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INFORMATION PAPER

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Mexico City, Mexico, 27-29 April 2015

Agenda Item 5: Status of ADS-B on-board avionics and Air Navigation Service Provider (ANSP) System

PERFORMANCE OF CURRENT ADS-B VERSION 2 SYSTEMS

(Presented by United States)

EXECUTIVE SUMMARY

This paper presents an analyses of observed ADS-B Version 2 quality parameters in comparison to the requirements of the United States ADS-B Out rule.

Strategic Objectives:

- Safety
- Air Navigation Capacity and Efficiency
- Environmental Protection

1. Introduction

1.1 The FAA is analysing outputs from current ADS-B Version 2 avionics during daily flight operations in the U.S., to derive operationally realistic benchmarks for the availability of the ADS-B quality parameters required by 14 CFR 91.227.

1.2 The FAA gathers and records the performance of ADS-B emitters that are detected by the current operational ADS-B radio stations in the U.S. The FAA has identified a set of aircraft with known ADS-B Version 2 equipage configurations for study, which includes 35 JetBlue A320s, 161 UPS aircraft (A300, B747, B757, B767, MD11), 18 American (formerly US Airways) A330s, 48 Embraer 170s flown by Skywest and Mesa, 5 FedEx B767s, and 49 A380s flown by Emirates, Korean, Lufthansa, Air France, British Airways, China Southern, and Singapore Airlines. The Embraer 170s and FedEx B767s are production installations; the A380s are believed to be a mix of production installations and software service bulletin “retrofits”; all other ADS-B Version 2 installations were retrofitted through projects that were partially funded by the FAA.

1.3 This paper focuses on the operational availability of Navigation Integrity Category (NIC) greater than 6 (a radius of containment less than 0.2 nautical miles), averaged over about 2 months of flight operations. Through GPS analyses performed during the FAA’s rulemaking process for the U.S. ADS-B mandate and validated by FAA data monitoring over the past two years, the critical ADS-B quality parameter in the U.S. ADS-B mandate is the NIC>6 requirement. This information is also available at the individual aircraft level if desired. The data quoted in this paper is for the period January 12 – March 30, 2015.

1.4 All JetBlue aircraft use the Rockwell Collins GLU-920 Multi-Mode Receiver (MMR). UPS has a mix of Rockwell Collins MMRs in their fleet of aircraft equipped with DO-260B transponders. All UPS wide-body aircraft have either the Rockwell Collins GLU-925 or the Rockwell Collins GLU-920. The Rockwell Collins GLU-925 is a GPS Selective Availability aware (SA-aware) receiver and calculates Horizontal Protection Limit (HPL) (which converts to NIC) accordingly; the GLU-920 calculates HPL as SA-unaware (assumes a User Range Error consistent with GPS Selective Availability being “on”, even though it is not). UPS is allowed to intermix these Rockwell MMRs on their wide-body aircraft, so a given aircraft can report different nominal NIC values from flight-to-flight. Additionally, UPS has a small number of B757s equipped with a Rockwell Collins GPS/SBAS receiver. American A330s are equipped with Thales SA-aware MMRs and the FedEx B767s are equipped with Rockwell GLU-925 MMRs. The Embraer 170s examined in this study are equipped with Honeywell Satellite-Based Augmentation System (SBAS) receivers. The A380s are equipped with a Honeywell GPS-IRU-coupled navigation system.

1.5 In the Table (**Appendix** to this paper), Operational Availability ranges are shown only for aircraft with more than 200,000 ADS-B reports during the analysis period. For this paper, Operational Availability is defined as the number of ADS-B reports with $NIC > 6$ divided by the total number of ADS-B reports. Operational Availability is calculated both at the aircraft level and at the aggregate level. The first Operational Availability column shows the range of “worst/best” results when Operational Availability is calculated at the aircraft level. The second Operational Availability column shows the average results for the fleet of aircraft by aggregating all of their collective ADS-B reports and computing Operational Availability over the operator fleet’s total number of ADS-B reports – since different aircraft have varying numbers of ADS-B reports and experience different environmental conditions, it is not an average of each aircraft’s Operational Availability.

1.6 The FAA is analysing $NIC < 7$ “outage” durations and probabilities of $NIC < 7$ “outage” events; these results will be reported later.

2. Discussion

2.1 The data in the Table shows that, as expected, $NIC > 6$ is the most challenging to achieve with high availability for GPS SA-unaware receivers (also known as “SA-on” GPS receivers). The lowest average operational availability of $NIC > 6$ is seen in the JetBlue and UPS fleets, at 98.82% and 99.29%, respectively. Compared to prior FAA data sampling, both fleets performed better than seen previously. The UPS aircraft have such a large range of $NIC > 6$ availability since this fleet uses both SA-aware and SA-unaware GPS MMRs, both across the fleet and even both MMR models on a single aircraft. The American and FedEx fleets are both equipped with SA-aware MMRs, each airline using a different manufacturer, yet the results are comparable. The average $NIC > 6$ performance of Embraer aircraft equipped with an Satellite-Based Augmentation System (SBAS) appears roughly equivalent to the average $NIC > 6$ performance of aircraft equipped with SA-aware MMRs, even though the U.S. SBAS service, the Wide-Area Augmentation System (WAAS) had no notable service outages during this period. Finally, the A380s had excellent average performance, albeit over a larger range of performance by aircraft.

2.2 Based on this data and the parameters examined, for the current GPS satellite constellation, it appears that ADS-B systems using SA-aware GPS receivers will generate average $NIC > 6$ operational availability values that are roughly equivalent to ADS-B systems using SBAS receivers or GPS-IRU-coupled navigation sources. It appears that ADS-B systems using SA-unaware GPS receivers will deliver average $NIC > 6$ operational availability values that airline operators may find unacceptable once the U.S. ADS-B rule (14 CFR 91.225 and 14 CFR 91.227) compliance date (1 Jan 2020) has been reached.

3. Conclusion

3.1 The meeting is invited to note the information contained in this paper, and discuss any relevant matters as appropriate.

APPENDIX

Aircraft	Operational Availability NIC>6 (worst->best)	Operational Availability NIC>6 (average)
JetBlue [35 A320s]	98.3791 -> 99.2492%	98.8178%
UPS [161 aircraft]*	95.3493 -> 100.0000%^	99.2929%
American [18 A330s]	99.9872 -> 99.9999%	99.9975%
FedEx [5 B767s]	99.9689 -> 99.9997%	99.9865%
Embraer 170s [48 aircraft]	99.9744 -> 99.9990%	99.9958%
A380s [49 aircraft]#	99.8046 -> 100.0000%^	99.9893%

*if the SBAS-equipped B757 had been excluded from this dataset, the highest operational availability would have been 99.9998%

#at least two flights of these aircraft are believed to have been impacted by GPS interference events in the Western U.S. (the events correlate well with published GPS testing NOTAMs); 26 of the 49 aircraft had 100.0000% availability of NIC>6

^in this Table, “100.0000%” means that there were zero ADS-B reports received during the sample period where NIC<7

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