

ELEVENTH AIR NAVIGATION CONFERENCE

Montreal, 22 September to 3 October 2003

Agenda Item 6: Aeronautical navigation issues

6.1 Global navigation satellite system (GNSS) development status based on : reports from States, service providers and industry organizations

MSAS (MTSAT SATELLITE-BASED AUGMENTATION SYSTEM) STATUS

(Presented by Japan)

SUMMARY

This paper presents current MSAS status and system overview. MSAS is one of SBAS using MTSAT and has been implemented by Japan Civil Aviation Bureau (JCAB). The schedule of the programme, current works and related activities are described.

1. INTRODUCTION

1.1 Since a decision made by Japan Civil Aviation Bureau (JCAB) to implement the CNS/ATM system using satellites in accordance with the Future Air Navigation System (FANS) concept endorsed at 10th Air Navigation Conference in 1991, JCAB has been developing multi-functional transport satellite (MTSAT) and MTSAT satellite-based augmentation system (MSAS). MTSAT is a geo-stationary satellite that has been jointly developed with Japan Meteorological Agency (JMA) and it naturally has meteorological observation mission as well as aeronautical mission.

1.2 The aeronautical mission consists of two functions, aeronautical mobile satellite service (AMSS) and GNSS satellite based augmentation system (SBAS). MSAS is one of SBASs that can provide GPS augmentation services covering Japanese FIR. MTSAT has a navigation transponder to provide aircrafts with GPS augmentation information uplinked from ground facilities.

2. BACKGROUND

2.1 Electronic Navigation Research Institute (ENRI) has been working on GNSS Integrity Channel since 1993 and has developed GNSS test bed system. In cooperation with ENRI, JCAB has developed the system design of MSAS.

2.2 In 1996, MSAS equipment was procured and the ground facility was installed to broadcast augmentation information via the first MTSAT (MTSAT-1). After the launch failure of MTSAT-1 in November 1999, JCAB procured an alternate satellite, MTSAT-1R with minor modification. Based on this modification, the high power amplifier (HPA) to be exclusively used for MSAS at the ground earth station (GES) was added to support MTSAT-1R. The ground facility for MTSAT-1R has almost completed, and the data collection and data analysis have been conducted at two Aeronautical Satellite Centers since 2001.

3. CURRENT WORK

3.1 Remaining works for MSAS implementation are facility deployments for MTSAT-2 and the system integration and certification for MTSAT-1R and MTSAT-2. A part of certification works was conducted in 2000 to the extent possible without MTSAT. As the verification with actual signal from MTSAT is indispensable, it will take one or two years to verify the MSAS after MTSAT launches. The most important issue on the certification is a safety analysis of MSAS software that has already initiated this year.

3.2 MTSAT-1R had been planned to launch this summer, but it has been delayed due to the defect of the imager for meteorological observation. Therefore, MTSAT-1R will be launched in early 2004 and MTSAT-2 will be launched in 2005. After completion of the certification, MSAS will be commissioned and be operational using only MTSAT-1R from 2005 and dual operation by MTSAT-1R and MTSAT-2 will be commissioned in 2006 respectively.

4. SYSTEM CONFIGURATIONS

4.1 Two aeronautical satellite centres to be engaged in controlling MTSATs are located in Hitachi-Ohta and Kobe and ground facilities for AMSS and SBAS have already been installed. MSAS master control stations (MCSs) have been installed at two aeronautical satellite centers, which have a redundancy to avoid service disruption due to equipment outage, natural disaster and severe weather condition etc.

4.2 To provide MSAS service over Japanese FIR, four ground monitor stations (GMSs) are installed at each air route traffic control centre (ARTCC); Sapporo, Tokyo, Fukuoka and Naha. To secure long base line for accurate orbit determination of MTSATs, two monitor and ranging stations (MRSs) are installed in Hawaii, United States and Canberra, Australia. There is also MRS at each aeronautical satellite centre. MRSs also have the function of GPS monitoring just like GMS. Each of GMS and MRS is connected with two MCSs by dedicated ground lines and sends received GPS/MSAS signals. MCSs generate the augmentation information for GPS using the received data from GMSs and MRSs, and uplink to MTSAT through ground earth stations (GESs). There are eight monitoring stations in total for GPS/MSAS signal reception.

5. ASSURANCE OF HIGHLY REDUNDANT AND RELIABLE SBAS SERVICE

5.1 There will be two satellites described above, that is, MTSAT-1R and MTSAT-2 in 2005 in the MTSAT system. Whereas MTSAT-1R will be launched at the location of 140 degrees east, MTSAT-2 will be launched at the location of 140±5 degrees east. In normal operation, the uplink to MTSAT-1R will be made from Kobe with the Pseudo Random Noise (PRN) Code of 129. The uplink to MTSAT-2 will be made from Hitachi-Ohta with the PRN Code of 137. In this normal condition, the user avionics (SBAS receiver) can receive two SBAS signals from different satellite locations with different PRN Codes (129 and 137).

5.2 Even if the malfunction takes place in either MTSAT-1R or MTSAT-2, it is still possible to continue MSAS service by switching to normal MTSAT to broadcast MSAS signal. If MTSAT-1R fails, then MCS at Kobe will switch to MTSAT-2 for the continuous operation of MSAS. If MTSAT-2 fails, then MCS at Hitachi-Ohta will switch to MTSAT-1R for the continuous operation of MSAS. In these abnormal conditions, the user avionics (SBAS receiver) can still receive two SBAS signals from the same satellite location with different PRN codes (129 and 137). This operation is called Dual PRN operation.

5.3 This can be done because each MCS has a capability of switching from one MTSAT to another for uplinking MSAS signal. One MTSAT is capable of broadcasting two MSAS signals simultaneously uplinked from two MCSs. In this dual PRN operation, even if a failure takes place in either ground facility, MTSAT can still continue to provide services without any disruption because of the redundancy. Thus, MSAS can support very reliable SBAS service through the system redundancy.

6. ASSURANCE OF FULL ICAO COMPLIANCE AND INTEROPERABILITY WITH ANOTHER SBAS SERVICES

6.1 The MSAS function of the MTSAT is fully compliant with the Standard and Recommended Practices (SARPs) of Annex-10 in ICAO. Technical details not specified in SARPs are coordinated through the activities of SBAS Technical Interoperability Working Group (IWG) that is composed of the United States, Canada, Europe, India and Japan.

6.2 Thus, the MSAS is fully interoperable with another SBAS services. That is, the United States wide area augmentation system (WAAS) which has already started its operation on 10th July this year and Europe's European Geostationary Navigation Overlay Service (EGNOS) to be operated in 2004. No matter where the aircrafts are flying in the world, the user avionics (SBAS receiver) can receive the SBAS signal from WAAS, MSAS and EGNOS seamlessly on a global basis.

7. TEST AND EVALUATION

7.1 MSAS flight test

7.1.1 While MTSAT has not been launched yet, the ground facility for MSAS has been able to generate augmentation information for GPS. MSAS flight test was conducted in January 2001 at Sendai Airport under the joint collaboration between JCAB and ENRI. MSAS signal generated at Kobe aeronautical satellite center was sent to Sendai by the ground telephone line and was transmitted to the aircraft by VHF data broadcast (VDB) system. Test results showed a satisfactory performance of MSAS augmentation.

7.2 MSAS-GAIA flight test

7.2.1 GPS aided inertial navigation avionics (GAIA) is a navigation avionics integrated INS with GPS and was developed under collaborative project by National Aerospace Laboratory (NAL) and National Space Development Agency (NASDA). GAIA generates basic navigation information by INS and removes the error by GPS and is also able to process GBAS signal near the airport. In order to enhance GAIA capability especially in en-route and terminal area, GAIA was upgraded to process MSAS information, and the test and evaluation of MSAS-GAIA were carried out in October 2002. The effectiveness of MSAS augmentation was confirmed and the ability to shift from MSAS in en-route and terminal area to GBAS in precision approach was successfully demonstrated.

8. SERVICE EXPANSION TO OVERSEAS

8.1 Approach to neighbouring States

8.1.1 Since the MSAS signal will be broadcasted by MTSAT that covers most of Asia/Pacific Region, MSAS service area can be easily expanded if GMSs are installed in MTSAT coverage area and the dedicated ground lines are connected to MCSs. Japan is the only country to implement SBAS in Asia/Pacific Region, JCAB recognize that the role of MSAS is significant from technical as well as financial perspective to provide seamless navigation service in this region. Therefore, JCAB is very active in helping neighboring states to receive MSAS service in their FIRs.

8.2 Service expansion to Philippine

8.2.1 Japanese government concluded 25th Japanese yen loan with Philippine government in March 2002. Philippine government will implement CNS/ATM systems by using this loan and plans to provide SBAS service in Manila FIR by installing three MSAS GMSs in Philippine islands.

9. CONCLUSION

9.1 JCAB believes that the MSAS service will increase the accuracy, availability and continuity of service for GPS and will assure the integrity of GPS not only for Japanese FIR but also for other FIRs in Asia/Pacific Region. JCAB also believes that the MSAS service will help Asia/Pacific states to shift from ground based navigation systems to satellite based navigation systems based on the concept of ICAO CNS/ATM.

9.2 JCAB offers the MSAS service to the Asia/Pacific States in order to achieve global, seamless, safer and more reliable air navigation system in this region. JCAB offers the MSAS service to Asia/Pacific States for free, and does not intend to seek economic profit from MSAS service.

10. ACTION BY THE CONFERENCE

10.1 The 11th Air Navigation Conference is invited to note this information contained in this paper.

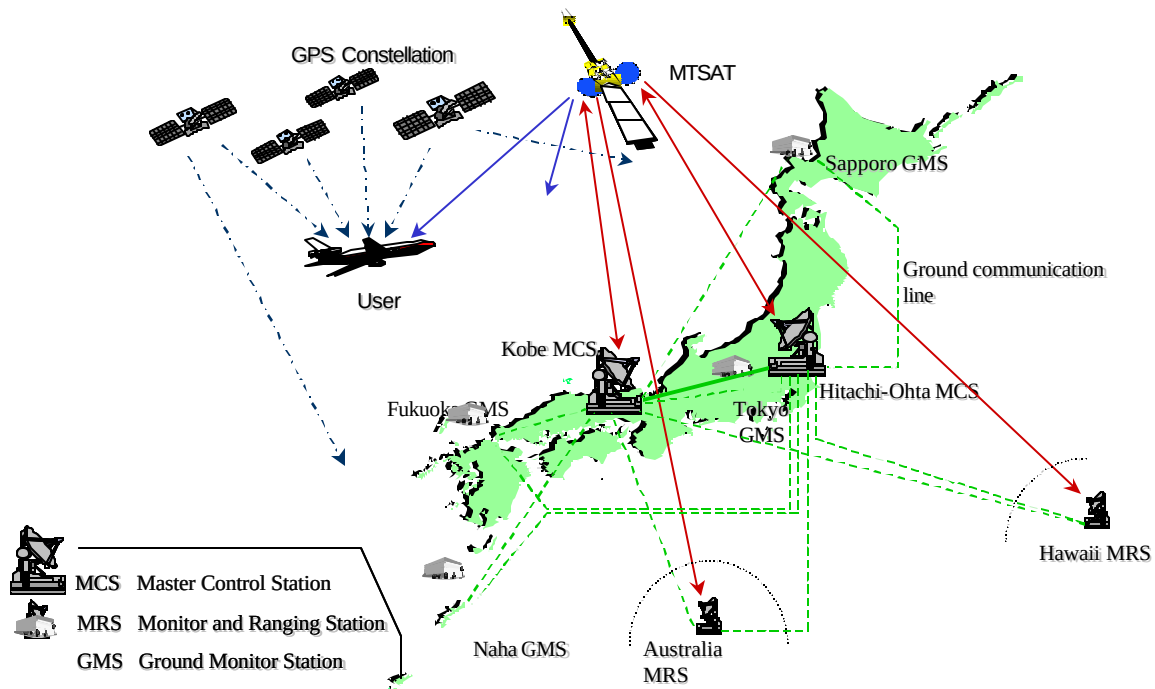


Figure 1. MSAS configuration

Single PRN Operation by Each MTSAT

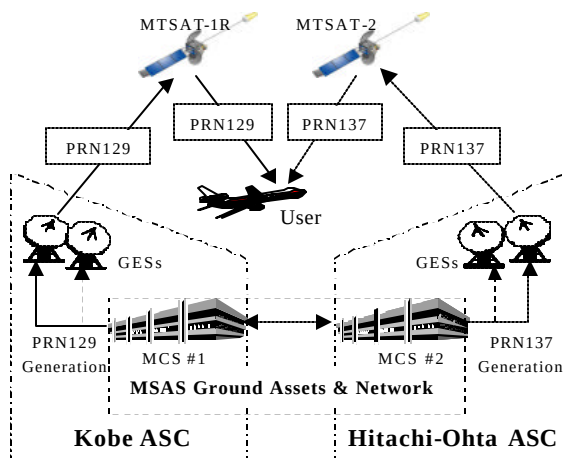
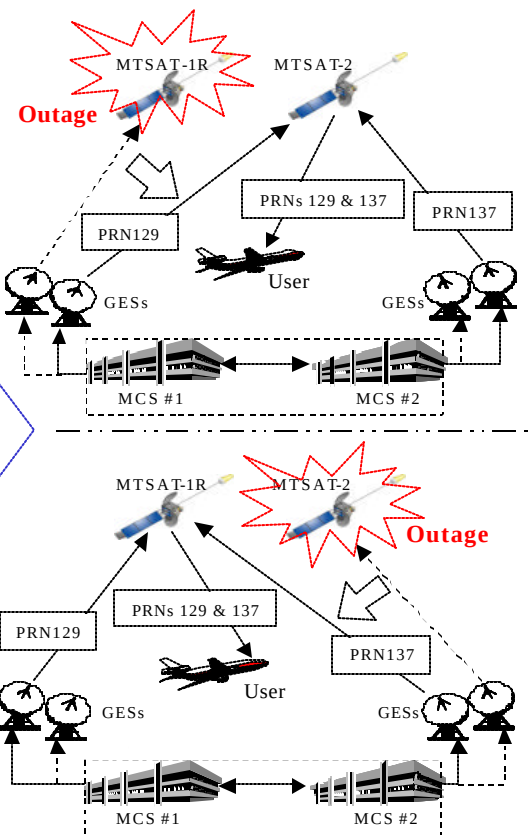
MTSAT-1R
OutageDual PRN
Operation
by One
MTSATMTSAT-2
Outage

Figure 2. Dual PRN operation