International Civil Aviation Organization

Fifth Meeting of the Surveillance Implementation Coordination Group (SURICG/5)

Web-conference, 22 – 24 September 2020

Agenda Item 5: Update on surveillance activities and explore potential cooperation opportunities

a) States/Administrations

ADS-B EQUIPAGE AND QUALITY PERFORMANCE IN THE U.S.

(Presented by United States/Federal Aviation Administration)

SUMMARY

This paper provides a summary of observed NIC/NACp performance compared to the requirements of the U.S. ADS B mandate, as well as ADS-B equipage trends in the U.S.

1. INTRODUCTION

1.1 This paper summarizes observed NIC/NACp performance compared to the requirements of the U.S. ADS-B mandate, as well as ADS-B equipage trends in the U.S.

1.2 As context for the information in this paper, the scope of U.S. ADS-B monitoring should be understood. The U.S. has ADS-B ground stations located in the 48 conterminous states, Alaska, Hawaii, as well as the following U.S. territories: Puerto Rico, U.S. Virgin Islands, Guam, and the Commonwealth of the Northern Mariana Islands. In addition, the U.S. receives ADS-B data from three ADS-B ground stations in Mexico, through a cooperative agreement with Mexico's ANSP. Maps showing the totality of this coverage at typical turbine-powered aircraft flight levels are shown in Attachment 1. Note that this coverage extends somewhat beyond the airspace where the U.S. ADS-B mandate (14 CFR 91.225) applies.

1.3 During the most recent two-month analysis window ending on 9 August 2020, almost 25% (1,711 out of 6,882) of the observed aircraft were not registered in the U.S.

2. DISCUSSION

2.1 Observed NIC/NACp performance compared to 14 CFR 91.227 requirements

The FAA's ADS-B Performance Monitor (APM) automatically generates a report used to analyse how well ADS-B Version 2 systems installed on air carrier aircraft are meeting the requirements of the U.S. ADS-B mandate. The FAA focuses on air carrier aircraft since general aviation aircraft with ADS-B Version 2 systems usually have Satellite-based Augmentation System (SBAS) position sources. See SP-ASWG6-IP/12 for more details. The table below is the NIC performance analysis for the two-year period ending 9 August 2020.

Radius of Containment (Rc)	NIC	2 months ending 9-Oct-2018	2 months ending 9-Dec-2018	2 months ending 9-Feb-2019	2 months ending 9-Apr-2019	2 months ending 9-Jun-2019	2 months ending 9-Aug-2019	2 months ending 9-Oct-2019	2 months ending 9-Dec-2019	2 months ending 9-Feb-2020	2 months ending 9-Apr-2020	2 months ending 9-Jun-2020	2 months ending 9-Aug-2020
Rc unknown	0	0.0160%	0.0135%	0.0112%	0.0240%	0.0134%	0.0165%	0.0210%	0.0159%	0.0156%	0.0135%	0.0123%	0.0146%
Rc < 20 nm	1	0.0001%	0.0001%	0.0002%	0.0001%	0.0004%	0.0003%	0.0003%	0.0003%	0.0002%	0.0003%	0.0001%	0.0002%
Rc < 8 nm	2	0.0002%	0.0002%	0.0002%	0.0003%	0.0005%	0.0004%	0.0006%	0.0003%	0.0002%	0.0002%	0.0001%	0.0004%
Rc < 4 nm	3	0.0002%	0.0002%	0.0001%	0.0004%	0.0005%	0.0005%	0.0007%	0.0005%	0.0002%	0.0002%	0.0003%	0.0005%
Rc < 2 nm	4	0.0005%	0.0004%	0.0003%	0.0009%	0.0007%	0.0009%	0.0015%	0.0007%	0.0004%	0.0004%	0.0004%	0.0010%
Rc < 1 nm	5	0.0009%	0.0006%	0.0006%	0.0012%	0.0009%	0.0012%	0.0022%	0.0009%	0.0005%	0.0006%	0.0004%	0.0012%
Rc < 0.6 nm	6(0)	0.0006%	0.0005%	0.0005%	0.0008%	0.0005%	0.0010%	0.0014%	0.0006%	0.0002%	0.0003%	0.0002%	0.0006%
Rc < 0.5 nm	6(1)	0.0167%	0.0131%	0.0055%	0.0087%	0.0088%	0.0152%	0.0181%	0.0087%	0.0023%	0.0017%	0.0013%	0.0039%
Rc < 0.3 nm	6(2)	0.1292%	0.1055%	0.0517%	0.1461%	0.1766%	0.2165%	0.2059%	0.1240%	0.0675%	0.1291%	0.1388%	0.2175%
	6 (Sum)	*0.1474%*	*0.1197%*	*0.0582%*	*0.1568%*	*0.1868%*	*0.2338%*	*0.2276%*	*0.1342%*	*0.0704%*	*0.1317%*	*0.1408%*	*0.2231%*
Rc < 0.2 nm	7	4.8391%	5.2624%	5.7308%	6.0630%	7.0961%	7.9018%	7.2975%	7.3115%	6.2241%	5.4899%	5.1574%	7.4748%
Rc < 0.1 nm	8	94.8360%	94.4705%	94.1175%	93.6675%	92.6185%	91.7730%	92.3854%	92.4719%	93.6219%	94.3022%	94.6329%	92.2468%
Rc < 75 m	9	0.1605%	0.1331%	0.0815%	0.0871%	0.0830%	0.0727%	0.0624%	0.0648%	0.0669%	0.0615%	0.0557%	0.0385%
Rc < 25 m	10	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0029%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%
Rc < 7.5 m	11	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%
# reports		5.355E+09	6.117E+09	7.192E+09	8.933E+09	9.588E+09	1.070E+10	1.063E+10	1.075E+10	1.141E+10	1.055E+10	4.859E+09	5.990E+09
# aircraft		4,204	4,802	5,608	6,426	6,766	7,519	8,286	9,121	9,627	9,605	6,628	6,882
reports/aircrft		1,273,760	1,273,915	1,282,473	1,390,210	1,417,063	1,423,663	1,283,031	1,179,053	1,185,265	1,098,528	733,139	870,447
	<7	0.1644%	0.1340%	0.0703%	0.1824%	0.2023%	0.2524%	0.2517%	0.1518%	0.0871%	0.1464%	0.1539%	0.2398%

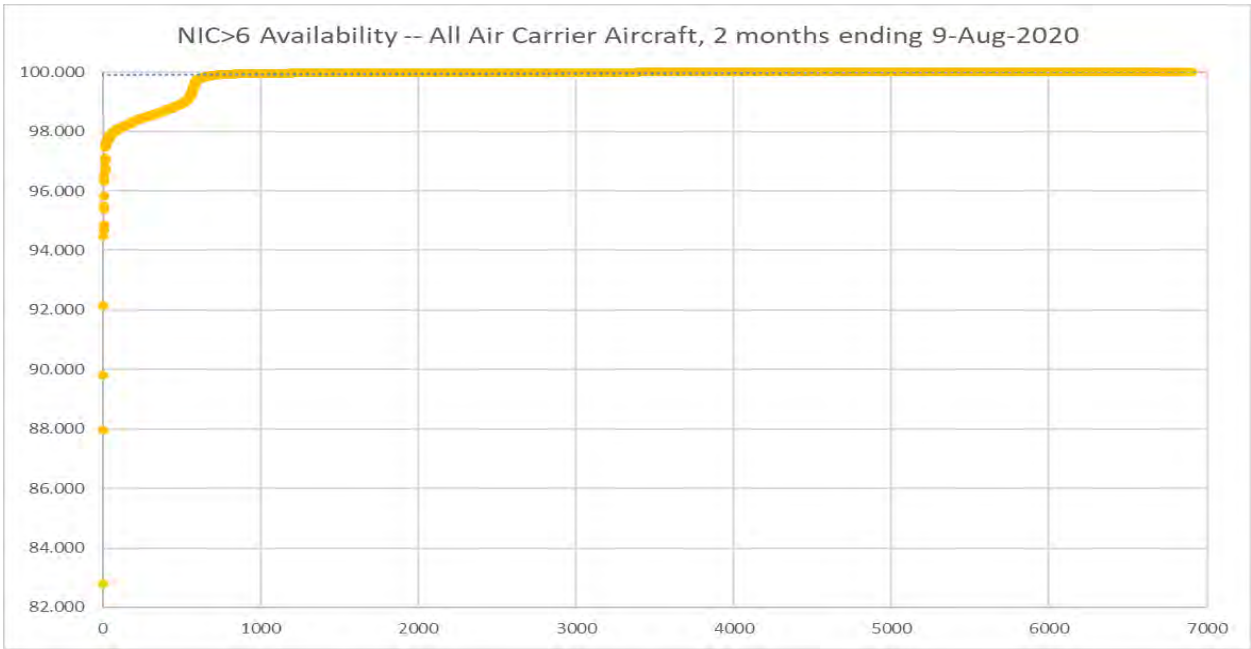
Although the number of air carrier aircraft included in the analysis has increased considerably over the two-year period (from 4,204 to 9,627 aircraft, before the traffic reductions due to COVID-19), the NIC results are relatively consistent over the analysis period. Note that once NIC falls below 6, the most likely value to be reported is NIC=0.
The table below is the NACp performance analysis for the two-year period ending 9 August 2020.

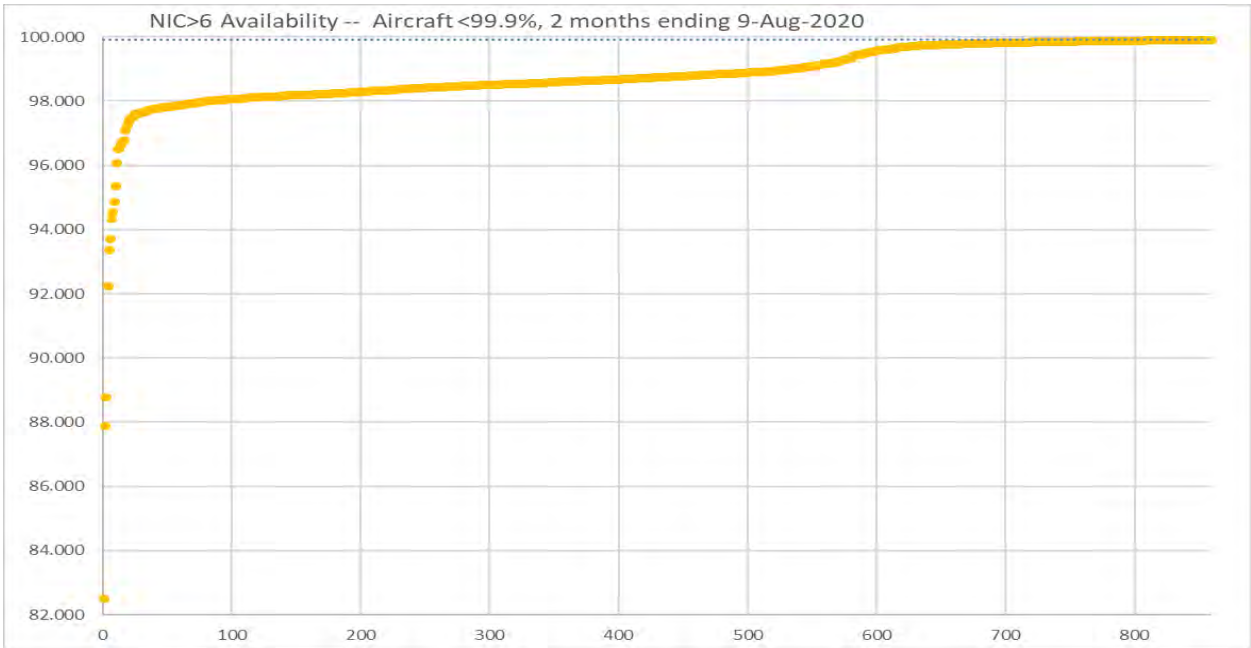
Est Position Uncertainty	NACp	2 months ending 9-Oct-2018	2 months ending 9-Dec-2018	2 months ending 9-Feb-2019	2 months ending 9-Apr-2019	2 months ending 9-Jun-2019	2 months ending 9-Aug-2019	2 months ending 9-Oct-2019	2 months ending 9-Dec-2019	2 months ending 9-Feb-2020	2 months ending 9-Apr-2020	2 months ending 9-Jun-2020	2 months ending 9-Aug-2020
EPU >= 10 nm	0	0.0414%	0.0417%	0.0244%	0.0157%	0.0052%	0.0062%	0.0118%	0.0075%	0.0064%	0.0082%	0.0024%	0.0061%
EPU < 10 nm	1	0.0000%	0.0000%	0.0001%	0.0000%	0.0001%	0.0001%	0.0001%	0.0001%	0.0001%	0.0002%	0.0000%	0.0000%
EPU < 4 nm	2	0.0000%	0.0000%	0.0001%	0.0001%	0.0001%	0.0001%	0.0001%	0.0001%	0.0000%	0.0001%	0.0000%	0.0000%
EPU < 2 nm	3	0.0002%	0.0001%	0.0002%	0.0001%	0.0002%	0.0001%	0.0002%	0.0001%	0.0000%	0.0000%	0.0000%	0.0000%
EPU < 1 nm	4	0.0000%	0.0000%	0.0002%	0.0001%	0.0002%	0.0003%	0.0003%	0.0002%	0.0001%	0.0001%	0.0000%	0.0001%
EPU < 0.5 nm	5	0.0000%	0.0001%	0.0001%	0.0001%	0.0002%	0.0002%	0.0003%	0.0002%	0.0001%	0.0001%	0.0001%	0.0002%
EPU < 0.3 nm	6	0.0001%	0.0005%	0.0008%	0.0011%	0.0013%	0.0012%	0.0018%	0.0009%	0.0005%	0.0005%	0.0005%	0.0010%
EPU < 0.1 nm	7	0.0011%	0.0012%	0.0022%	0.0045%	0.0052%	0.0090%	0.0131%	0.0053%	0.0040%	0.0023%	0.0020%	0.0050%
EPU < 0.05 nm	8	0.4489%	2.7607%	7.5463%	10.1093%	11.9817%	12.9684%	13.1616%	13.7400%	12.4515%	11.5853%	10.8401%	14.5714%
EPU < 30 m	9	70.2584%	68.1576%	64.7317%	64.2970%	63.3747%	63.2764%	60.3573%	60.2502%	60.4150%	60.4906%	58.3762%	59.9414%
EPU < 10 m	10	26.7846%	26.7127%	25.4476%	23.6106%	23.0814%	22.6529%	25.2650%	24.8840%	26.0182%	26.7333%	29.1522%	24.1750%
EPU < 3 m	11	2.4652%	2.3254%	2.2464%	1.9613%	1.5495%	1.0850%	1.1884%	1.1114%	1.1039%	1.1793%	1.6265%	1.2998%
	<8	0.0429%	0.0436%	0.0280%	0.0218%	0.0126%	0.0172%	0.0277%	0.0145%	0.0114%	0.0115%	0.0050%	0.0125%

Note the increased reporting of NACp=8 and NACp=7 during 2019; this is believed to be due to late transponder retrofits of aircraft having pre-existing SA-On GPS position sources. Similar to the NIC results, once NACp falls below 7, the most likely value to be reported is NACp=0.

These analyses of air carrier aircraft NIC/NACp performance includes all major types of GNSS receivers (SA-On, SA-Aware, and SBAS). An analysis in October 2018 which was limited to aircraft with known SA-On GPS receivers showed NIC>6 performance that was worse than indicated in the above results. A more recent analysis described in SP-ASWG12-WP/05, sections 2.7-2.8 ("airborne"), also shows that a similar "sub-fleet" of U.S.-registered air carrier aircraft is about five times more likely to report NIC<7 than the aggregate fleet shown above.

The graphs below show this effect for the most recent analysis period. The first graph shows the NIC>6 availability in percent for the total number of air carrier aircraft (6,882 aircraft). Each data point is the NIC>6 availability for that aircraft computed over the two-month period. The blue dotted line in both graphs shows 99.9% availability, which is the FAA performance target for this parameter. The second graph only shows the 858 air carrier aircraft whose NIC>6 Availability was less than 99.9% during the period. Most of these aircraft are likely using an SA-On GNSS receiver as their position source. Other causes for such NIC reporting can include an aircraft installation issue, a GNSS receiver fault, or GNSS interference testing.



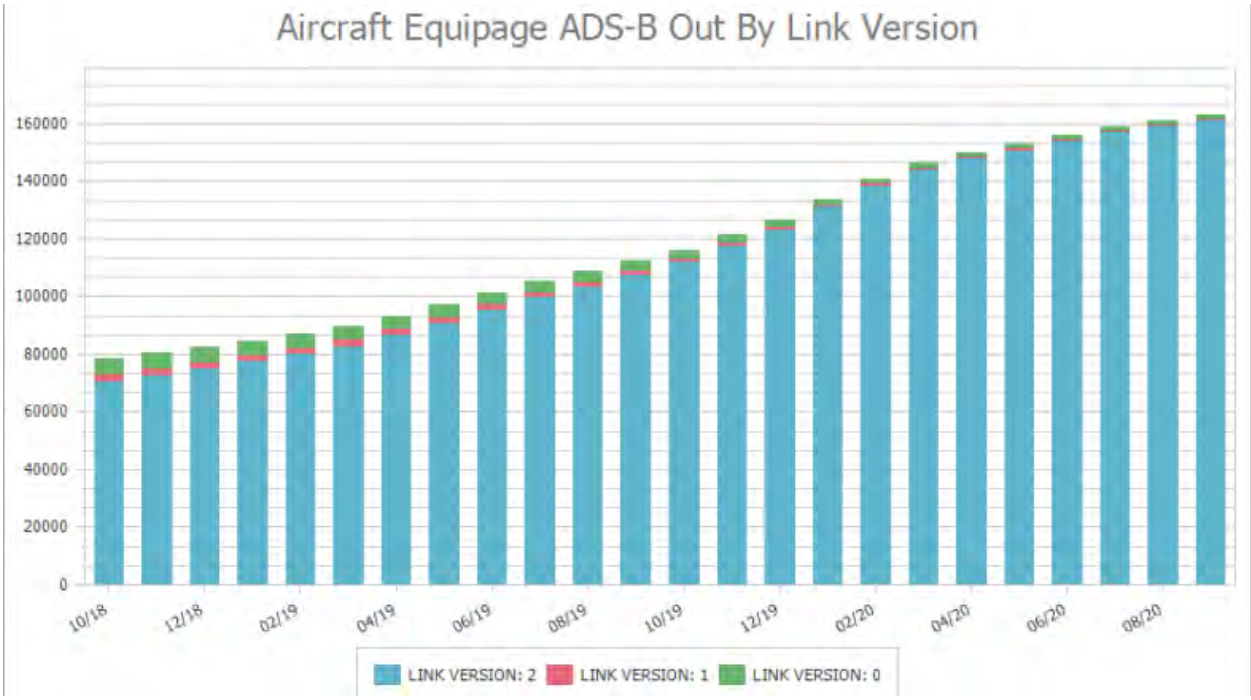


2.2 Tracking ADS-B equipage trends in the U.S.

The FAA's ADS-B Performance Monitor (APM) also has various capabilities for tracking ADS-B equipage trends. The APM tracks unique ICAO aircraft addresses and keeps statistics over the past two years. The count of ICAO aircraft addresses is based on the number of detected addresses during the year prior to the count period. For example, the count of ICAO aircraft addresses in July 2018 includes all addresses detected since July 2017. If an ICAO aircraft address is not detected for over a year, it is dropped from the count in the month when that occurs. Note that the APM counts aircraft detected within U.S. ADS-B coverage, regardless of airspace class; therefore, many ADS-B-equipped aircraft are detected which do not fly in the airspace where the U.S. ADS-B mandate applies.

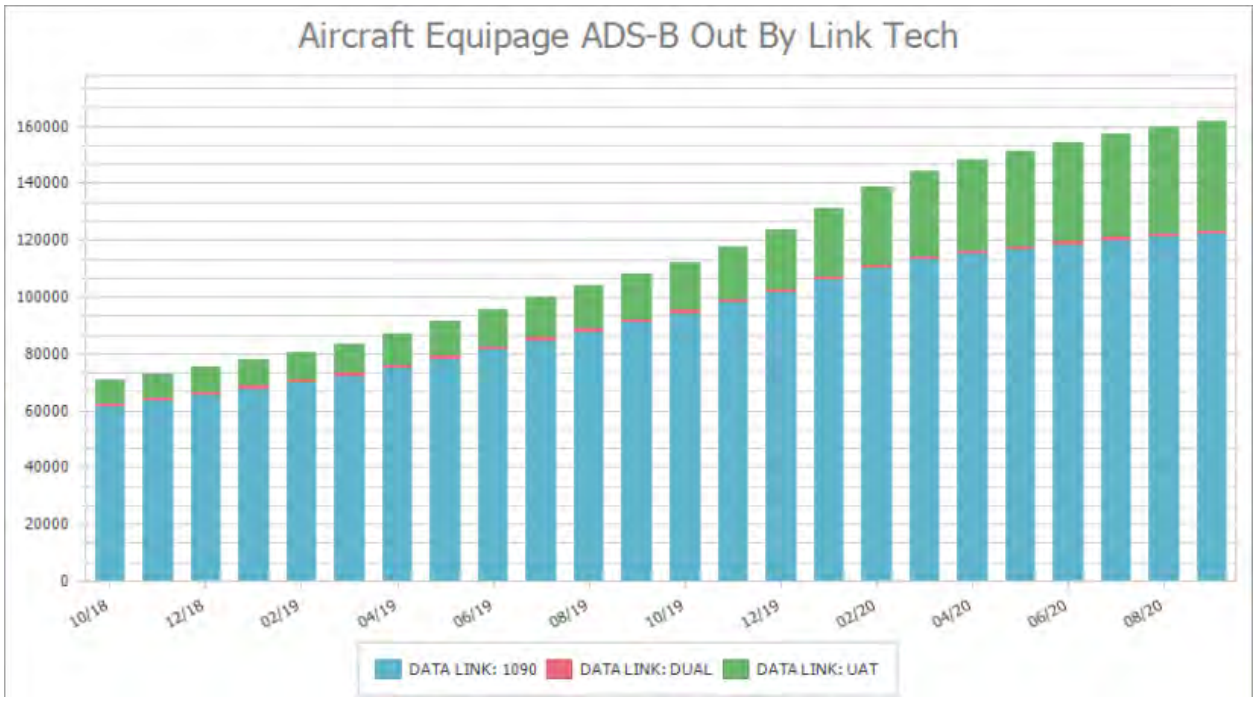
The figure below shows the number of aircraft with different ADS-B versions since 1 October 2018. During this period, the number of ADS-B Version 0 aircraft has decreased from 5,091 to 788; the

number of ADS-B Version 1 aircraft has decreased from 2,537 to 388. In contrast, ADS-B Version 2 aircraft equipage has more than doubled.

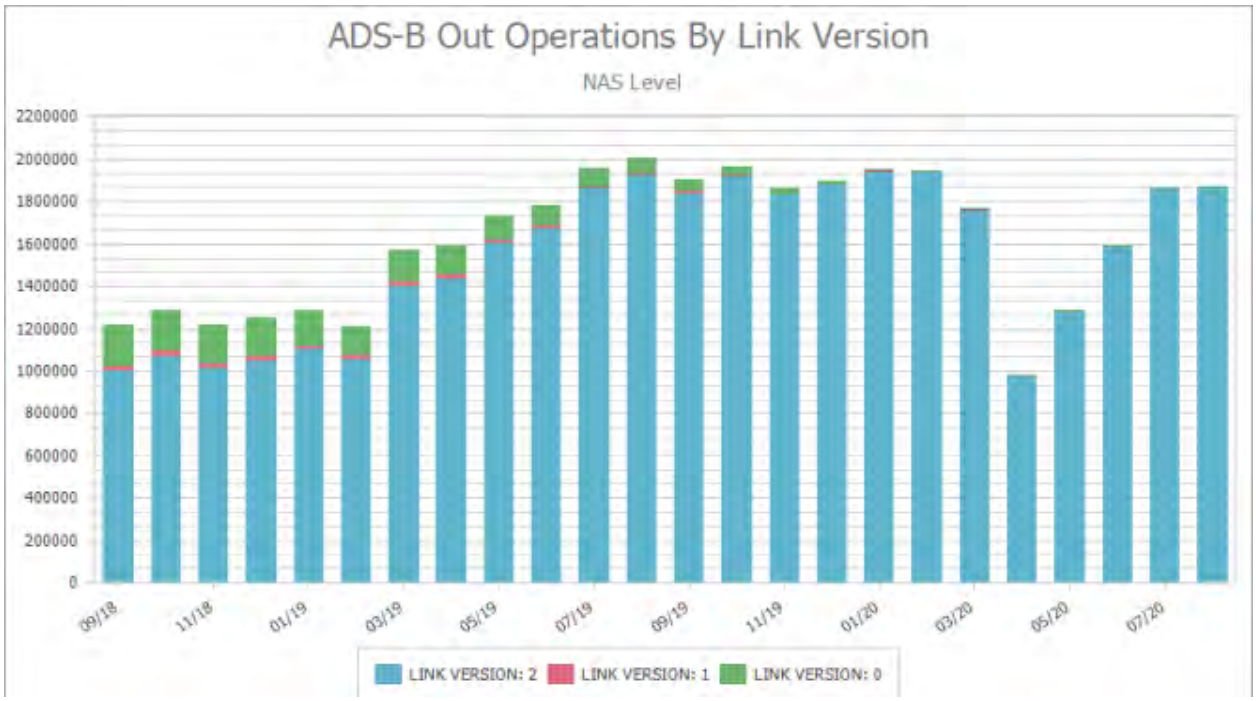


The APM is also capable of showing data by "link technology" – this is useful for understanding the relative fraction of UAT and 1090ES equipage in the U.S. The figure below shows the number of aircraft using different ADS-B technologies since 1 October 2018. Since the U.S. allows use of either 1090ES or UAT ADS-B Out devices, the APM tracks these categories, along with a "Dual" category, as some operators have elected to equip their aircraft with both a 1090ES and UAT device to ensure that their aircraft will be "seen" in U.S. airspace where FAA ADS-B coverage does not exist.

During the period shown, the number of 1090ES-equipped aircraft has roughly doubled, the number of "Dual"-equipped aircraft has been roughly flat at just over 1,000 aircraft, and the number of UAT-equipped aircraft has more than quadrupled. The rapid increase in UAT equipage which began in late 2019 is due largely to the popularity of a UAT product which is packaged with either a wingtip or tailcone light and marketed as a "quick, easy and cheap" installation.

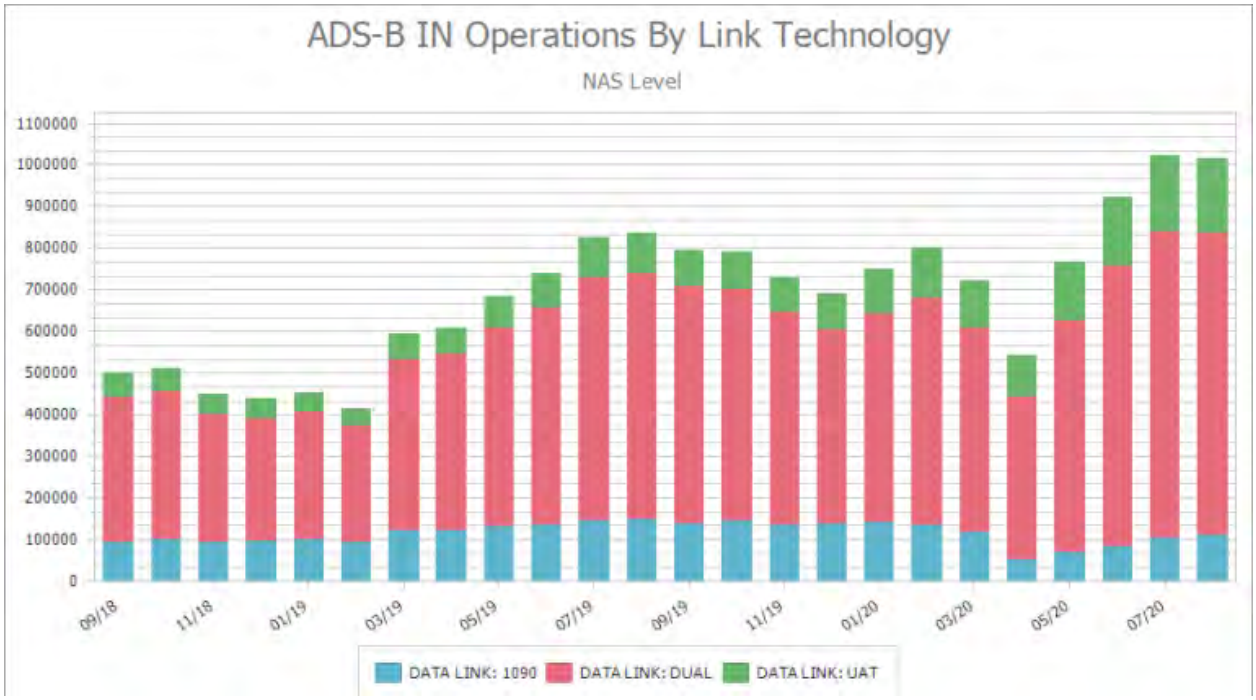


The APM can also display equipage trends as they impact flight operations. The figure below shows the number of operations by different ADS-B versions since 30 September 2018. During this period, the number of ADS-B Version 0 operations has decreased from 188,190 per month to 313 per month; the number of ADS-B Version 1 operations has decreased from 23,688 per month to 1,393 per month. In contrast, ADS-B Version 2 operations almost doubled in January-February 2020, until COVID-19 affected air traffic beginning in March 2020.



The figure below shows the number of operations by different ADS-B-In link technology variations since 30 September 2018 (ADS-B Version 1 is incapable of reporting "Dual" In). During this period, the number of 1090ES ADS-B-In operations has ranged from a low of 56,034 per month to 150,526 per

month; the number of UAT ADS-B-In operations has ranged from 38,788 per month to 181,675 per month. Meanwhile, the number of Dual-In ADS-B-In operations has generally increased from 279,843 per month to 734,144. The seasonal variations seen in this two-year data sample show that most ADS-B-In systems are installed in general aviation aircraft – these aircraft fly more often in the summer than in the winter. Similar to above, the impact of COVID-19 on U.S. air traffic operations in April 2020 can be clearly observed.



3. CONCLUSION

3.1 The meeting is invited to:

a) note the information contained in this paper; and

b) discuss any relevant matters as appropriate.

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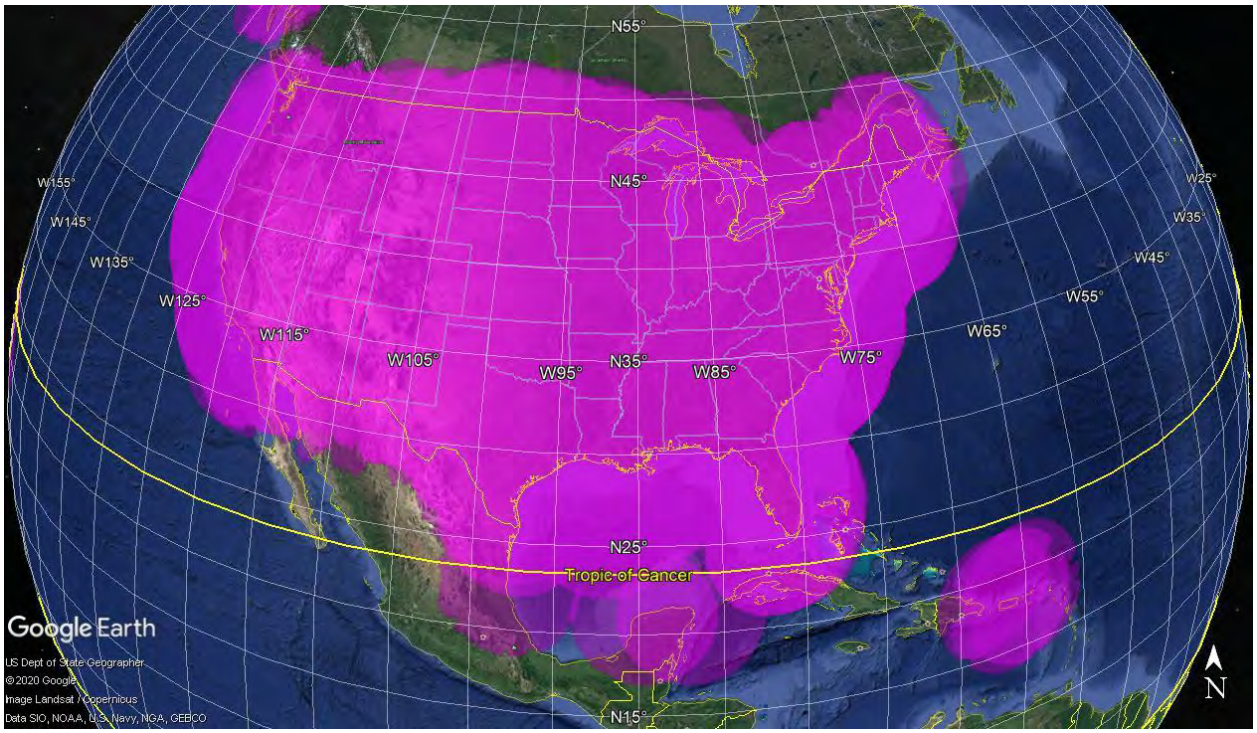
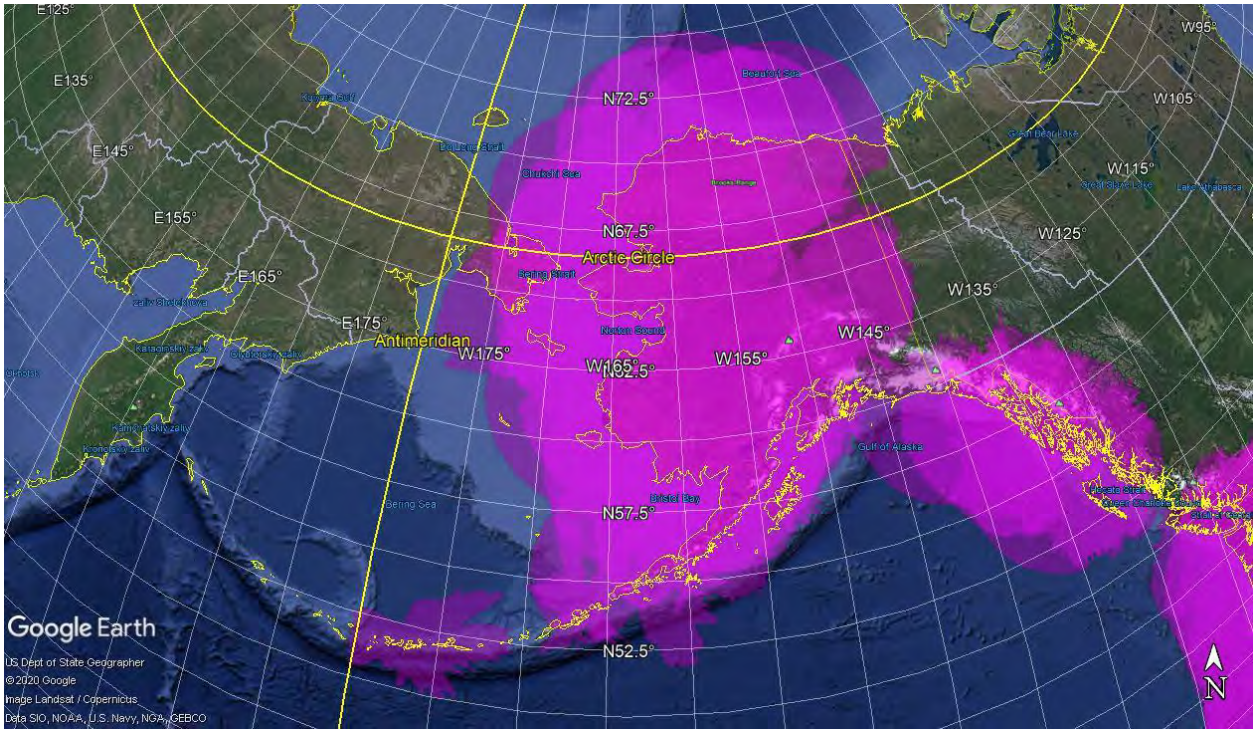
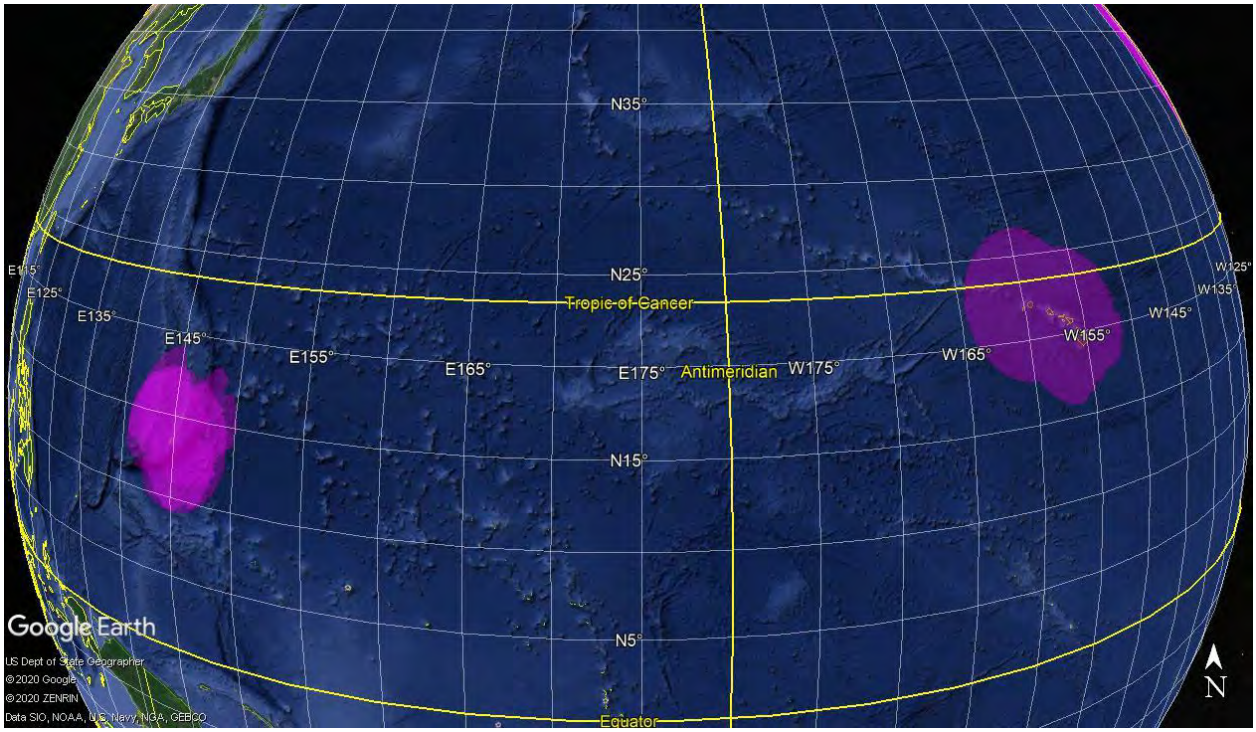
ATTACHMENT 1
FAA ADS-B Coverage at FL350 (shading intensity indicates degree of overlap in coverage)



North America and Puerto Rico/Virgin Islands



Northwestern North America (Alaska)



Guam/CNMI and Hawaii

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