QZSS CLAS Status and Progress
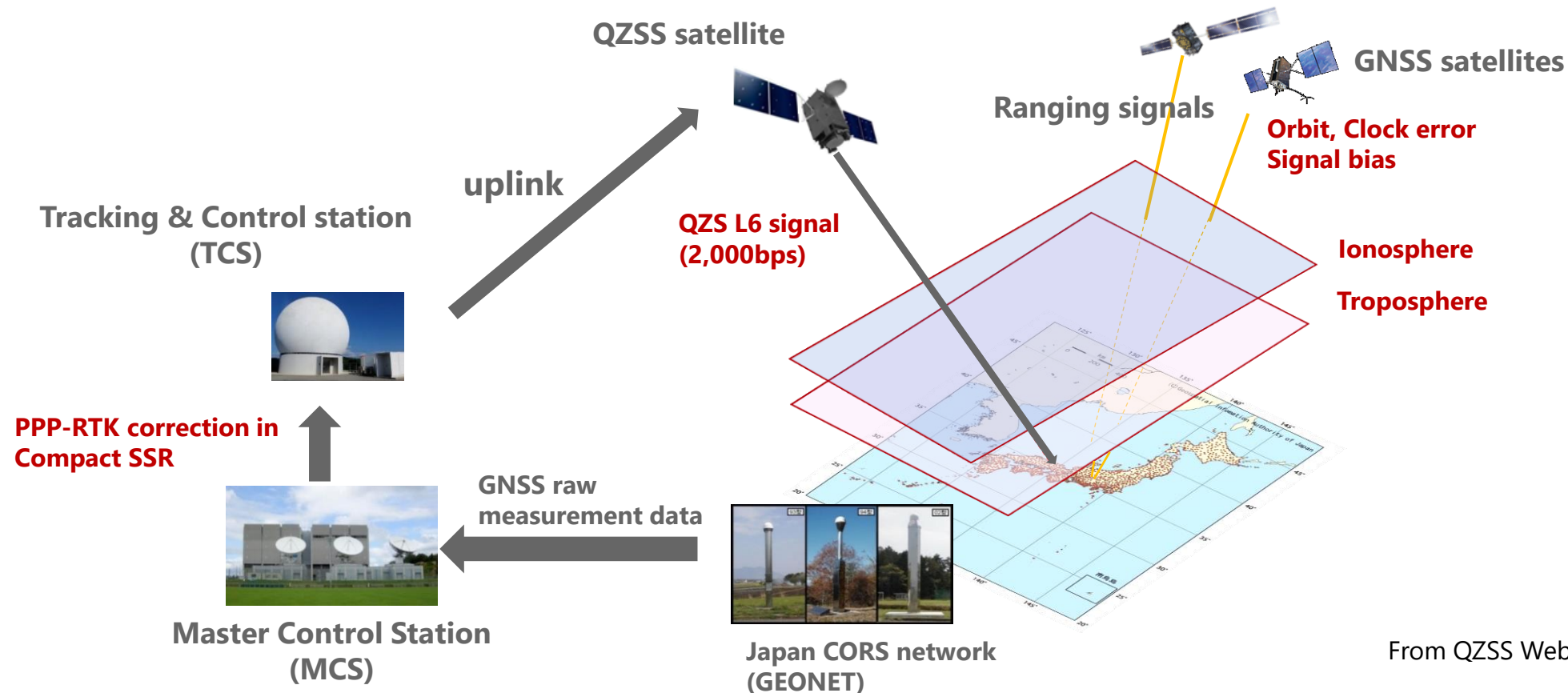
2nd ICG Workshop on Interoperability of Precise Point Positioning

at Joint Research Centre, Ispra, Italy

March 22, 2023

MITSUBISHI ELECTRIC CORPORATION

- QZSS CLAS, a satellite-base open PPP-RTK service provides centimeter level positioning in a minute.
- Operation of QZSS CLAS for Japan, first satellite-based open PPP-RTK service has started on November 2018.
- The states including SIS-error and atmospheric delay are estimated in MCS using the GNSS measurement from Japan CORS network.
- The correction data is formatted in Compact SSR, broadcasted from QZSS satellite using L6 signal.

QZSS satellite

GNSS satellites

Ranging signals

Orbit, Clock error Signal bias

uplink

Tracking & Control station (TCS)

QZS L6 signal (2,000bps)

Ionosphere

Troposphere

PPP-RTK correction in Compact SSR

GNSS raw measurement data

Master Control Station (MCS)

Japan CORS network (GEONET)

From QZSS Web site (https://qzss.go.jp)

- QZSS CLAS provides PPP-RTK correction service for Japan using 2,000bps L6D signal.
- QZSS CLAS supports multi-GNSS including GPS, Galileo, and QZSS.

The specification of CLAS

Item	Specification		
GNSS: Signal *1	**GPS**: L1CA, L2P, L2C, L5 **QZSS**: L1CA, L2C, L5 **Galileo**: E1b, E5a		
Service Area	Japan with territorial waters		
Positioning Accuracy (95%)		**Horizontal**	**Vertical**
	Static	6cm	12cm
	Kinematic	12cm	24cm
Time to First Fix (95%) *2	60 sec		
Continuity	$1\text{-}2{\times}10^{-4}$ /hour		
Integrity	$1{\times}10^{-5}$ /hour		
Time-to-alert	9.2 sec		

*1: L1C(GPS/QZS), GLONASS CDMA (L1/L2) will be added in future
*2 it includes time-to-receive the correction data (=30s)
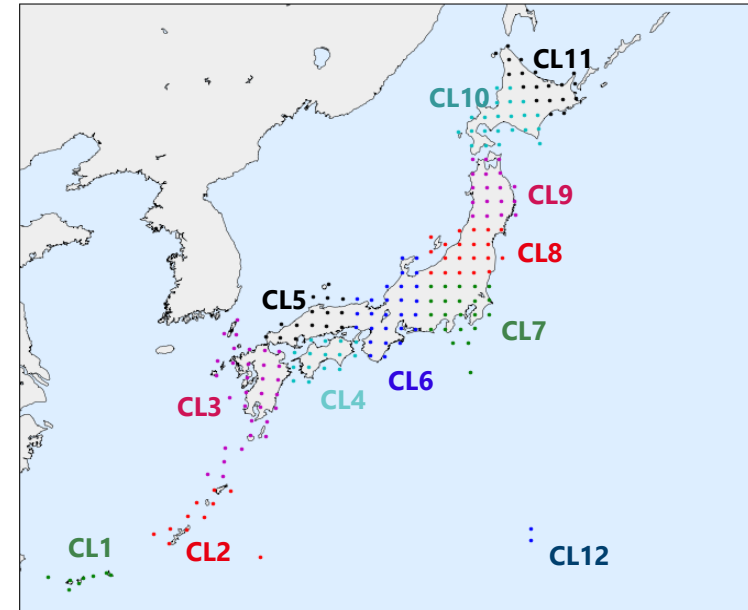
The location of 212 grids in 12 sub-networks for atmospheric correction

■ There are wide variety of application for QZSS CLAS such as automotive, agriculture, maritime, drone.

Agriculture (Hokkaido Univ.)

ADAS (Nissan Aria)

Construction (Automatic crane control)

Shipboard applications (Automatic berthing)

Drone applications (Delivery, Agriculture,Monitor)

From QZSS Web site (https://qzss.go.jp)

Performance of QZSS CLAS

- QZSS CLAS is operational since Nov. 2018, it proves quite good performance and the reliability.
- High-accuracy positioning solution can be obtained in 5 seconds after receiving correction data.
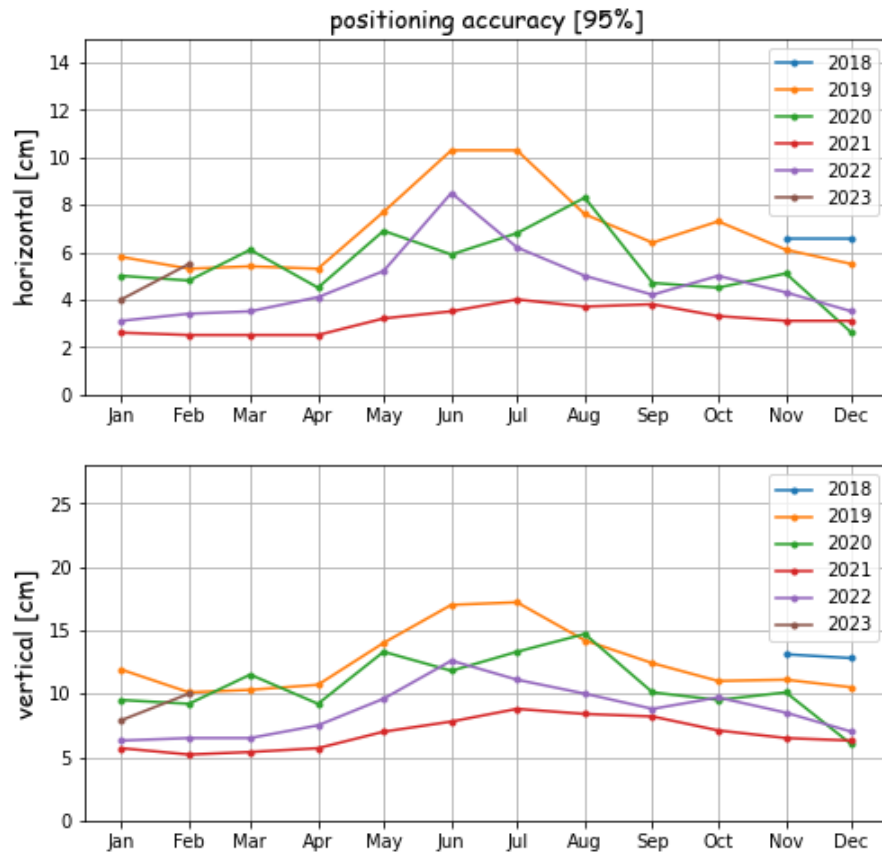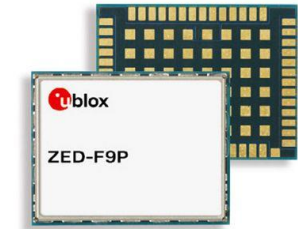
Kinematic mode
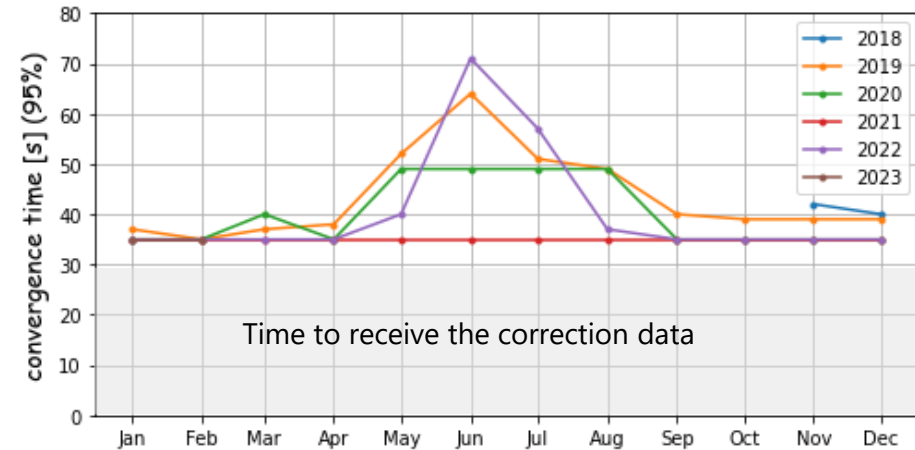
* Analyzed by CLASLIB, based on the daily solution of 72 CORS stations in Japan
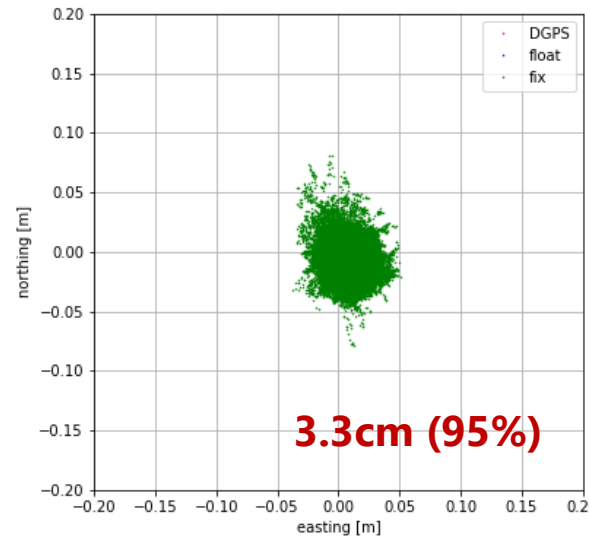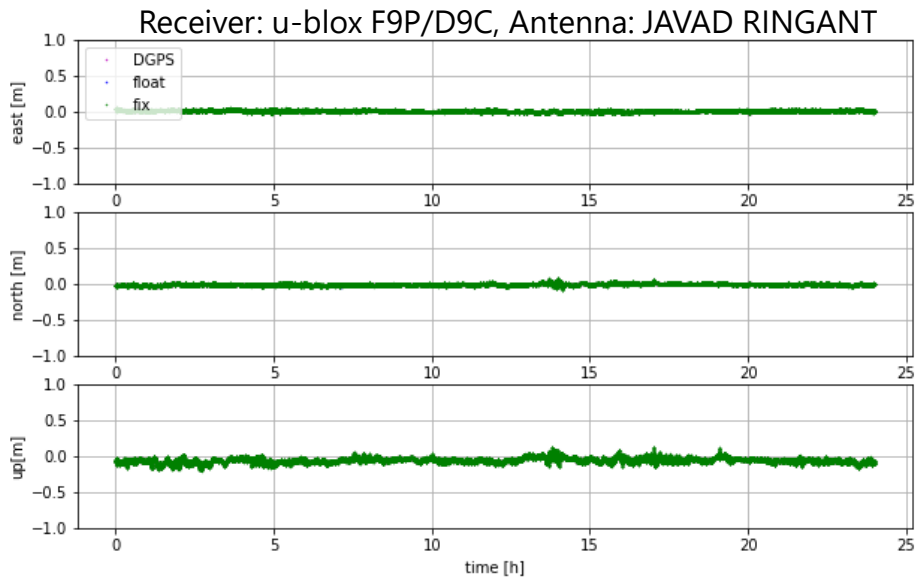
- QZSS CLAS provides highly accuracy cm-level positioning result in a minutes.
- Low-cost high-performance GNSS receivers such as u-blox F9P, Septentrio mosaic are supporting QZSS CLAS.

Signal	Data rate	Service	Name
L6D	2,000bps	PPP-RTK	CLAS

u-blox F9P/D9C

Receiver: u-blox F9P/D9C, Antenna: JAVAD RINGANT

3.3cm (95%)

Septentrio mosaic-CLAS

(From https://qzss.go.jp)

Example PPP-RTK positioning result (u-blox F9P/D9C, December 2021)

- Compact SSR, an effective open format compatible with RTCM SSR

- Archived correction data on QZSS Web site.
- Use-cases in many fields are available on QZSS Web site.

Open Format

Open Data

Reference Implementation

User Support

- CLASlib, OSS toolkit for PPP-RTK based on RTKLIB [1]

- E-mail based technical support
- Evaluate the interoperability on the major GNSS receivers
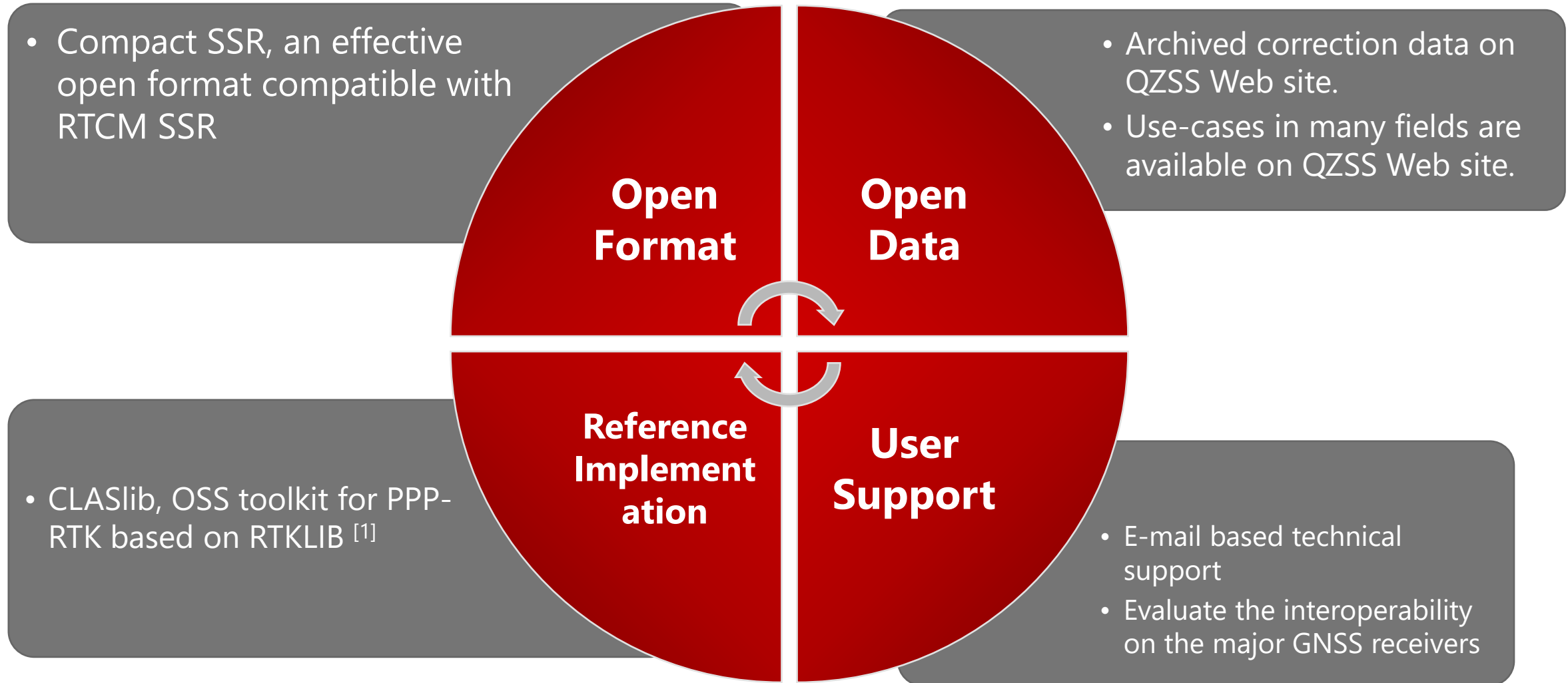
[1] "CLASLIB: An Open-source Toolkit for Low-Cost High-precision PPP-RTK Positioning", ION-GNSS+ 2019

Interoperability issue between GPS/QZSS

- Inter-receiver inter-system bias (ISB) is existing between GPS/QZSS
- Zero-baseline analysis using RTCM MSM was conducted for major GNSS receivers
- The large code bias in Trimble receivers was fixed in the recent firmware.
- ¼ cycle phase bias was observed in Javad/TOPCON, it was also fixed in the recent firmware.

Large code bias
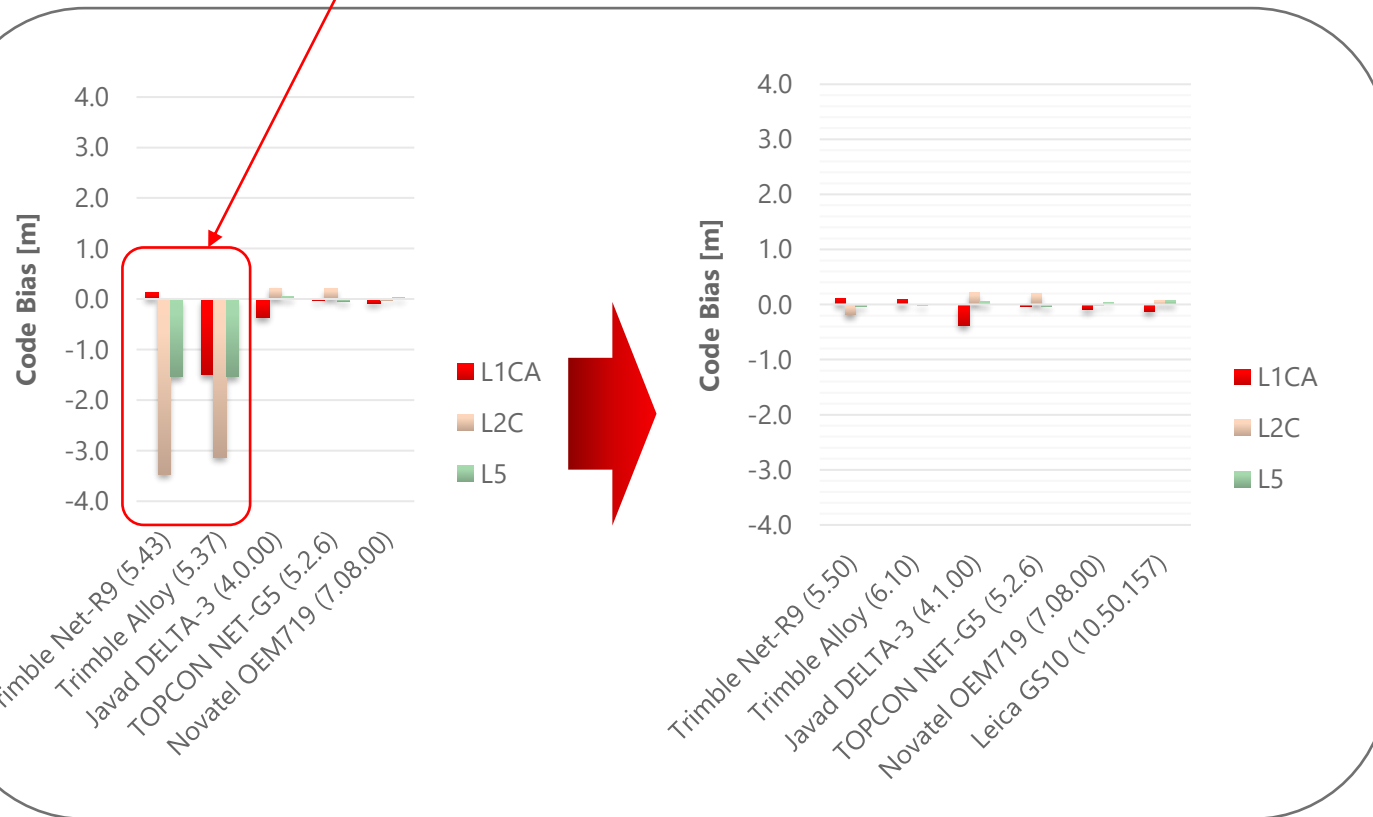
1/4 cycle phase bias in L2C
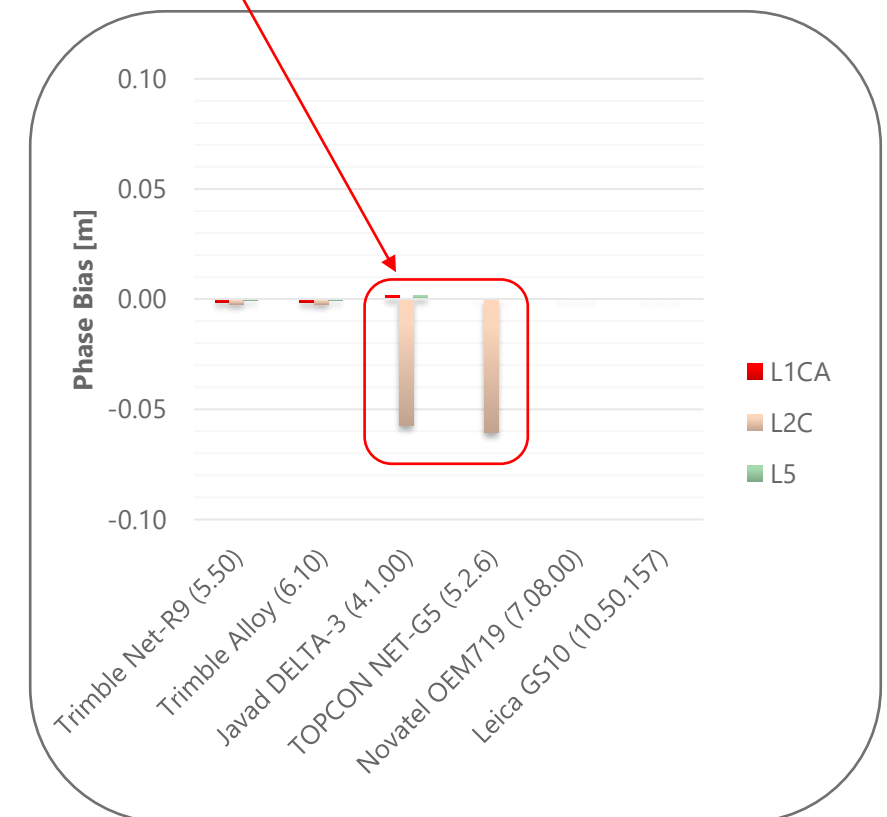
Reference: Septentrio PolaRx5 FW: 5.4.0, Antenna: JAVAD RINGANT
Processing S/W: GSILIB v1.0.3: https://www.gsi.go.jp/ENGLISH/eiseisokuchi-e31001.html

- More satellites by combining multiple channels of multiple QZSS satellites.

- Correction Message Authentication (CMA) for PPP/PPP-RTK.

Availability

Cyber-security

Disaster Prevention

Integrity

- Localized heavy rainfall prediction by estimating IPWV.

- Applying the standardized message in RTCM SC-134 and 3GPP.
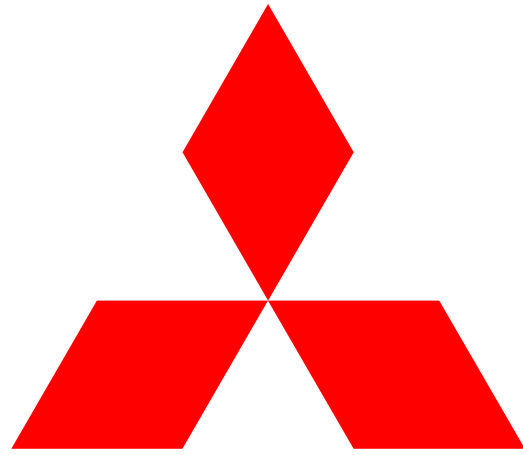
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Changes for the Better