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Agenda Item 6: Report on surveillance ground system and avionics performance monitoring and improvement in compliance

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

(Presented by name of United States/Federal Aviation Administration)

**SUMMARY**

This paper provides a summary of observed NIC/NACp performance for air carrier aircraft 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 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 a typical turbine-powered aircraft flight level (FL350) 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.

1.2 In early 2022, the FAA added the ability within its ADS-B Performance Monitor (APM) to compute NIC/NACp performance only when aircraft are within the airspace defined in 14 CFR 91.225[1], which is limited to U.S. domestic airspace. U.S. domestic airspace exists over all land mass regions of the U.S. as defined in 14 CFR § 1.1 and includes the individual states of the U.S. (contiguous and non-contiguous), the District of Columbia, Puerto Rico, and U.S. possessions, including the surrounding territorial waters. Areas beyond 12 nautical miles from the U.S. coastline are considered part of ICAO airspace. U.S. airspace regulations do not apply in ICAO airspace even when the FAA opts to apply domestic air traffic procedures in certain regions of U.S.-managed ICAO airspace.

[1] In general, the U.S. ADS-B mandate applies to operations in Domestic Class A/B/C airspace, and Domestic Class E airspace above 10,000 ft MSL or 2,500 ft above the local terrain, whichever is higher.

## 2. DISCUSSION

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

2.1.1 The FAA's APM automatically generates a report used to analyse how well ADS-B Version 2 systems installed on aircraft are meeting the requirements of the U.S. ADS-B mandate. This paper only discusses the performance of air carrier aircraft; 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. To ensure statistical validity, detected aircraft with less than 10,000 ADS-B reports during each two-month analysis period are excluded from the results. Additionally, for all analysis results since the beginning of 2022, aircraft with known avionics installation issues (SDA<2, SIL<3, or NACv<1 for more than about 40% of each aircraft's operational time during the analysis period) are also excluded from this analysis – in an average two-month analysis period, this is typically around 10-20 air carrier aircraft during each analysis period. These analysis results include all major types of ADS-B position sources (SA-On, SA Aware, and SBAS) currently available on air carrier aircraft.

2.1.2 During the most recent two-month analysis window ending on 9 April 2024 for the full airspace shown in Attachment 1, just over 31.5% (3,131 out of 9,926) of the observed air carrier aircraft were registered outside the U.S. However, during the same two-month analysis window for aircraft operating only in the airspace defined by 14 CFR 91.225, approximately 29.2% (2,798 out of 9,575) of the air carrier aircraft were registered outside the U.S.

2.1.3 As used in this paper, "operational availability" is defined as the percentage of time that a system or service is available at the expected level of performance, relative to its expected use. In this paper, the term "outage" typically refers to the system or service dropping below the expected level of performance (versus complete failure of the system or service). Since FAA ATC applications always operate, the expected use period does not end. Therefore, 100% operational availability would be a system or service which is continually available at the expected level of performance during the entire measurement period. Traditionally, the FAA has used an operational availability requirement of greater than or equal to 99.9% for each surveillance sensor when engineering FAA ATC surveillance systems. This allows a maximum surveillance sensor "outage" duration of 0.1%, which is about 86 seconds during a given 24-hour period (or almost 9 hours per year). The analysis results discussed in this paper proceed with this surveillance requirement in mind.

2.1.4 As noted above in section 1, the APM is now capable of creating operational availability reports in two forms – one for all ADS-B data received by the U.S. ADS-B ground stations, and one for only the U.S. domestic airspace in which the provisions of 14 CFR 91.225 apply. The latter report is referred to as a "rule airspace" report and the analysis of this report is described in sections 2.1.11 to 2.1.16.

2.1.5 In the tables below, red cell shading indicates that the ADS-B position quality is insufficient for the data to be used by FAA ATC systems, green cell shading indicates that the ADS-B position quality meets the requirements of 14 CFR 91.227, and yellow cell shading indicates that the ADS-B data may be used by ATC but is insufficient to support separation minima of 3 nm or closer. Therefore, for FAA to consistently support 3 nm separation in en route airspace below FL230 using ADS-B data, aircraft must produce "green shading" performance. In the bottom row of each table, orange shading indicates the aggregation of the red and yellow shaded rows, when the requirements of 14 CFR 91.227 are not being met.

2.1.6 NIC performance for air carrier aircraft during the two-year period ending 9 April 2024 is shown in the below table.

| Radius of Containment (Rc) | NIC | 2 months ending 9-Jun-2022 | 2 months ending 9-Aug-2022 | 2 months ending 9-Oct-2022 | 2 months ending 9-Dec-2022 | 2 months ending 9-Feb-2023 | 2 months ending 9-Apr-2023 | 2 months ending 9-Jun-2023 | 2 months ending 9-Aug-2023 | 2 months ending 9-Oct-2023 | 2 months ending 9-Dec-2023 | 2 months ending 9-Feb-2024 | 2 months ending 9-Apr-2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rc unknown | 0 | 0.0084% | 0.0102% | 0.0118% | 0.0131% | 0.0123% | 0.0102% | 0.0084% | 0.0090% | 0.0118% | 0.0120% | 0.0101% | 0.0107% |
| Rc < 20 nm | 1 | 0.0002% | 0.0001% | 0.0003% | 0.0002% | 0.0002% | 0.0002% | 0.0002% | 0.0003% | 0.0005% | 0.0004% | 0.0002% | 0.0002% |
| Rc < 8 nm | 2 | 0.0003% | 0.0003% | 0.0003% | 0.0002% | 0.0002% | 0.0001% | 0.0004% | 0.0002% | 0.0003% | 0.0003% | 0.0001% | 0.0001% |
| Rc < 4 nm | 3 | 0.0002% | 0.0002% | 0.0002% | 0.0002% | 0.0001% | 0.0001% | 0.0002% | 0.0001% | 0.0003% | 0.0002% | 0.0001% | 0.0001% |
| Rc < 2 nm | 4 | 0.0003% | 0.0004% | 0.0005% | 0.0004% | 0.0002% | 0.0003% | 0.0003% | 0.0002% | 0.0006% | 0.0005% | 0.0002% | 0.0003% |
| Rc < 1 nm | 5 | 0.0004% | 0.0005% | 0.0005% | 0.0004% | 0.0003% | 0.0005% | 0.0003% | 0.0003% | 0.0007% | 0.0007% | 0.0003% | 0.0002% |
| Rc < 0.6 nm | 6(0) | 0.0002% | 0.0003% | 0.0002% | 0.0003% | 0.0001% | 0.0002% | 0.0001% | 0.0001% | 0.0004% | 0.0003% | 0.0002% | 0.0001% |
| Rc < 0.5 nm | 6(1) | 0.0021% | 0.0012% | 0.0016% | 0.0032% | 0.0010% | 0.0018% | 0.0007% | 0.0012% | 0.0040% | 0.0014% | 0.0026% | 0.0016% |
| Rc < 0.3 nm | 6(2) | 0.0110% | 0.0068% | 0.0278% | 0.0282% | 0.0207% | 0.0120% | 0.0124% | 0.0186% | 0.0367% | 0.0169% | 0.0418% | 0.0097% |
| | *6 (Sum)* | *0.0137%* | *0.0088%* | *0.0302%* | *0.0321%* | *0.0221%* | *0.0145%* | *0.0135%* | *0.0203%* | *0.0418%* | *0.0192%* | *0.0449%* | *0.0117%* |
| Rc < 0.2 nm | 7 | 4.4369% | 3.8917% | 4.0658% | 3.5675% | 3.2447% | 2.8407% | 2.7048% | 2.6429% | 2.3536% | 1.9500% | 1.8256% | 1.3422% |
| Rc < 0.1 nm | 8 | 95.4807% | 96.0303% | 95.8380% | 96.3277% | 96.6773% | 97.0929% | 97.2384% | 97.2923% | 97.5623% | 97.9958% | 98.0889% | 98.6084% |
| Rc < 75 m | 9 | 0.0499% | 0.0487% | 0.0530% | 0.0549% | 0.0428% | 0.0409% | 0.0338% | 0.0346% | 0.0288% | 0.0214% | 0.0299% | 0.0264% |
| Rc < 25 m | 10 | 0.0093% | 0.0094% | 0.0000% | 0.0037% | 0.0000% | 0.0000% | 0.0000% | 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 | | 1.178E+10 | 1.196E+10 | 1.179E+10 | 1.190E+10 | 1.179E+10 | 1.249E+10 | 1.173E+10 | 1.263E+10 | 1.249E+10 | 1.255E+10 | 1.193E+10 | 1.161E+10 |
| # aircraft | | 9,155 | 9,235 | 9,277 | 9,340 | 9,443 | 9,493 | 9,538 | 9,671 | 9,761 | 9,815 | 9,644 | 9,926 |
| reports/aircrft | | 1,286,910 | 1,295,551 | 1,270,467 | 1,273,947 | 1,248,975 | 1,315,749 | 1,229,386 | 1,305,515 | 1,279,246 | 1,278,354 | 1,236,806 | 1,169,232 |
| | <7 | 0.0232% | 0.0200% | 0.0432% | 0.0462% | 0.0351% | 0.0255% | 0.0229% | 0.0301% | 0.0553% | 0.0328% | 0.0556% | 0.0230% |

2.1.7 The NIC results are generally consistent over the analysis period. Note that once NIC falls below 6, the most likely value to be reported is NIC=0.

2.1.8 NACp performance for air carrier aircraft during the period ending 9 April 2024 is shown in the below table.

| Est Position Uncertainty | NACp | 2 months ending 9-Jun-2022 | 2 months ending 9-Aug-2022 | 2 months ending 9-Oct-2022 | 2 months ending 9-Dec-2022 | 2 months ending 9-Feb-2023 | 2 months ending 9-Apr-2023 | 2 months ending 9-Jun-2023 | 2 months ending 9-Aug-2023 | 2 months ending 9-Oct-2023 | 2 months ending 9-Dec-2023 | 2 months ending 9-Feb-2024 | 2 months ending 9-Apr-2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EPU >= 10 nm | 0 | 0.0053% | 0.0039% | 0.0052% | 0.0069% | 0.0058% | 0.0060% | 0.0038% | 0.0052% | 0.0075% | 0.0078% | 0.0057% | 0.0078% |
| EPU < 10 nm | 1 | 0.0000% | 0.0001% | 0.0000% | 0.0001% | 0.0001% | 0.0002% | 0.0001% | 0.0001% | 0.0003% | 0.0002% | 0.0001% | 0.0002% |
| EPU < 4 nm | 2 | 0.0000% | 0.0003% | 0.0002% | 0.0002% | 0.0001% | 0.0001% | 0.0004% | 0.0003% | 0.0004% | 0.0003% | 0.0001% | 0.0003% |
| EPU < 2 nm | 3 | 0.0000% | 0.0000% | 0.0001% | 0.0000% | 0.0000% | 0.0000% | 0.0000% | 0.0000% | 0.0000% | 0.0000% | 0.0000% | 0.0000% |
| EPU < 1 nm | 4 | 0.0000% | 0.0001% | 0.0001% | 0.0001% | 0.0001% | 0.0000% | 0.0001% | 0.0000% | 0.0001% | 0.0000% | 0.0000% | 0.0000% |
| EPU < 0.5 nm | 5 | 0.0000% | 0.0001% | 0.0001% | 0.0001% | 0.0001% | 0.0000% | 0.0000% | 0.0000% | 0.0001% | 0.0000% | 0.0000% | 0.0000% |
| EPU < 0.3 nm | 6 | 0.0004% | 0.0004% | 0.0005% | 0.0005% | 0.0005% | 0.0002% | 0.0003% | 0.0001% | 0.0006% | 0.0004% | 0.0001% | 0.0004% |
| EPU < 0.1 nm | 7 | 0.0062% | 0.0032% | 0.0014% | 0.0051% | 0.0116% | 0.0045% | 0.0021% | 0.0021% | 0.0053% | 0.0045% | 0.0050% | 0.0045% |
| EPU < 0.05 nm | 8 | 9.7848% | 9.6341% | 9.6076% | 9.5536% | 9.0487% | 7.5731% | 6.6929% | 6.0039% | 5.0640% | 4.6697% | 3.7394% | 4.6697% |
| EPU < 30 m | 9 | 54.2403% | 53.5885% | 52.8062% | 51.2732% | 49.9289% | 47.0670% | 45.8047% | 44.6650% | 42.9137% | 40.8351% | 40.8629% | 40.8351% |
| EPU < 10 m | 10 | 34.9988% | 35.8851% | 36.6322% | 38.0891% | 39.6077% | 44.1965% | 46.1073% | 48.1682% | 50.8646% | 53.3660% | 54.2723% | 53.3660% |
| EPU < 3 m | 11 | 0.9641% | 0.8842% | 0.9465% | 1.0711% | 1.3965% | 1.1523% | 1.3884% | 1.1550% | 1.1435% | 1.1158% | 1.1143% | 1.1158% |
| | <8 | 0.0120% | 0.0081% | 0.0075% | 0.0130% | 0.0182% | 0.0110% | 0.0068% | 0.0079% | 0.0142% | 0.0133% | 0.0111% | 0.0133% |

2.1.9 The overall trends are similar to the NIC analyses results, but it is clear that NACp rule violations are less likely than for NIC. For this and other reasons, NIC performance generally defines the limits for using ADS-B data in ATC operations.

2.1.10 Figure 1 shows the percentage of air carrier aircraft in each bimonthly data sample in all airspace within range of U.S. ADS-B ground stations since 9-Apr-2017 which failed to meet the previously defined criteria of NIC>6 at or above 99.900 percent. The dashed line is the Excel-computed trend line and shows a declining trend. It is expected that an overall declining trend will contine in the future as air carrier aircraft with newer position sources are introduced (new production aircraft) and as aircraft equipped with GPS SA-On ADS-B position sources are retrofitted with modern position source solutions.

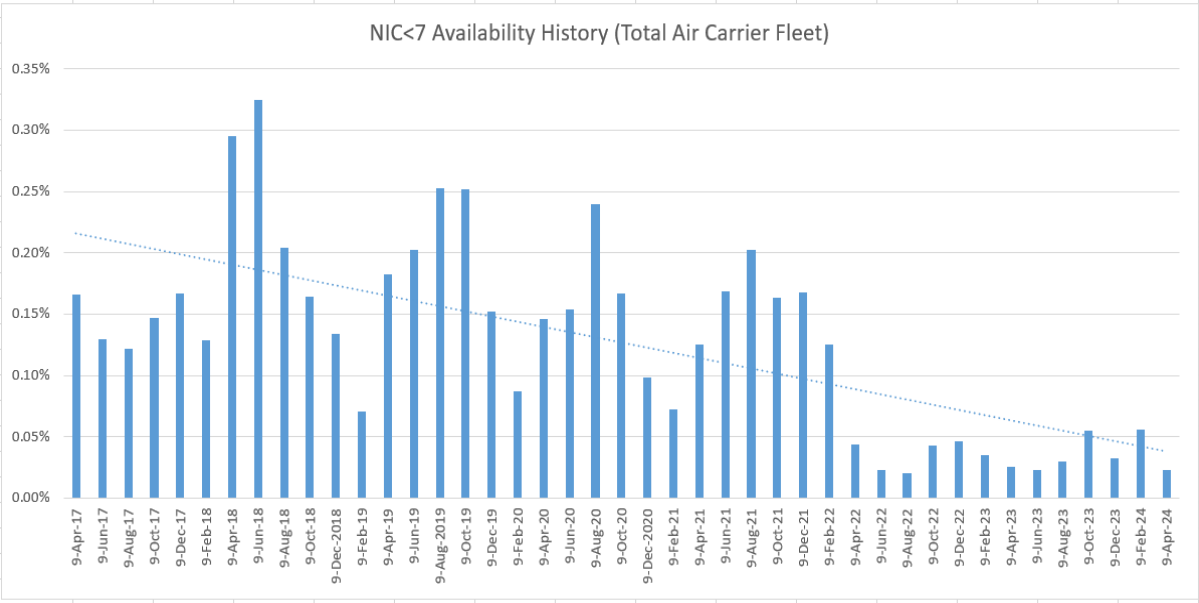


Figure 1 – Percentage of air carrier aircraft not meeting NIC>6 availability criteria

2.1.11 This section through section 2.1.16 presents analyses of operations which are limited to the airspace defined in 14 CFR 91.225 (see section 1.2), in a format equivalent to that provided in 2.1.6 through 2.1.10 above. Since these analyses cover smaller regions of airspace than shown in Attachment 1, the number of air carrier aircraft is fewer. The air carrier aircraft excluded are typically operated by non-U.S. air carriers which do not fly in the airspace where the U.S. ADS-B mandate applies.

2.1.12 NIC performance in rule airspace for air carrier aircraft from 9 June 2022 to 9 April 2024 is shown in the below table.

| Radius of Containment (Rc) | NIC | 2 months ending 9-Jun-2022 | 2 months ending 9-Aug-2022 | 2 months ending 9-Oct-2022 | 2 months ending 9-Dec-2022 | 2 months ending 9-Feb-2023 | 2 months ending 9-Apr-2023 | 2 months ending 9-Jun-2023 | 2 months ending 9-Aug-2023 | 2 months ending 9-Oct-2023 | 2 months ending 9-Dec-2023 | 2 months ending 9-Feb-2024 | 2 months ending 9-Apr-2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rc unknown | 0 | 0.0068% | 0.0081% | 0.0102% | 0.0122% | 0.0109% | 0.0085% | 0.0065% | 0.0068% | 0.0105% | 0.0107% | 0.0080% | 0.0088% |
| Rc < 20 nm | 1 | 0.0002% | 0.0001% | 0.0003% | 0.0002% | 0.0002% | 0.0003% | 0.0003% | 0.0003% | 0.0005% | 0.0005% | 0.0002% | 0.0002% |
| Rc < 8 nm | 2 | 0.0003% | 0.0003% | 0.0003% | 0.0002% | 0.0002% | 0.0002% | 0.0003% | 0.0002% | 0.0003% | 0.0003% | 0.0001% | 0.0001% |
| Rc < 4 nm | 3 | 0.0002% | 0.0002% | 0.0003% | 0.0002% | 0.0001% | 0.0001% | 0.0001% | 0.0001% | 0.0003% | 0.0003% | 0.0001% | 0.0001% |
| Rc < 2 nm | 4 | 0.0003% | 0.0004% | 0.0006% | 0.0004% | 0.0002% | 0.0003% | 0.0003% | 0.0002% | 0.0007% | 0.0006% | 0.0002% | 0.0003% |
| Rc < 1 nm | 5 | 0.0004% | 0.0006% | 0.0005% | 0.0004% | 0.0003% | 0.0005% | 0.0003% | 0.0003% | 0.0007% | 0.0007% | 0.0003% | 0.0002% |
| Rc < 0.6 nm | 6(0) | 0.0003% | 0.0003% | 0.0003% | 0.0003% | 0.0002% | 0.0003% | 0.0001% | 0.0001% | 0.0004% | 0.0003% | 0.0002% | 0.0001% |
| Rc < 0.5 nm | 6(1) | 0.0022% | 0.0013% | 0.0018% | 0.0033% | 0.0011% | 0.0019% | 0.0008% | 0.0014% | 0.0044% | 0.0015% | 0.0028% | 0.0015% |
| Rc < 0.3 nm | 6(2) | 0.0119% | 0.0071% | 0.0294% | 0.0302% | 0.0223% | 0.0130% | 0.0136% | 0.0209% | 0.0402% | 0.0185% | 0.0446% | 0.0105% |
| | *6 (Sum)* | *0.0148%* | *0.0093%* | *0.0319%* | *0.0342%* | *0.0238%* | *0.0157%* | *0.0148%* | *0.0227%* | *0.0458%* | *0.0210%* | *0.0478%* | *0.0123%* |
| Rc < 0.2 nm | 7 | 4.7598% | 4.1837% | 4.3390% | 3.8150% | 3.4989% | 3.0550% | 2.9127% | 2.8720% | 2.5281% | 2.0922% | 1.9724% | 1.4433% |
| Rc < 0.1 nm | 8 | 95.1682% | 95.7504% | 95.5666% | 96.0859% | 96.4254% | 96.8835% | 97.0327% | 97.0671% | 97.3909% | 97.8556% | 97.9470% | 98.5141% |
| Rc < 75 m | 9 | 0.0435% | 0.0410% | 0.0509% | 0.0512% | 0.0402% | 0.0364% | 0.0323% | 0.0305% | 0.0229% | 0.0190% | 0.0240% | 0.0208% |
| Rc < 25 m | 10 | 0.0059% | 0.0064% | 0.0000% | 0.0005% | 0.0000% | 0.0000% | 0.0000% | 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 | | 1.020E+10 | 1.037E+10 | 1.027E+10 | 1.036E+10 | 1.016E+10 | 1.082E+10 | 1.021E+10 | 1.088E+10 | 1.087E+10 | 1.094E+10 | 1.024E+10 | 9.997E+09 |
| # aircraft | | 8,860 | 8,945 | 8,948 | 8,979 | 9,084 | 9,160 | 9,215 | 9,360 | 9,439 | 9,516 | 9,355 | 9,575 |
| reports/aircrft | | 1,151,217 | 1,158,906 | 1,148,126 | 1,154,016 | 1,118,058 | 1,180,820 | 1,107,653 | 1,162,074 | 1,151,830 | 1,149,324 | 1,094,090 | 1,044,079 |
| | <7 | 0.0225% | 0.0184% | 0.0435% | 0.0474% | 0.0355% | 0.0251% | 0.0223% | 0.0303% | 0.0581% | 0.0332% | 0.0565% | 0.0217% |

2.1.13 The NIC results in rule airspace appear comparable to the results in all U.S. ADS-B coverage areas.

2.1.14 NACp performance in rule airspace for air carrier aircraft from 9 June 2022 to 9 April 2024 is shown in the below table.

| Est Position Uncertainty | NACp | 2 months ending 9-Jun-2022 | 2 months ending 9-Aug-2022 | 2 months ending 9-Oct-2022 | 2 months ending 9-Dec-2022 | 2 months ending 9-Feb-2023 | 2 months ending 9-Apr-2023 | 2 months ending 9-Jun-2023 | 2 months ending 9-Aug-2023 | 2 months ending 9-Oct-2023 | 2 months ending 9-Dec-2023 | 2 months ending 9-Feb-2024 | 2 months ending 9-Apr-2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EPU >= 10 nm | 0 | 0.0037% | 0.0046% | 0.0067% | 0.0059% | 0.0068% | 0.0056% | 0.0034% | 0.0045% | 0.0073% | 0.0076% | 0.0052% | 0.0064% |
| EPU < 10 nm | 1 | 0.0001% | 0.0000% | 0.0002% | 0.0001% | 0.0001% | 0.0002% | 0.0001% | 0.0002% | 0.0003% | 0.0002% | 0.0001% | 0.0001% |
| EPU < 4 nm | 2 | 0.0002% | 0.0002% | 0.0002% | 0.0001% | 0.0002% | 0.0002% | 0.0003% | 0.0003% | 0.0003% | 0.0003% | 0.0001% | 0.0001% |
| EPU < 2 nm | 3 | 0.0000% | 0.0001% | 0.0000% | 0.0000% | 0.0000% | 0.0000% | 0.0000% | 0.0000% | 0.0000% | 0.0000% | 0.0000% | 0.0000% |
| EPU < 1 nm | 4 | 0.0001% | 0.0002% | 0.0001% | 0.0001% | 0.0000% | 0.0000% | 0.0001% | 0.0000% | 0.0001% | 0.0000% | 0.0000% | 0.0000% |
| EPU < 0.5 nm | 5 | 0.0001% | 0.0001% | 0.0001% | 0.0001% | 0.0000% | 0.0000% | 0.0000% | 0.0001% | 0.0001% | 0.0000% | 0.0000% | 0.0000% |
| EPU < 0.3 nm | 6 | 0.0004% | 0.0005% | 0.0006% | 0.0006% | 0.0003% | 0.0003% | 0.0003% | 0.0002% | 0.0007% | 0.0004% | 0.0001% | 0.0002% |
| EPU < 0.1 nm | 7 | 0.0035% | 0.0015% | 0.0055% | 0.0125% | 0.0081% | 0.0049% | 0.0022% | 0.0022% | 0.0057% | 0.0049% | 0.0056% | 0.0013% |
| EPU < 0.05 nm | 8 | 10.1819% | 10.1639% | 10.0751% | 9.5768% | 8.5639% | 7.9829% | 7.1096% | 6.4369% | 5.3753% | 4.9333% | 3.9931% | 3.3270% |
| EPU < 30 m | 9 | 52.5418% | 51.8153% | 50.4375% | 49.0151% | 47.6975% | 46.0009% | 44.8155% | 43.6550% | 41.9022% | 39.6992% | 39.5528% | 38.1303% |
| EPU < 10 m | 10 | 36.3005% | 36.9816% | 38.3119% | 39.8696% | 42.5087% | 44.7381% | 46.5438% | 48.6205% | 51.4501% | 54.1266% | 55.1921% | 57.1642% |
| EPU < 3 m | 11 | 0.9676% | 1.0320% | 1.1622% | 1.5191% | 1.2145% | 1.2669% | 1.5247% | 1.2802% | 1.2579% | 1.2274% | 1.2508% | 1.3704% |
| | <8 | 0.0082% | 0.0071% | 0.0133% | 0.0194% | 0.0155% | 0.0112% | 0.0064% | 0.0074% | 0.0144% | 0.0135% | 0.0111% | 0.0081% |

2.1.15 The NACp results in rule airspace are comparable to the results in all U.S. ADS-B coverage areas.

2.1.16 Figure 2 shows the percentage of aircraft in each bimonthly data sample in rule airspace taken since 9-Apr-2022 which failed to meet the previously defined criteria of NIC>6 at or above 99.900 percent. The dashed line is the Excel-computed trend line and shows a slight declining trend, though clearly there are variations in the bi-monthly results around this trend line. It is expected that an overall declining trend will continue in the future as air carrier aircraft with newer position sources are introduced (new production aircraft) and as aircraft equipped with GPS SA-On ADS-B position sources are retrofitted with modern position source solutions. A comparison of Figure 2 with Figure 1 for the same analysis periods shows that in general, rule airspace had about one-half to one percent fewer air carrier aircraft which did not meet the criteria of NIC>6 at or above 99.900 percent availability during each analysis period. Note also that although data trends are comparable in Figure 1 and Figure 2 during the last year, the Excel-computed trend line in Figure 2 is different, reflecting the fact that the recent data trend is relatively flat, even though the longer-term trend from Figure 1 is more favorable.

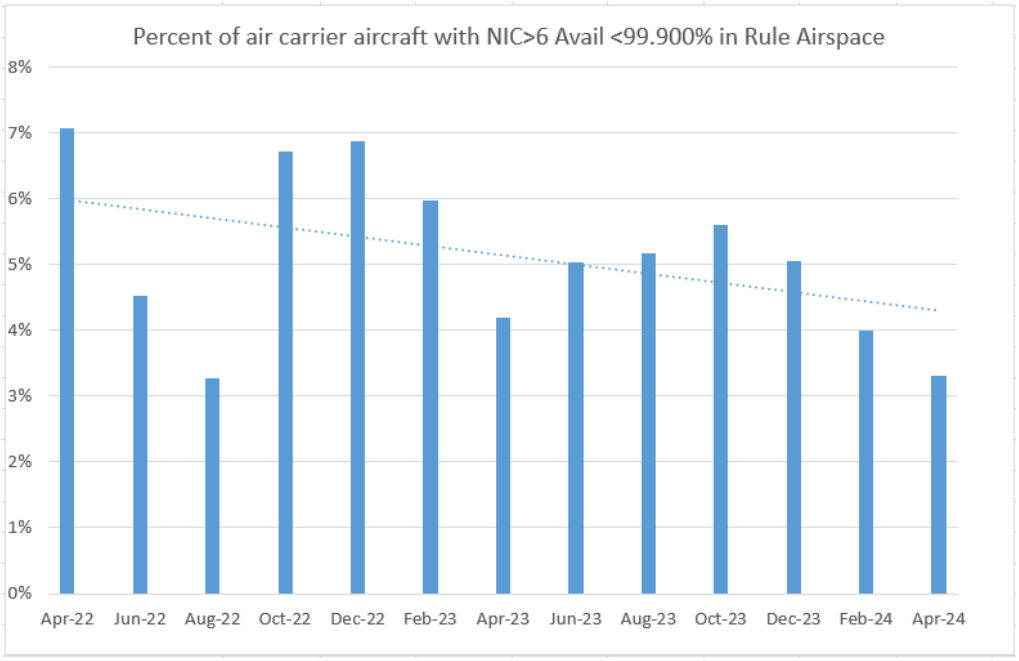


Figure 2 – Percentage of air carrier aircraft in rule airspace not meeting NIC>6 availability criteria

2.1.17 Figures 3 and 4 summarize the NIC>6 Availability performance for air carrier aircraft not meeting NIC>6 Availability of 99.900%, sorted from worst to best performing aircraft operating during the bimonthly period ending 9 April 2024. Figure 3 is for all ADS-B-covered U.S. airspace and Figure 4 is for rule airspace, with the horizontal scale compensated to align with Figure 3 for comparison purposes. These figures show very similar results. It should be noted that causes for degradation in NIC performance can be due to the position source type (GPS SA-On), an aircraft installation issue (including a degraded/faulty GNSS antenna or cabling), a GNSS receiver fault, or GNSS interference testing.

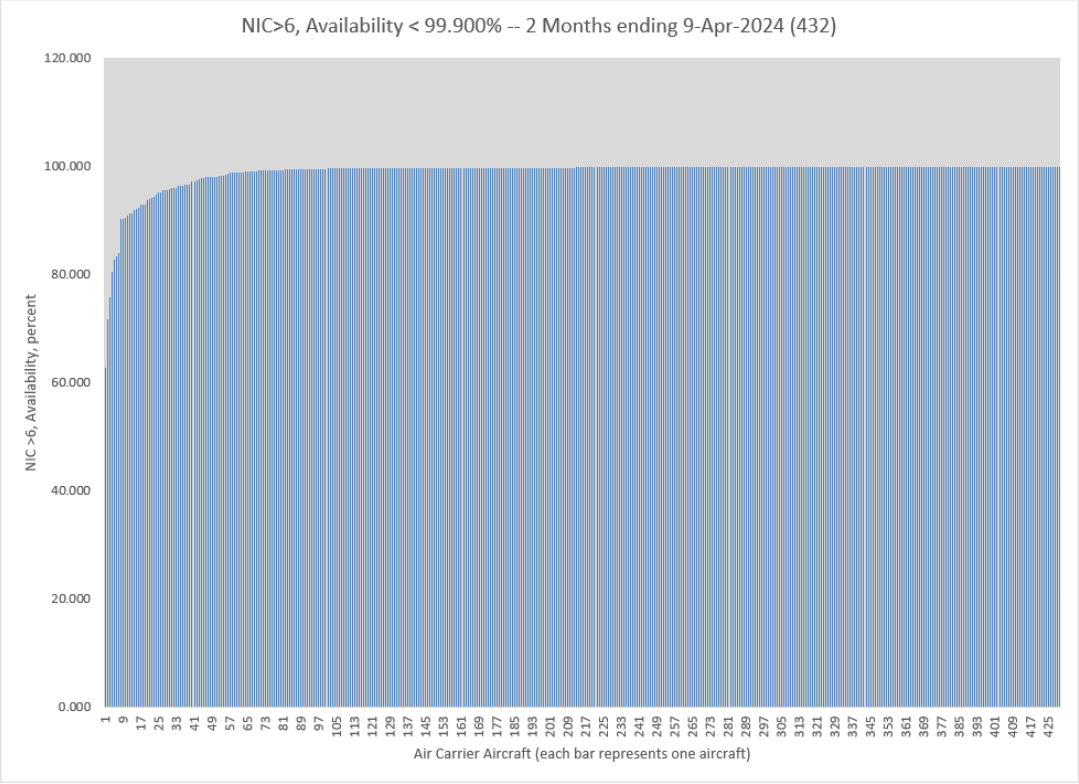


Figure 3 – NIC>6 availability performance for air carrier aircraft not meeting NIC>6 Availability of 99.900%, sorted from worst to best NIC>6 Availability performance (four aircraft were below 82%)

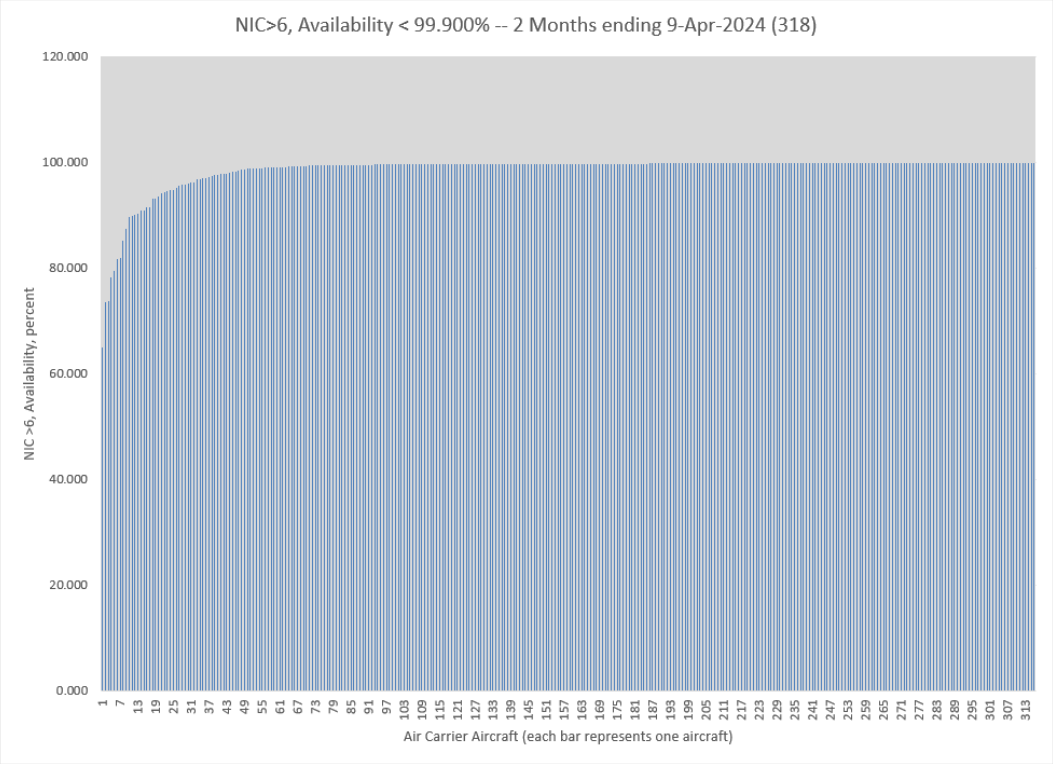


Figure 4 – NIC>6 availability performance in rule airspace for air carrier aircraft not meeting NIC>6 Availability of 99.900%, sorted from worst to best NIC>6 Availability performance (horizontal scale compensated to align with Figure 3 for comparison purposes) (seven aircraft were below 82%)

## 2.2 Tracking ADS-B Equipage Trends in the U.S.

2.2.1 The FAA's 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 May 2023 includes all addresses detected since May 2022. If an ICAO aircraft address is not detected for over a year, it is dropped from the current month's count. Other facts to note include the reality that incorrect ICAO aircraft addresses are counted just the same as "correct" ones, and if multiple aircraft use a single ICAO aircraft address, the address is only counted once. An example of an "incorrect" ICAO aircraft address is the use of an ICAO aircraft address which is outside of any address block allocated by ICAO to an ICAO-contracting State.

2.2.2 Note that the APM is counting ICAO aircraft addresses detected within U.S. ADS-B coverage, regardless of airspace class; therefore, some ADS-B-equipped aircraft are detected which do not fly in the airspace where the U.S. ADS-B mandate applies.

2.2.3 Figure 5 shows the number of ICAO aircraft addresses with different ADS B versions since April 2022. During this period, the number of ADS B Version 0 ICAO aircraft addresses decreased from 67 in April 2022 to 20 in March 2024; the number of ADS B Version 1 ICAO aircraft addresses decreased from 91 to 57. In contrast, ADS-B Version 2 ICAO aircraft addresses increased from 159,911 to 168,434.

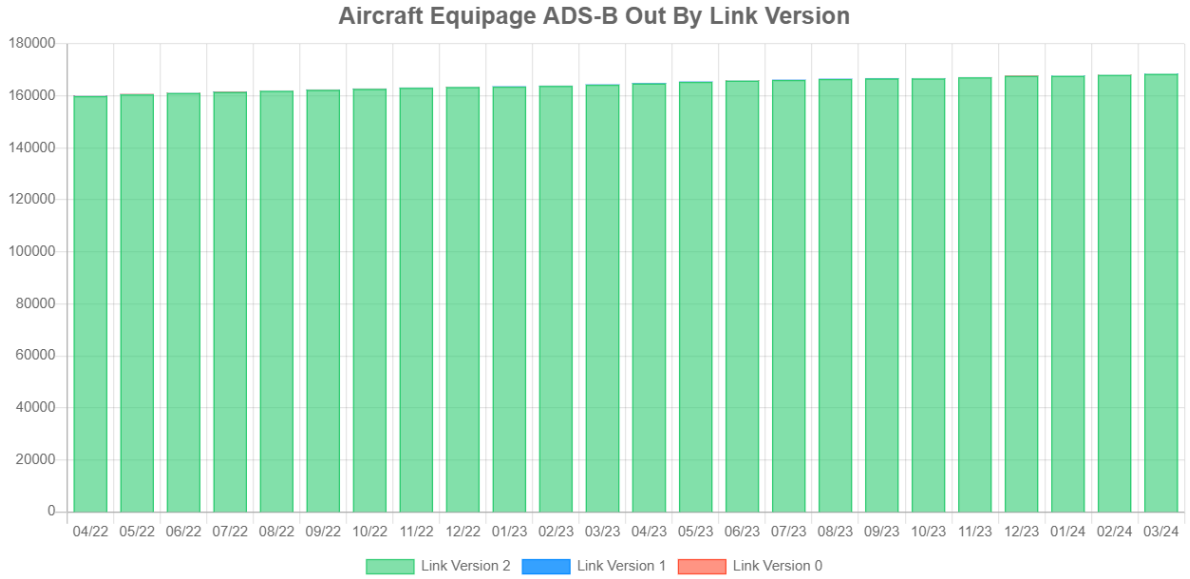


Figure 5 – ICAO aircraft address by ADS-B Version (Link Version)

2.2.4 The APM is also capable of showing data by "link type" – this is useful for understanding the relative fraction of UAT and 1090ES equipage in the U.S. Figure 6 shows the number of ICAO aircraft addresses using different ADS-B technologies since April 2022. 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 (the same ICAO aircraft address received on both links at the same time, as some operators have elected to equip their aircraft with both a 1090ES and UAT transmitter to ensure that their aircraft will be "seen" in U.S. airspace where FAA ADS-R service coverage does not exist.

2.2.5 During the period shown, the number of ICAO aircraft addresses received via 1090ES has increased steadily from 117,646 to 126,917, but the number of ICAO aircraft addresses received via UAT has fluctuated between a peak of 41,344 (November 2022) and a minimum of 40,230 (March 2024). Similarly, the number of ICAO aircraft addresses registering in the APM as "Dual"-equipped has fluctuated between a peak of 1,310 (September 2023) and a minimum of 1,257 (February 2023).

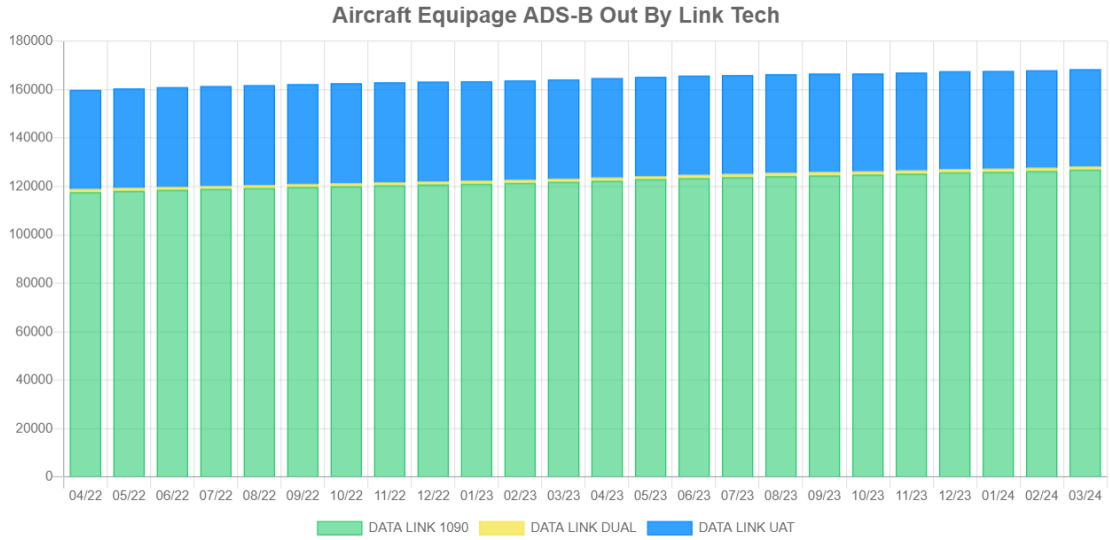


Figure 6 – ICAO aircraft addresses by ADS-B Link Type (1090ES, UAT, or DUAL)

2.2.7 The APM can also display equipage trends as they impact flight operations. An operation in the APM is defined as the consecutive receipt of ASTERIX reports from the first report until reports are no longer detected within an FAA ADS-B service volume. For aircraft which operate continuously within FAA ADS-B coverage and do not turn off their transponder at the gate at an airport with ADS-B surface coverage, an operation will automatically terminate after 8 hours. Figure 7 shows the number of operations by different ADS-B versions since April 2022. During this period, the number of ADS-B Version 0 operations peaked at 511 per month (October 2022) and has declined to as low as 253 per month (December 2023); the number of ADS-B Version 1 operations has ranged from 227-564 per month with no discernable trend. ADS-B Version 2 operations ranged from a low of 1,980,076 per month (December 2022) to a peak of 2,673,328 per month (July 2023). The seasonality of traffic can be clearly seen.

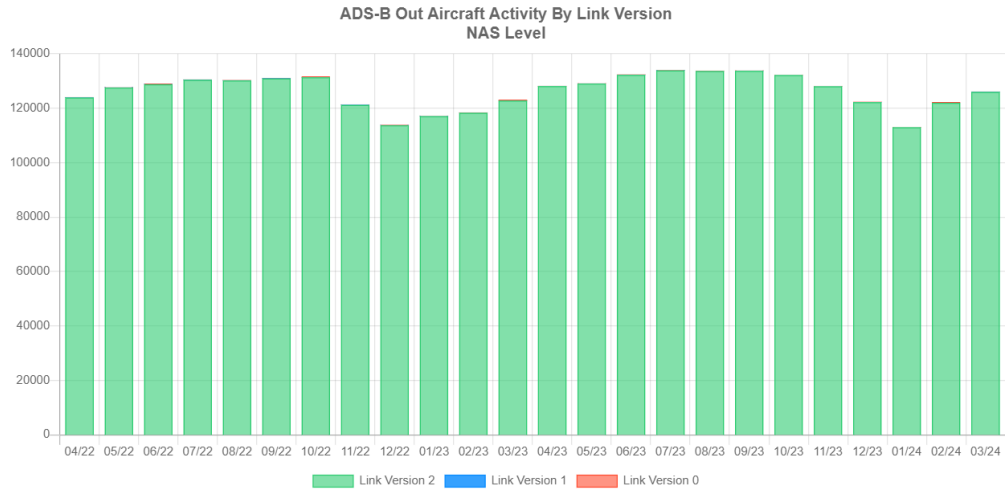


Figure 7 – Aircraft ADS-B Out Operations by ADS-B Version (Link Version)

2.2.8 Figure 8 shows the number of operations by different ADS-B-In link types since April 2022. Note that ADS-B Version 1 is incapable of reporting "Dual" In, so all "Dual" In configurations are being reported by ADS-B Out Version 2 systems. During this period, the number of 1090ES ADS-B-In operations has ranged from a low of 176,504 per month (February 2024) to 217,800 per month (July 2023); the number of UAT ADS-B-In operations has ranged from 100,364 per month (January 2024) to 195,409 per month (July 2022). Meanwhile, the number of Dual-In ADS-B-In operations has ranged from 560,854 per month (December 2022) to 955,281 per month (July 2023). The larger seasonal variations (compared to Figure 7) seen in this two-year data sample show that most ADS-B-In systems are currently installed in general aviation aircraft.

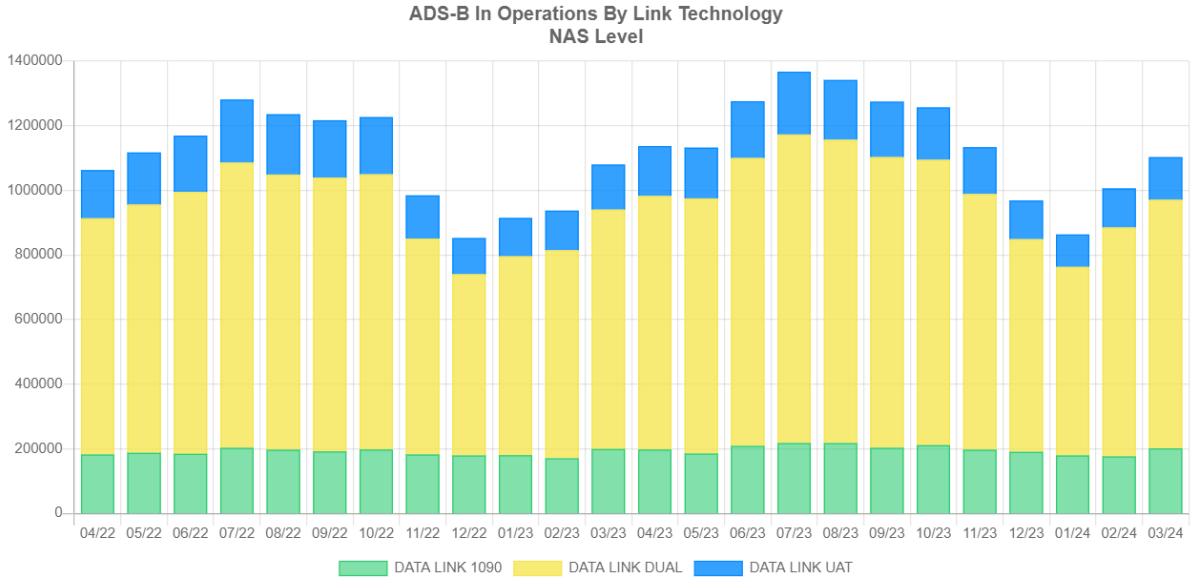


Figure 8 – Aircraft ADS-B In operations by ADS-B Link Type (1090ES, UAT, or DUAL)

## 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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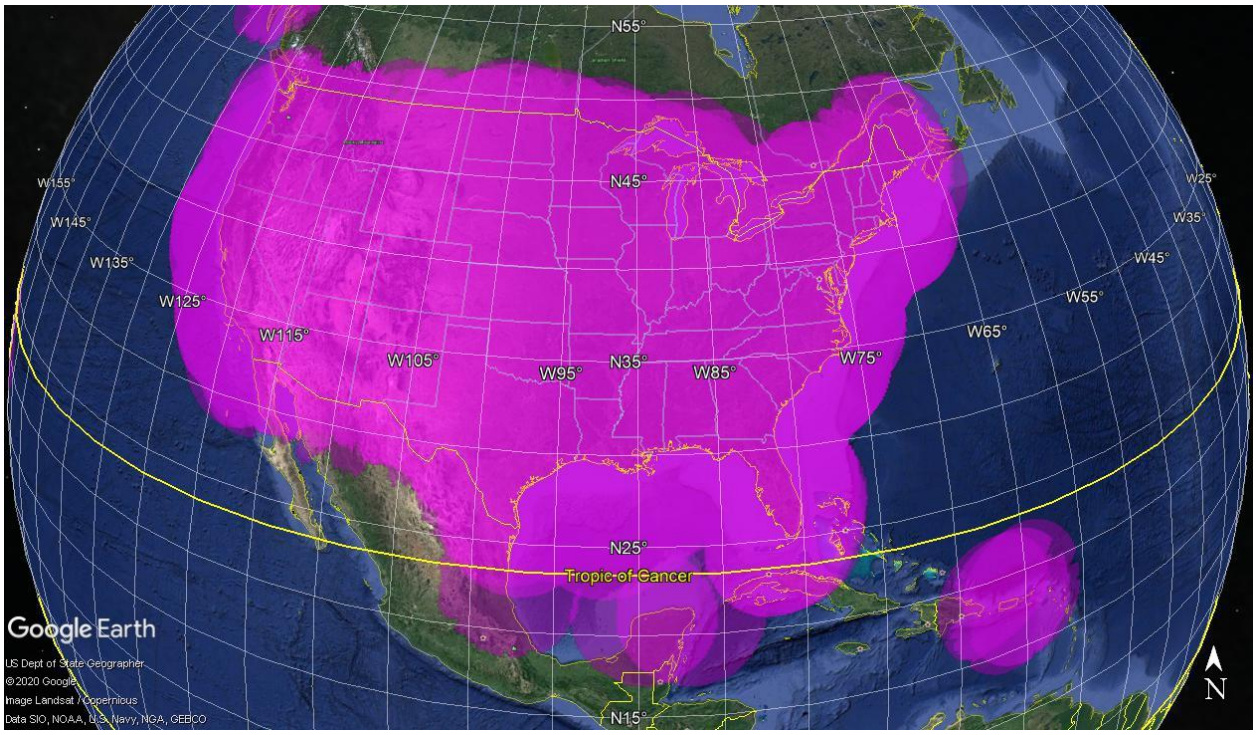
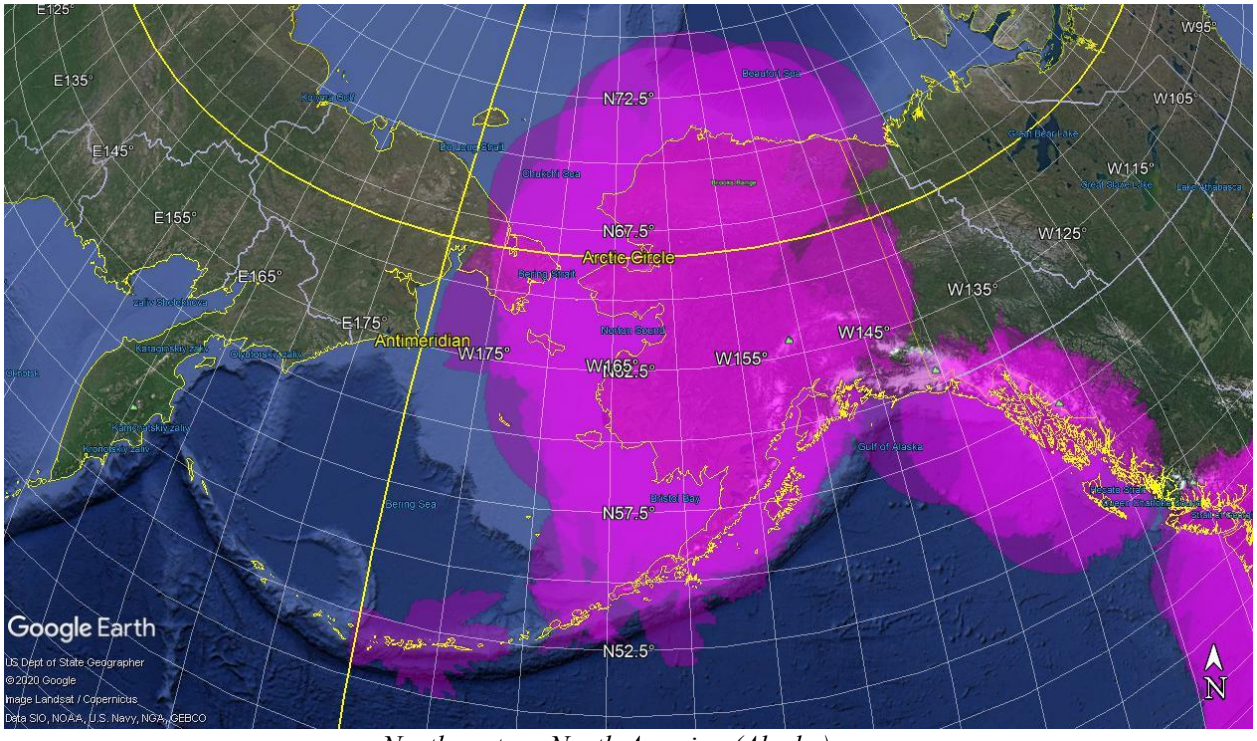
SURICG/9
Attachment 1 to IP/13

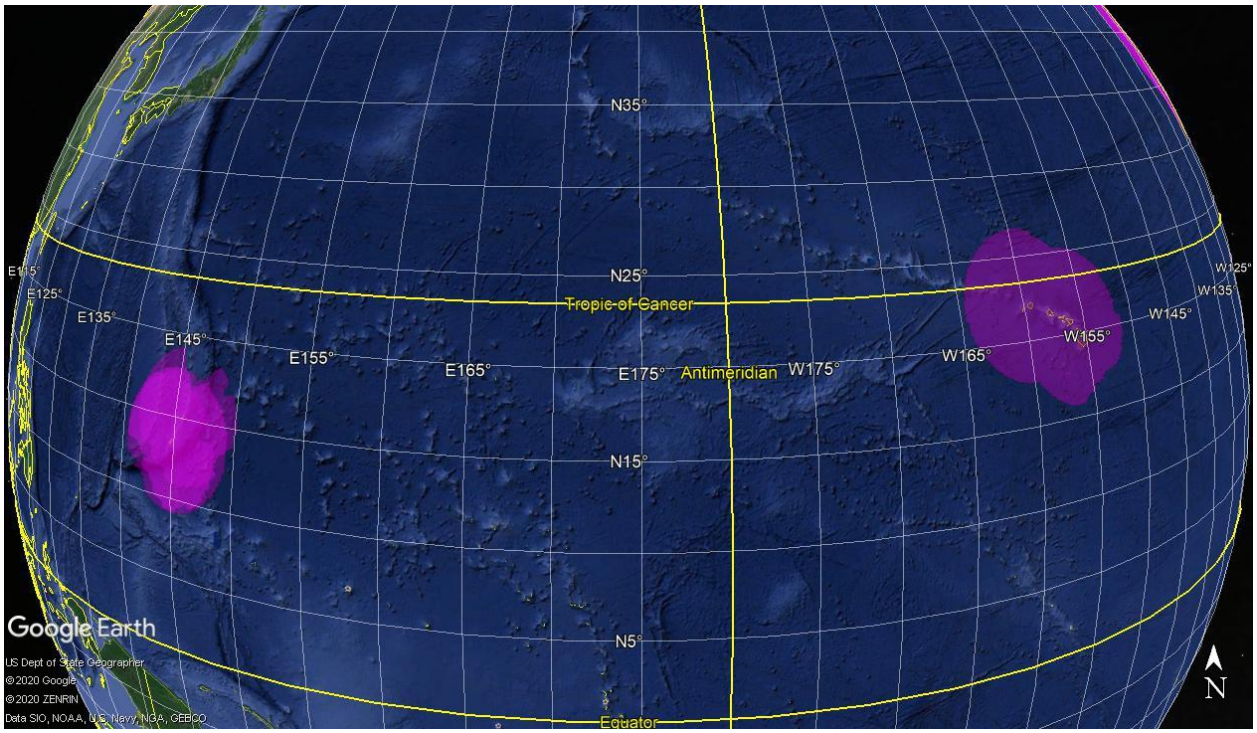
**FAA ADS-B Coverage at FL350** (shading intensity indicates degree of overlap in coverage)




*North America and Puerto Rico/Virgin Islands*




*Northwestern North America (Alaska)*




*Guam/CNMI and Hawaii*

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