International Civil Aviation Organization
North American, Central American and Caribbean Office

INFORMATION PAPER

E/CAR/NTG/9 & E/CAR/RD/7 — IP/02
09/07/20

Ninth Eastern Caribbean Network Technical Group (E/CAR/NTG/9) and Seventh Eastern Caribbean Radar Data Sharing Ad hoc Group (E/CAR/RD/7) Meetings

On-line, 14 and 15 July 2020

Agenda Item 2: **Review of Valid Conclusions from E/CAR/NTG/8, E/CAR/RD/6, and ANI/WG/5 Meetings Related to the Work of the NTG and RD**
2.2 Follow-up on the ANI/WG/5 Meeting

STATUS OF FAA'S OPERATIONAL EVALUATION OF SPACE-BASED ADS-B IN THE CARIBBEAN

(Presented by the United States)

EXECUTIVE SUMMARY	
This Information Paper provides a status update of the Federal Aviation Administration's (FAA's) planned Operational Evaluation of Space-Based ADS-B (SBA) trials in the Caribbean. The paper provides an overview of the SBA trials, data analysis summary, and identified installation and coverage issues.	
Strategic Objectives:	• Safety • Air Navigation Capacity and Efficiency
References:	• Eighth Eastern Caribbean Network Technical Group (E/CAR/NTG/8) and Sixth Eastern Caribbean Radar Data Sharing Ad hoc Group (E/CAR/RD/6) report.

1. Introduction

1.1 Enhancing surveillance in oceanic airspace can provide improvements to air navigation services by reducing separation minima for optimum routing, depending on the communications and navigation services available in the airspace.

1.2 To date, the FAA has supported the development and maturation of the technology by developing proposed service performance requirements and by modifying oceanic and en-route automation to accept Space-Based ADS-B (SBA) data. The FAA is working to assess the feasibility of the technology in order to implement a phased approach that will address technical, operational and safety issues pertinent to a potential long-term investment in SBA.

2. **Discussion**

2.1 Section 2 provides a high level summary of the FAA's Space Based ADS-B (SBA) trials in US managed Caribbean airspace. The **Appendix** to this IP contains a detailed outline of the approach, and analysis of data obtained to date from the FAA SBA trials.

2.2 As noted, the FAA is conducting an operational assessment of SBA to assess system performance in an operational environment. The assessment will garner sufficient data to better forecast the long-term applications of SBA across a broader range of operational environments.

2.3 The Miami ARTCC (ZMA) offshore airspace has been determined by the FAA to be a suitable location for an initial evaluation site for the provision of en-route surveillance and separation services using the En-Route Automation Modernization (ERAM). Currently, ZMA offshore oceanic air traffic is monitored and controlled using instantaneous push-to-talk voice (i.e., VHF/UHF) communication and radar surveillance feeding ERAM.

2.4 Prior to the initial operational phase of the trial, Air Traffic Controllers at ZMA identified a number of issues related to ADS-B installation and performance. During this initial testing, ZMA has determined the number of aircraft exhibiting issues exceeds the minimum acceptable level required to begin using SBA.

2.5 Initial review of data obtained from Aireon has highlighted the following issues:

1) Lack of detection for single antenna installations (e.g., bottom only installations)
2) Poor performance (e.g., low power) from diversity installations
3) Areas with single satellite coverage

2.6 In order to assess feasibility of using SBA operationally, the following update threshold requirements must be met

1) 8 second 97%
2) 30 second 99.9%

2.7 Using the above criteria, a total of 611 aircraft were identified as failing the 8 second 97% requirement, and 710 aircraft failed the 30 second 99.9% requirement.

2.8 The FAA further analysed the data with a focus on TCAS II equipped aircraft. Based on existing requirements, a TCAS II aircraft requires diversity antennas (e.g., Top and Bottom) for the on-board transponder(s). This data showed at least 20% of the aircraft transiting through the airspace as having a probability of detection below 97%.

2.9 For each aircraft having flown in US ADS-B coverage exhibiting issues, the FAA used the ADS-B Performance Monitor (APM) to compare SBA vs Terrestrial performance.

2.10 The FAA, in collaboration with Aireon, has identified the following next steps as potential mechanisms to improve airspace performance:

1) Identify poor performing aircraft for remediation

2) Aireon to modify system in July 2020 to utilize more receiver beams on the satellite payload

3. **Conclusion**

3.1 The FAA will continue to analyse data to identify improvements made from coordinated work with Aireon and relevant stakeholders.

3.2 FAA Lines of Business (i.e. ZMA, International office, etc.) will work with appropriate foreign counterparts to create an adequate Standard Operating Procedure (SOP) for handling aircraft with diversity antenna installations versus non-diversity installations.

3.3 The FAA will use the operational evaluation to evaluate SBA performance in mitigating impacts of GDT radar outages; augmenting existing terrestrial ADS-B coverage; and enabling potential route structure optimization.

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APPENDIX

In the near term, the FAA is conducting an Operational Assessment of SBA that will allow the FAA to assess system performance in an operational environment. The assessment will allow the FAA to gain sufficient data to better forecast the long-term applications of SBA across a broader range of operational environments.

The Miami ARTCC (ZMA) offshore airspace has been determined by the FAA to be a suitable location for an initial evaluation site for the provision of en-route surveillance and separation services using the En-Route Automation Modernization (ERAM). Currently, ZMA offshore oceanic air traffic is monitored and controlled using instantaneous push-to-talk voice (i.e., VHF/UHF) communication and radar surveillance feeding ERAM.

Prior to 2020, ADS-B surveillance coverage in this airspace was limited to coverage provided by ground stations located on the Florida peninsula and Puerto Rico. There is a broad expanse of airspace in the corridor between these areas where existing ADS-B terrestrial coverage is unavailable and where existing surveillance sources have reliability/redundancy issues.

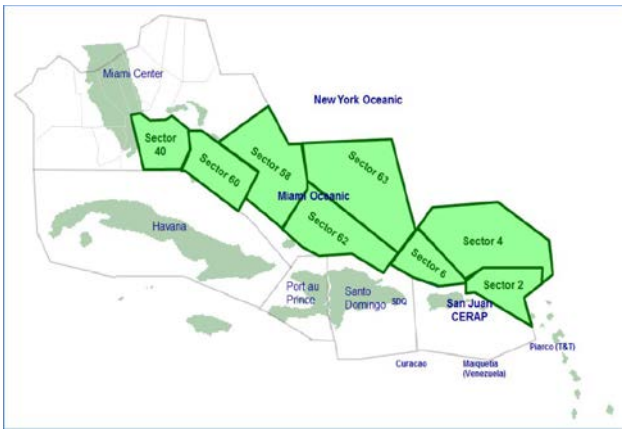

Figure 1: FAA Caribbean Airspace Sectors

The radar site at Grand Turk (GDT), in the Turks and Caicos Islands is a single point of failure impacting Sectors 62 and 63 due to the lack of terrestrial ADS-B or redundant surveillance coverage. Figure 2 illustrates the surveillance gap created by a GDT radar outage.

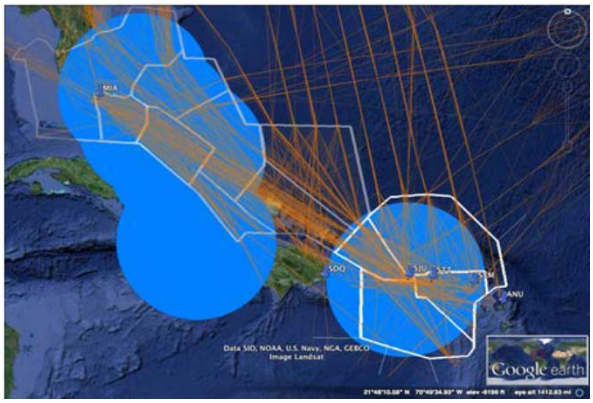

Figure 2: Grand Turk Surveillance Gap

As the FAA moved toward the Operational Assessment, Air Traffic Controllers at ZMA identified a number of issues related to ADS-B installation and performance. Review of data obtained from Aireon has highlighted the following issues:

1) Lack of detection for single antenna installations
2) Poor performance (e.g., low power) from diversity installations
3) Areas with single satellite coverage

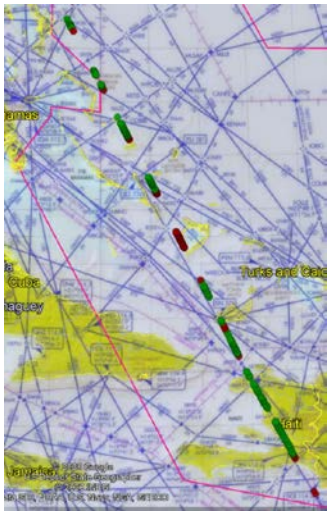

Figure 3: Bottom Only Installation

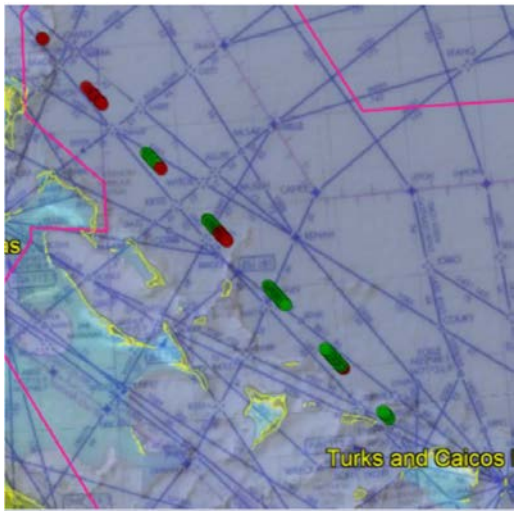

Figure 4: TCAS II aircraft potential low power or antenna issues.

The FAA conducted an initial analysis of aircraft equipage (e.g., diversity, single antenna, link version) flying through the trial airspace. This analysis was done prior to ZMA's operational use of the SBA data initially scheduled for March 2020. Table 1 provides a breakdown of the data captured for January and February 2020.

Category	Sub Category	January All Altitudes	February All Altitudes	February Above FL180	February Below FL180
Total Flights		**21298**	**18981**	**18150**	**831**
ADS-B		**97.5%**	**97.2%**	**97.8%**	**83.0%**
	LV2	97.3%	96.8%	97.5%	83.0%
	LV1	0.1%	0.1%	0.1%	0.0%
	LV0	0.1%	0.3%	0.3%	0.0%
	Diversity	83.0%	83.8%	85.1%	56.4%
	Lower	3.6%	3.4%	3.1%	9.0%
	TBD	10.9%	10.0%	9.6%	17.6%
Radar		**0.5%**	**0.8%**	**0.6%**	**4.6%**
Unknown		**2.0%**	**2.0%**	**1.6%**	**12.4%**

Table 1: Aircraft Equipage

Note that in Table 1, Lower refers to single antenna aircraft. In addition, MITRE assisted in analysing the data by using an avionics database they had created along with the ADS-B Performance Monitor to determine diversity versus single antenna installations.

As shown in Table 1, aircraft equipage between January and February 2020 did not vary significantly. In order for SBA to be used operationally, the following update threshold requirements must be met

1) 8 second 97%
2) 30 second 99.9%

The 8 second 97% requirement is necessary to meet the RTCA DO-318 requirement for use of SBA in radar airspace. The 30 second 99.9% requirement is used by the FAA to track aircraft that have entered into a coasting condition.

Using the above criteria, MITRE further examined aircraft performance above and below FL180 for the collected data on both a daily and hourly basis for the month of February 2020. Figure 5 and Figure 6 provides a breakdown of the poor performing aircraft exceeding either the 8 second 97% or 30 second 99.9% update threshold requirement. In total 611 aircraft were identified as failing the 8 second 97% requirement, and 710 Aircraft failed the 30 seconds 99.9% requirement.

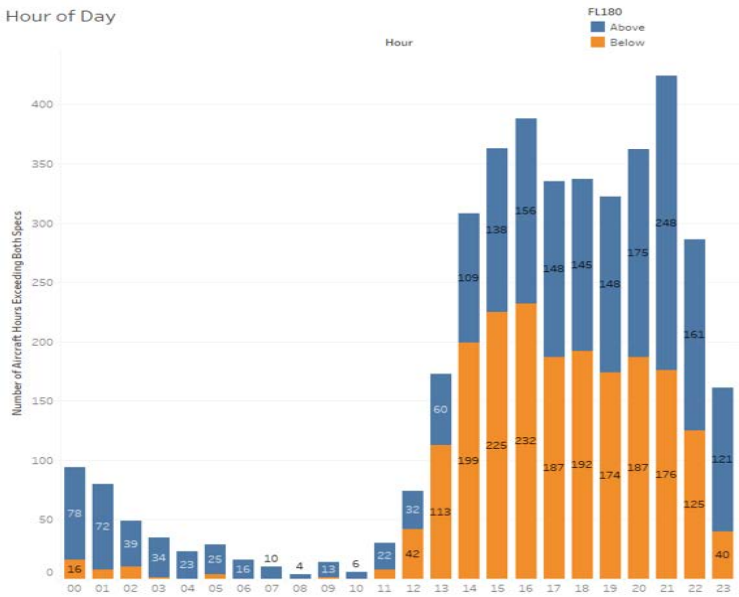

Figure 5: Poor performing aircraft per hour of day.

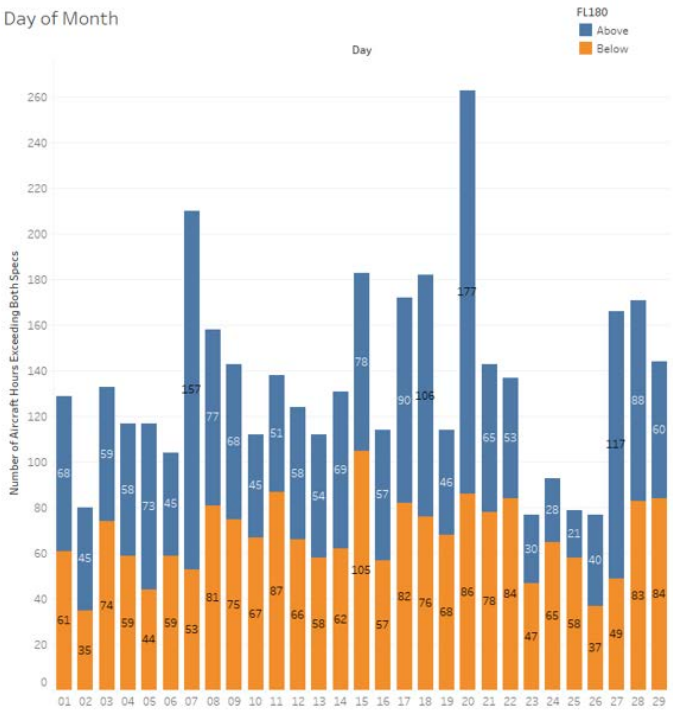

Figure 6: Poor performing aircraft per day of month.

After further analysis, the FAA determined that an additional validation method was needed to adequately identify aircraft diversity. The TCAS Operational bit in the Airborne Aircraft Operational Status Message (ADS-B Version 2) was identified as a viable alternative to determine aircraft equipage. If set properly, the TCAS Operational bit would identify target aircraft equipped with TCAS II systems. Based on existing requirements, a TCAS II aircraft requires diversity antennas for the on-board transponder(s).

Figure 7 illustrates the average 8 second probability of detection (PD) distribution across the entire data set for TCAS II equipped aircraft for the months of February and March 2020.

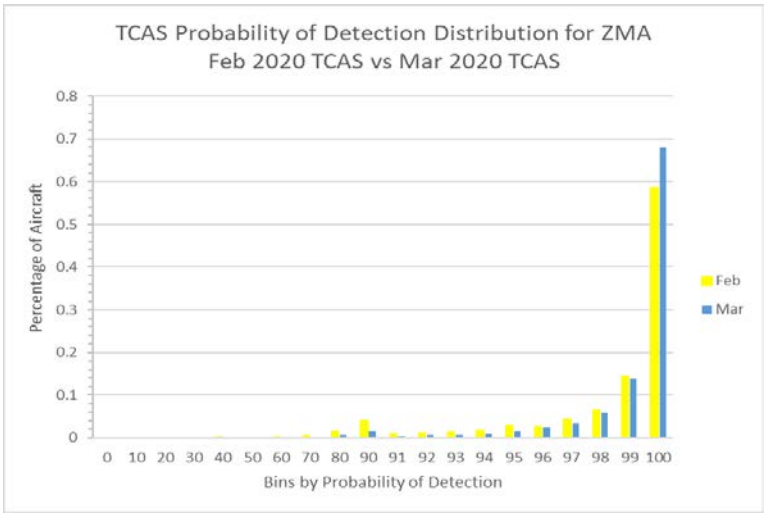

Figure 7: Probability of Detection Distribution for TCAS II Equipped Aircraft for ZMA

As shown in Figure 7, the PD distribution from February to March shows improvement for the lower end and 100% PD bins. Average PD across the system for both months is roughly the same. Note that at least 20% of the aircraft have a probability of detection below 97%.

Using ADS-B received data, the FAA filtered the data for all targets that had over 500 ADS-B reports and a PD percentage less than 80% in both February and March 2020. For each aircraft on the resulting list that had operated within coverage of a U.S. ADS-B ground station, the FAA used the ADS-B Performance Monitor (APM) to compare SBA vs Terrestrial performance. Figure 8 is an example of this comparison

Figure 8: FAA APM Terrestrial data (left); SBA data (right)

For diversity installations (e.g., top and bottom transponder antenna), and no satellite outages in areas with single satellite coverage, the data has shown that SBA provides the coverage necessary to properly surveil an aircraft as illustrated in Figure 9.

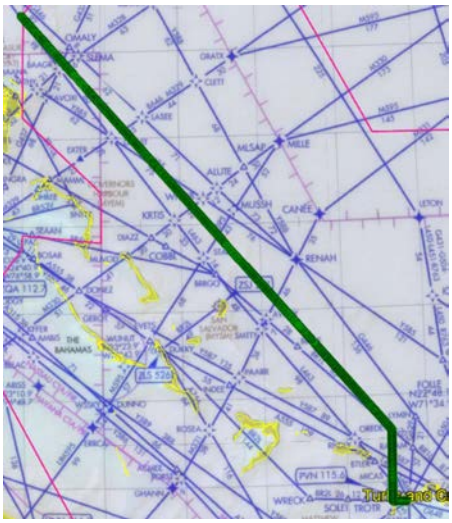

Figure 9: SBA coverage into MBPV Airport

ZMA controllers have used the test area in Miami Center to determine the feasibility of using SBA data operationally to separate aircraft transiting through Sectors 62 and 63. During this testing, ZMA has determined the number of aircraft exhibiting issues exceeds the minimum acceptable level required to begin using SBA.

The FAA, in collaboration with Aireon, has identified the following next steps as potential mechanisms to improve airspace performance:

1) Identify poor performing aircraft for remediation
2) Aireon to modify system in July 2020 to utilize more receiver beams on the satellite payload

The FAA will continue to compare data sets to identify noticeable improvements from receiver enhancements and operator avionics/installation corrections. Additionally, the FAA will compare aircraft performance captured by SBA in Miami oceanic airspace with data in Oakland oceanic airspace. This comparison may be helpful to identify potential trends in avionics/installation issues, equipage trends, and overall SBA system performance.

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