International Civil Aviation Organization

Twenty Sixth Meeting of the Communications/ Navigation and Surveillance Sub-group (CNS SG/26) of APANPIRG

Video Tele-Conference, 5 – 9 September 2022

Agenda Item 7: Surveillance

7.2 Other surveillance related issues

RESEARCH ON ADS-B POSITION VERIFICATION

(Presented by Japan/ENRI)

SUMMARY

This paper presents research outcome on ADS-B position verification obtained in Electronic Navigation Research Institute (ENRI), Japan. The purpose of position verification is detecting false positions which may be caused by illegal transmissions or avionics failures. By experiment and computer simulation, we identified two effective methods; a Time-Difference of Arrival (TDOA) method and the reasonableness test for compact position reporting (CPR) decoding.

1. INTRODUCTION

1.1 ADS-B is a dependent surveillance and is also open system without encryption and authentication. Consequently, there is a possibility of false position information caused by avionics and security issues.

1.2 Electronic Navigation Research Institute (ENRI) have been working on this issue. By experiment and computer simulation, we identified two effective methods.

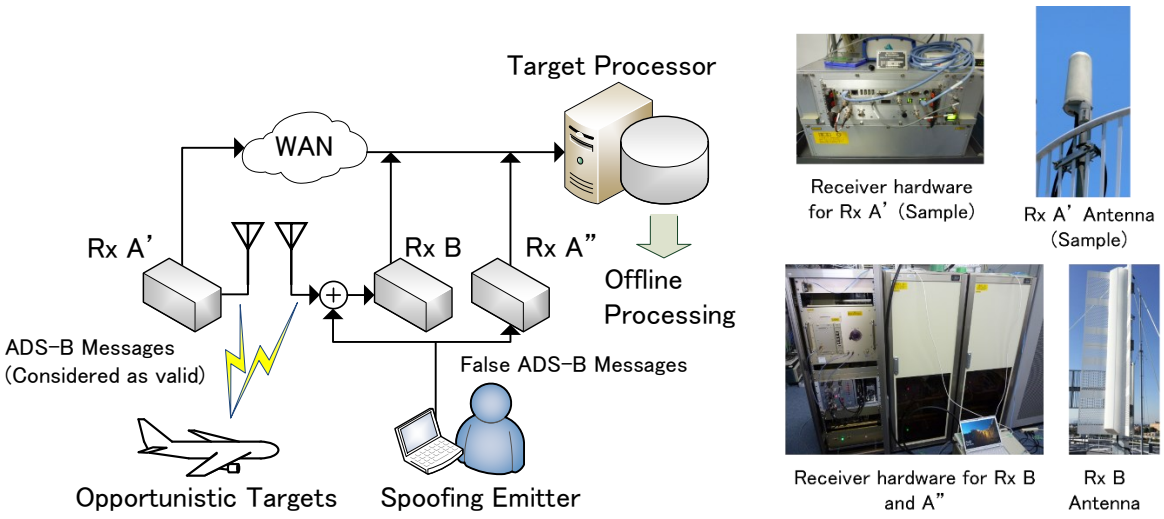
1.3 One is a Time-Difference of Arrival (TDOA) method as the primary method. With at least two receivers, the TDOA of an ADS-B signal can be measured. The measurement of TDOA is then compared to the ADS-B position. We evaluated this method by our experiment system and obtained a good performance. This result was reported in SURICG/5–WP/7 and contributed to the update of the ADS-B Implementation and Operations Guidance Document (AIGD).

1.4 The other is the reasonableness test for compact position reporting (CPR) decoding as a supplemental method. CPR is the format to encode/decode the longitude and latitude into/from bits. The reasonableness test is a method to verify a decoded latitude/longitude. The test rejects signals from uncompliant emitter with CPR encoding. In other words, illegal transmission will be more difficult to be successful. Moreover, from our computer simulation, we found the test can reduce some of false targets that are intentionally transmitted, although the method is not originally aimed at security

measure. This result was reported in SURICG/7–WP/11 in order to contribute to the update draft of the AIGD.

2. Experimental Evaluation of TDOA Method

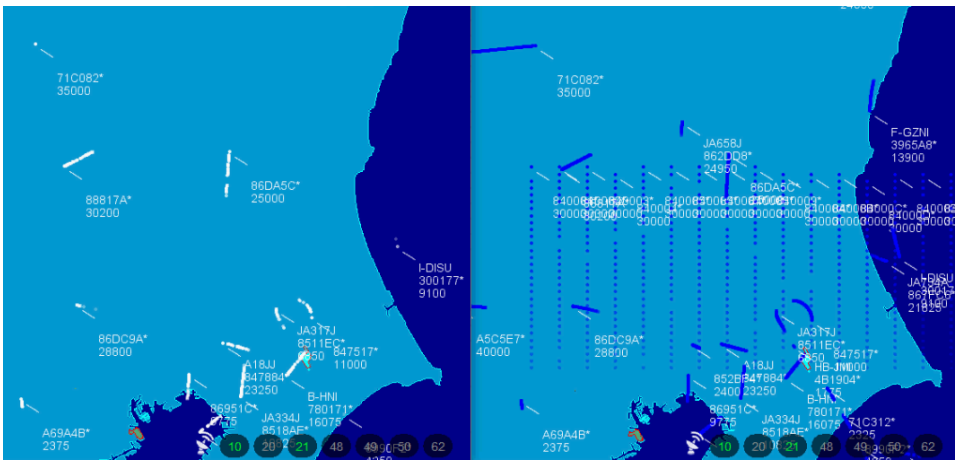
2.1 Figure 1 shows the experimental setup. The setup includes a spoofing emitter (simulated by a signal generator), targets of opportunity (all considered legitimate), and two receivers (one remote and one local are simulated by using three receivers).



(a) Configuration (b) Photos of the equipment

Figure 1. Setup for experiment of the TDOA method.

2.2 Figure 2 shows a snapshot during the experiment. The right map shows the target without position verification, where false targets appeared (the trajectories in the straight lines). The left map shows the targets after position verification, where the false targets were clearly removed. It is noted that some valid targets were removed for being out of TDOA coverage or too low altitude.



(left) after verification (right) without verification

Figure 2. A snapshot of the experiment.

2.3 We conducted a 24-hour experiment. The result is shown in Figure 3. The probability of detection was 99.81% (624889 signals were successfully detected as anomalous among 626053 false signals generated). The probability of a false alarm was confirmed to be consistent with the design (5%).

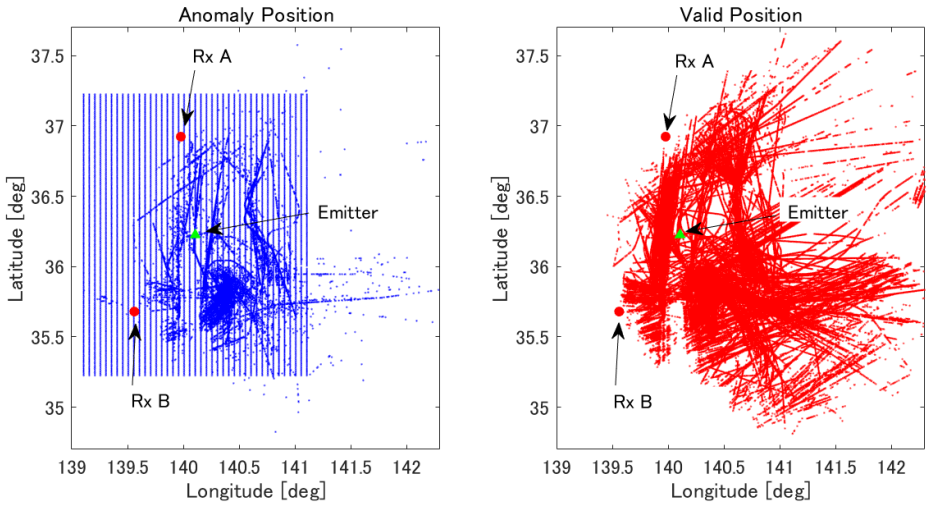


Figure 3. Result of the 24-hour spoofing experiment: (left) the positions determined as anomalous and (right) the positions determined as valid.

3. Computer Simulation of the reasonableness test for CPR decoding

3.1 CPR is the format to encode/decode the longitude and latitude into/from bits. The reasonableness test is a method to verify a decoded latitude/longitude, which is available in RTCA DO-260B. Because there are two decoding methods defined, namely globally unambiguous decoding and locally unambiguous decoding, two tests are defined accordingly.

a) The reasonable test for locally unambiguous decoding detects a position jump from the previous position, for example, 6 NM for airborne positions within 30 seconds.

b) The globally unambiguous decoding requires two signals called “even” and “odd”. The reasonable test for globally unambiguous decoding decodes an additional pair of signals and use it for verifying the decoding of the previous pair.

3.2 The test rejects signals from uncompliant emitter with CPR encoding. In other words, illegal transmission will be more difficult to be successful.

3.3 Moreover, from our computer simulation, we found the test can reduce some of false targets that are intentionally transmitted. Figure 4 shows the setup; ADS-B airborne position messages were generated for a correct track and a false track. The decoding method in RTCA DO-260B was then applied. The signals passed the reasonableness test for globally unambiguous decoding.

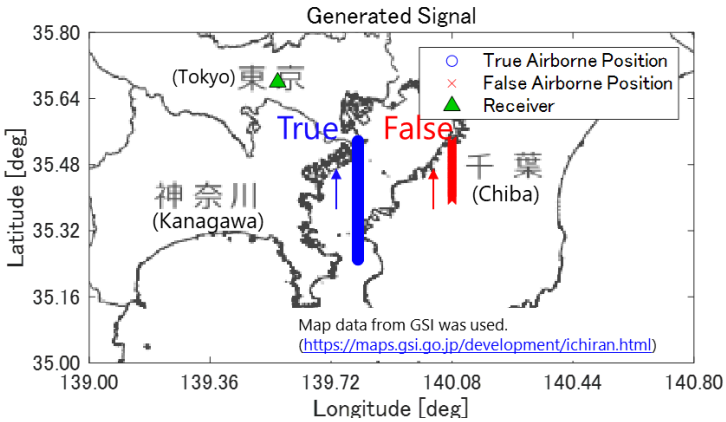


Figure 4. Generated signal in the computer simulation.

3.4 However, the false positions did not pass the reasonableness test for locally unambiguous decoding as shown in Figure 5. Position jumps of 13.7 NM, which are larger than 6 NM threshold, were detected. In other words, unreasonable movement of the aircraft was detected.

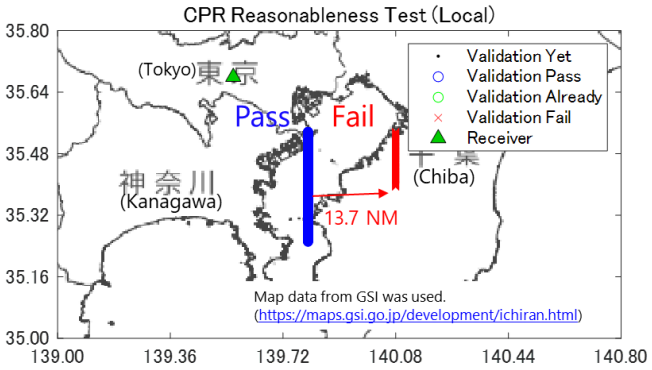


Figure 5. Simulation result of reasonableness test for locally unambiguous decoding.

4. ACTION BY THE MEETING

4.1 The meeting is invited to:

a) Note the information contained in this paper

b) Discuss any relevant matters as appropriate.

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