

[EN-105] Evaluation Results of Airport Surface Multilateration (EIWAC 2010)

[†]H. Miyazaki*, T. Koga**, E. Ueda*, Y. Kakubari*, S. Nihei*

*Communication, Navigation and Surveillance Department

**Airborne System Technology Department

Electronic Navigation Research Institute (ENRI)

Tokyo, Japan

hiro@enri.go.jp

Abstract: The Multilateration (MLAT) is a new surveillance system which has been introduced worldwide for air traffic control. Electronic Navigation Research Institute has conducted evaluation tests of MLAT by using an evaluation system at some Japanese major airports. ⁽¹⁾ This paper describes evaluation results of MLAT for airport surface surveillance conducted at Kansai International airport. The evaluation results indicated that performance satisfied requirement values at almost area of the airport. A main point of this paper is to share our experiences obtained from the evaluation results with the lessons learned from the evaluation.

Keywords: Airport Surface Surveillance, Multilateration

1. INTRODUCTION

Air traffic controllers have usually used conventional Surface Movement Radar (SMR) for ground control. However, the SMR has some problems, such as no display of identification data, performance degradation in bad weather condition, and blind area by construction.

On the other hand, the Multilateration (MLAT) is a new surveillance system which is capable of resolving the SMR problems. Therefore, it is expected that surface surveillance system can achieve advanced functions and higher performance by operating MLAT in combination with SMR. From this reason, Japan Civil Aviation Bureau decided to introduce Multilateration system to some Japanese airports.

In order to achieve high performance in MLAT, one of important factors is to select appropriate antenna installation positions based on the airport layout. However, Kansai international airport (Kansai A/P) has specific restrictions for antenna installation positions. Therefore, Electronic Navigation Research Institute (ENRI) conducted evaluation tests of MLAT by using an evaluation system at Kansai international airport. Main purposes of the evaluation are to verify performances of MLAT and to propose the appropriate antenna allocation based on the test results.

This paper describes test results of the evaluation at Kansai international airport. In addition, causes of performance degradation and their mitigation means are also described in this paper.

2. Overview of MLAT

Figure 1 represents a conceptual figure of MLAT positioning. MLAT detects SSR “squitter” signals ⁽²⁾ transmitted from aircraft transponder by ground Receiver Units (RUs), and measures the aircraft position by using TDOA technique. This means, the time differences of arrival among ground RUs are transformed to the distance differences between the aircraft and RUs. Then the aircraft position is fixed as the intersection of the two hyperbolic lines.

Main advantages of MLAT are as follows; display of identification information on radar screen, no performance degradation in bad weather condition, complement to SMR blind area, and no additional equipment to aircraft.

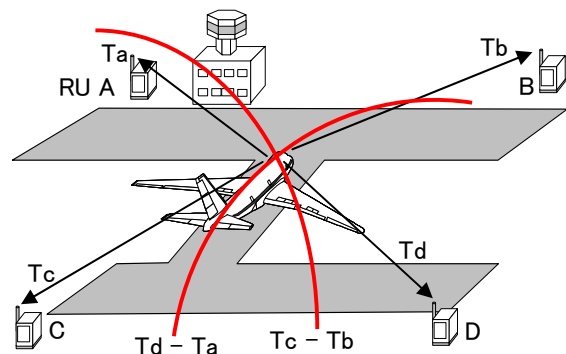


Figure 1 Conceptual figure of MLAT positioning

Position accuracy of MLAT mainly depends on precision of signal detection time and positional relation among the aircraft and RUs, which is GDOP (Geometrical Dilution of Precision). The GDOP becomes fine if RUs surround the aircraft. Also precise time synchronization among RUs is important, because MLAT measures aircraft position by TDOA.

On the other hand, one of main causes of performance degradation is signal corruption by multipath. It is highly required to avoid the multipath, because it brings undetected signal or false detection. From above facts, it is important to select the antenna layout and antenna positions appropriately based on the airport layout and the signal environment.

3. Evaluation System

Figure 2 represents system architecture of the evaluation system. The evaluation system consists of RUs, Reference Transmitter (RefT), and Central Processing Station (CPS). The RU detects SSR signal and transfers the CPS signal information with detection time as target reports. There are two types of RU. One is Receiver only (Ro); another one is Receiver/Transmitter (R/T). R/T interrogates aircraft to get additional information (Identification, Altitude) and to measure ranges between R/T and aircraft for selecting the best solution. The RefT transmits squitters for time synchronization among RUs and for monitoring of the whole system. And the CPS calculates target positions from target reports including detection time and conducts tracking for updating target positions.

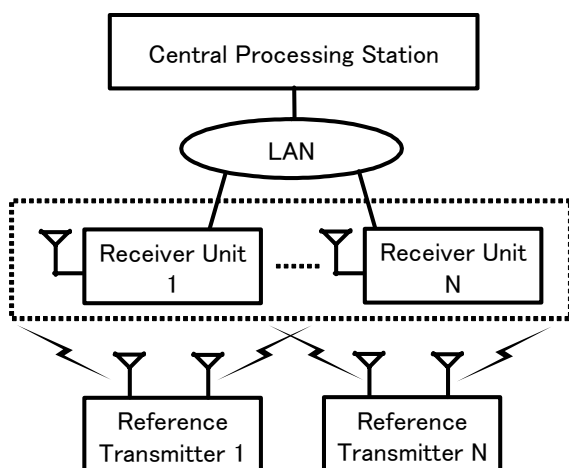


Figure 2 System architecture of the evaluation system

4. Kansai International Airport

Kansai A/P is a main international airport for west part of Japan and exists in Osaka prefecture, actually on the Osaka bay. Figure 3 represents location of Kansai A/P. Figure 4 represents overview of the airport. There are two runways and a sophisticated terminal building at the airport. Figure 5 represents a picture of the terminal building. This terminal building was designed by a famous architect.

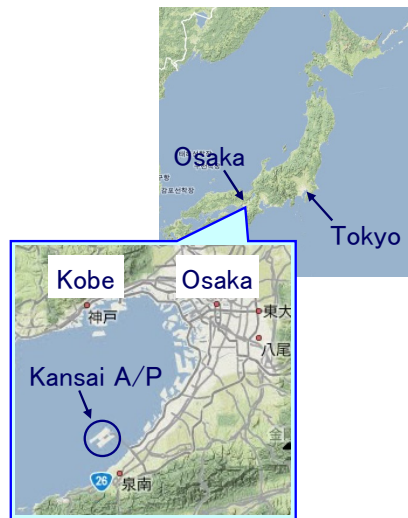


Figure 3 Location of Kansai A/P



Figure 4 Overview of the airport.

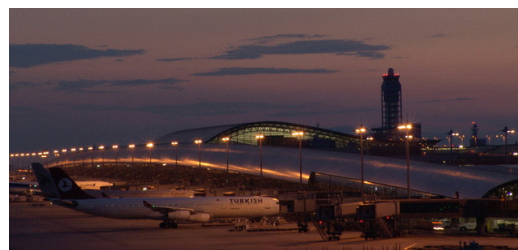


Figure 5 picture of the terminal building

5. Antenna Layout

5.1 Concept

As mentioned above, antenna layout is most important to achieve good performance in MLAT. On the other hand, one of main causes of performance degradation is signal corruption by multipath. To resolve this problem, it is typically effective to put antennas as much as higher. In addition, high installation cost is also big problem to introduce MLAT system. This problem inhibits installing antennas to ideal place. From these matters, our concept is to install antennas on existing facility, as much as possible. Furthermore, we keep a number of antennas as low as possible.

5.2 Specific Restrictions

There are specific restrictions for antenna installation at Kansai A/P. As mentioned above, Kansai A/P is surrounded on all four sides by sea. So it is difficult to install antennas widely around the airport. This means antenna height is restricted by the regulation of transition surface. This is a strong limitation for MLAT to achieve high performance at runway/taxiway area. In addition, it is restricted to install antennas on the roof of the terminal building due to structural problem. This is a strong limitation for MLAT to achieve high performance at terminal apron area. From these restrictions, some ideas were required to select the antenna installation positions.

5.3 Antenna Installations

Based on our concept and the specific restrictions, we designed the antenna layout for Kansai A/P. Figure 6 represents the antenna layout of the evaluation system. The evaluation system consists of 13 Ro units, 5 RT units, and one RefT. Figure 7 shows pictures of some antenna installations. We installed antennas on existing facilities, such as ILS middle marker, glide slope, A/G radio tower, and roof of Cargo building. 2 antennas were installed on top of ATC tower. Top of ATC tower is the most ideal place, due to taking fine line-of-sight to whole airport.

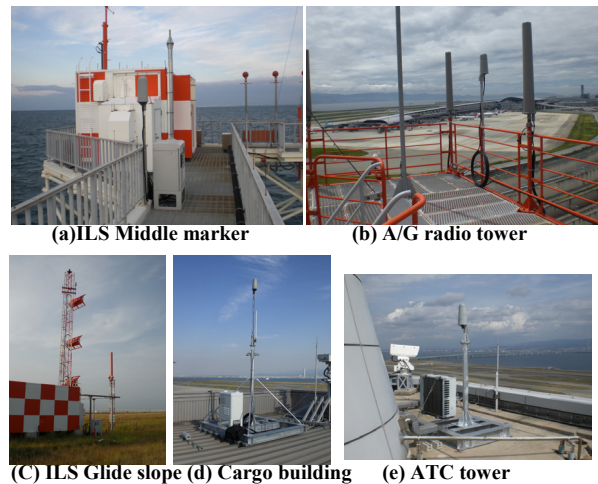


Figure 7 Antenna installations

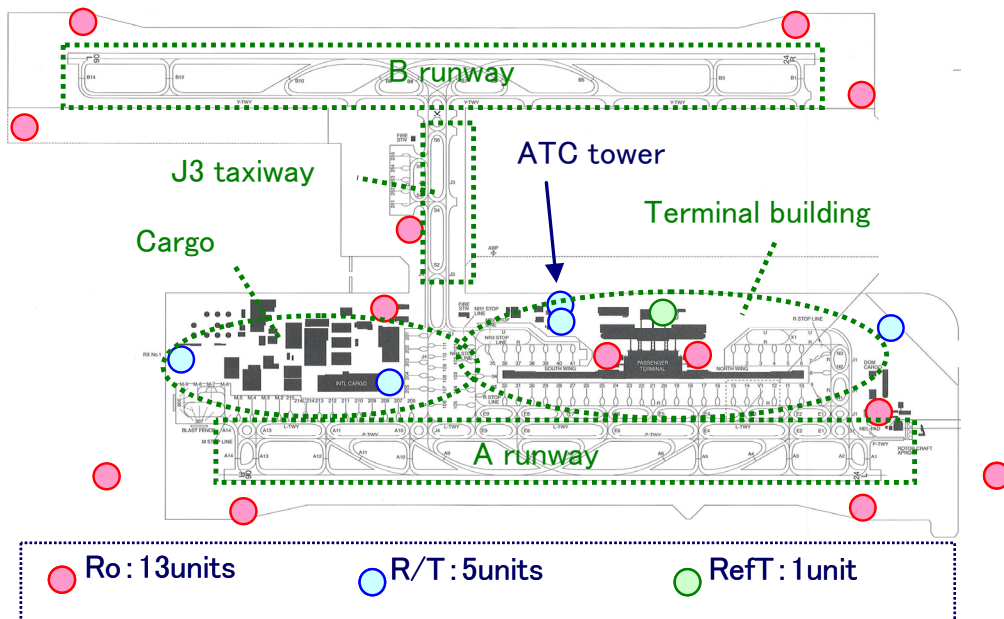


Figure 6 Antenna layout of the evaluation system

6. Evaluation Tests

6.1 Evaluation Method

The tests were conducted by using a test vehicle equipping a transponder. Figure 8 shows a picture of the test vehicle. Evaluation items are position accuracy and detection rate. European standard ⁽³⁾ was used as the performance requirement. Table 1 shows requirement values for position accuracy and detection rate. Kinematic GPS data was used as reference points to calculate position accuracy.



Figure 8 Picture of the test van

Table 1 requirement values for accuracy and detection rate

Area	Position Accuracy	Detection Rate
Runway/Taxiway	7.5m	99.9% (2sec)
Apron (Stand)	20m	99.9% (5sec)

6.2 Test Results

Evaluation tests were conducted from September to December 2009. Figure 9 represents test tracks with performance values at each runway/taxiway areas. Red lines and blue lines mean tracks by MLAT and Kinematic GPS, respectively. It was confirmed that the performance at runway/taxiway areas satisfied the requirement values.

Figure 10 and Figure 11 represent test tracks with performance values at cargo area and terminal building area, respectively. It was confirmed that performance values satisfied performance requirements at almost apron area. However, certain area has not yet satisfied the requirement values. main cause of this performance degradation was signal corruption by multipath. This area where the performance degradation occurred was most difficult area for signal environment.

The picture within figure 11 shows the most difficult area. This area is surrounded on all four sides by building. In order to improve performance in such difficult area, ENRI has developed advanced techniques for signal detection and processing. The advanced techniques include to apply sophisticated pulse detection methods and bit demodulation methods that are effective against corruption by multipath,

6.3 The Lessons Learned from the Evaluation

An apron area where is surrounded on all four sides by building is most difficult area to achieve good performance. In order to improve performance in such difficult area, some advanced techniques are required for signal detection and signal processing.

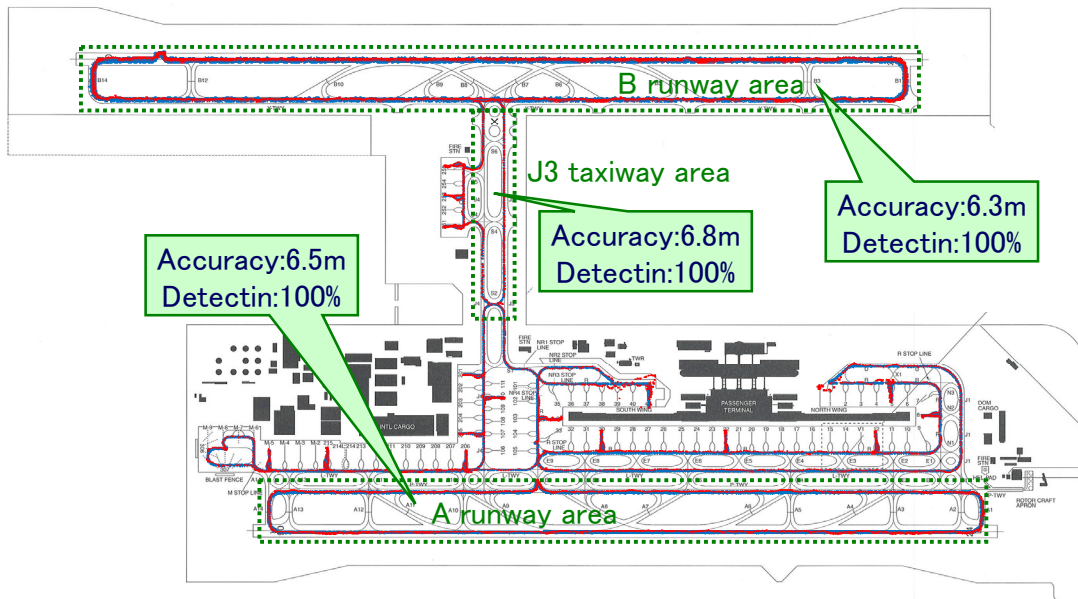


Figure 9 Test tracks with performance values at each runway/taxiway areas

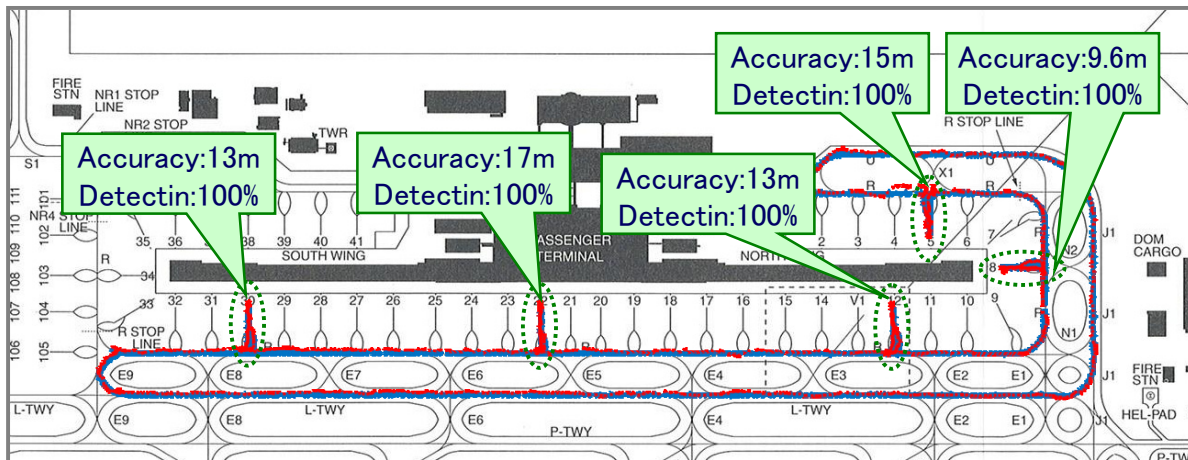


Figure 10 Test tracks with performance values at cargo area

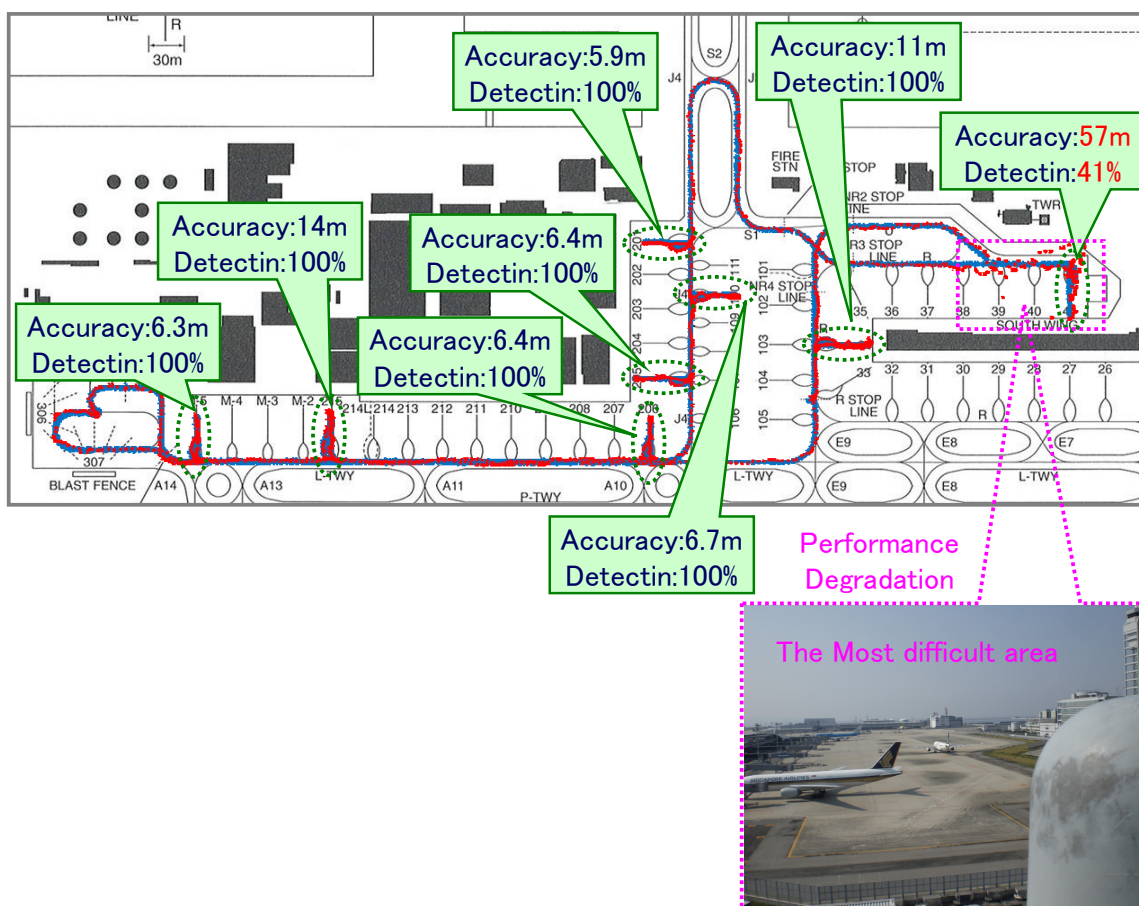


Figure 11 Test tracks with performance values at terminal building area

7. Conclusion

This paper described evaluation results of MLAT conducted at Kansai A/P. MLAT is an advanced surveillance system which is capable of improving functions and performance of airport surface surveillance. It was confirmed in the evaluation tests that performance values satisfied performance requirements to almost area of the airport. Actually, there are some restrictions for installing antennas to airports. And the restrictions bring performance degradation. In order to avoid performance degradation, the most important factor is to select antenna layout appropriately. From these matters, it is considered that our lessons learned from the evaluation are effective. MLAT operation at Kansai A/P will start next year.

8. ACKNOWLEDGMENTS

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9. REFERENCES

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