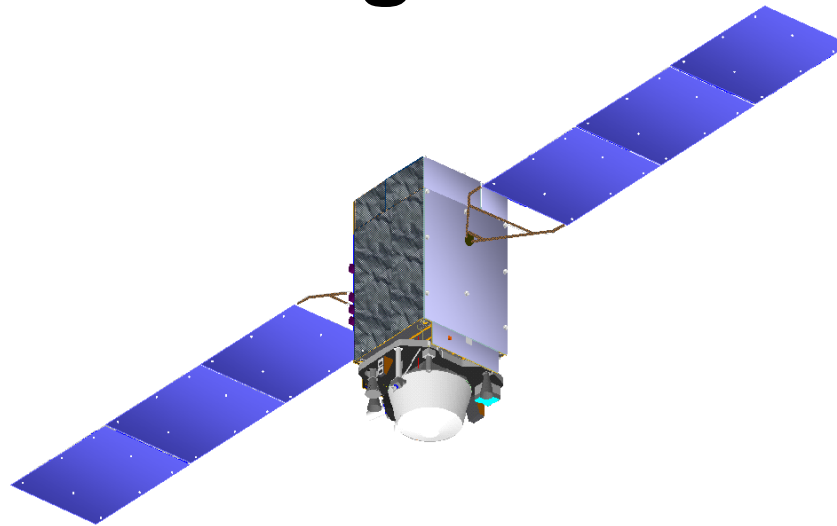




DFMC SBAS: Reception of QZSS L5 SBAS Signal in Europe



Takeyasu Sakai <sakai@mpat.go.jp>

Electronic Navigation Research Institute

National Institute of Maritime, Port and Aviation Technology, Japan

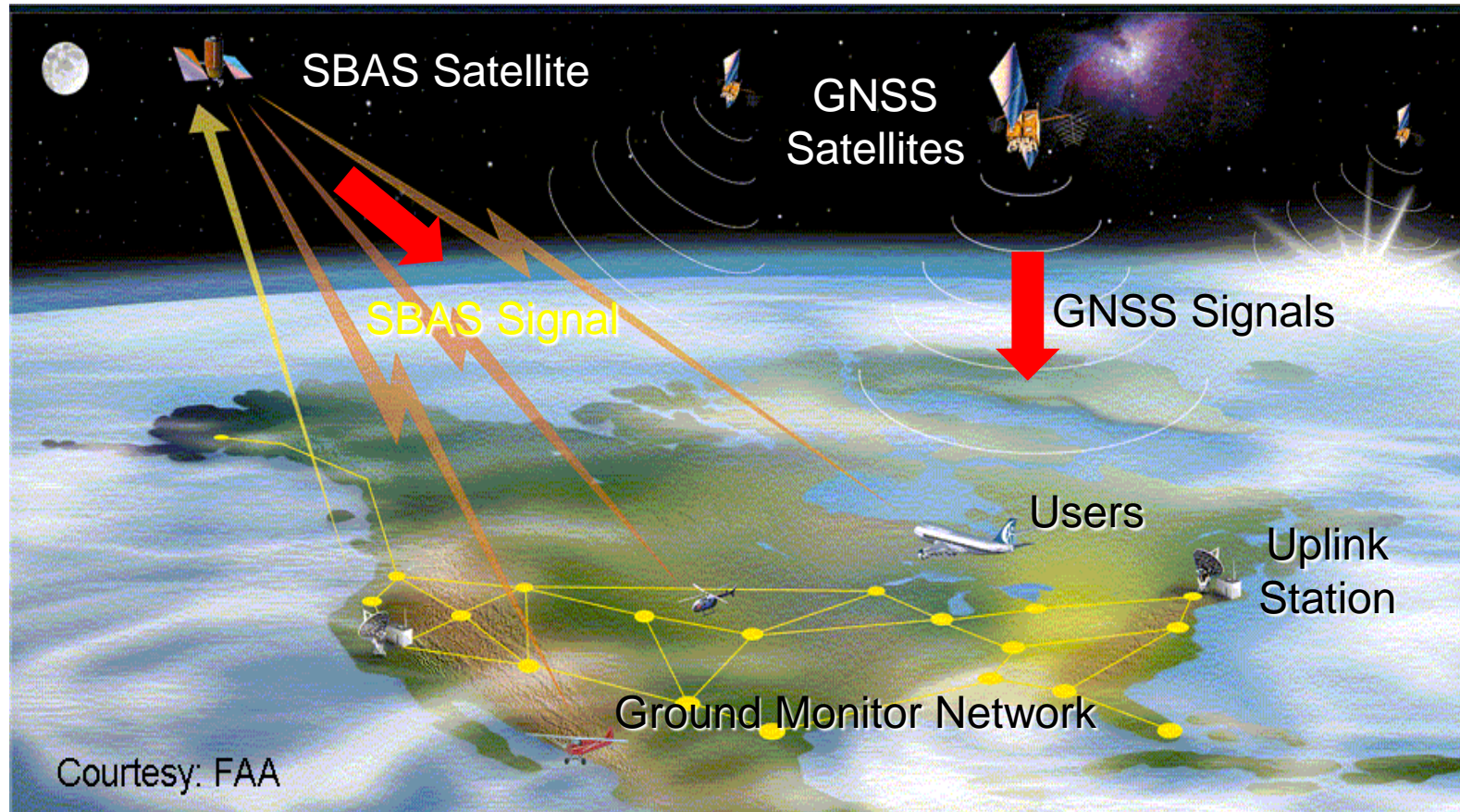


Introduction

- **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 GNSS in terms of accuracy and integrity.*
 - *Current standard: Single-frequency SBAS on L1.*
 - *US WAAS, Japanese MSAS, European EGNOS, and Indian GAGAN.*
- **DFMC SBAS: The Second Generation SBAS**
 - Dual-Frequency Multi-Constellation SBAS using L5 frequency.
 - *Standardization activities ongoing: Recently defined the baseline.*
 - ENRI has been conducting DFMC SBAS experiment with QZSS L5S signal.
- **EU-Japan Joint Experiment**
 - Joint experiment of DFMC SBAS: Including reception in Nordic region.
 - Trial of receiving the signal at GSA HQ in Prague next week (March 21-22).



SBAS Architecture



- Monitors consistency of GPS 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.*

- *Supports Galileo (and QZSS).*

- *Allows non-GEO transmission.*

- Standardization activities ongoing at the ICAO.

- New Feature: Transmission by Non-GEO SBAS

- DFMC SBAS could be transmitted by non-GEO satellites like QZSS IGSO.

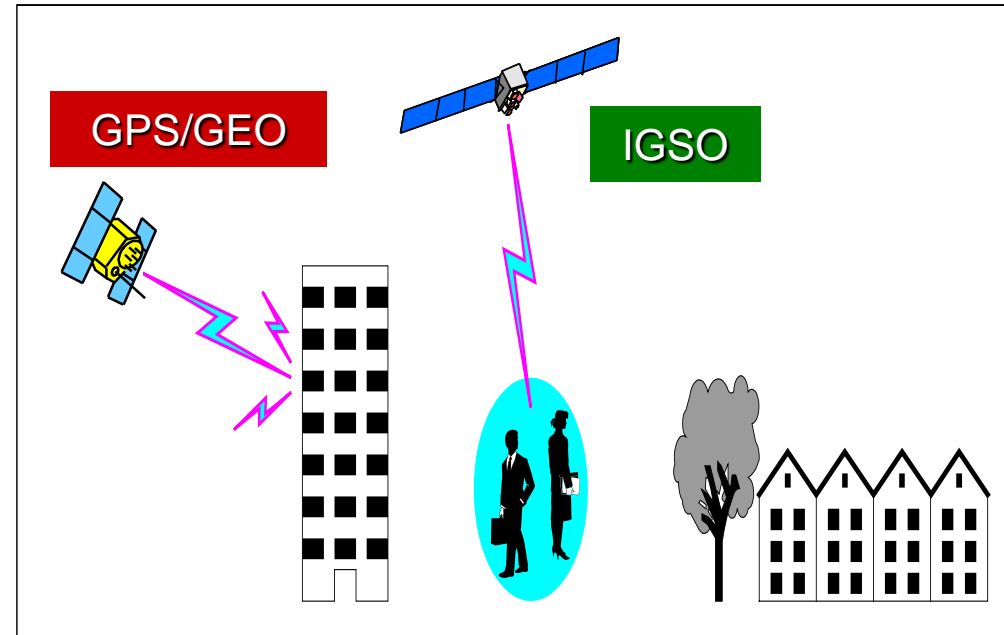
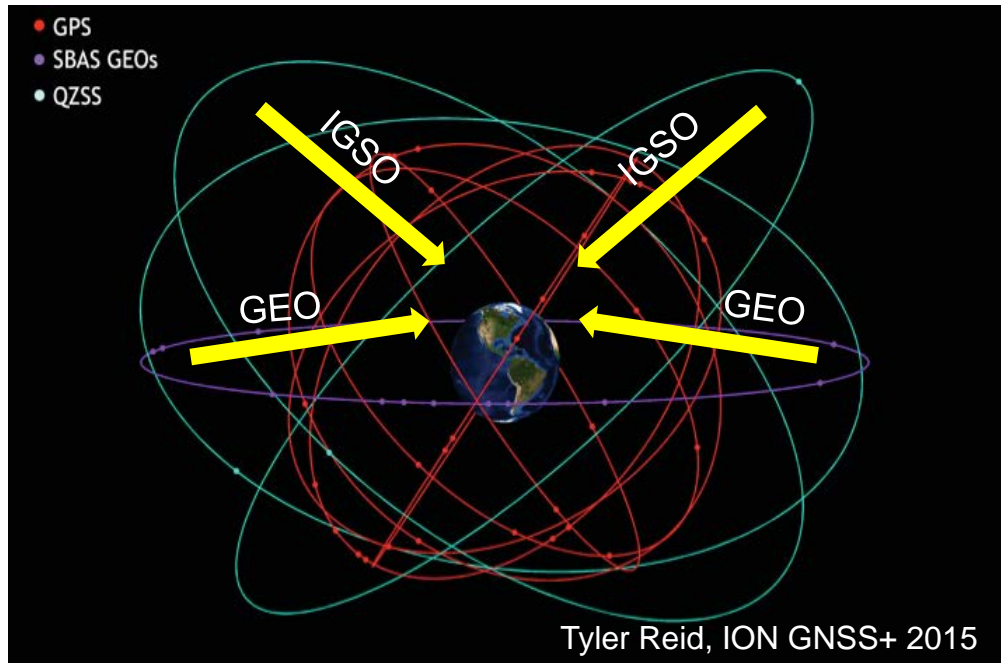
- *Improves availability of SBAS signal by transmission from high elevation angle.*

- *Possible solution for applications where GEO signal is likely blocked.*

- *Enables SBAS service independent of the latitude of the service area by combination of dual-frequency operation and non-GEO transmission.*



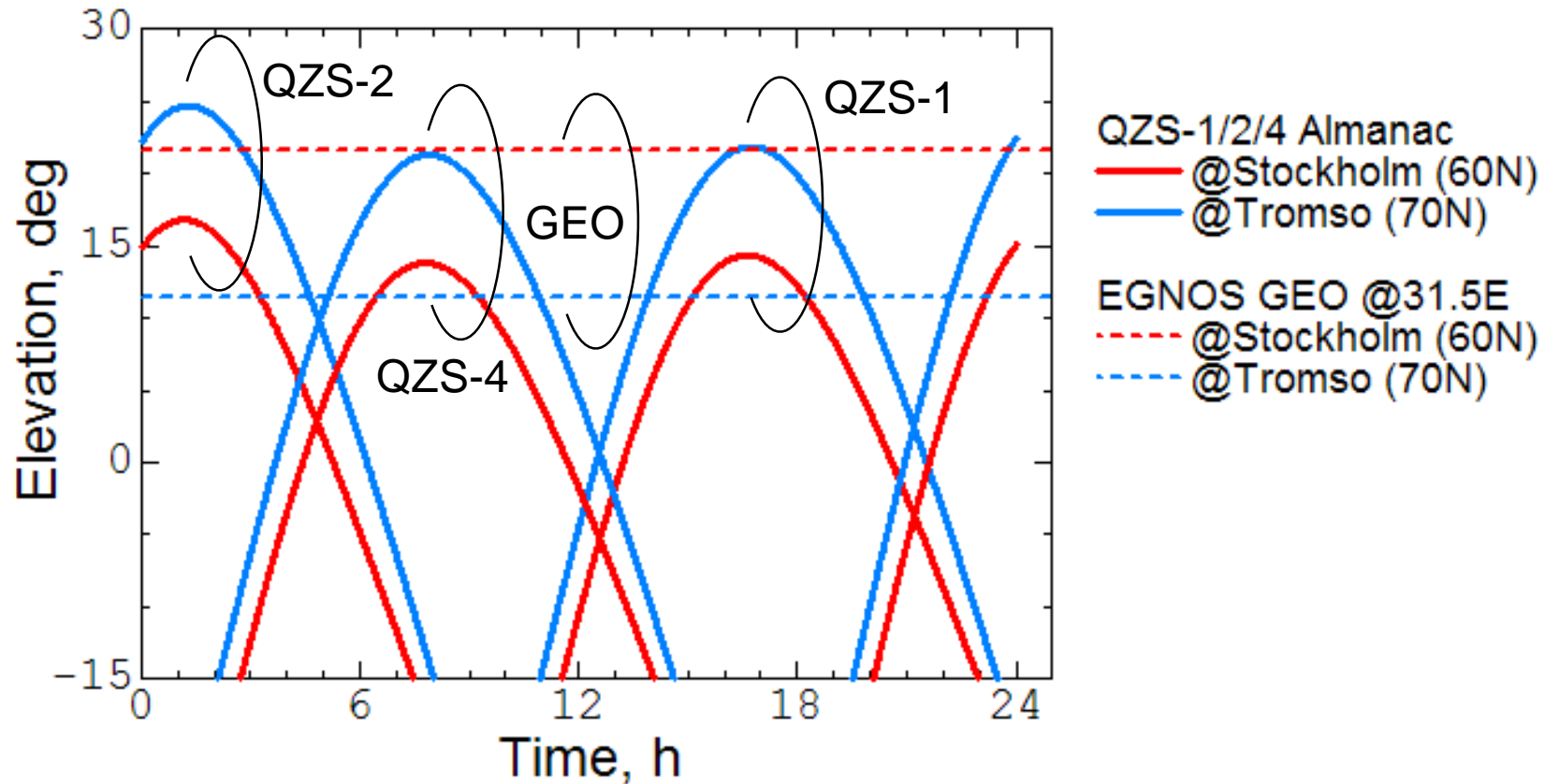
Usage of IGSO Satellites



- DFMC SBAS could be transmitted by non-GEO satellites like QZSS IGSO.
- Improves availability of augmentation signals where GEO signal is blocked.
 - *Arctic/Nordic regions, mountain area, urban canyon,...*
 - *Navigating Arctic routes and precise positioning for resource exploration.*
 - *Note DFMC SBAS is not influenced by ionosphere even in Equatorial regions.*
 - ◆ Seamless service from Equator to Poles, mountain to urban canyons...



Visibility from Nordic Region



- Elevation angles computed from QZS-1/2/4 almanacs.
- QZSS IGSO satellites are visible in Nordic region; Elevation is higher than EGNOS GEO at some Northern location.

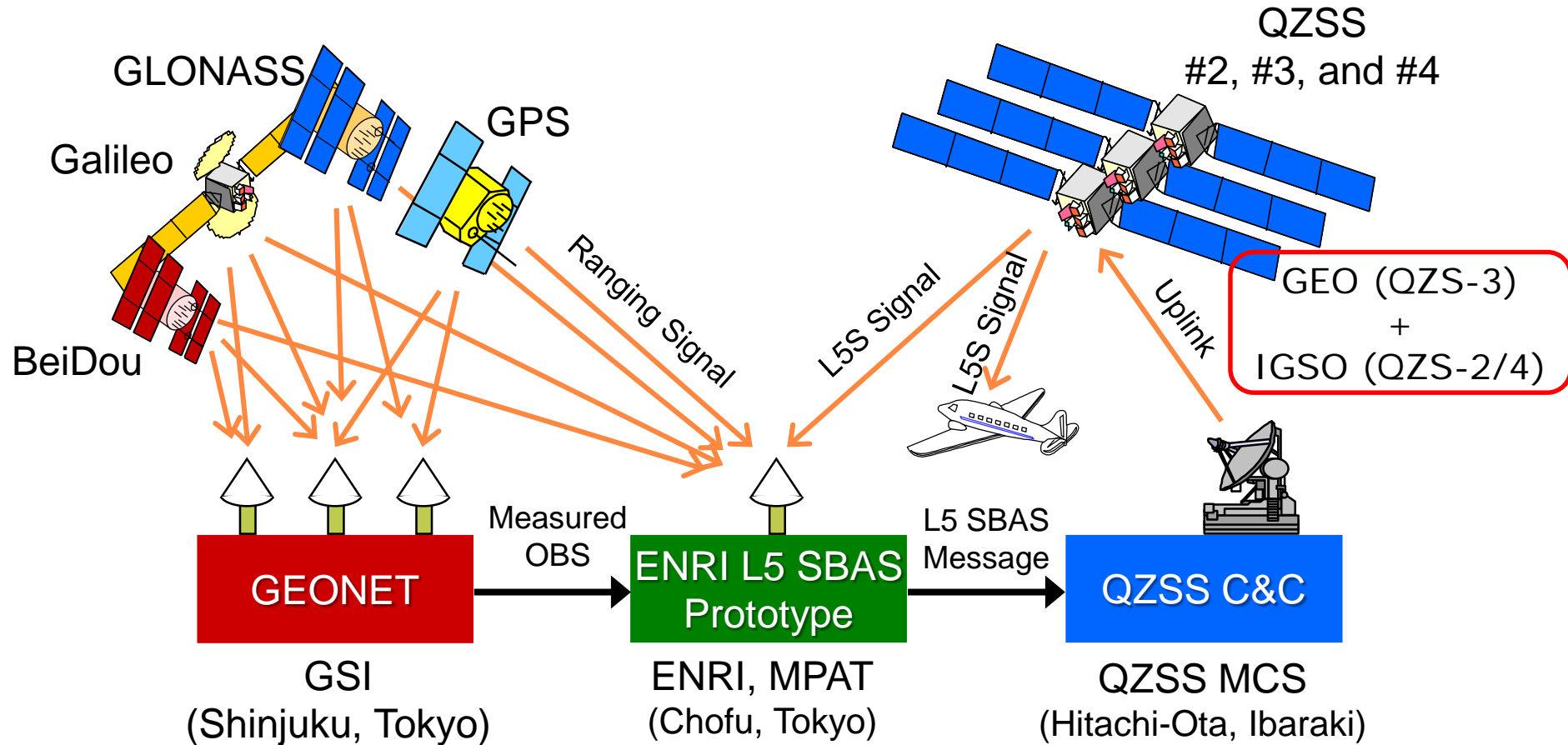


Prototype DFMC SBAS

- **Prototype DFMC SBAS Developed by Japan**
 - The second generation SBAS following L1 SBAS.
 - *Eliminates ionospheric effects thanks to dual-frequency operation.*
 - ◆ Vertical guidance service everywhere in the coverage.
 - Electronic Navigation Research Institute, National Institute of Maritime, Port and Aviation Technology has developed the prototype.
 - *GPS/GLONASS/Galileo/QZSS-capable dual-frequency SBAS.*
 - *Compliant with the draft standards of L5 SBAS being discussed at ICAO.*
 - ◆ Helps validation activities ongoing at ICAO.
- **DFMC SBAS Experiment has been Conducted with QZSS**
 - The First L5 SBAS experiment with live L5 signal from the space.
 - *Using QZSS L5S augmentation signal transmitted from QZS-2, -3, and -4.*
 - Prototype DFMC SBAS is used for the experiment.
 - Began the experiment on 23 Aug. 2017 via L5S signal of QZS-2 IGSO.
 - *Now transmitting from QZS-2/4 IGSO and QZS-3 GEO.*



Experimental Configuration



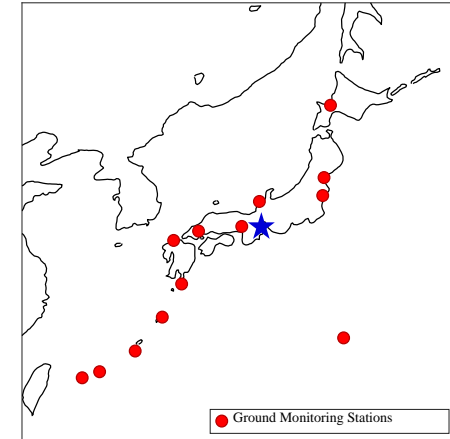
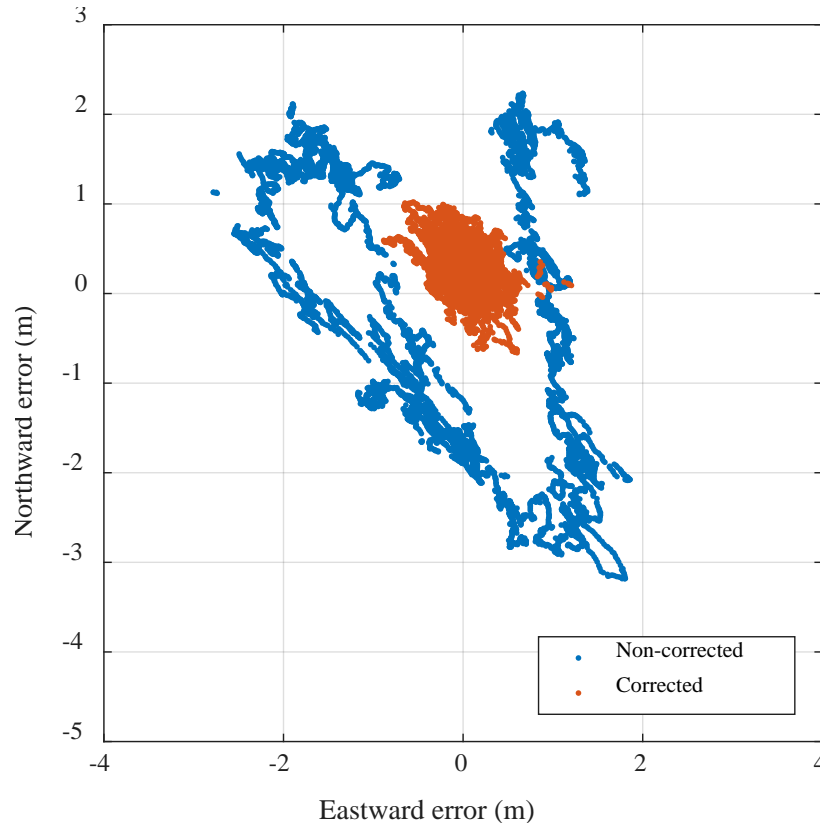
- Supports DFMC
- Provides observation in real time

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

- Uplinks L5 SBAS message stream for transmission



Real Time Experiment



Monitor Stations

- GPS+Galileo+QZSS
- Dual Frequency (L1+L5)
- DFMC L5 SBAS
- Location:
GEONET 950369 (Wakayama)
- Period:
2017/11/13 01:00 - 07:00 (6H)

- Evaluation of L5 SBAS message generated in real time.
 - *Supporting GPS, Galileo, and QZSS in L1/L5 dual-frequency mode.*
- Confirmed that L5 SBAS augments multi-constellation of GPS+Galileo+QZSS.



Reception in Nordic Region

- EU-Japan Joint Experiment

- Planned under the Cooperation Arrangement on GNSS.

Schedule for DFMC SBAS Reception Trial

Transmission from	2018 to 2019	2020 to 2022	After 2023
QZSS L5S	ENRI receiver	ENRI & Thales Rx	ENRI & Thales Rx
EGNOS V3			ENRI & Thales Rx

- First Step: Reception trial in Prague

- Trial of receiving L5S at GSA HQ in Prague next week (March 21 to 22).
- Using ENRI L5S-capable receiver.

- Next Step: Reception trial in Nordic Region

- Likely in this summer.