International Civil Aviation Organization

Tenth Meeting of the Surveillance Implementation Coordination Group (SURICG/10)

Bangkok, Thailand, 21 - 23 April 2025

Agenda Item 7: Report on surveillance ground system and avionics performance monitoring and improvement in compliance

ADS-B PERFORMANCE MONITOR UNDER DEVELOPMENT AT ENRI

(Presented by Japan)

SUMMARY

This paper provides a concept for an ADS-B performance monitor under development at ENRI.

1. INTRODUCTION

1.1 The Japan Civil Aviation Bureau (JCAB) is planning to use ADS-B for air traffic control. Therefore, the evaluate system for ADS-B performance is required to ensure safe aircraft operations.

1.2 The Electronic Navigation Research Institute (ENRI) developed an algorithm for appropriately analyzing the ADS-B message. We measured the equipage of ADS-B and the statistical values of the quality of ADS-B performance in the airspace and on the airport surface in Japan. The analyzed results were reported in SP-ASWG (SP-ASWG17-IP/05, SP5-ASWG18-IP/05, SP-ASWG19-IP/07R1, SP-ASWG20-IP/08). The results are similar to those reported by the FAA.

1.3 ENRI is currently developing a performance monitor for evaluating the quality of ADS-B performance based on the algorithm we developed. It can be used to evaluate the present ADS-B situation in Japan air space and to extract error aircraft that does not meet surveillance requirement. This information paper (IP) introduces the ADS-B performance monitor being developed.

2. DISCUSSION

2.1 An ADS-B message includes not only its own position (latitude, longitude, and altitude) but indices of positional performance (NIC and NACps) which are computed using data obtained from the onboard GNSS receiver. In addition, operational information regarding avionics installation issues (NACv, SDA, SIL, etc.) is provided. Even if the computational result of the position is correct, ADS-B sometimes provides error information owing to the installation performance. Therefore, we need to evaluate the types of ADS-B information to determine the total ADS-B performance. Statistical analysis can be used to evaluate the quality of ADS-B performance.

2.2 According to 14 CFR 91.227, the requirements for ADS-B Out performance are defined as follows:

- Navigation Accuracy Category; position (NACp) must be less than 0.05 NM, resulting in NACp≧8.

- Navigation Accuracy Category; velocity (NACv) must be less than 10 m/s, resulting in NACv≧1.
- Navigation Integrity Category (NIC) must be less than 0.2 NM, resulting in NIC≧7.
- System Design Assurance (SDA) must be less than or equal to 10-5 per flight hour, resulting in SDA≧2.
- Source Integrity Level (SIL) must be less than or equal to 10-7 per flight hour, resulting in SIL=3.

Operational availability is also defined as the percentage of time that a system is available at the expected level of performance (SP-ASWG17-IP01). We selected an operational availability requirement of greater than or equal to 99.9%.

On the other hand, the EUROCAE document ED-163, pertaining to ADS-B airport surface surveillance application, stipulates NACp≧8, NIC>0, and SIL=3 (expressed on a per hour basis). The parameters mentioned here could be useful in finding error aircraft.

2.3 Figure 1 shows a block diagram of ADS-B processing. Our software operates in two formats: one is the use of Mode S messages, and the other is the use of CAT21 which is an ADS-B ASTERIX format processed by the operational systems. When we use Mode S format observed ADS-B receiver or MLAT receivers, processing is based on the developed algorithm as follows:

1) Decoding Mode S messages and extracting DF=17. ADS-B equipage in Japan can be estimated.
2) Classifying aircraft in each ADS-B version using FTC=31 and the datasheet of ADS-B version (aircraft lists prepared).
3) Create a dataset of positional data connected to various data (NIC, NACp, NACv, SDA, SIL, etc.) as presented in the previous section. Position data is always set with the various data mentioned above.
4) Statistically analyse using the dataset created in the previous process.

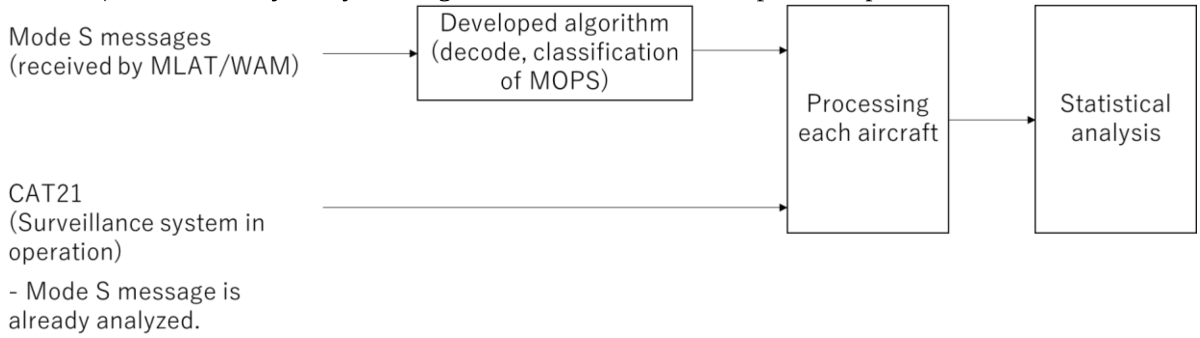


Figure 1 Block diagram of ADS-B processing

The reasons for inputting two format types are as follows. One is to flexibly customize the analytical procedure of ADS-B messages and the other is to check whether the surveillance system in operation transmits accurate data.

2.4 We are developing software for evaluating the quality of ADS-B performance using the developed algorithm. Some window screen shots are shown below. The software is based on MATLAB in the research phase. The results were analyzed using the Mode S messages obtained using the MLAT system.

Figure 2 Initial window of the software.

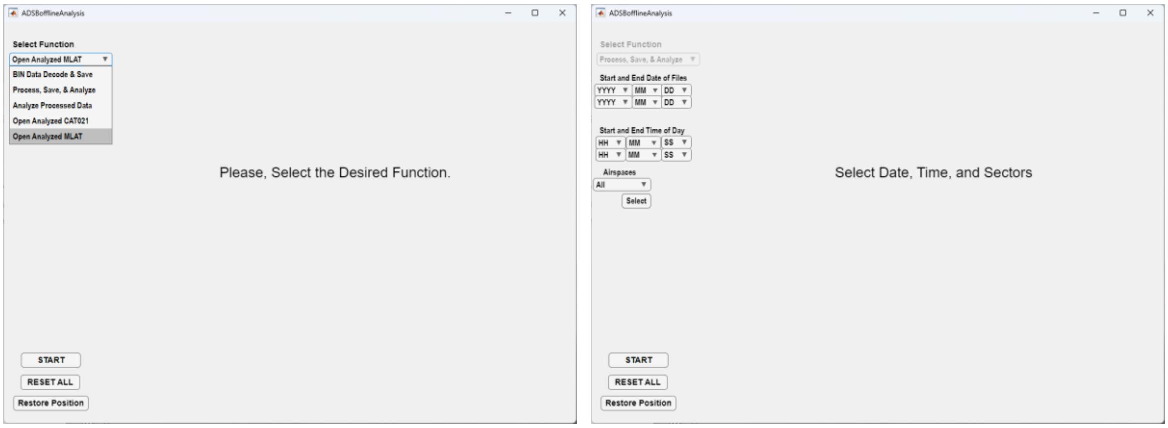


Figure 3 Mode setting (left), and selection of time span and airspace (right).

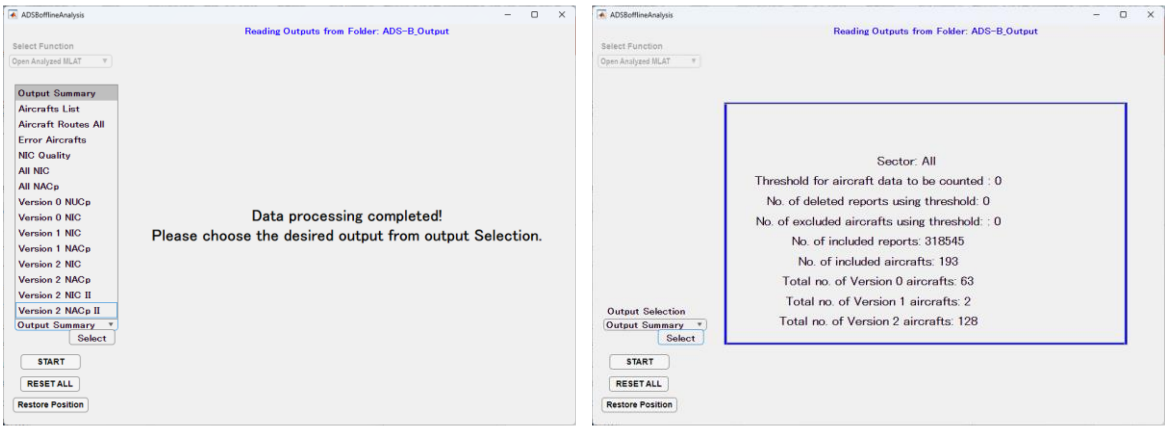


Figure 1 **Window of analysis completion (left) and summary of the result (right).**

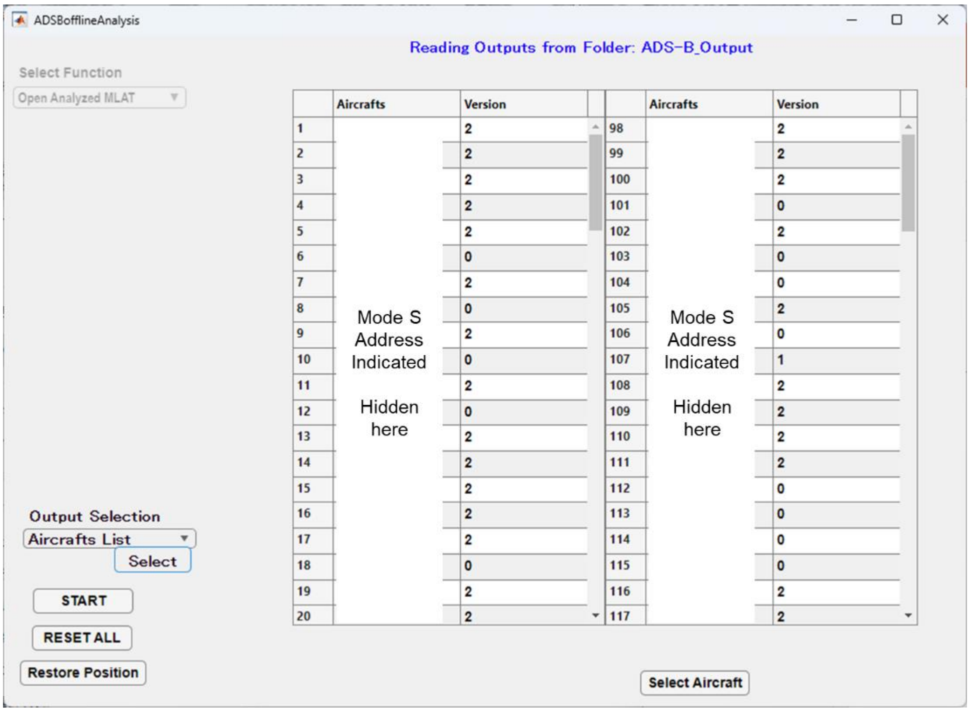


Figure 5 List of all of aircraft and error aircraft.

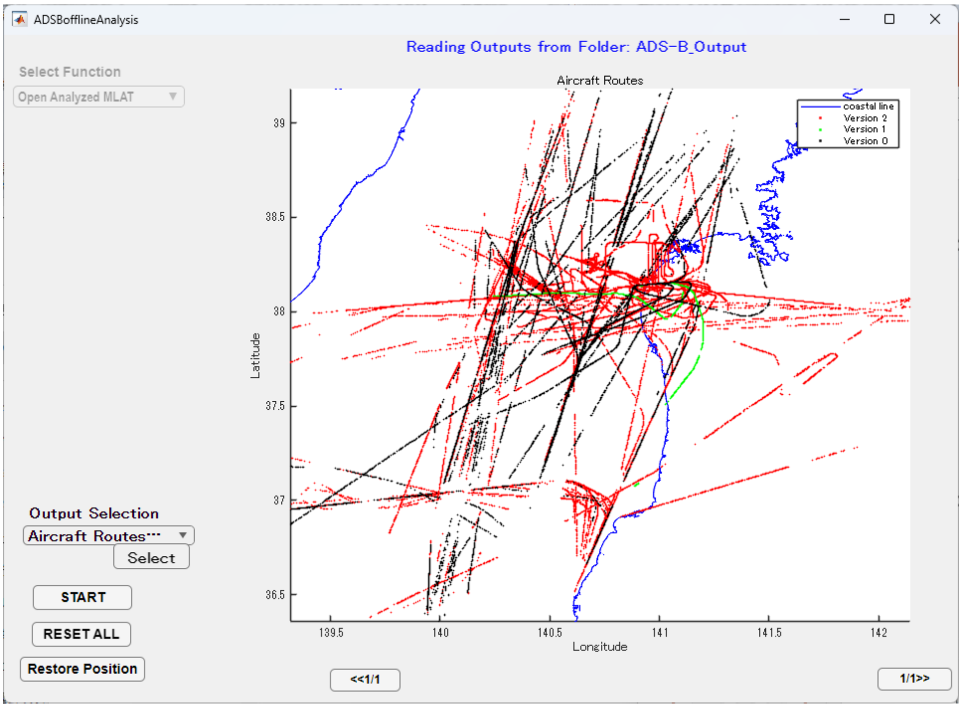


Figure 6 Trajectories of all aircraft depending on the ADS-B version. Red, green and black lines indicate Ver. 2, Ver. 1 and Ver. 0 aircraft, respectively.

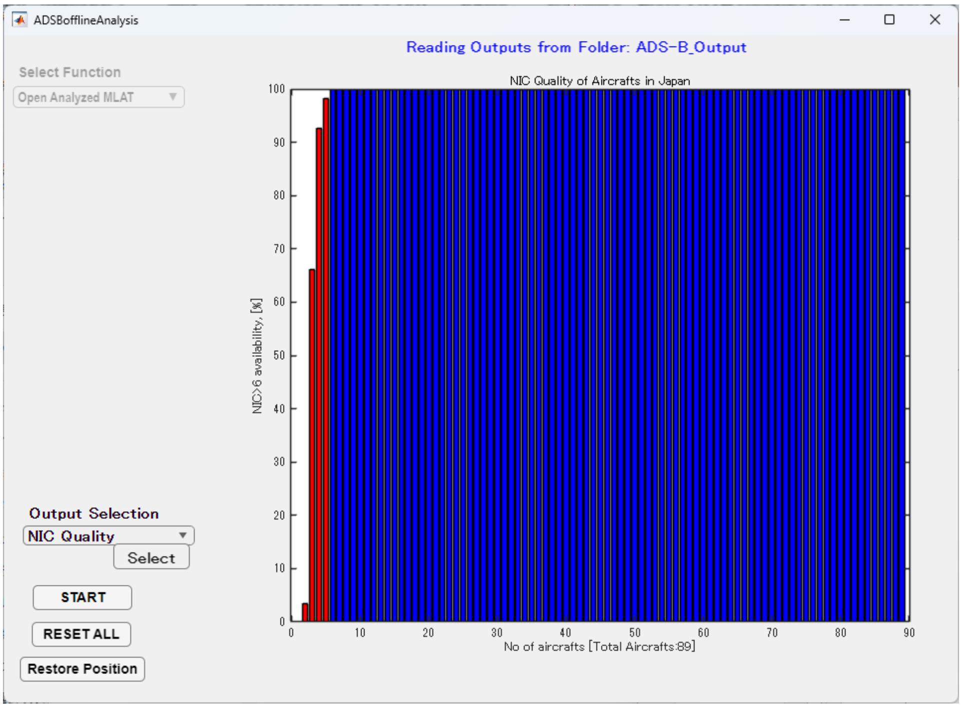
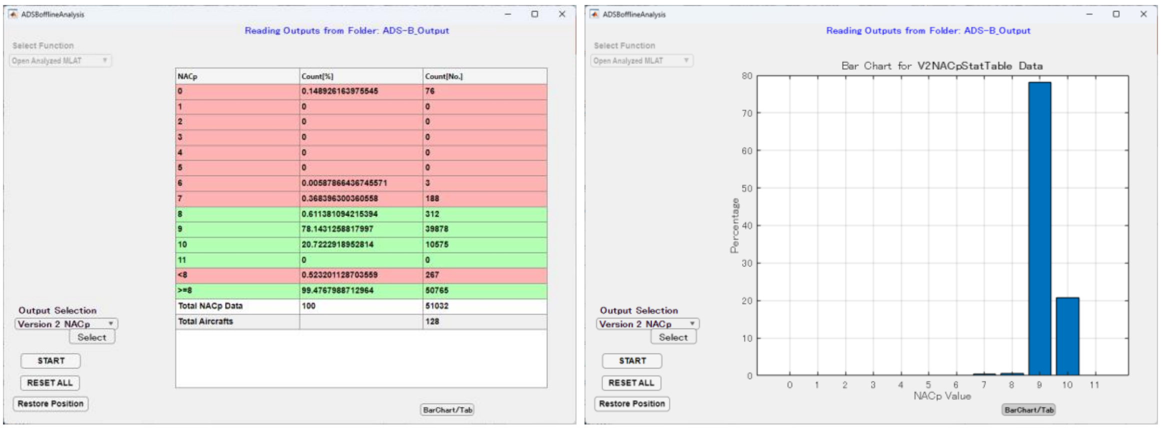


Figure 7 NIC quality based on the availability of Ver. 2. Aircraft shown in red color bar does not meet surveillance requirement.

NIC	Count[%]	Count[No.]
0	0	0
1	0	0
2	0	0
3	0	0
4	0	0
5	0.00438663829973899	4
6	0.54503980874257	497
7	0.637159213037089	581
8	98.8134143399206	90104
9	0	0
10	0	0
11	0	0
<7	0.549426447042309	501
>=7	99.4505735529577	90685
Total NIC Data	100	91186
Total Aircrafts		128

Figure 8 Statistical results of NIC for Ver. 2 ADS-B. A table and bar chart are shown on the left and right, respectively.



NACp	Count[%]	Count[No.]
0	0.148926163975545	76
1	0	0
2	0	0
3	0	0
4	0	0
5	0	0
6	0.00587866436745571	3
7	0.368396300360558	188
8	0.611381094215394	312
9	78.1431258817997	39878
10	20.7222918952814	10575
11	0	0
<8	0.523201128703559	267
>=8	99.4767988712964	50765
Total NACp Data	100	51032
Total Aircrafts		128

Figure 9 Statistical results of NACp for Ver. 2 ADS-B. A table and bar chart are shown on the left and right, respectively.

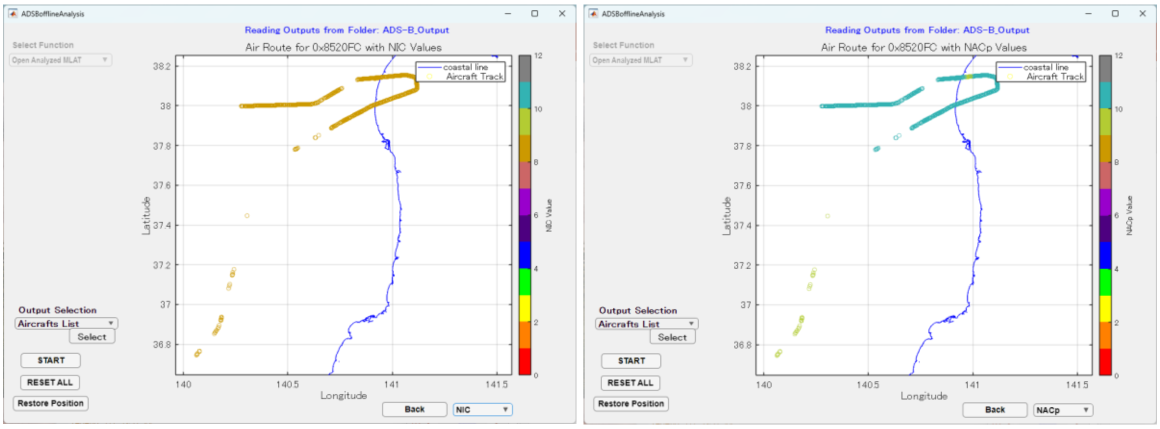


Figure 10 **Trajectories of single aircraft with NIC (left) and NACp (right) values. Constant NIC values are observed, whereas NACp varies.**

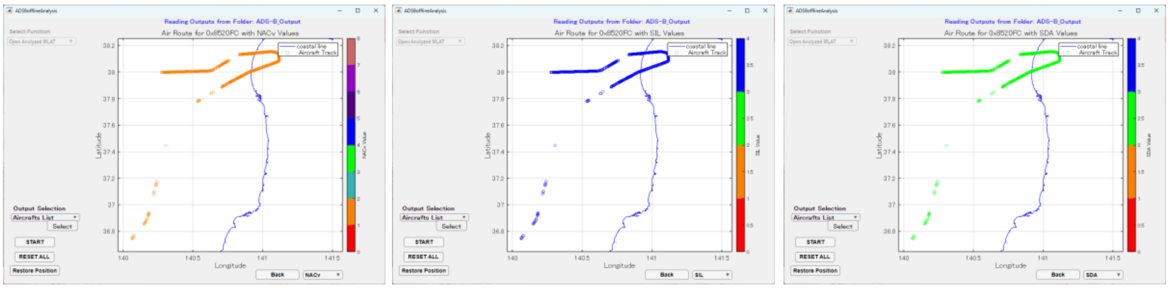


Figure 11 **Trajectories of single aircraft with NACv (left), SIL (center) and SDA (right) values.**

2.5 As explained in this IP, the developed software provides the statistical values of the quality of ADS-B performance as well as variations in the values in each trajectory. In addition, it helps in finding error aircraft such as aircraft with low quality values and implementation errors. The software will be updated to add other functions and to meet operational work.

2.6 We measured ADS-B equipage using one week data collected by MLAT. Percentage of ADS-B aircraft was approximately 91% in all Mode S aircraft. Additionally, Ver. 0, Ver. 1, and Ver. 2 aircraft was 14.8%, 0.4%, and 84.8%, respectively. Noted that the data were not covered whole Japan airspace and ATCRBS only transponders were excluded.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

a) note the information contained in this paper; and

b) discuss any relevant matter as appropriate

— — — — — — — — — — — —