ICG/12 WG-B
Kyoto, Japan
Dec. 2-7, 2017

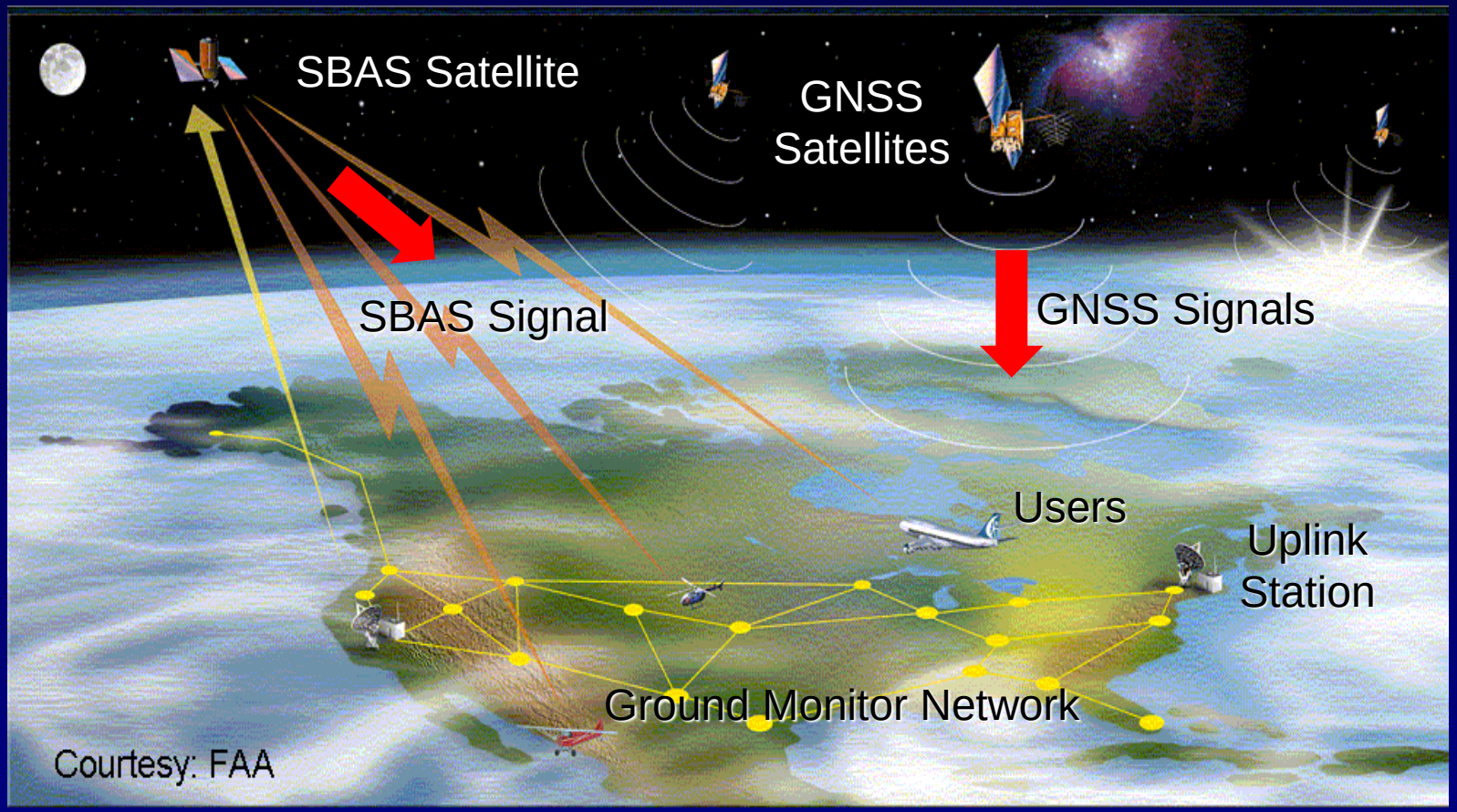
# The Experiment on DFMC SBAS via QZSS L5S Signal

Takeyasu Sakai
*Electronic Navigation Research Institute*
*National Institute of Maritime, Port and Aviation Technology, Japan*

# Introduction

- SBAS: Satellite-Based Augmentation System
  - International standard augmentation system primarily for aviation.
    - *International standard by ICAO (International Civil Aviation Organization).*
    - *Transmits Augmentation information from the SBAS satellite.*
      - Augments GPS in terms of accuracy and integrity.
    - *Current standard: Single-frequency SBAS on L1.*
    - *US WAAS, Japanese MSAS, European EGNOS, Indian GAGAN.*
  - Japan has been operating its own SBAS called MSAS since 2007.
    - *MSAS: MTSAT-based Augmentation System.*
    - *Horizontal navigation service within Japanese airspace.*
- DFMC SBAS: The Second Generation SBAS
  - Dual-Frequency Multi-Constellation SBAS using L5 frequency.
  - Standardization activities ongoing by the ICAO.
- ENRI is now conducting DFMC SBAS Experiment.
  - The First DFMC SBAS experiment with live L5 signal from the space.

# SBAS Architecture

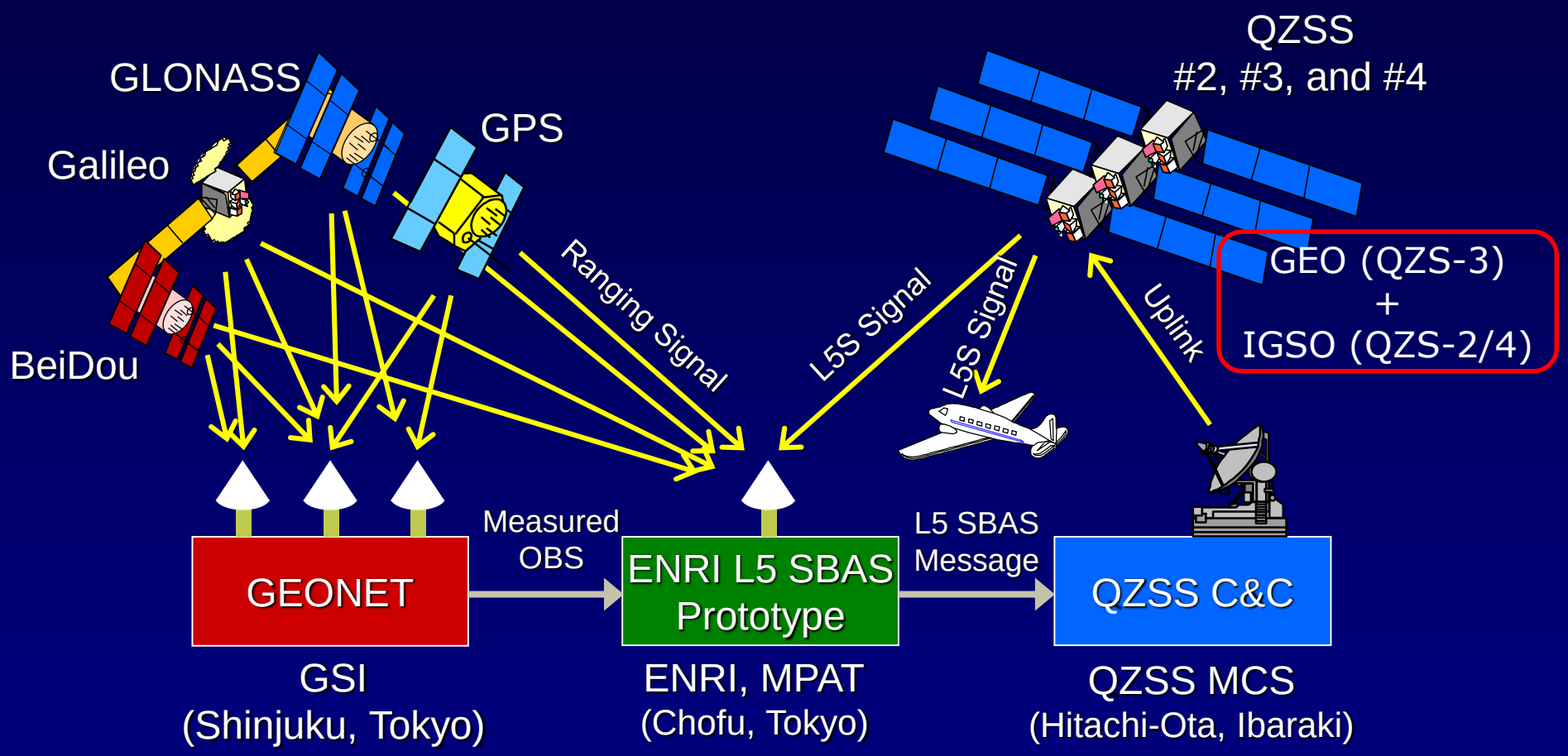



- Monitors consistency of GNSS signals on the ground.
- Transmits differential correction and integrity information via SBAS satellite.

# DFMC SBAS

- DFMC (Dual-Frequency Multi-Constellation) SBAS
  - The second generation SBAS following L1 SBAS.
    - *Using L5 SBAS signal instead L1.*
    - *Eliminates ionospheric effects thanks to dual-frequency operation.*
      - Vertical guidance service everywhere in the coverage.
    - *Could be transmitted by non-GEO SBAS satellites like QZSS IGSO.*
      - Possible solution for applications where GEO signal is likely blocked.
  - Standardization activities ongoing by the ICAO.
- ENRI is now conducting DFMC SBAS Experiment
  - The First L5 SBAS experiment with live L5 signal from the space.
    - *Using QZSS L5S signal transmitted from GEO (QZS-3) and IGSO (QZS-2/4).*
  - Prototype DFMC SBAS for the experiment has been developed.
    - *GPS/GLONASS/Galileo-capable dual-frequency SBAS.*
    - *Compliant with the draft standards of DFMC SBAS being discussed at ICAO.*
  - Began the experiment on 23 Aug. via L5S signal of QZS-2 IGSO.
  - Contributes to standardization activities by the ICAO.

# Configuration

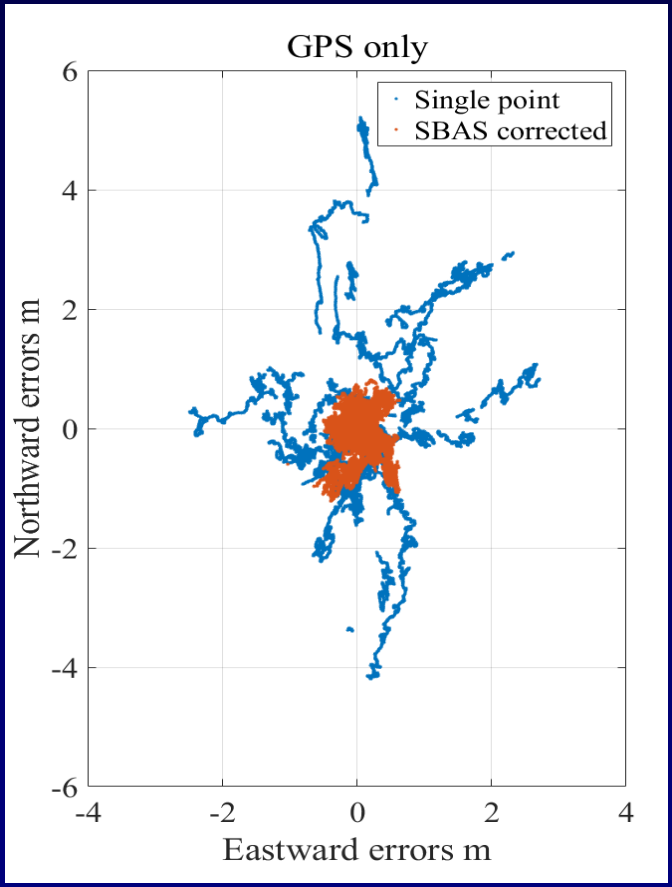


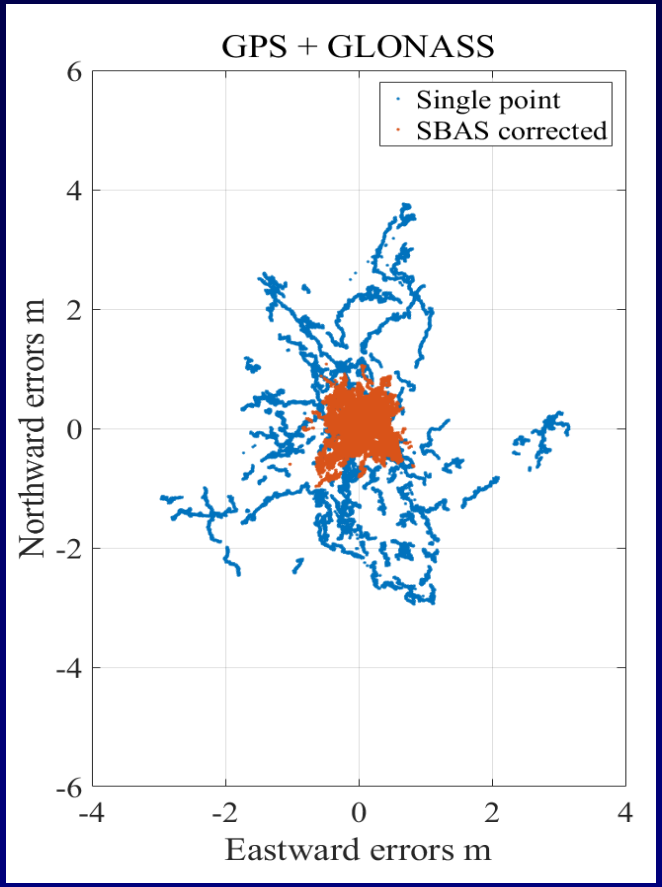

- Supports DFMC
- Provides observation in real time

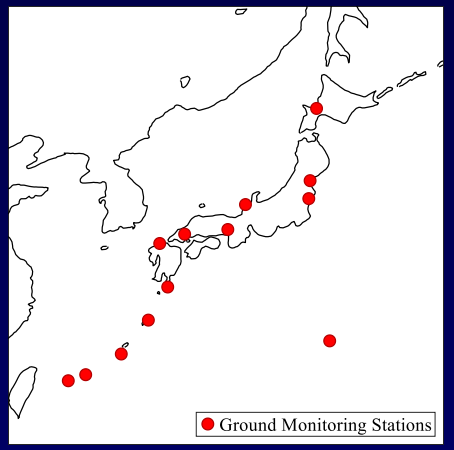
- Operates in real time
- Dual-Frequency
- Supports GPS, GLONASS, and Galileo

- Uplink L5 SBAS message stream for transmission

# Prototype DFMC SBAS



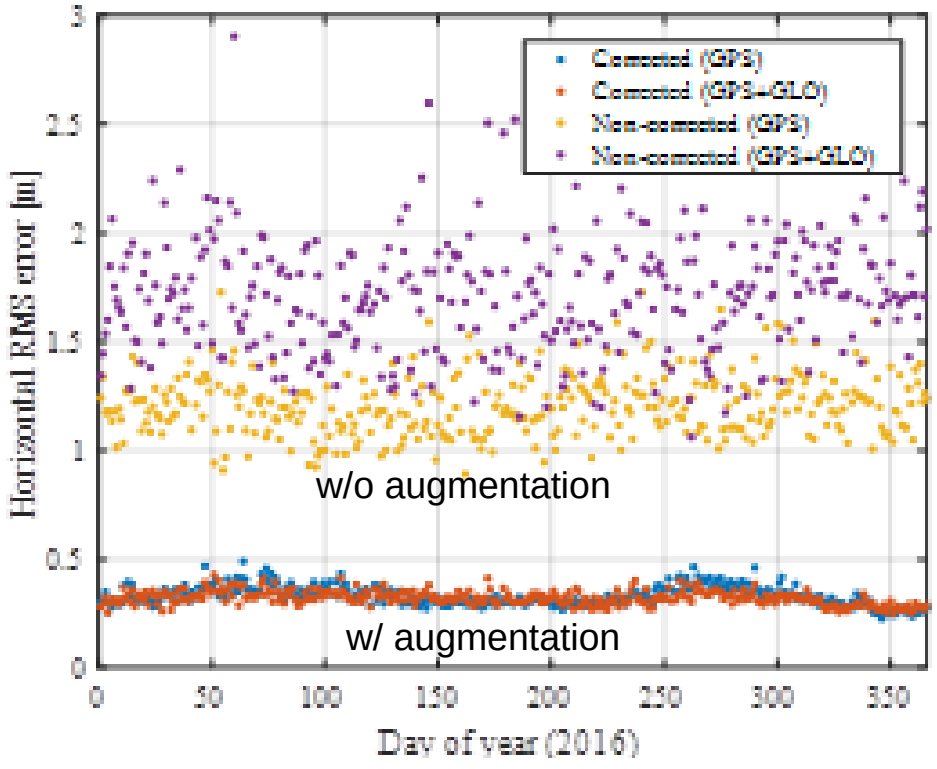




13 Monitor Stations

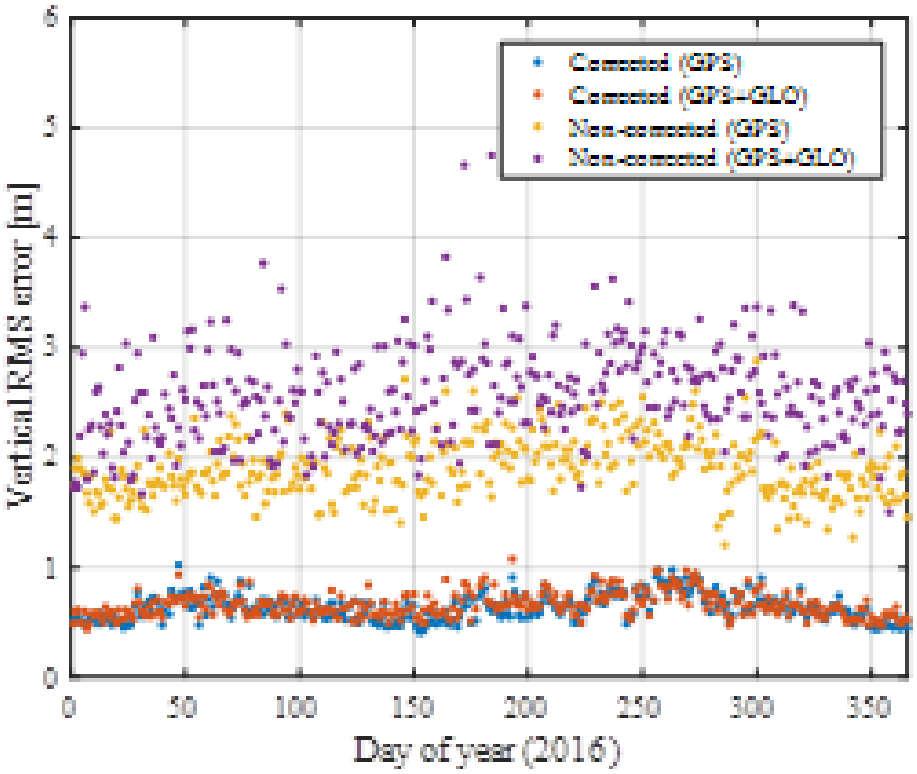
- Dual Frequency
- DFMC L5 SBAS
- Location:
  GEONET 950369
  (Wakayama)
- Period:
  2016/12/15 (24H)

- SBAS corrections improve position accuracy in both modes of GPS and GPS+GLONASS.
- SBAS messages are generated by the prototype DFMC SBAS developed by ENRI in accordance with the draft DFMC L5 SBAS standards.

# Prototype DFMC SBAS



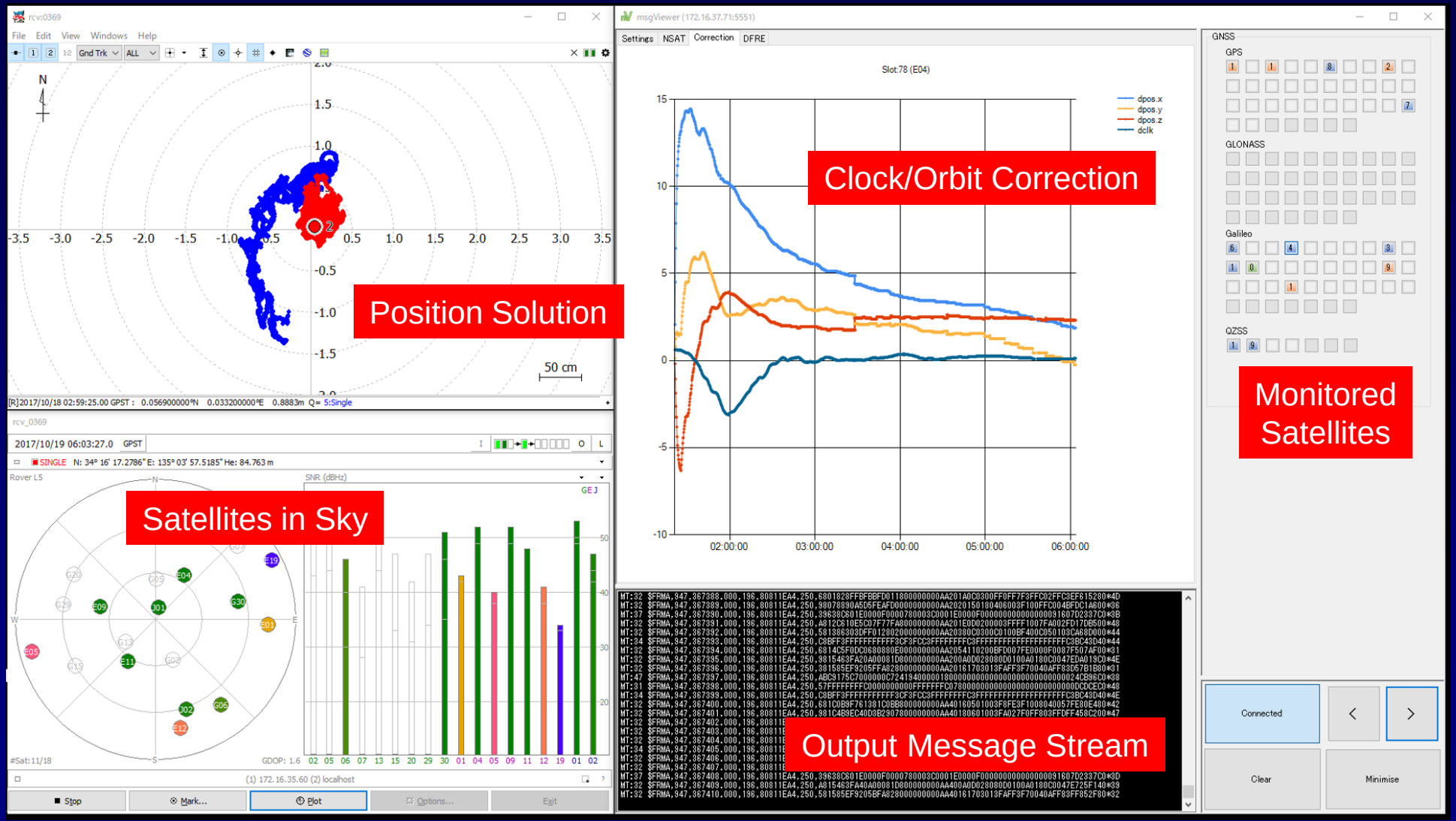

Horizontal Accuracy



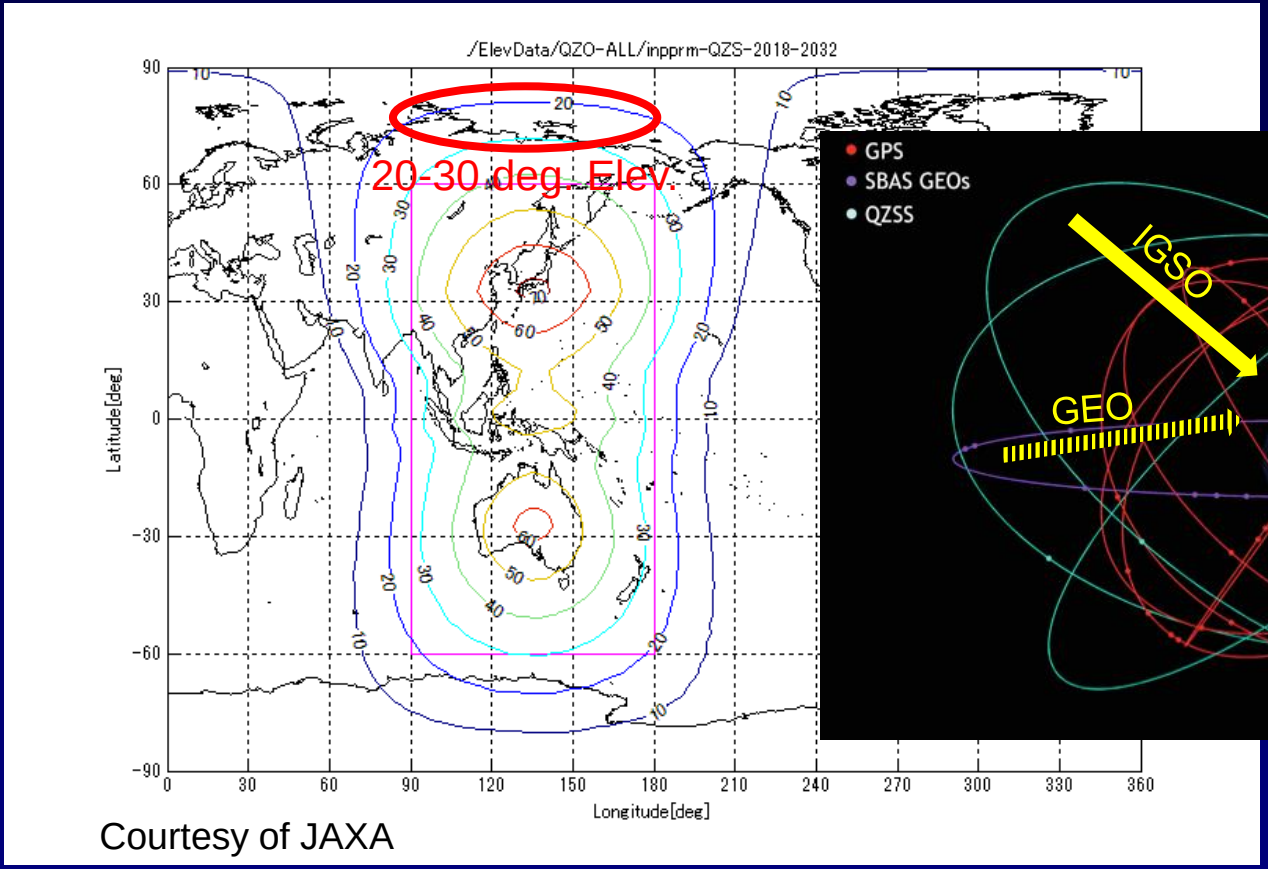

Vertical Accuracy

- Evaluated long-term performance using archive data at GEONET 950369 Wakayama.
- Confirmed stable performance for a year; Horizontal ~0.5m and Vertical ~1m.

# Real Time Experiment



# Non-GEO SBAS Concept




Courtesy of JAXA

- DFMC SBAS could be transmitted by non-GEO satellites like QZSS IGSO.
- Improves availability of augmentation signals where GEO signal is blocked.
  - *Arctic region, mountain area, urban canyon,…*

# Conclusion

- SBAS: International Standard Augmentation System
  - Augments GNSS in terms of accuracy and integrity.
  - The standardization of DFMC SBAS is ongoing by the ICAO.
    - *Using L5 SBAS signal instead L1.*
    - *Eliminates ionospheric effects thanks to dual-frequency operation.*
    - *Could be transmitted by non-GEO SBAS satellites like QZSS IGSO.*
- DFMC SBAS Experiment Using QZSS L5S Augmentation Signal
  - The First L5 SBAS experiment with live L5 signal from the space.
  - ENRI has developed the prototype SBAS for experiments.
    - *GPS/GLONASS/Galileo-capable dual-frequency SBAS.*
    - *Compliant with the draft standards of DFMC SBAS being discussed.*
  - The experiment has been conducted since 23 August, 2017.
- Contact for more information:

Dr. Takeyasu Sakai <sakai@mpat.go.jp>
*Electronic Navigation Research Institute*
*National Institute of Maritime, Port and Aviation Technology, Japan*