MSAS System Development

Susumu Saito
Electronic Navigation Research Institute
National Institute of Maritime, Port and Aviation Technology, Japan
(E-mail: susaito@mpat.go.jp)
Outline

- MSAS development
  - MSAS history
  - MSAS configuration
  - Ionosphere threat mitigation

- MSAS upgrade
  - MTSAT to Michibiki (QZSS)
  - Further upgrade plan
Japan Civil Aviation Bureau (JCAB) decided implementation of its own SBAS in 1993, aiming at commissioning in 2000.
- Named as MSAS (MTSAT (Multi-functional Satellite) Satellite-based Augmentation System)

Ground facility (MSAS-96 System)
- Completed in 1996.

GEOs
- MTSAT-1 failed in 1999.

Operation
- Test signal broadcast from summer 2005
- Certification activities for 2 years
- Operation started from September 2007
Augments GPS L1 signals

Two GEOs
- MTSAT-1R (PRN129)*
- MTSAT-2 (PRN137)

Ground Facility
- 2 Master Control Stations (MCSs)
- 6 Ground Monitoring Stations (GMSs) (Two of them are with the MCSs)
- 2 Monitoring and Ranging Stations (MRSs)**

*MTSAT-1R has been decommissioned in December 2015
**MRSs have been decommissioned.
**MSAS original configuration - GEO**

- 3-axis stabilized spacecraft
- Together with instruments for weather monitoring missions
- L-band transponder with 2.2 MHz bandwidth
  - Uplink in Ku-band (13 GHz)
MSAS original configuration - MCS

KASC (Kobe Aeronautical Satellite Center)
- Nominally for MTSAT-1R
- Backup for MTSAT-2
- 3 dish antennas (2 for GEOs and one for emergency)

HASC (Hitachi-Ota Aeronautical Satellite Center)
- Nominally for MTSAT-2
- Backup for MTSAT-1R
- 3 dish antennas (2 for GEOs and one for emergency)
Current MSAS operations

- Augments GPS L1 signals
- System configuration
  - 1 GEO (MTSAT-2) with two signals (dual-PRN operation)
  - MTSAT-1R was decommissioned in December 2015.
  - 2 MCSs, 6 GMSs (including 2 GMSs with MCSs) and no MRS
  - 2 MRSs were decommissioned in February 2015.
- Service level
  - RNAV (en-route to RNP-0.3) in Fukuoka FIR
  - Horizontal guidance only due to ionospheric activities
MSAS Coverage

MSAS Service Area

MTSAT Coverage (AMSS and MSAS)

©2003 NEC Media Products
**Ionospheric Conditions in Japan**

- Japan is located at mid- to low magnetic latitude region (~15-41° in magnetic latitude).
- Subject to both mid-latitude type and low latitude type ionospheric anomalies.
Threat space is wider for MSAS than WAAS.
- Severer ionospheric conditions
- Limited distribution of GMSs

⇒ Currently only horizontal guidance can be provided.
Performance of MSAS - Accuracy

8-12 August 2016
Independent receiver at Takayama

Horizontal RMS error: 0.722 m

GPS only
MSAS PRN129

Takayama
Performance of MSAS - Integrity

19 April 2016

Independent Receiver at Ishigaki,

Horizontal Error [m]

Horizontal Alert Limit

Loss of Availability: 0

Normal Operation: 100%

Loss of integrity: 0

Horizontal Protection Level [m]

556

Loss of integrity: 0

19 April 2016

Independent Receiver at Ishigaki,

Horizontal Alert Limit

Loss of Availability: 0

Normal Operation: 100%

Loss of integrity: 0

Horizontal Error [m]

556
The number of SBAS equipped aircraft is increasing.
RNAV/RNP Implementation

As of 13 September 2018
RNAV/RNP Approach at 72 airports
- RNAV Approach: 21
- RNP AR Approach: 30
- RNP Approach: 26
- Basic RNP 1: 39
- RNAV 1: 37

Southwestern Islands

RNAV Approach:

RNP AR Approach:

RNP Approach:

Basic RNP 1:

RNAV 1:
MSAS upgrade

- **MSAS V2 (2020-)**
  - System update with QZSS (Michibiki)
  - RNAV (en-route to RNP-0.3) in Fukuoka FIR (Same as current MSAS)

- **MSAS V3 (2023(TBD)-)**
  - Additional GEOs and GMSs
  - LPV implementation

- **MSAS V4**
  - DFMC (Dual-Frequency and Multi-Constellation) SBAS
  - Validation activities by ENRI (2017-)