



ICAO

International Civil Aviation Organization

**Eighth Meeting of the Surveillance Implementation
Coordination Group (SURICG/8)**

Bangkok, Thailand, 6 – 9 June 2023

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

**FACTORS AFFECTING PERFORMANCE OF ADS-B POSITION VERIFICATION BY
TDOA**

(Presented by ENRI, Japan)

SUMMARY

TDOA is an effective approach to detect false ADS-B positions. This IP reports a numerical simulation on average performance. The result showed that TDOA accuracy and receiver position (sufficient separation between the two receivers) are important for a better performance.

1. INTRODUCTION

1.1 To detect false positions in ADS-B due to spoofing, TDOA measured with two receivers can be used.

1.2 ENRI reported an experimental result in SURICG/5-WP07, which demonstrated a good probability of detecting a false position. The method was mentioned in AIGD as an option for improving security.

1.3 This IP reports numerical simulation on detection performance, where average performance was theoretically calculated under various conditions. The result showed that TDOA accuracy and receiver position (sufficient separation between the two receivers) are important.

2. SIMULATION PROCEDURE

2.1 Surveillance coverage and possible area of malicious transmitter are given first. The coverage and transmitter area are separated into grids. The following figure shows an example. The circle in blue indicates the surveillance coverage, which is divided into $k = 1 \cdots N_a$ points. The circle in purple indicates the transmitter area, which is divided into $l = 1 \cdots N_t$ points.

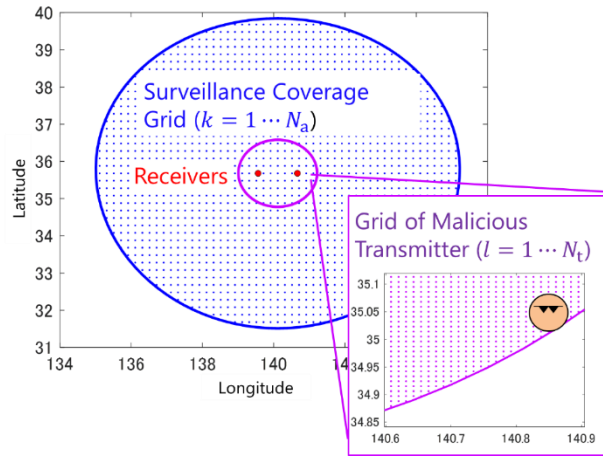


Fig1. Example of surveillance coverage and transmitter grids.

2.2 Whether detection is possible or not depends on the positional relation among the receivers, transmitter, and surveillance coverage. For all the possible combinations of coverage position (k) and malicious-emitter position (l), probability of detection is calculated. Then, the average is taken, which is written mathematically as follows.

$$P_{D,avg} = \frac{1}{N_a N_t} \sum_l^{N_t} \sum_k^{N_a} P_D(k, l) \quad (1)$$

where $P_D(k, l)$ means probability of detection for the combination of k th coverage position and l th transmitter. Note that some combinations such as out of line-of-sight should be removed in practice.

2.3 The calculation was repeated by changing the conditions as the following table. Here, $\sigma_t = 30$ nsec was selected as a typical value. $\sigma_t = 300$ nsec was selected to examine the effect of accuracy as a bad value.

Table 1. Parameters for simulation.

| | |
|---|--|
| Measurement accuracy (σ_t) | 30 nsec, 300 nsec |
| Distance between the two receivers | 0.5 km, 1.0 km, 5.0 km, 10.0 km, 50.0 km, 100.0 km, 150.0 km |
| Probability of false alarm (desired value: used for deciding the detection threshold) | 0.05, 0.01, 0.005, 0.001 |
| Surveillance Coverage | 250 NM (Radius of circle) |
| Surveillance Altitude | 5,000 ft, 10,000 ft 20,000 ft, 30,000 ft, 40,000 ft |
| Area of malicious emitter | 10 km, 30 km, 100 km (Radius of circle) |

3. RESULT

3.1 The calculation results were grouped by the measurement accuracy and the separation between the two receivers. Then, for each group, the minimum, average, and maximum of average probability of detection are plotted as an error bar style, as shown in Fig. 2. The left and right plots compare the effect of σ_t , where the performance was better with the better σ_t . The horizontal axis of each plot indicates the separation between the receivers, and the performance was better with a larger separation. The height of each bar indicates the effect of the other parameters, which is relatively small.

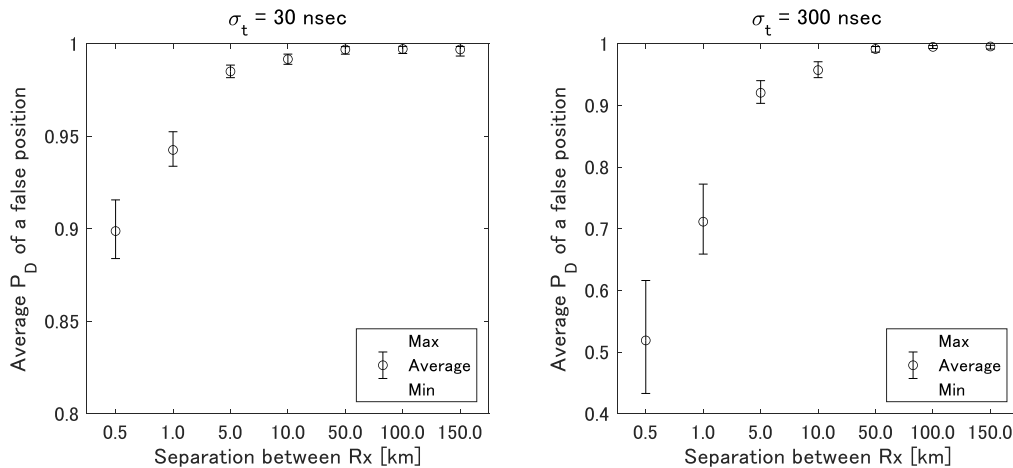


Fig. 2 Result: Average probability of detecting a false position.

3.2 The probability of detection was mainly determined by the accuracy and the separation. Especially when the accuracy is bad and the separation is small, the performance significantly degraded. Otherwise, the performance was good. This result shows that accuracy and separation between the receivers are important for a better performance.

4. ACTION BY THE MEETING

4.1 The meeting is invited to:

- a) note the information contained in this paper; and
- b) discuss any relevant matter as appropriate.
