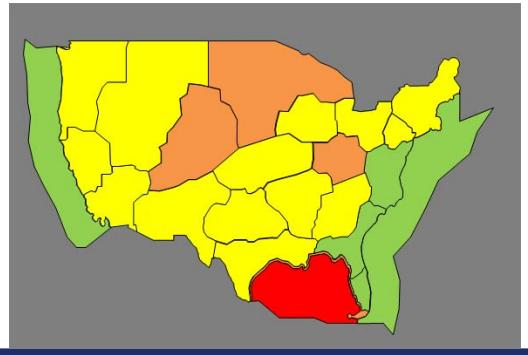


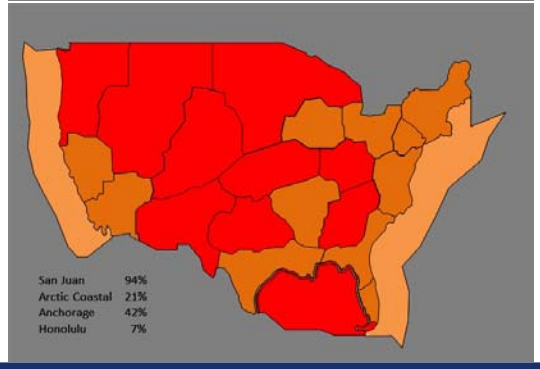
Class E Rule Airspace





Class E Non-Rule Airspace

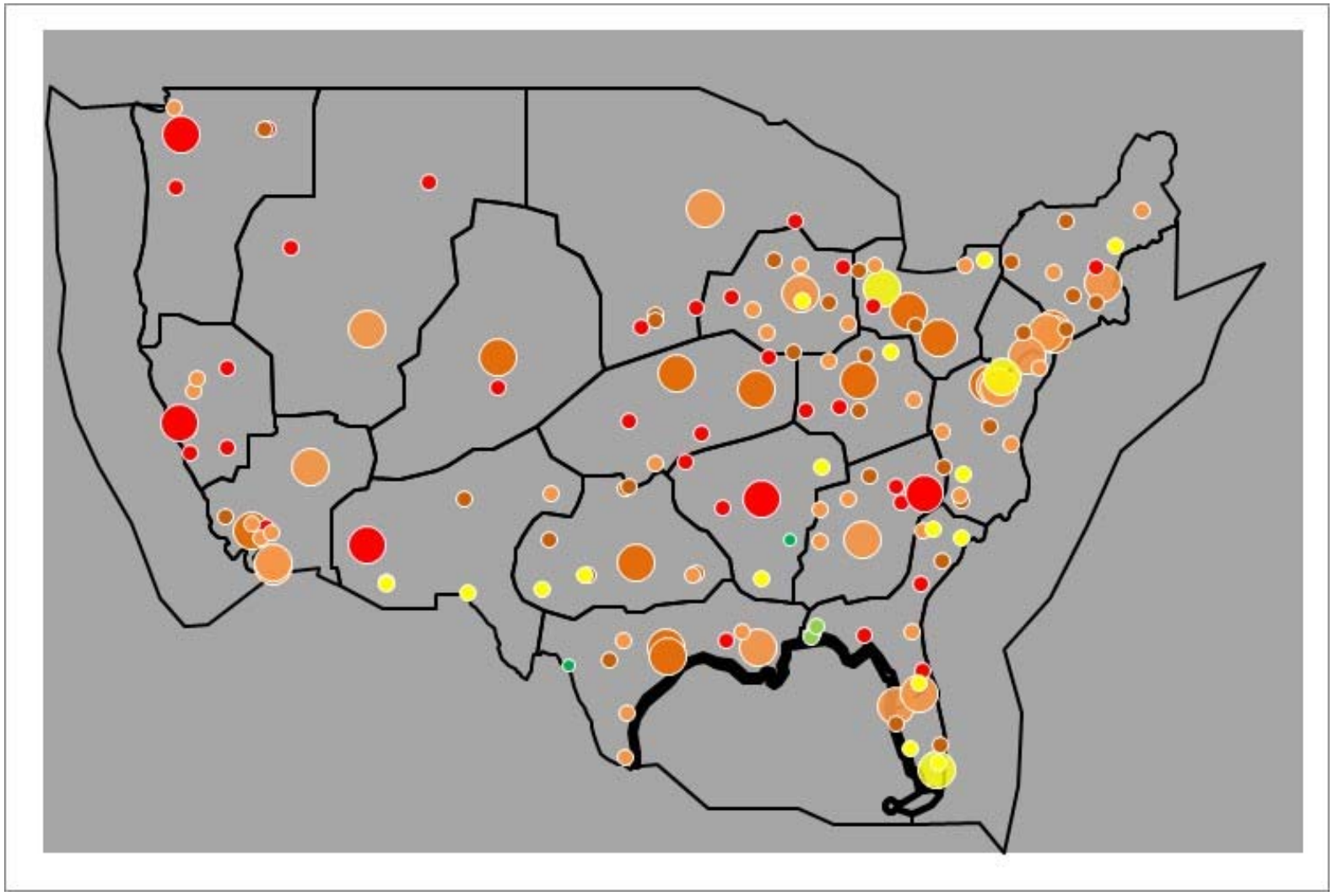




Equipped Operations – Heat Maps

June 2017(Class B with Mode C Veil and Class C airports) V2

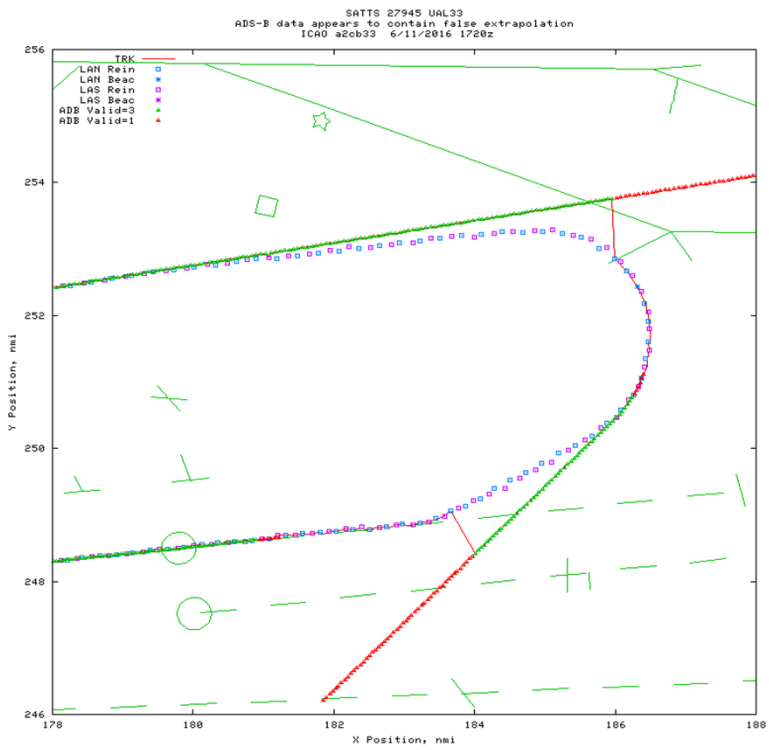
Percent Equipped
25+
20-24
15-19
10-14
5-9
0-4



B787 ADS-B issue, 1 of 2

Issue

- 11-Jun-2016, UAL33, on downwind for final approach at LAX (see picture, right)
- Aircraft Integrated Surveillance System (ISS) extrapolates position along a straight line based on current track, while sending “good” quality parameters
- Problem not detected by SBS validation until radar and ADS-B positions differ by 0.57nm (where green line becomes red)
- As of 02-Aug-2017, FAA ADS-B Performance Monitor has observed 6 additional events (arrival & departure scenarios); additionally, on 21-Jun-2017, New Zealand observed an occurrence on their ADS-B test system
- Problem has not reoccurred yet on same aircraft



Solution(s)

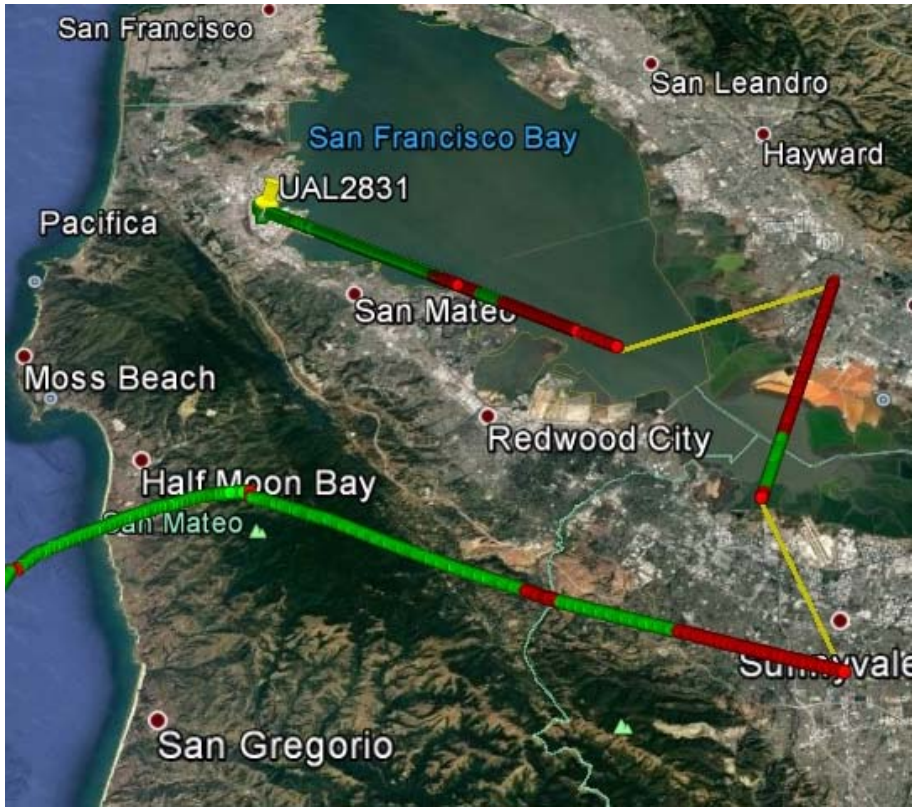
- Boeing/Rockwell determined root cause; Boeing implemented fix for production aircraft starting with Line# 544; Boeing Service Bulletin B787-81205-SB340036-00 available
- FAA has implemented improved position validation and a No Services Aircraft List to allow ADS-B for specific ICAO addresses to be excluded from ATC automation

B787 ADS-B issue, 2 of 2

Examples of events

Departure from SFO

Arrival/Approach to SFO



Validation Enhancements

- **Change Standard Validation logic**
  - Use all validation sources in valid/invalid determination (versus prior hierarchy of sources) -- addresses issues with radar validation providing false invalid during aircraft maneuvers
- **Apply Enhanced Validation to eliminate erroneous ADS-B earlier in approach situations**
  - Validation threshold of 0.2NM within 15 NM of an MSSR
  - Use TDOA to compensate for slow radar response to accelerating / decelerating aircraft
  - No ATC automation changes

No Services Aircraft List (NSAL)

- **Background**
  - NSAL is a list of ICAO addresses used to filter flow of FAA-received ADS-B data; NSAL prevents potentially false or misleading data from reaching FAA ATC automation
- **Governance**
  - NSAL Review Board is FAA's body charged with the governance of the No Services Aircraft List; Board governance activities include:
    - Determining criteria for inclusion on and removal from the NSAL
    - Reviewing individual cases and making decisions
    - Defining procedures for Board decision-making and communications
- **Current status:**
  - All 787s subject to Boeing Service Bulletin were placed on NSAL until they apply this SB – with exception of Gulf of Mexico offshore airspace, should not impact any operators
  - FAA letter dated 11-Oct-2017 to sent to all affected B787 operators, describing steps needed to be removed from NSAL

GA Rebate- Objective

Efforts to incentivize General Aviation adoption of ADS-B

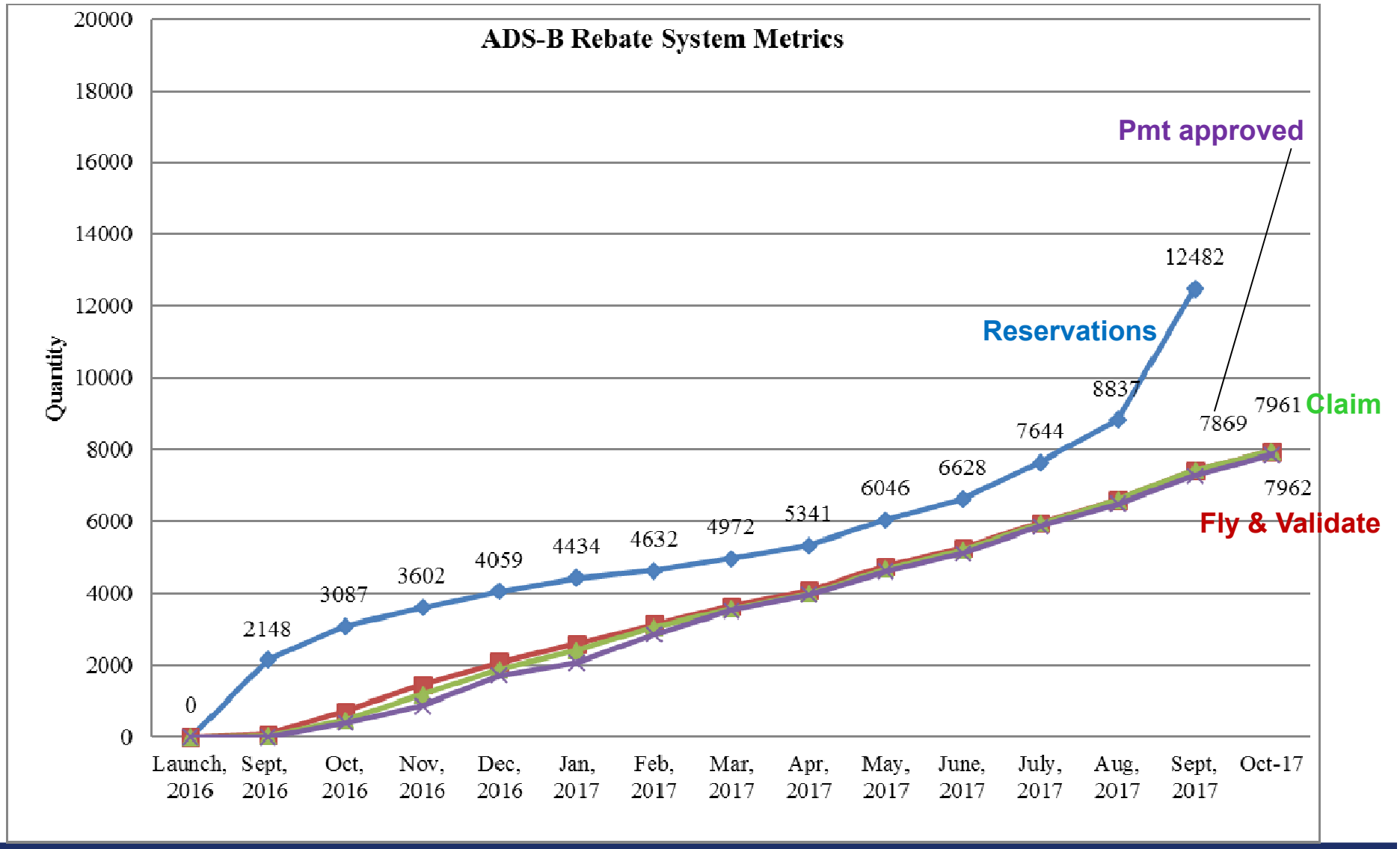
- FAA's Surveillance and Broadcast Services (SBS) Program funded several projects to develop and certify options for ADS-B avionics for GA fixed-wing aircraft and rotorcraft
- ADS-B program was structured to provide benefits to GA (traffic and weather broadcast services deployed first, emphasized in remote areas)

ADS-B benefit widely accepted, yet equipage rates remained below expectations (cost/complexity/lack of urgency)

- In 2012, equipage prediction estimate updated to approx. 60,000 GA/Air Taxi aircraft equipped by 2016
- Detected19,517 GA targets as of January 2016

Increase GA equipage rates in advance of 2020 ADS-B Out Mandate to help ensure access to rule airspace by general aviation users

ADS-B GA Rebate Update, 25-Oct-2017



FAA currently tracked ADS-B avionics problems

Unique to UAT

- Baro/Geo Altitude Spikes
- Missing Baro Altitude
- Missing Flight ID
- Missing Mode 3/A
- Aircraft using FAA N47 Flight ID
- UTC toggling

Both UAT & 1090

- **Kinematic Issues (aka, “position jumping”)**
- **Duplicate & Wrong ICAOs**
- **Air/Ground determination issues**
- **Incorrect Emitter Category**
- **Flight ID Error (includes Partial Flight ID)**

Unique Aircraft

- **B787 erroneous position**
- **A380 Flight ID change on Surface**
- **A380 Geo Altitude**
- **B777-300ERs Delivered with wiring error, resulting in non-compliant NACv/SDA/EmitCat/LW Code**

ITP Project

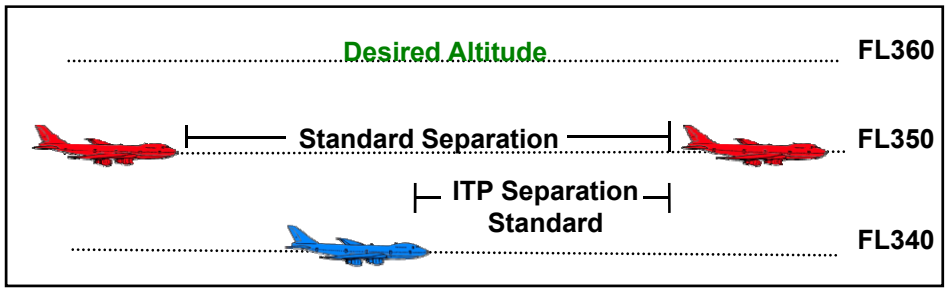
Done!

Purpose: Provide operational benefits in non-surveillance airspace by enabling “in-trail” climbs/descents at reduced separation distances

Goal: Employ ITP in oceanic air carrier operations (revenue service)

Objectives: Develop and validate ADS-B ITP avionics standards
Validate operational performance and economic benefits of ITP
Modify ATM automation software to support application

Partners: United Airlines, Honeywell, Goodrich, Airports Fiji Limited, Airways Corp NZ



Complete; In Progress; Not Yet Started;

ATOP ITP MODS Completed	Release ATOP ITP Mods to sites	ATOP ITP Operational Readiness (at ZOA)	ITP Implemented at ZAN	ITP Implemented at ZNY	ITP Operational at all sites
Nov 2015	March 2016	June 2016	Feb 2017	Aug2017	Aug2017

ITP Operational Evaluation Metrics

January – June 2017

Application Validation Metric	June 2017	Totals	
		10/2016 – 6/2017	8/2011 – 6/2017
Number of ITP requests	2	18	350
Number of ITP maneuvers performed	0	2	63
Number of "standard" flight level changes	2	6	142
Number of denied flight level changes	0	10	83
Number of immediate limited standard climbs	0	0	29
Number of climbs after moving reference aircraft	0	0	14
Number of standard climbs after period of time	0	0	19
Percent of climbs resulting from ADS-B ITP requests	100%	44%	76%

Safety Related Parameter	Key Parameters	Totals January – June 2017			Totals (10/2016 – 6/2017)			Totals (8/2011 – 6/2017)		
		Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
ITP Initiation Distance	15 nm				39.3	43.0	39.3	17.6	29.4	88.4
ITP Distance at Co-altitude	10 nm				42.1	44.8	42.1	17.6	29.9	88.5
Time From ITP Initiation to Level Off at New Altitude	7 min				6.0	6.0	6.0	2.0	4.6	8.0
Percentage of ITPs where a wake encounter occurred and a wake incident was reported	2%									
Wake Turbulence Incident Severity (5-1) (5 is minimal, 1 is catastrophic)	5									

ADS-B-In ARC Priority Applications

ARC recommended FAA focus funding on accelerating development of equipment standards, certification guidance, operational approval guidance, ground automation, and any policy adjustments to enable operational implementation of applications listed below, in priority order [with targeted completion date]:

1. **CDTI-Assisted Visual Separation (CAVS) [FY12]**
2. **Flight-deck-based Interval Management–Spacing (FIM–S) [FY15]**
3. **Traffic Situation Awareness with Alerts (TSAA) [FY13]**
4. **Oceanic In-Trail Procedures (ITP) [FY13]**
5. **CDTI-Enabled Delegated Separation (CEDS) (ending in a visual approach) [FY16]**
   [[now called CDTI-Assisted Pilot Procedures (CAPP)]]
6. **Ground-based Interval Management–Spacing (GIM–S) with Wake Mitigation [FY18]**
7. **Flight-deck-based Interval Management—Defined Interval (FIM–DI) [FY19]**
   [[application considered part of Advanced Interval Management (A-IM)]]
8. **FIM–DI for Closely Spaced Parallel Runway Operations (CSPO) [FY17]**
   [[application considered part of A-IM Paired Approach]]
9. **Oceanic Interval Management (IM) [FY15]**
   [[now called Pairwise Trajectory Management]]
10. **Airport Traffic Situation Awareness with Indications and Alerts (SURF–IA) [FY17]**

Except for SURF-IA (#10) and possibly GIM-S with Wake Mitigation (#6), all of above referenced applications are compatible with U.S. ADS-B Out Rule compliant avionics & performance requirements

FAA Next Steps

- **Continue rollout of Air Traffic Control Separation Services**
- **Monitor avionics compliance and work with industry on the *Equip 2020* initiative**
- **Prepare for JRC requests**
  - Final Investment Decision for Advanced Surveillance-Enhanced Procedural Separation (ASEPS)
  - Final Investment Decision for the Next Segment of the “Baseline” SBS Program (FY20-25 funding)

Operator Next Steps

- **Considerations for the U.S. ADS-B mandate**
  - **Version 2 ADS-B transmitter**
  - **Compliant position source approved to “pair” with V2 ADS-B transmitter**
  - **Aircraft wiring as needed**

- **As of 26-Oct-2017, 2 years, 66 days to go!**

BACKUP

SBS Standard Validation Capabilities

- **Validation of ADS-B position in the SBS system utilizes independent position estimates from:**
  - Radar based on set of radars covering airspace
  - TDOA with two or more radios covering airspace
  - Passive Ranging (UAT only) requires 1 or more radio coverage
- **Validation precedence**
  - Radar takes precedence over other estimates
  - Ranging is second for UAT aircraft
  - TDOA is second for 1090-ES and third for UAT
- **Validation thresholds:**
  - Terminal: 0.56 NM
  - Enroute: 1.9 NM
- **Validation Probability**
  - Determine validation state 99% within 15 sec Terminal and 36 sec En Route
  - Incorrectly identify position as invalid < 0.001
- **Thresholds selected to support**
  - 5NM en route and 3NM terminal separations
  - Performance capabilities of radar at max allowed sep. range

SBS Enhanced Validation Capabilities

- **Enhanced Validation of ADS-B position was implemented to assess avionics compliance to NIC performance for the rule**
  - Validation threshold of 0.2NM
  - Applied within 15 NM of a terminal MSSR due to tighter threshold and radar ability to meet this performance level
- **Enhanced Validation techniques**
  - Radar
  - Ranging
  - TDOA
- **Utilized in ADS-B Performance Monitor to assess avionics compliance to NIC=7/SIL=3 (Integrity of ≥ 0.2NM with a 0.9999999 probability)**

Acronyms

ADS-B: Automatic Dependent Surveillance – Broadcast
ADS-R: Automatic Dependent Surveillance – Rebroadcast
AML: Approved Model List
APB: Acquisition Program Baseline
ASSC: Airport Surface Surveillance Capability
ATC: Air Traffic Control
ATOP: Advanced Technologies and Oceanic Procedures
ConOps: Concept of Operations
ES: Extended Squitter
FIM-S: Flight Deck Based Interval Management – Spacing
FIS-B: Flight Information Services - Broadcast
GIM-S: Ground-Based Interval Management – Spacing
GOM: Gulf of Mexico
IOC: Initial Operating Capability
ISAT: Implementation Service Acceptance Test
ITP: In Trail Procedures
MFD: Multi-Function Display
MHz: Megahertz
MOPS: Minimum Operational Performance Standards
NCT: Northern Cal TRACON
NM: Nautical Mile
O&M: Operations and Maintenance
PED: Portable Electronic Device
RIO: Risks, Issues, and Opportunities
SBS: Surveillance and Broadcast Services
SFO: San Francisco International Airport
STC: Supplemental Type Certificate
SVR: Service Volume Rollout
TAMR: Terminal Automation Modernization and Replacement
TIS-B: Traffic Information Services - Broadcast
TRACON: Terminal Radar Approach Control
TSAA: Traffic Situation Awareness with Alerts
UAT: Universal Access Transceiver