International Civil Aviation Organization

AUTOMATIC DEPENDENT SURVEILLANCE – BROADCAST SEMINAR AND TWELFTH MEETING OF AUTOMATIC DEPENDENT SURVEILLANCE – BROADCAST (ADS-B) STUDY AND IMPLEMENTATION TASK FORCE (ADS-B SITF/12)

Kolkata, India, 15-18 April 2013

Agenda Item 5: ADS-B performance monitoring

ADS-B STATION AND AVIONICS PERFORMANCE MONITORING

(Presented by Singapore)

SUMMARY

This paper updates the meeting on the measures that Singapore has put in place to monitor the performance of the ADS-B stations and the ADS-B avionics of aircraft operating in our Flight Information Region (FIR).

1. INTRODUCTION

1.1 Singapore has acquired a surveillance monitoring system (SMS) to monitor the performance of the surveillance sensors supporting its operations. Although it is primarily used to monitor the performance of radars, we can use it to monitor, *inter alia*, the performance of the ADS-B ground stations and to indirectly measure the performance of the ADS-B avionics of aircraft operating in our FIR.

2. DISCUSSION

Monitoring of performance of ADS-B ground station

2.1 Using targets of opportunity, the SMS can monitor the ADS-B coverage and generate various performance figures such as probability of detection. The screen shots and the explanations are shown in **Annex A**. Poor probability of detection could be due to either problem of a station (e.g. faulty antenna or poor location) or a particular aircraft's avionics. Overall probability of detection can be logged in a pseudo real-time manner once an hour.

Measuring performance of ADS-B avionics

2.2 Usually, we expect the ADS-B reported position to be accurate according to their NUC value (for e.g. If NUC = 4, 99.999% chance that the aircraft is within 1NM from the reported position). There is a possibility that an aircraft is transmitting misleading data and it is necessary to inform the operator so that the problem could be rectified. To identify aircraft transmitting misleading data, we can check the deviation between the ADS-B reported positions and the respective radar reported positions. The detailed explanation is shown in **Annex B**.

2.3 The SMS also generates statistics on probability of detection per aircraft. When the probability of detection of an aircraft goes too low, say less than 50% consistently, it may be worthwhile to investigate the cause of such low probability of detection. See details in **Annex B.**

2.4 Separately, errors in the air traffic control automation system will also be monitored. The reasons of such error events could be as follows:

a) Split track: ADS-B reported position might be off;

b) Coupling failure: aircraft ID might be wrong;

Performance indicators to be monitored in future

2.4 Currently, we are exploring means to monitor the following performance indicators:

a) To measure gaps between geometric heights and the respective barometric heights;
This is to prevent misleading Mode C heights being used.

b) To compare ADS-B reports from two separate stations;
This is to detect corruption in the ADS-B data from a particular station or even spoofing.

c) To monitor the spread of the ADS-B position data;
A large spread may imply poor position integrity.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

a) Note the contents in the paper; and

b) To derive a set of performance indicators for monitoring of ADS-B stations and avionics.

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Annex A

Coverage and Probability of Detection of ADS-B Ground Station

Figure 1: Coverage diagram generated by the SMS.

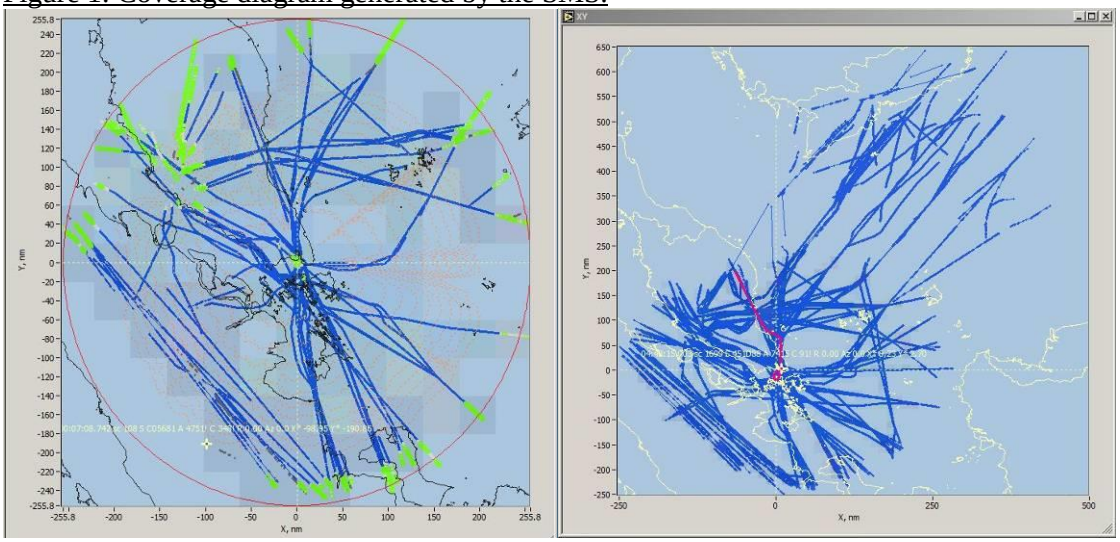

Figure 2: Probability of detection at different geographical area

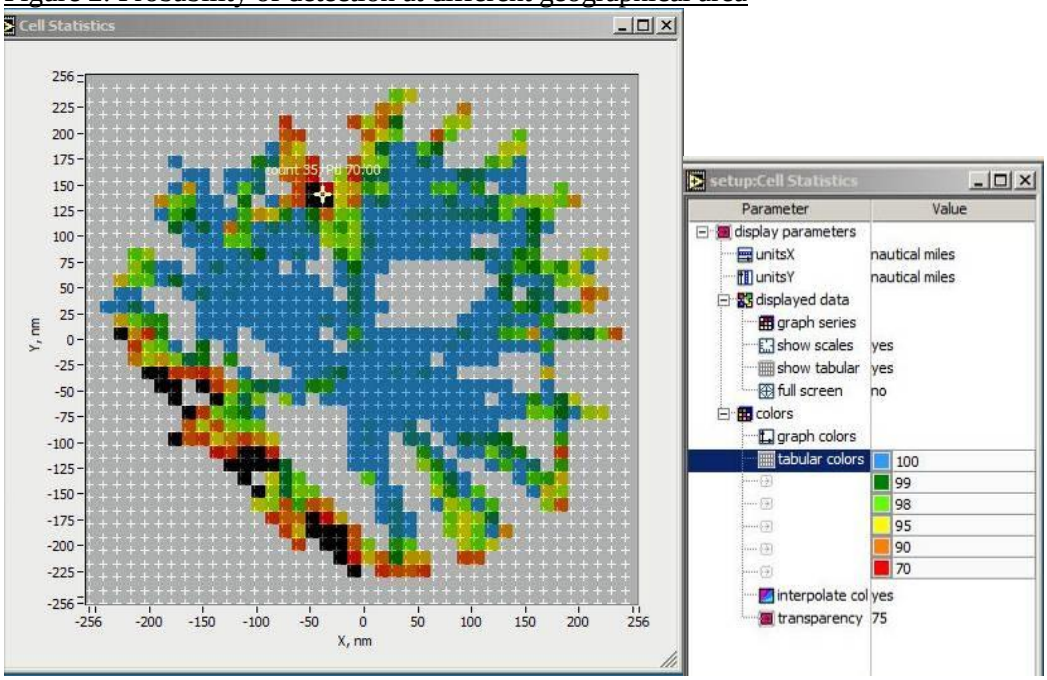

Figure 1 shows the coverage of the ADS-B sensor, generated by the SMS. The blue portions are the areas where there is coverage verified by targets of opportunity. The green portions are the areas where targets were detected, but were out of the theoretical coverage based on line of sight.

Figure 2 gives an indication of where the areas of low probability of detection are. From the figure, it shows that the areas of low probability of detection are in the South-western part probably owing to obstacles along that direction.

Annex B

Performance of Avionics

The SMS is able to compare and generate the statistic of the variances in the reported aircraft positions between those from ADS-B and radar, giving the mean and the standard deviation. With that, we can reasonably check whether the variance is within 1NM or 1,852m (NUC = 4). Since NUC = 4 means a radius of containment of 1NM with 99.999% level of confidence, we calculate the variance at 4σ.

Table 1 below shows the mean errors (average of differences between the position reported by the radar and ADS-B) and the standard deviations of the errors, as well as the derived containment radius. From this example, it can be seen that the containment radius within 1NM.

Table 1: Derivation of variance at 4σ per airframe (measured within one-hour period)

Mode S Address	Mean Error (m)	Standard Deviation (m)	Differences in reported position at 99.994% or 4σ	Operator
4BA9CB	-28.91	19.331	106.234	Turkish Airlines
7500C2	33.557	59.463	271.409	AirAsia
750200	7.523	43.811	182.767	Malaysia Airlines
7580B3	44.818	71.151	329.422	Philippine Airlines
76AA61	-4.955	32.233	133.887	Jetstar Asia Airways
76CC45	20.173	47.201	208.977	Silkair
76CD88	6.026	49.273	203.118	Silkair
76CE4A	5.547	39.899	165.143	Singapore Airlines
76CEF3	16.886	71.423	302.578	Singapore Airlines
7805C2	6.969	42.164	175.625	Xiamen Airlines
88001A	0.643	48.667	195.311	Thai Airways Intl
8A01BB	8.493	40.452	170.301	Indonesia AirAsia
8A02D4	28.634	51.304	233.85	Garuda Indonesia
ABDE34	5.393	50.693	208.165	Federal Express

Table 2 below shows the probability of detection per aircraft movement. In the event that a probability of detection falls below a preset acceptable level, it may warrant an investigation. In the initial phase, we will use the SSR probability of detection of 50% for monitoring. We will adjust it upward if long term statistics shows almost all ADS-B equipped aircraft could achieve a much higher probability of detection.

Table 2: Probability of detection per airframe (measured within one-hour period)

Mode S Address	Pd %	Operator
750245	99.104	FireFly
7500DF	99.556	Malaysia Air System
7580B3	99.509	Philippine Airlines
76AA64	100	Jetstar Asia Airways
76CD8A	98.784	Silkair
76CE84	100	Singapore Airlines
77044F	100	Sri Lanka
7801DD	98.006	Cathay Pacific Cargo
8A017E	98.502	Garuda Indonesia
8A01C9	98.125	Indonesia AirAsia