Flight Inspection for MTSAT

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1. ABSTRACT
MTSAT-1R was launched from TNSC (the Tanegashima Space Center) in Japan in the late afternoon of February 26th, 2005. The MTSAT-1R is located about 36,000 km above the equator and longitude 140 degrees east as one of the geostationary satellite.

MTSAT-1R is a compound type satellite purporting “Multifunctional Transport Satellite”, which is charged with Aeronautical mission and Meteorological mission. Of the two missions, JCAB takes charge of Aeronautical mission, which is divided into Aeronautical communication function and navigation function. Not only are the data and voice communications with aircraft flying over the FIR of Japan but also Air traffic control communications with overseas air traffic control center via SITA network and operational information sent to the airlines, provided by the aeronautical communication function. In addition, GPS augmentation system) signals. MTSAT provides aircraft with augmentation information to improve the reliability and accuracy of GPS navigation system (hereinafter called non-ATS), which provide Airline Operational Communications (AOC), Aeronautical Administrative Communications (AAC) and Aeronautical Passenger Communications (APC), and so on.

MTSAT services

Of the above-mentioned services, JCAB takes charge of ATS for aeronautical communications and navigation, and surveillance.

Here shows each service in greater detail below.

I. ATS
a. [Communications]
Aeronautical communications are realized by CPDLC and Sat Voice. Currently, HF voice is used for communication between aircraft and ATCC (Air Traffic Control Center). MTSAT provides direct controller-pilot communication in voice and data, thereby improving the quality and efficiency of communication significantly.

b. [Surveillance]
Surveillance is realized by ADS. Aircraft flying outside of radar coverage transmits its own position data automatically to ATCCs via MTSAT. The position of aircraft is displayed on screen like as Radar.

II. Navigation
Navigation is realized by receiving MSAS (MTSAT satellite based augmentation system) signals. MTSAT provides aircraft with augmentation information to improve the reliability and accuracy of GPS for aircraft navigation.

III. Effect
ATS utilizing MTSAT function provides controller with the position of aircraft fly over the ocean. In addition, the MTSAT enables controllers to communicate with pilot directly. The introduction of MTSAT achieves reduction of separation minima and enhancing the capacity in oceanic air space. Especially in North Pacific route, minimum longitudinal separation between leading aircraft and trailing aircraft on the same route and the same altitude will be reduced from current 15 minutes at most (about 120NM) to 6.5 minutes (about 50NM) in order to cope with the increasing air traffic.

MTSAT Coverage

2. MTSAT SERVICES
MTSAT system provides new communication services and can push past the limits of Navigation utilizing ground radio facilities in the oceanic airspace where we cannot support its services by the existing systems and in the area where the state of radio wave is unstable.

Also, MTSAT is expected to play an important role in increasing airspace capacity and ensuring air navigation safety.

MTSAT provides aeronautical communications and navigation.

The aeronautical communications are classified roughly into Air Traffic Communication Services (hereinafter called ATS) or non-Air Traffic Communication Services (hereinafter called non-ATS), which provide Airline Operational Communications (AOC), Aeronautical Administrative Communications (AAC) and Aeronautical Passenger Communications (APC), and so on.

MTSAT provides services for aircraft navigation.
On the other hand, Navigation utilizing MTSAT function enables to set air routes flexibly while the existing air routes are fixed linearly between the ground radio facilities

IV. Non-ATS

Non-ATS function provided by MTSAT is realized by the partnership with SITA.

MTSAT system will provide ATS and non-ATS as one package.

AOC is utilized to communicate between aircraft side and ground side for airlines. With the communication services, information of airline operational control duties, airline operational duties and maintenance schedule are treated. And AAC is utilized to deal with information of crew schedule, aircraft equipments, reservations, and connection at the airport.

In addition, APC is utilized as public telecommunication service in the cabin.

MTSAT system also provides those non-ATS under the cooperation with SITA.

3. MTSAT SYSTEM CONFIGURATION

In order to realize air navigation high safety and reliability, GESs (Ground Earth Station) for MTSAT-1R are located at two places. One is located at North Kanto region (Hitachi-Ohta: about 120km east of Tokyo) and another is at Kansai region (Kobe: about 40km west of Osaka) in Japan and distance between them is about 600km.

Therefore, MTSAT enables to provide consistently services by transferring GES in case of the impact on the electric wave propagation by bad weather, and so on.

In addition, in case of GES trouble, it is automatically transferred in no time at all not to suspend its operation.

4. MTSAT-1R TEST IMPLEMENTATION SCHEDULE

MTSAT system is connected with a lot of systems. Therefore, its performance was tested through the following phases to maximize its abilities.

- Interface testing
  - Basic function testing such as the communication protocol testing that is necessary for information exchanges were performed.
- Ground network testing
  - By connecting all systems constituting a ground network, AMSS (Aeronautical Mobile Satellite Service) basic function and the data and voice communications by using test-AES (Aircraft Earth Station) were tested.
- In-geostationary orbit testing
  - Various testing such as confirmation of the basic function that MTSAT-1R is equipped with and setting of each parameter for the operation were performed after MTSAT-1R was injected into a predetermined geostationary orbit.
- Satellite testing
  - Confirmation of AMSS basic function between MTSAT-1R and GES, and End-to-End testing of data and voice communications via MTSAT-1R by using test-AES were performed after In-geostationary orbit testing.
- Aircraft testing on the ground
  - End-to-End testing of Data and Voice communication function via MTSAT-1R were performed by Flight Inspection aircraft on the ground.
- Aircraft testing in flight
  - Flying in over Japan and the other countries by Flight Inspection aircraft, global and spot beam functions of MTSAT-1R were confirmed. Also handover testing, and End-to-End testing of Data and Voice communication function via MTSAT-1R were performed.

Those above testing made a progress smoothly as scheduled. The test results shows high reliability and safety, which MTSAT system aimed for.

Then the test phase shifted to the final stage toward the operation commencement.

5. TEST SYSTEM

AMSS function test of MTSAT by Flight Inspection aircraft was carried out mainly with Gulfstream-IV Flight Inspection aircraft equipped with MCS-6000+ SATCOM system manufactured by Honeywell, also SAAB2000 Flight Inspection aircraft, which was equipped with SAT-906
SATCOM system manufactured by Collins was used secondarily, ATC data communication function of these Flight Inspection aircraft is equivalent to the FANS-1 function of Boeing 747-400 aircraft. However, the function is not applicable for actual operation because its system is certified only for test purpose.

Almost all of test items to be carried out during ground parking test phase are the first experience for us, and we concerned about occurrence of some malfunction what neither Flight Inspector nor the ground engineer can imagine.

At the worst, it is easy to interrupt anytime during the test.

It is necessary for personnel who execute the test to take a rest, because there were too many confirmation items and the test took a lot of time. In order to confirm the global beam and the spot beam which we can confirm at domestic airport on the ground, the test was carried out as Flight Inspection aircraft parking at 3 airports in Japan. The first one is Tokyo International Airport that is a base airport of ICBF Flight Inspection. The second one is Miyako-jima Airport that is an airport of the southern end in Japan. And the last one is Kushiro Airport that is an airport of the northern end in Japan.

The final purpose of the test with Flight Inspection aircraft is to confirm End-to-End communication. However, the total system of satellite communication which enables reliable End-to-End communication is intricately-intertwined with various systems including both space segment and ground segment, which is out of Flight Inspector's scope. So that many prior consultations with many ground engineer about test item and its method were conducted again and again. Furthermore, the exchange of information between Flight Inspector and the ground engineer was very important. Because Flight Inspector has no expertise in satellite communications, also the ground engineer has no expertise in aircraft system (including onboard SATCOM system). The ground test for AMSS with Flight Inspection aircraft for was started on July 19th, 2005.

In this test period, most test items except the items in the air were carried out. First of all, it was necessary for the onboard SATCOM system to logon to MTSAT at the beginning of the test. Basic performance of MTSAT has complete compatibility with existing INMARSAT satellite. As for the SATCOM system, information (a satellite number / satellite longitude / Psid frequency) of an individual satellite is to be written automatically in the System Table recorded in the onboard SDU by receiving a broadcasted Psid (the information related to Satellite Identification broadcasted by P-ch) signal from a satellite. A SATCOM system is to try to logon to desired satellite/GES on the basis of this information of the System Table recorded in onboard SDU. However, MTSAT information was not included in Psid signal broadcasted by INMARSAT at the first stage of the test. So that SDU could not know even Psid frequency to logon to MTSAT. Therefore we directly accessed to SDU with a notebook PC and wrote MTSAT information at SDU which MTSAT planned to broadcast in Psid. Afterwards, it was necessary to set MTSAT information correctly into ORT (Owner's Requirement Table) file where priority of satellite / GES etc. is registered, and to load the ORT file into SDU. The tools to change configuration of ORT, for Honeywell system is called as "ORT tool", for Collins system is called as "SATCOM tool". We added MTSAT as satellite number "04" and Kobe GES as GES number "161 (octet)" by these software, and we set this priority in GES list as the highest preference (set

The core component of the SATCOM system is SDU (Satellite Data Unit), which is connected to other major components related to the SATCOM system. It manages input and output of data or control of transmission frequency, etc.

The SATCOM data was collected by using a notebook PC at a SATCOM port wired from a maintenance port of SDU to an AFIS (Automated Flight Inspection System) console in RS232C protocol. A kind of the data acquired here is as follows.

- Periodic Data: Some pre-specified parameters (e.g. Bit Error Rate(BER), Carrier Strength, Signal Quality Index) are collected at pre-specified time intervals (e.g. 20sec)
- Trace Data: Pre-specified parameter is acquired when some event happened (e.g. Log_On to satellite, Log_Off from satellite). With these Trace Data, we can easily recognize which Satellite/GES is logged on to or logged off from.
- Data Event Log: Quantity of packet data during Log_On to one Satellite is recorded.
- System Management Event Log: Places (latitude/longitude) and time (UTC) are recorded when some events (satellite / GES Handover, Log_On/OFF, taking off/landing etc) occurred in a SATCOM system.
- Call Event Log: The phone number, start/stop time of call and GES ID etc that performed Sat Voice are recorded.
- System Event Log: Log_On/OFF, taking off/landing etc that performed Sat Voice are recorded.

Above 2 data can be acquired by using D-CMT (Direct-Commissioning & Maintenance Function) of SDU in real time.

• Event Log: The phone number, start/stop time of call and GES ID etc. that performed Sat Voice are recorded.

The application software that we used for all of data acquisition and saving is the Hyper Terminal that is general communication software.
to “9” in the case of Honeywell, set to “1” in the case of Collins), then prepared an ORT file. Log_On to MTSAT was enabled by loading the ORT file that had been prepared here into SDU.

Furthermore, there seemed to be some difference in a control protocol of SDU by difference of a SATCOM system manufacturer, therefore we confirmed that a required function was satisfied for both SATCOM systems made by Honeywell and made by Collins which are two major companies of SATCOM system manufacturer. Also both of them have been equipped in our Flight Inspection aircraft.

**Schematic diagram to collect MSAS signal**

The JCAB Flight Inspection established Flight Inspection criteria for AMSS function of MTSAT originally. The reason why we established it is that MTSAT has a function (Sat Voice / CPDLC / ADS) similar to existing ATC voice communication or a Radar, as a communication device used for ATC purpose. Also we thought that at least JCAB has a responsibility to have to confirm the basic function of MTSAT as a service provider of AMSS. A basic way of thinking on establishing Flight Inspection criteria for AMSS function of MTSAT is whether a user can establish reliable End-to-End communication (between ATC controllers and Pilots) and whether MTSAT is able to be used for ATC purpose in actual operations. The following JCAB Flight Inspection criteria for MTSAT show the evaluation item and its tolerance.

- **Sat Voice:** Sensitivity / articulation should be satisfactory for aircraft operation. There should not be significant time delay in transmitting and receiving.
- **Data Communication:** It should be reliable two-way communication without garbled characters in both up-link and down-link message. It should not require overload to a pilot in ADS / CPDLC operation in normal condition.
- **Beam Transfer:** The communication (voice / data) quality should not have a difference between before and after beam transfer.
- **Coverage:** When MTSAT was set as the highest priority onto ORT satellite (GES) preference list, AES should surely log on to MTSAT in the range required for ATC purpose within planned coverage of MTSAT.

**8. RESULT OF FLIGHT TEST**

On this flight trial, we could solve many things that were unknown to JCAB Flight Inspectors and ground engineer. For example, a certain...
number of differences in its protocol behavior by each SATCOM airborne equipment, the way to set parameter in airborne AES equipment in the case of exchanging data communication through MTSAT, the mechanism of how and where Handover function happens in actual AES, etc. Concerning coverage of each spot beam, we confirmed that Handover functions were done properly from a spot beam to another one or to global beam at the boundary line of Spot Beam Map broadcasted from MTSAT. Also, concerning coverage of global beam, Handover function between MTSAT and INMARSAT POR was done at N60°47'29" W152°55'32" (20 minutes before landing to Anchorage Airport) in the flight from Tokyo to Anchorage and at N27°35'34" W142°20'34" (between DIALO and DEROK) in the flight from Long Beach to Honolulu. Those Handover points were as supposed in advance, and we did not recognize any differences of the quality of data and voice communication between before and after Handover. And, MTSAT functions were satisfied with Flight Inspection criteria established by JCAB. Therefore AMSS communication through MTSAT was confirmed its normal function under actual operation.

9. CONCLUSION

Regarding protocol behavior of SATCOM system, there seems to be a little difference by each manufacturer’s equipment. Of course, it is the only manufacturer to know its detail, so there are many things on what each user never knows its mechanism. Also, it is impossible to make sure about its technical behavior for all aircraft, because there are various configurations on SATCOM systems equipped in each aircraft. However, once the order of priority of Satellites and GES which would be entered in ORT was set to MTSAT properly according as configuration of your aircraft, you can exchange data and voice communication through MTSAT system, with safe, comfortable and definite quality. To use MTSAT system, user needs to register his or her aircraft information in MTSAT-GES. And, since the transferring behavior between satellites would be carried out seamlessly with interoperability between MTSAT and INMARSAT, all users must be promised very comfortable utilization in coverage. Let JCAB know users who make use of MTSAT system. In the case of other utilization except ATC communication with Japanese ATC Center (ATM Center*), user would need to contract with SITA who is partnered with JCAB. JCAB’s final goal is to establish operational structure with dual MTSAT system. The second MTSAT called as MTSAT-2 was also launched by H-2A rocket successfully from TNSC in the evening of February 18th, 2006. From now on, similar test to MTSAT-1R is planned by JCAB Flight Inspection aircraft. Please look forward to the promising MTSAT system.

*ATM Center : JCAB’s ATM Center is located at Fukuoka in Japan. It has ASM (Air Space Management) function, ATFM (Air Traffic Flow Management) function and ATS (Air Traffic Service for Oceanic Control area) function. These 3 functions are collaborated with each other.

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### HANDOVER

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### COVERAGE

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### Flight Inspection Criteria

- SATCOM system: Satisfactory
- Handling of handover: Properly handled
- Quality of voice communication: No difference

**Final Remarks:**

- MTSAT functions satisfied with Flight Inspection criteria established by JCAB.
- AMSS communication through MTSAT confirmed normal function under actual operation.

**Note:**

- JCAB's final goal is to establish operational structure with dual MTSAT system.
- The second MTSAT called as MTSAT-2 was launched by H-2A rocket successfully.
- Users need to register aircraft information in MTSAT-GES.
- Interoperability between MTSAT and INMARSAT promised.

**To Use MTSAT System:**

- Register aircraft information in MTSAT-GES.
- Interoperability between MTSAT and INMARSAT promised.

**Final Goal:**

- Establish operational structure with dual MTSAT system.