International Civil Aviation Organization

AUTOMATIC DEPENDENT SURVEILLANCE – BROADCAST SEMINAR AND TWELFTH MEETING OF AUTOMATIC DEPENDENT SURVEILLANCE – BROADCAST (ADS-B) STUDY AND IMPLEMENTATION TASK FORCE (ADS-B SITF/12)

Kolkata, India, 15-18 April 2013

Agenda Item 6: **Review States' activities and interregional issues on trials and implementation of ADS-B and multilateration**

SURVEILLANCE ACTIVITIES IN JAPAN

(Presented by Japan)

SUMMARY

ADS-B has been introduced worldwide as a key component for air traffic control. However, the ADS-B has challenges, such as avionics equipage and vulnerability of security. Therefore, other surveillance system is required like a MLAT to complement ADS-B operation.
JAPAN Civil Aviation Bureau, Electronic Navigation Research Institute and Japan Radio CO. ,LTD have developed an advanced airport surface surveillance MLAT system which is called "OCTPASS (Optically Connected Passive Surveillance System)" The OCTPASS can provide improved surveillance performance with low cost compared with conventional MLAT systems. Of course, the OCTPASS has a compatibility with ADS-B.
This paper provides a summary of the OCTPASS.

1. INTRODUCTION

1.1 Based on the CARATS road map, which is described as future CNS/ATM implementation plan in Japan, JAPAN Civil Aviation Bureau (JCAB) has conducted a number of activities to realize the implementation plan CARATS road map.

1.2 This paper provides activities regarding to an advanced airport surface surveillance MLAT system and a data fusion system. The advanced MLAT system is called "OCTPASS (Optically Connected Passive Surveillance System). The OCTPASS has a superior ability for positioning aircraft with a small component. On the other hand, the data fusion system has already been reported in the last ADS-B SITF meeting in Jeju.

2. OCTPASS

2.1 MLAT system is an important component for airport surface surveillance at this time. However, MLAT system requires a number of receiver stations in large airports. And this requirement brings high initial cost and running cost (e.g. parts cost and electrical charges and so on). To improve this requirement, OCTPASS can realize a compact system configuration (i.e. a small number of receiver stations) by using a superior signal detection technique against multipath interference. The OCTPASS has been developed by JCAB, Electronic Navigation Research Institute (ENRI) and JRC, as a concept of high performance and low cost. See the Attachement-1.

2.2 The OCTPASS is a passive surveillance system using Mode-S signals (i.e. SSR reply and squitter) transmitted from the aircraft transponder. The squitter is a cyclic self-generated signal which is same signal format with SSR Mode-S reply.

2.3 The positioning principle of OCTPASS is same with the conventional MLAT system. This is squitter signals transmitted from the aircraft are received by three or more receiving stations at each of which the Time Difference of Arrival (TDOA) is detected to calculate the position of the aircraft. The transmitting and receiving directions are opposite, but the similar calculation equation as in the positioning by the GPS (Global Positioning System) can be used. On the airport surface, the 2-dimensional positioning is often sufficient. In this case, the airport surface can be approximated to a simple plane, on which the TDOA may be detected by at least three receiving stations.

2.4 The largest difference in positioning between the OCTPASS and the conventional MLAT system consists in the timing for signal detection and processing (signal detection and signal arrival time detection). In the conventional MLAT system that is widely used, the received signal is detected and processed at each receiving station. The detected time (time stamp) obtained at the station and the decoded data including the identification information of the aircraft are transmitted via Ethernet to the target processor unit, at which the position calculation is made based on the collected data.

2.5 In this contract, the OCTPASS uses the method of collecting the RF signals from the individual receiving stations at one receiver/signal processor unit in which those signals are detected and processed. To collect the RF signals at the receiver without their attenuation and deterioration, the analogue Radio over Fiber (RoF) transmission units are used to transmit the RF signals via optical fiber cables. This RoF transmission system has the following two advantages:

2.6 One advantage is that the received signal can be used for position calculation even if it cannot be deciphered. On the airport surface, the sufficient signal strength can be obtained, but there may be a situation in which the data bits are damaged and unable to be decoded. Even if any receiving station cannot decode the received signal and decipher the aircraft identification information, the OCTPASS collects the received RF signal at one node and obtains the time correlation between the RF signals, so that it can determine that those signals are transmitted from the same aircraft.

2.7 Another advantage is that the receiving station can have a simple composition. Each receiving station has no signal processor unit to make a complicated process, but it is provided only with the function of converting the received signal into an optical signal for transmission. Therefore, each receiving station can consist only of an antenna and a RoF transmitter, allowing a compact and lightweight design. The receiving stations are installed at multiple spots on the airport surface, but as they can be of compact design, their installation layout can be designed flexibly.

3. Data fusion system

3.1 JCAB has focused on the difference of ADS-B data format and/or ATC transponder type.

3.2 During the design process for the Data fusion system, JCAB has considered how to use only valid data and cancel low reliability data.

3.3 It should be needed to exchange information among relevant States how to handle these ADS-B data with different version, reliability, accuracy indication（NIC/NUC/NAC）and so on.

(Reference) JCAB presented a working paper（WP-133）including the above mentioned issue in the ICAO AN-Conf/12.

4. Action by the meeting

4.1 The meeting is invited to note the information.

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Attachment 1

OCTPASS

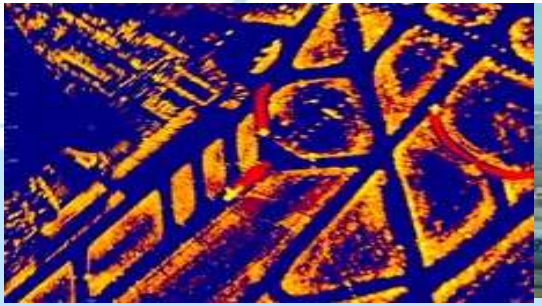
(Optically Connected Passive Surveillance System)

Presented by Japan Civil Aviation Bureau (JCAB),
Electronic Navigation Research Institute (ENRI)
and Japan Radio Co., Ltd (JRC)

Contents

1. Development Background of OCTPASS

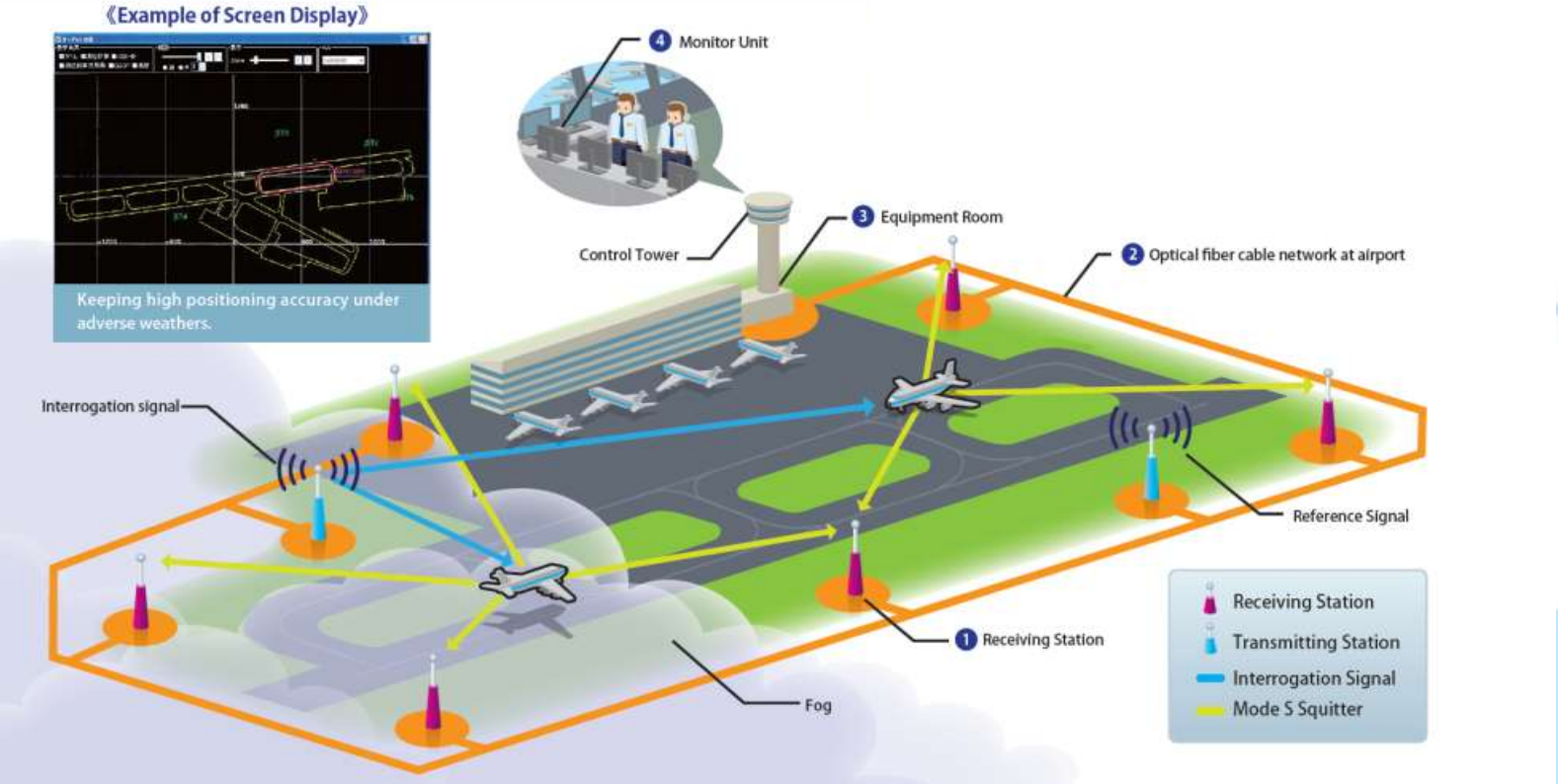
1. Civil aviation is continuously expanding application in various fields and the usage of them also increasing rapidly in year by year.
2. In recent years, the airport surfaces of large-scale airports are forced to make high-density operation due to the increasing demand for air transport. In this situation, the airports are required to maintain safe and smooth taxiing of aircraft. In order to realize reliable aircraft surveillance at a low visibility in the nighttime or in adverse weathers.
3. It is expected that the realization of safe and efficient aircraft operation through the accurate and precise monitor of the aircraft and airport safety related service vehicles moving location at airport surface.
4. In monitor accurate and precise aircraft moving location, existing mechanically rotated primary radar (SMR) application has some issues such as the acquisition of the identification signal, performance degradation under the bad weather condition, airport surface coverage, and maintenance cost of continuously operating mechanical components.



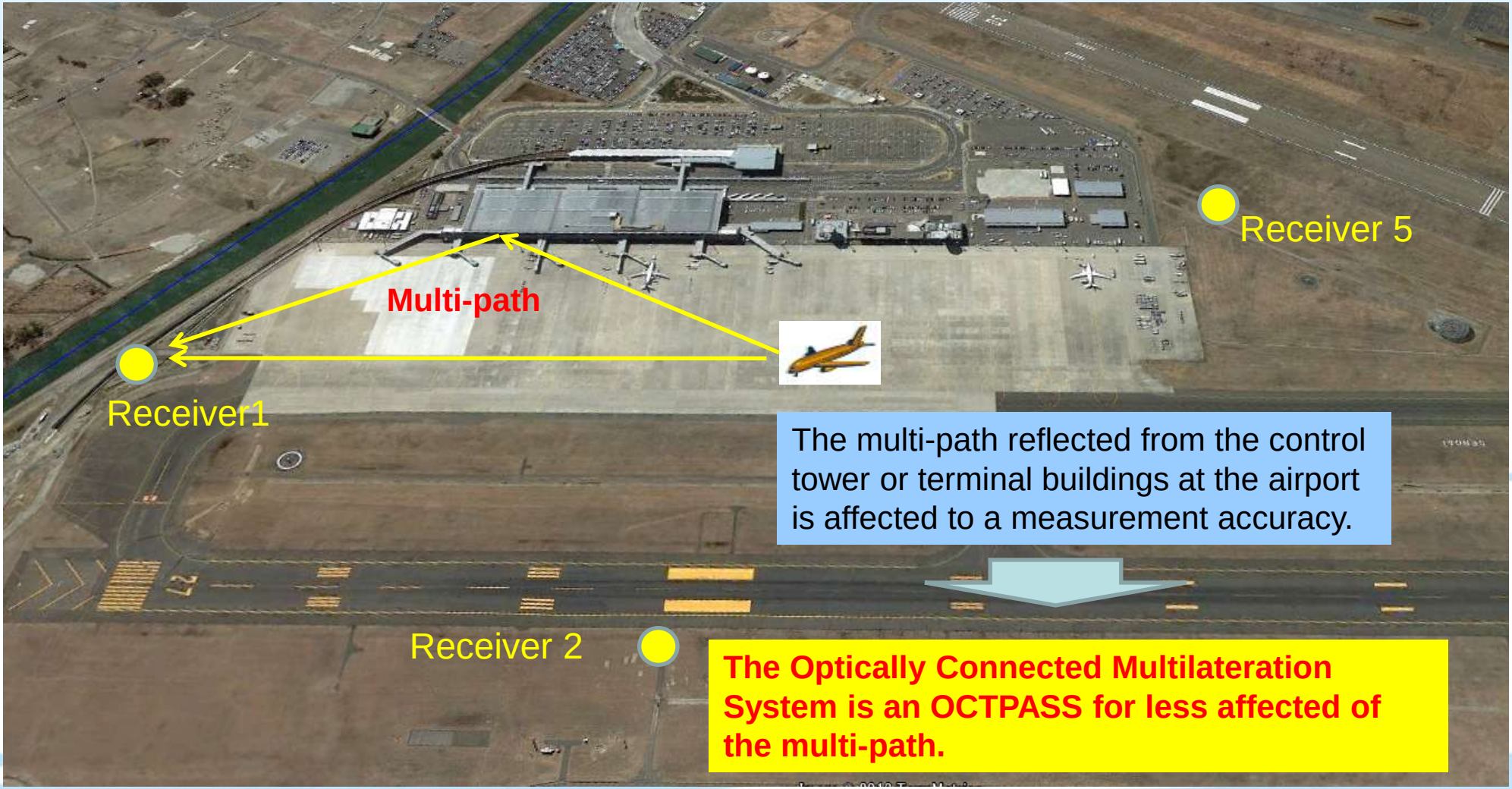
1. Development Background of OCTPASS

4. The introduction of ADS-B system is progressing in aircraft flight location surveillance field. But the deployment of the ADS-B has the challenge that required the SSR mode S transponder equipment provision for the aircraft.

5. OCTPASS was developed by Japan Civil Aviation Bureau (JCAB), Electronic Navigation Research Institute (ENRI) and JRC. The OCTPASS provides improved position and surveillance performance for aircraft which has SSR mode S transponder provision, and it has compatibility with ADS-B system.

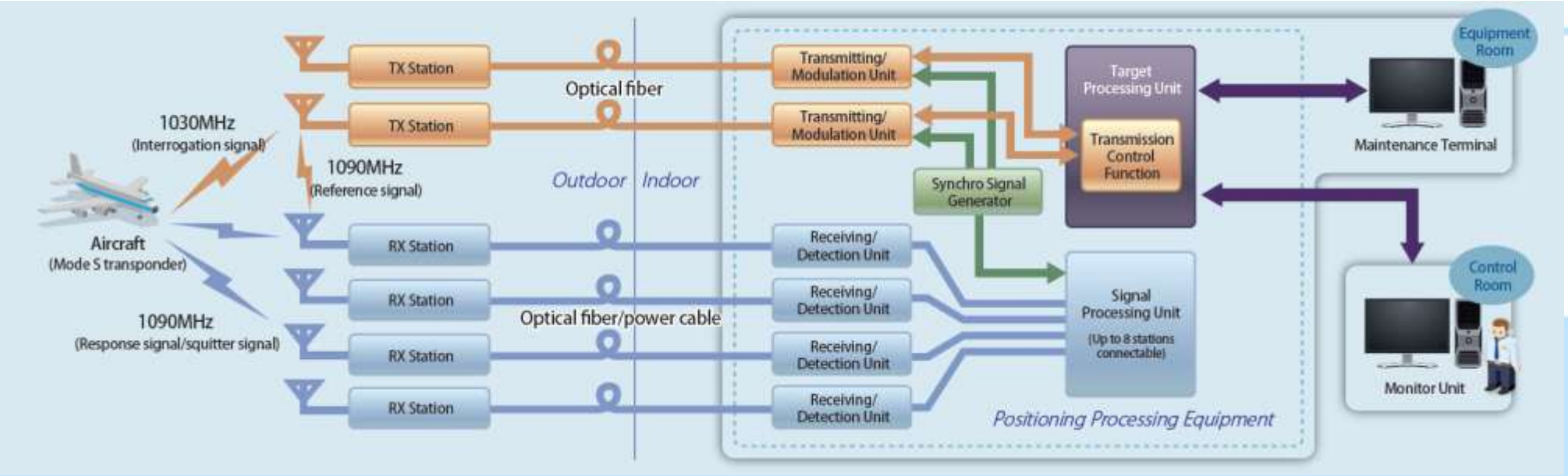


2. MLAT System

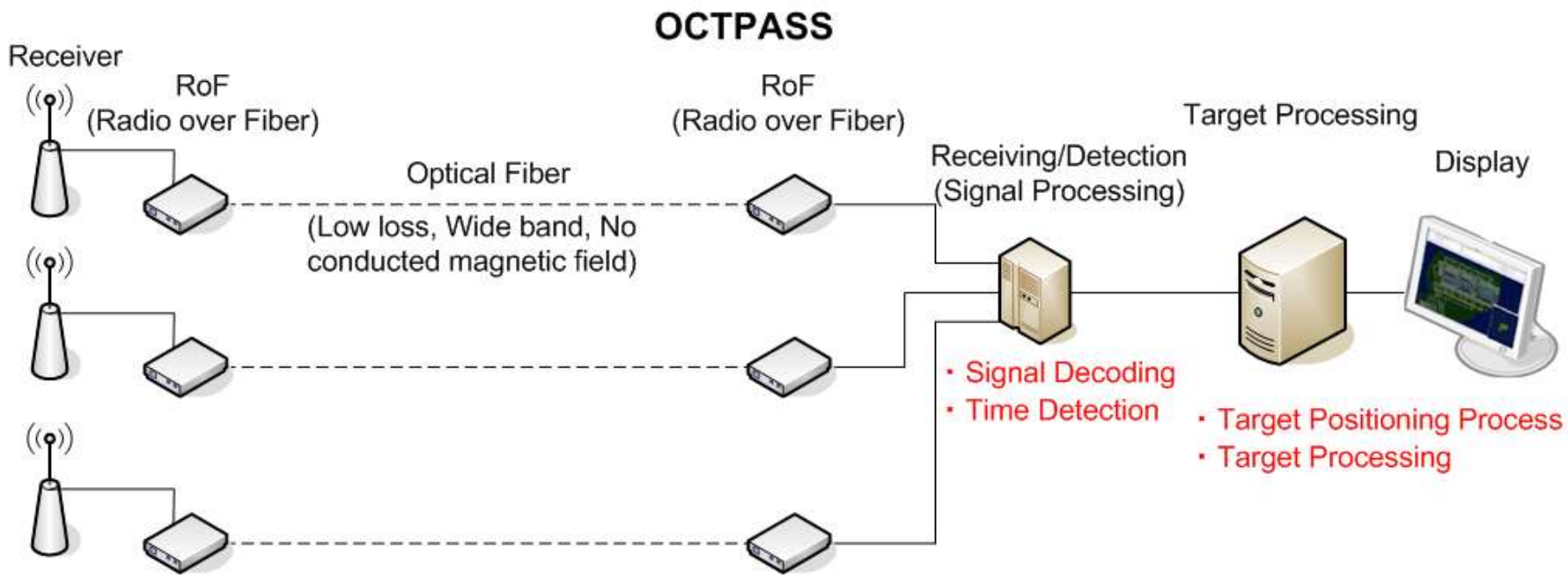


3. Description of the OCTPASS

1. OCTPASS is configured by the SSR transponder signal receivers at several sensor sites connected by optical fiber cables, SSR interrogator transmitter, centralized positioning signal processing equipment, system performance monitor equipment, and display unit for the aircrafts and airport safety related service vehicle movements.
2. The centralized positioning signal processing equipment calculates the position of the aircraft by a multiple replies signal. And the position information of the aircraft are displayed at the display unit for the person in charge of the operation.
3. In addition, the OCTPASS transmits SSR interrogation signal for aircraft to improve the performance and flight altitude data acquisition.



4. Description of Signal Processing (1)



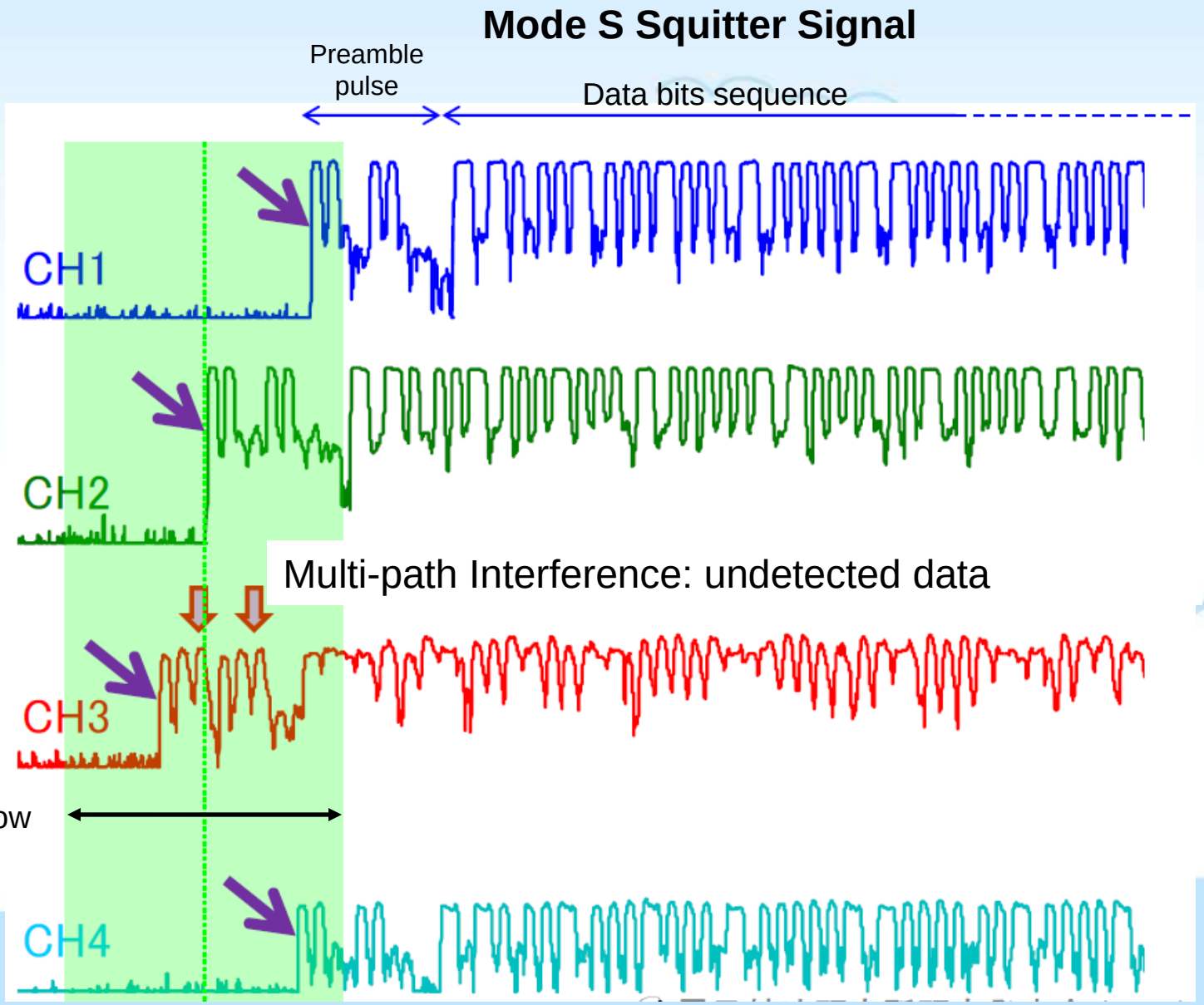
➢OCTPASS uses the method of collecting the RF signals from the individual receiving. To collect the RF signals at the receiver without their attenuation and deterioration, the analog Radio over Fiber (RoF) transmission units are used to transmit the RF signals via optical fiber cables.

➢The advantage is that the received signal can be used for position calculation even if it cannot be deciphered due to multi-path in which the data bits are damaged and unable to be decoded. The OCTPASS collects the received RF signal at one node and obtains the time correlation between the RF signals, so that it can determine that those signals are transmitted from the same aircraft.

➢Another advantage is that the receiving station can have a simple composition. Each receiving station has no signal processor unit to make a complicated process, but it is provided only with the function of converting the received signal into an optical signal for transmission. Therefore, each receiving station can consist only of an antenna and a RoF transmitter, allowing a compact and lightweight design. It is expected to be of compact design, their installation layout can be designed flexibly.

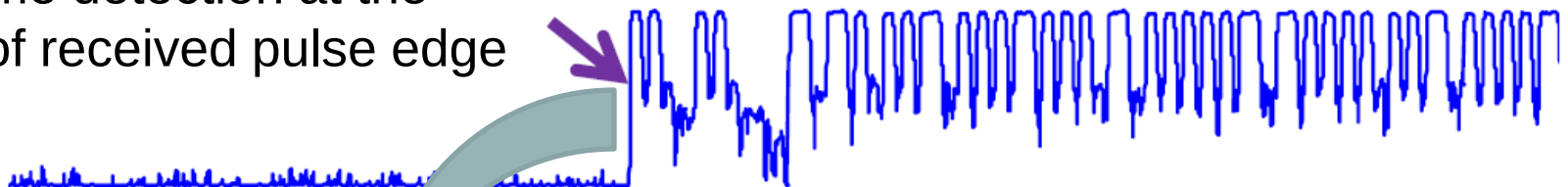
5. Signal Processing (2) (Grouping)

① **To detect CH1 mode S squitter signal.**
② **To search a mode S squitter signal around CH1 within presetting time window.**
③ **To make a group of the same mode S squitter signal of the time window.**

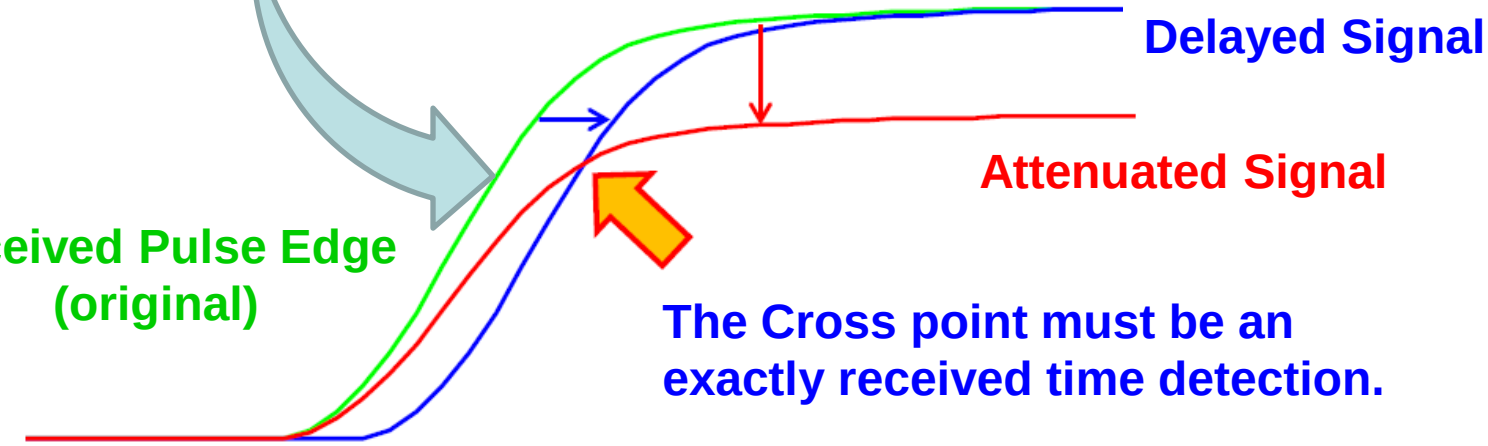


6. Signal Processing (3) (Time Detection by DAC Method)

The time detection at the point of received pulse edge



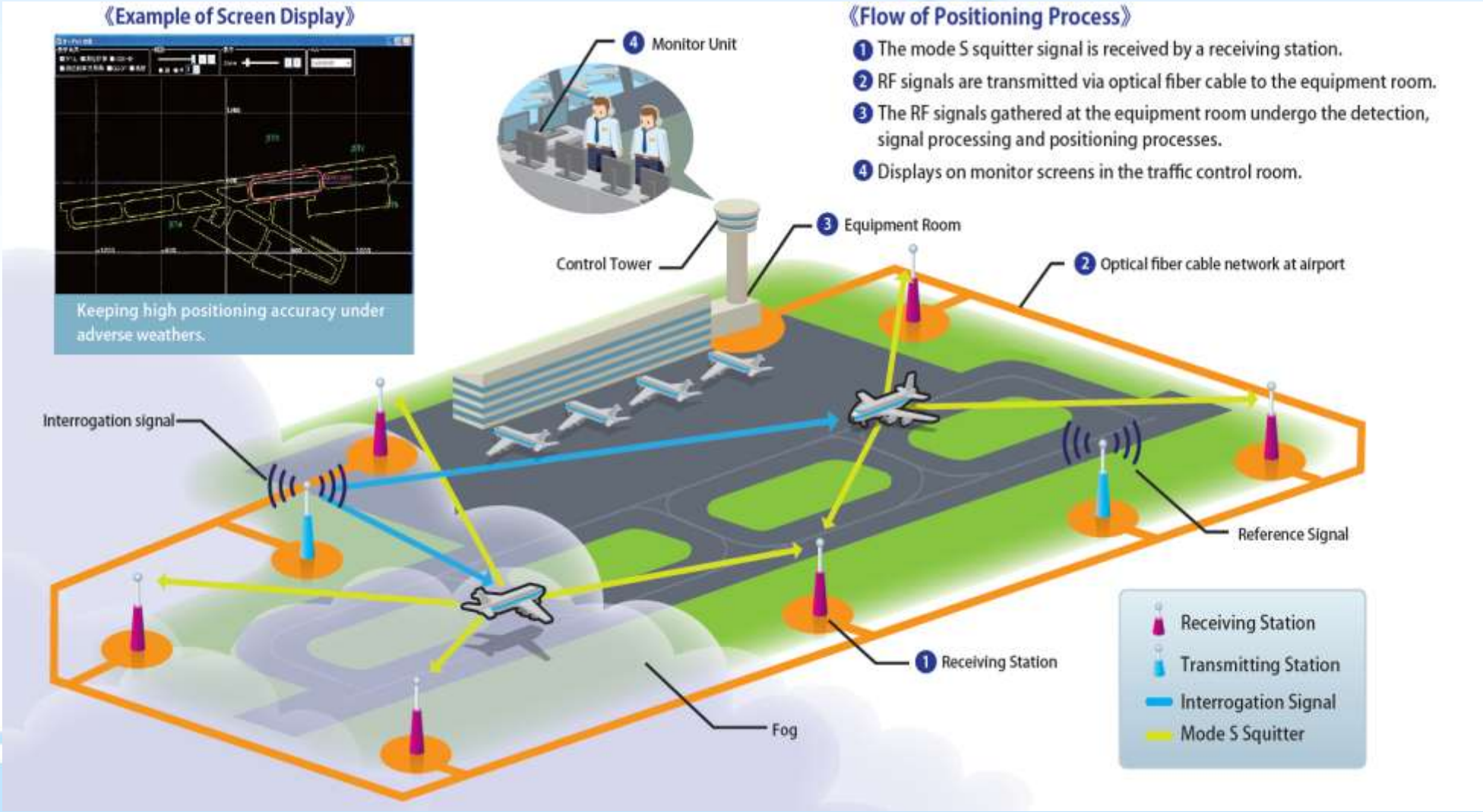
DAC (Delay, Attenuate and Compare)



It is available for the time detection with very high resolution due to 5ns sampling frequency.

7. System Configuration

OCTPASS is compatible with the ADS-B system, it is a solution to make enable to the economical operation of the civil aviation field.



8. Characteristics of the OCTPASS

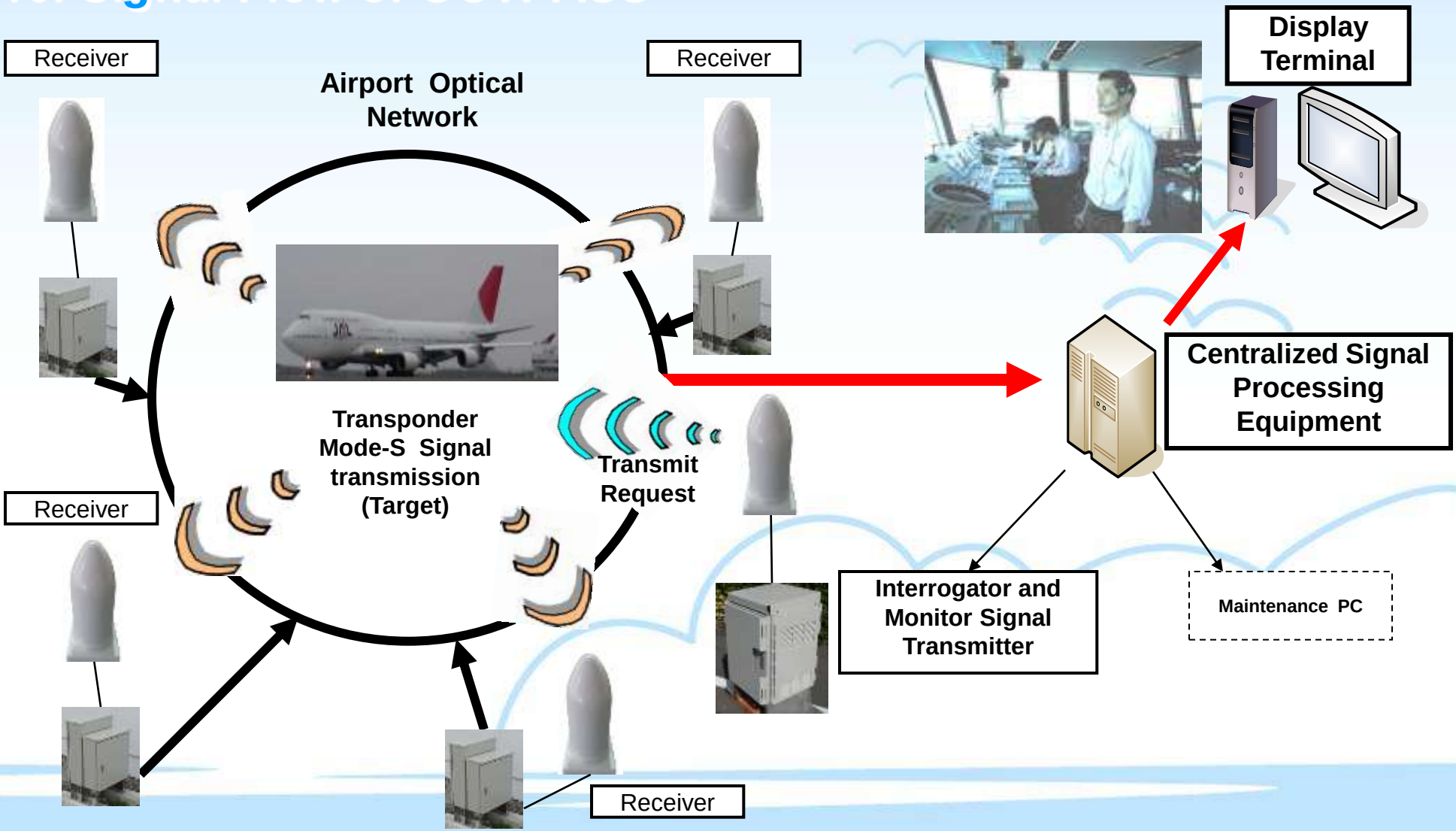
OCTPASS has following characteristics.

- to employ a centralized processing system, so that each receiving unit is not required undertaking so complicated time processing, which lead to be a high cost by the receiver unit.
- enable to realize the simple, smart and light-weighting of the receiving unit, so that you could design the system to reduce the initial construction, operation and maintenance cost.
- to gather the RF signal from the receiving sites by optical fiber cables to centralized signal processing equipment and computes position.
- Through this processing scheme, the detection probability is remarkably improved.
- to be less affected for the multi-path interference by deployment of OCTPASS detection algorithm, even if it is a few receiving sites in the airport.

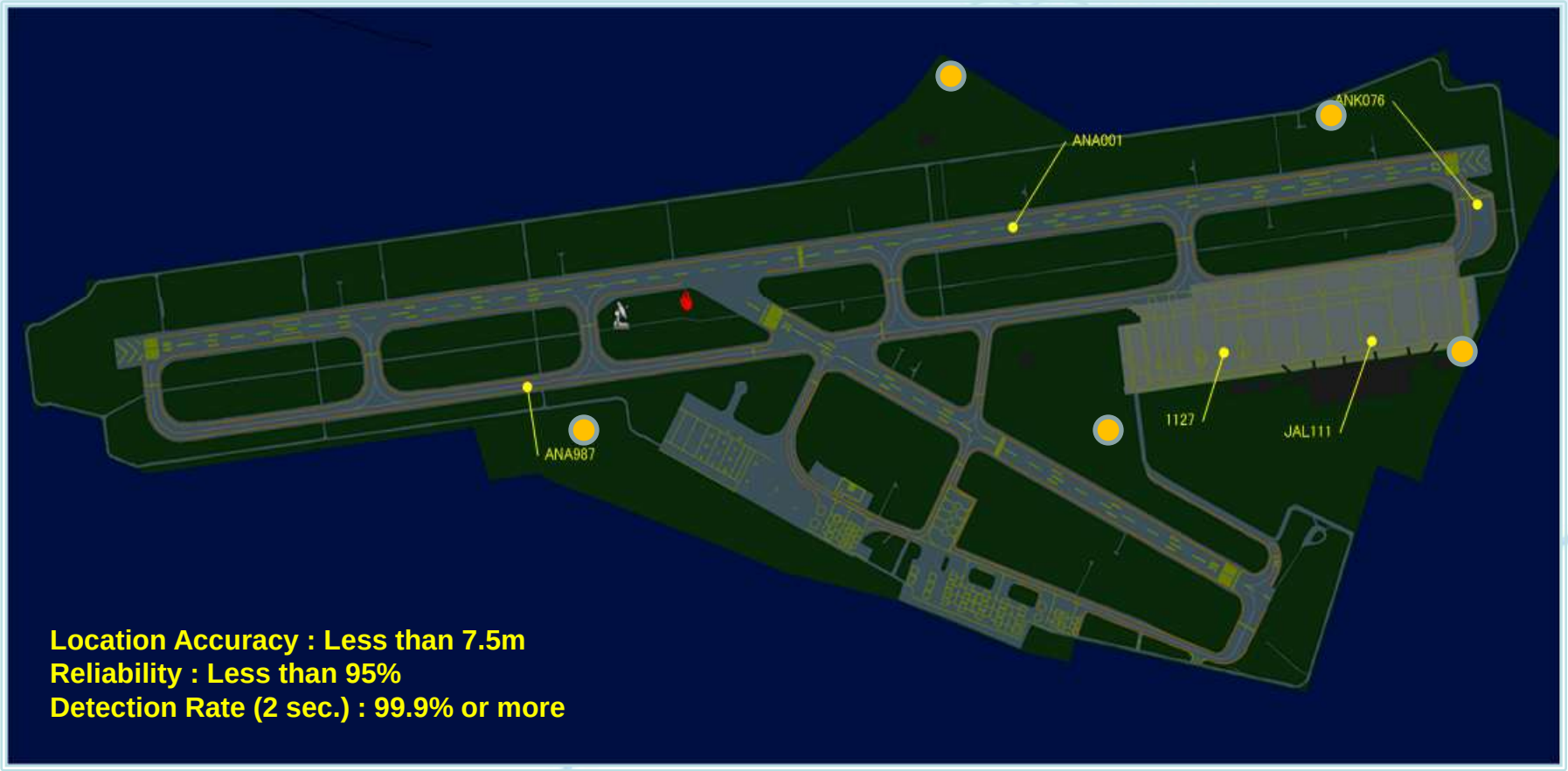
9. Features of the OCTPASS

- Available for displaying target location with call sign.
- High reliability under severe weather condition.
- Complimentary support for no target detection areas of SMR.
- No requirement of any instruments on the aircraft.
- Compact size of Receiver Equipment and extremely low power consumption, available of the solar power battery.
- Low cost of the system implementation

10. Signal Flow of OCTPASS



11. System Configuration (1)



Monitor Image of Airport Surface Movements

SSR Transponder Signal Receiver & Receiver Antenna

(SENDAI Airport in JAPAN)

11. System Configuration (2)

Receiver Antenna

Receiver Station
(Radio over Fiber)

Battery (33Ah)
(18 days continuous operation)

12. Conclusion

- OCTPASS assists efficient aircraft operation at the airport by the economical aircraft moving location positioning performance and airport safety related service vehicle moving location positioning performance.

- OCTPASS is supplemented compatibility with the ADS-B system, and is able to obtain the detailed aircraft on-board flight data from the SSR mode S transponder squitter pulse signal reception.

- OCTPASS has the robust surveillance performance for the radio wave multi-path affections emerged at the airport surface in the airport surrounded by the buildings or other obstacles.

Contribution of Safe and Efficient Airport Operation

- **To supports the complicated traffic control services and the safety at airport**
- **To improve surveillance data in low visibility**
- **To decrease aircraft taxi delay and reduce runway incursions**
- **To required no synchronous signal for each receiving station**
- **To reduce an implementation cost**
- **To achieve low power consumption and flexible layout design of Airport**

Thank You for Your Attention !

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