Estimation of 1090 MHz Signal Environment on Airport Surface by Using Multilateration System

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Abstract ─ This paper is concerned with an estimation of 1090 MHz signal environment on airport surface. Secondary surveillance radar and its applications share 1030 MHz and 1090 MHz. Since many aircraft emit signals with same frequency band, increasing signal amount will be saturated and result in the performance degradation. To meet the aviation requirement, it is important to manage the signal amount. In this paper, focusing on 1090 MHz, we propose an estimation method for signal amount on airport surface, by using multilateration system.

Index Terms ─ 1090 MHz, ATCRBS, Mode S, multilateration, secondary surveillance radar, signal amount.

I. INTRODUCTION

Secondary surveillance radar (SSR) has become one of main surveillance systems in the civil aviation, and multilateration (MLAT), wide area MLAT (WAM) and automatic dependent surveillance - broadcast (ADS-B) have been developed as SSR applications. In those systems, 1030/1090 MHz frequency bands are employed and shared with each other [1],[2]. Therefore, with increasing the demand of aircraft, signal environment is getting worse. In order to maintain the safety operation, signal amount and signal rate should be appropriately managed.

The purpose of this study is to estimate the current signal environment of 1030/1090 MHz to evaluate the future signal environment. In addition, we consider the environment of distorted signals which affects to the detection rate. In this paper, focusing on 1090 MHz, we propose an estimation method for analyzing signal environment on airport surface. Currently we are under the investigation of a new MLAT system by using radio-over-fiber (RoF) [3],[4]. A prototype system is deployed at Sendai airport, Japan. The proposed method to acquire signal data uses receiver units implementing to MLAT system. Comparing with the signal data between receivers, we analyze signal amount, signal rate and the amount of distorted signals on airport surface. In this paper, we firstly introduce the experimental system for collecting 1090 MHz signals and secondly discuss the estimation method of signal environment. Finally we show the signal amount and distorted signals of ATCRBS (Air Traffic Control Radar Beacon System) and Mode S of which are signal types employed in 1090 MHz [5]. We discuss the signal environment on airport surface.

II. ESTIMATION METHOD OF SIGNAL ENVIRONMENT

To obtain 1090 MHz signals, MLAT system is employed. ENRI developed a new MLAT system named as OCTPASS (Optical Fiber Connected Passive Surveillance) [3],[4], and the system is deployed at Sendai airport which is a middle size airport in Japan. OCTPASS has eight receiver units connected to a central signal processing unit by optical fiber. The received signals are transmitted to the central processing unit by RoF technology. RoF enables to transmit RF signals in the long distance by amplitude modulation in the optical region. Consequently, OCTPASS directly processes the RF signals at the central processing unit. Our method to analyze 1090 MHz signals uses its characteristics.

Figure 1 shows an experimental environment in Sendai airport. As shown in this figure, eight OCTPASS receivers are located in the airport. In addition, three transmitters exist. The first is used for the actual operation, second one is for trainees, and the final is our experimental system. Signal amount is anticipated to be larger than that of same size airports due to three transmitters.

Next, we explain the method to count the number of 1090 MHz signals. All received RF signals are transmitted to the central processing unit. The central unit makes groups as signals are collected within the arbitrary time gate. Therefore, we can count and compare the signals at the same arrival time. Statistical signal amount in the

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airport is considered if a receiver unit detects a signal, even if the signals are not decoded. On the other hand, distorted signals are counted by compared with all receiver data. If a received signal is different from other received signals, we regard it as a distorted signal. Figure 2 is an example for distinguishing received signals.

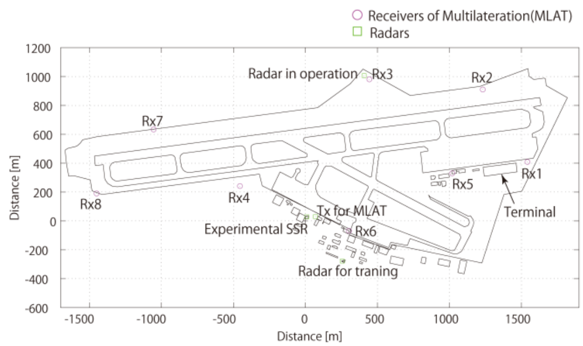

Fig. 1. Experimental environment in Sendai Airport.

Time	Receiver							
	Rx1	Rx2	Rx3	Rx4	Rx5	Rx6	Rx7	Rx8
t_1	AA11	0000	0000	AA11	AA11	0000	AA11	AA11
⋮		Received signals			No signal			
t_2	0000	AB12	AB12	0000	0000	0000	AB00	0000
⋮		Received correct signals			Received signals, but distorted one			

Note:
t_1 - "AA11" is the received signal from an aircraft.
t_2 - "AB12" is the correct signal emitted from an aircraft, but "AB00" is the distorted signal by comparing with other received signals.

Fig. 2. Distinction of received signals.

III. ESTIMATED SIGNAL AMOUNT AND DISTORTED SIGNALS

We analyzed ATCRBS and Mode S signals used in 1090 MHz. Figure 3 shows signal amount of ATCRBS. This figure indicates that the signal amount depends on the receiver position. The data is the averaged value for 10 second. The maximum value is about 3,000 per second. The largest number of signals is obtained by Rx7, and the minimum one is at Rx6. As Rx7 is relatively open area, the signal amount is large, while the value of Rx6 is small because it is located around the buildings such as hanger and shadowed by airport terminal. Figure 4 shows signal amount of Mode S. As shown in this figure, the amount is less than 1/10 of ATCRBS. The characteristic for time dependence is the almost same as that of Fig. 1.

Finally we analyzed the distorted signals. In this paper, we show the result of ATCRBS. Figure 5 is the estimated amount of distorted signals based on the idea shown in Fig. 2. As an example, we compare the signals of Rx7 at 1:00. The number of distorted signal is about 450, and the total received signal is about 1750 from Fig. 3. Therefore, the rate of distorted signals is approximately 25%. The rate of distorted signals depends on the receiver allocation, but in this airport the performance of a normal MLAT system which needs the decoded signals, might become worse in comparison with OCTPASS.

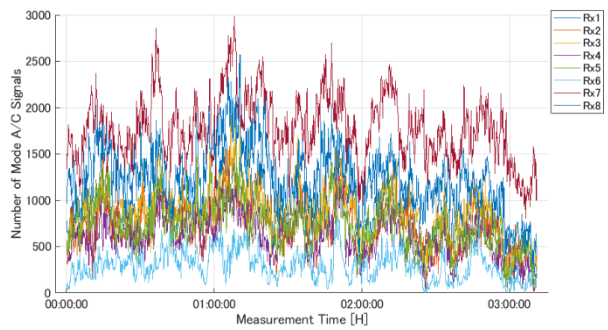

Fig. 3. Signal amount of ATCRBS.

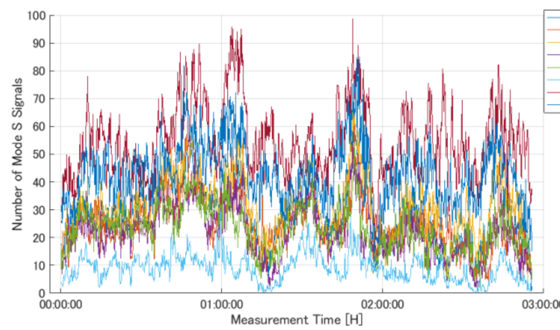

Fig. 4. Signal amount of Mode S.

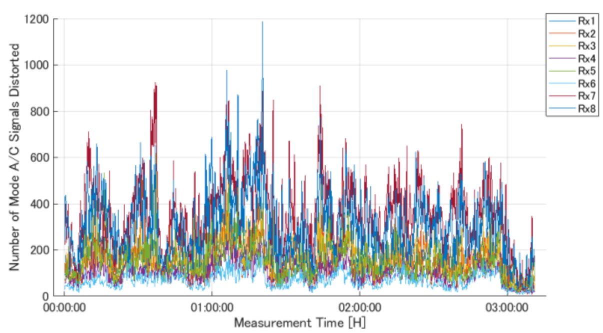

Fig. 5. Amount of distorted signals of ATCRBS.

IV. CONCLUSION

In this paper, we have introduced the estimate method for analyzing 1090 MHz signal environment in airport. The proposed method uses OCTPASS system with several receiver units deployed in airport whose receiver units are connected by the RoF. Collecting RF signals to the central processing unit, we can easily estimate the received signal amount and the number of distorted signals. It has been found that the signal amount depends on the receiver allocation. It has been also found that the signal amount of Mode S is much less than that of ATCRBS. Moreover, we checked the rate of distorted signals at Rx7 as example. It has been demonstrated that the distorted signals were detected about 1/4 of total received signals.

We would like to analyze other experimental data, and would also like to make the expectancy value of future signal amount. We need to evaluate the performance of OCTPASS by comparing with the normal MLAT. They deserve as future studies.

ACKNOWLEDGMENT

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