未来导航
FUTURE NAVIGATION

In-orbit Testing Results of CENTISPACE LEO Augmentation Experimental Satellites

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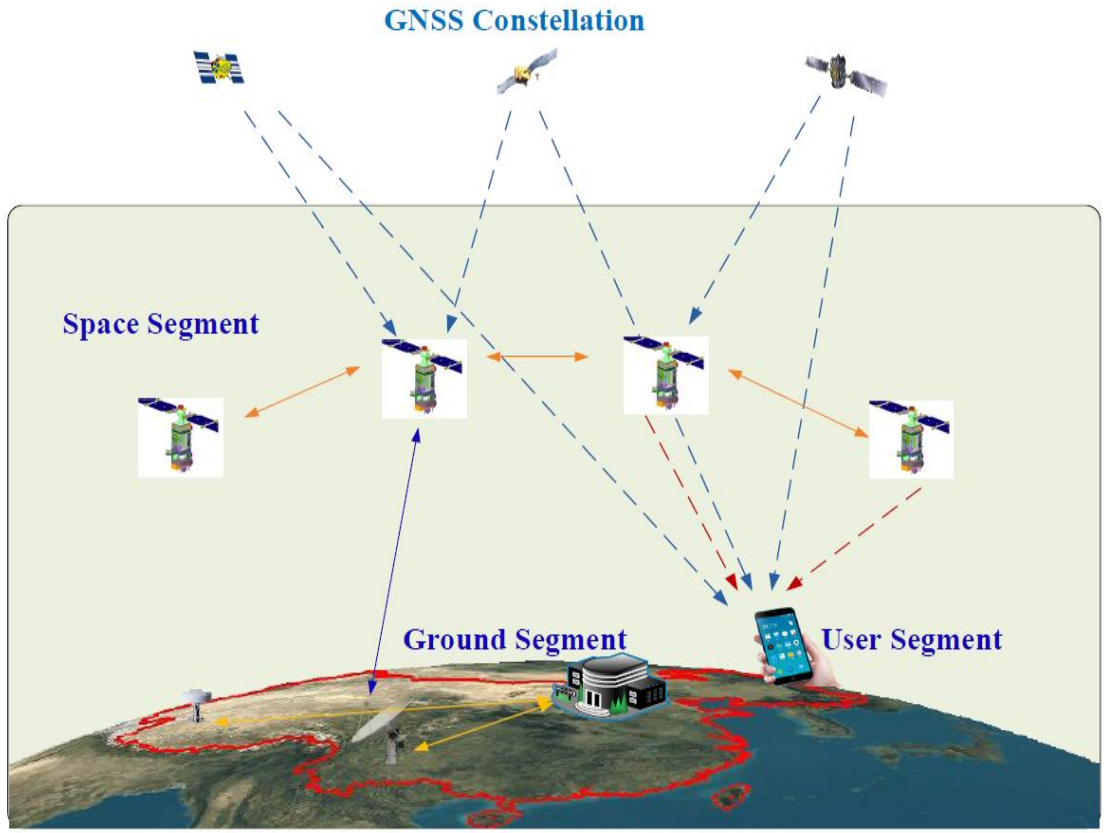
Outline

1. CENTISPACE program overview
2. In-orbit Testing Results
3. Next steps

1. CENTISPACE program overview

System Description

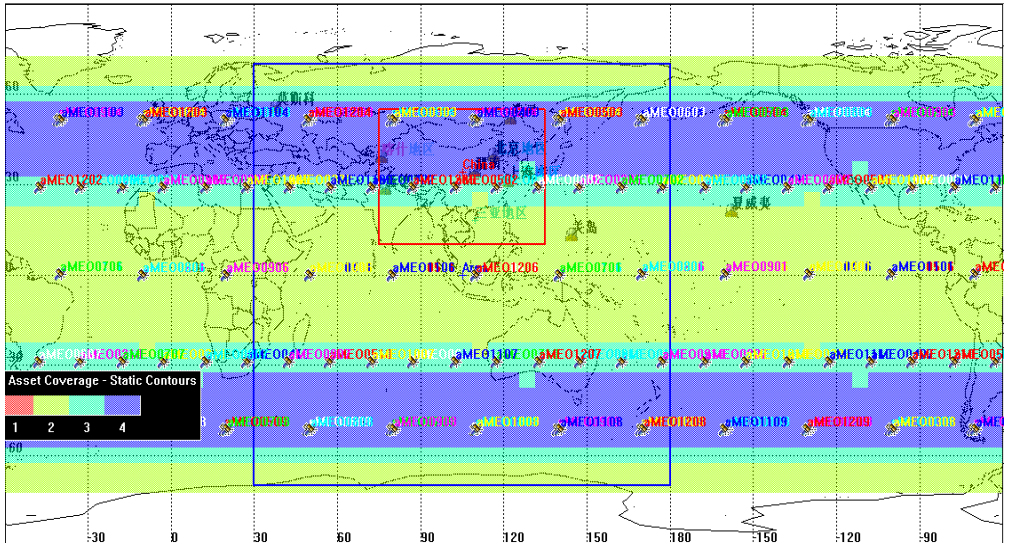
- Commercial LEO argumentation navigation system
- High Accuracy Service, Integrity augmentation Service, and GNSS monitoring Service
- Global System
- Space Segment, Ground Segment and User Segment

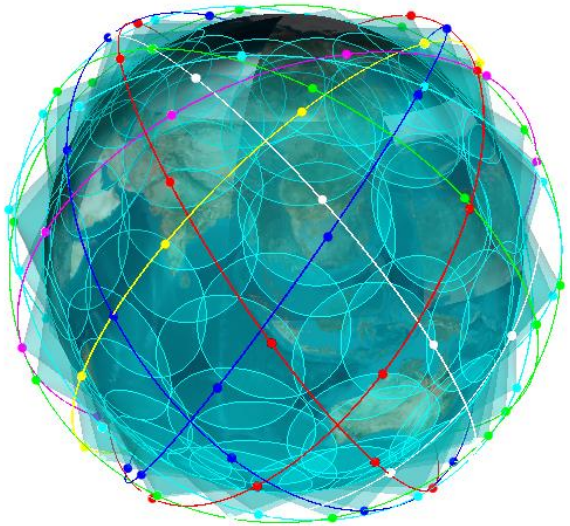


1. CENTISPACE program overview

Sub-constellation I

- ★ Constellation：WALKER120/12/1
- ★ Orbit altitude：975km
- ★ Inclination：55°





Lat，Lon	Visable Sats	Lat，Lon	Visable Sats
(0°，0°)	2-6	(40°，0°)	5-7
(5°，0°)	2-5	(45°，0°)	5-7
(10°，0°)	3-4	(50°，0°)	5-7
(15°，0°)	3-5	(55°，0°)	4-7
(20°，0°)	3-4	(60°，0°)	4-6
(25°，0°)	3-5	(65°，0°)	2-5
(30°，0°)	4-5	(70°，0°)	2-3
(35°，0°)	5-6		
More than 2 coverages are between 70°N and 70°S			

1. CENTISPACE program overview

Sub-constellation II

- ★ Constellation：WALKER 30/3/1
- ★ Orbit altitude：1100km
- ★ Inclination：87.4°
- ★ Expand coverage in polar regions

Sub-constellation III

- ★ Constellation：WALKER 40/4/1
- ★ Orbit altitude：1100km
- ★ Inclination：30.0°
- ★ Expand coverage in low latitude regions

1. CENTISPACE program overview

Ground Segment

- **Master Station:** manage and control of the entire system equipment; process monitoring data observed by satellite or ground GNSS receiver; calculate and generate precise ephemeris and satellite clock correction data
- **TT&C Station:** tracking and controlling satellites
- **Monitoring Station:** generate GNSS observation data

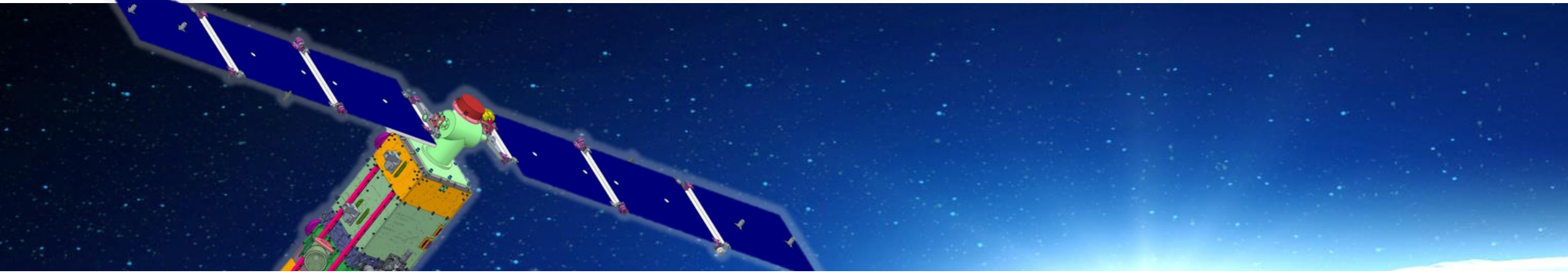
1. CENTISPACE program overview

Our ITU Filings

ID number (SNS)	adm	ORG or Geo.area	Satellite name	Earth station	long_nom	Date of receipt	ssn_ref	ssn_no	WIC/IFIC (ific.mdb)	WIC/IFIC date
up down	up down	up down	up down	up down	up down	up down	up down	up down	up down	
118520162	CHN		CENTISPACE-1		N-GSO	06.07.2018	API/C	488	2878	04.09.2018
118520162	CHN		CENTISPACE-1		N-GSO	06.07.2018	CR/C	4801	2882	30.10.2018
118520283	CHN		CENTISPACE-2		N-GSO	11.09.2018	API/C	539	2881	16.10.2018
118520283	CHN		CENTISPACE-2		N-GSO	11.09.2018	CR/C	4847	2886	08.01.2019
120545323	CHN		CENTISPACE-3		N-GSO	29.12.2020	API/A	12741	2942	23.03.2021
120520264	CHN		CENTISPACE-3		N-GSO	29.12.2020	CR/C	5516	2953	24.08.2021
122545286	CHN		CENTISPACE-4		N-GSO	24.11.2022	API/A	13236	2991	07.03.2023

RF Characteristics of Ranging Signal

Parameters	GENTISPACE	
	CL1	CL5
Modulation Type	BPSK	BPSK
Frequency Band (MHz)	1569 - 1581	1170 - 1182
Data rate(bps)	1000	1000
Chip Rate(Mcps)	2.046	2.046
User Received Power (Typical, dBW)	-157.0	-157.0



Outline

1. CENTISPACE program overview
2. In-orbit Testing Results
3. Next steps

2. In-orbit Testing Results

Space Segment

- 5 experimental satellites in orbit.
- Conducted some effective experiments on satellite platforms and payloads.
- The experiment is still ongoing.

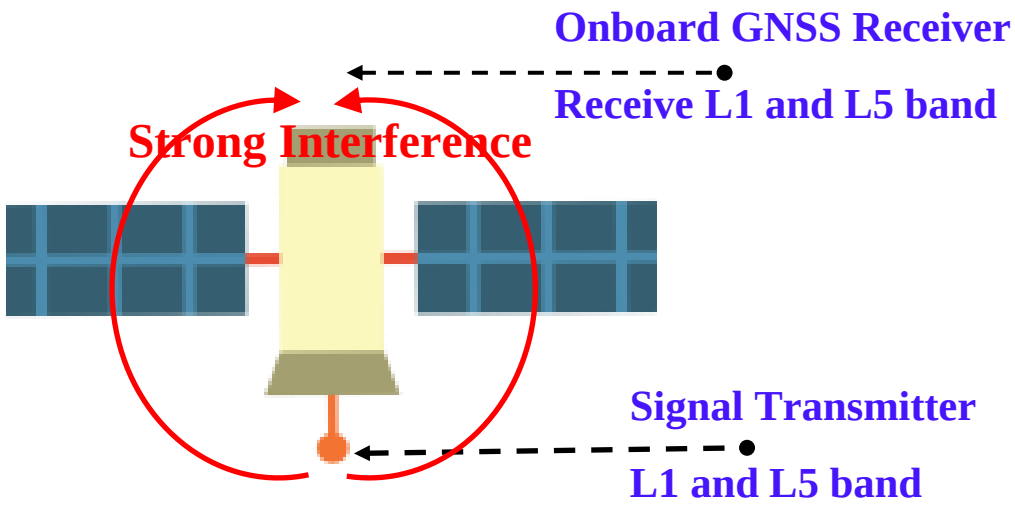
CENTISPACE-S1
(Launch Date: 29 Sep 2018)

CENTISPACE-S3 / S4
(Launch Date: 6 Sep 2022)

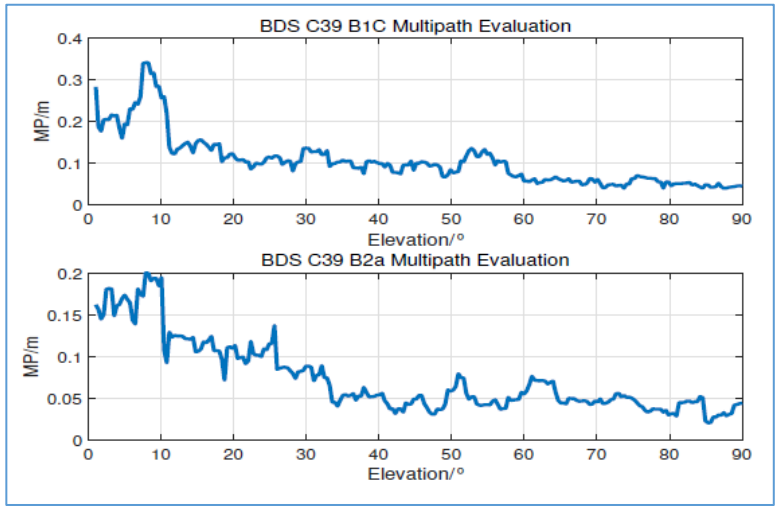
CENTISPACE-S5 / S6
(Launch Date: 7 Oct 2022)

2. In-orbit Testing Results

Onboard GNSS Observation Quality Test



Multipath of Onboard GNSS Receiver

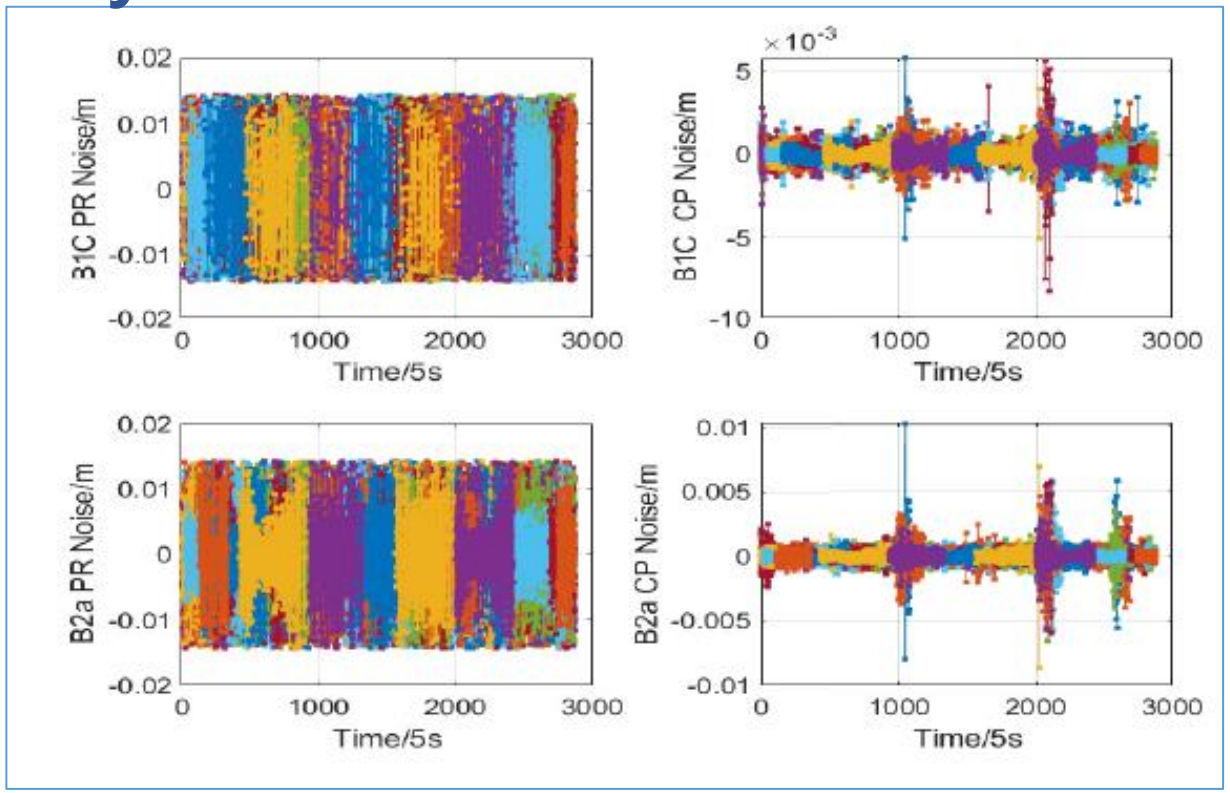


- The multipath statistical results of all the BDS satellites are <0.48m for B1C signal and <0.33m for B2a signal respectively, which are all less than 0.5m and are comparable with the multipath of a ground tracking stations.

2. In-orbit Testing Results

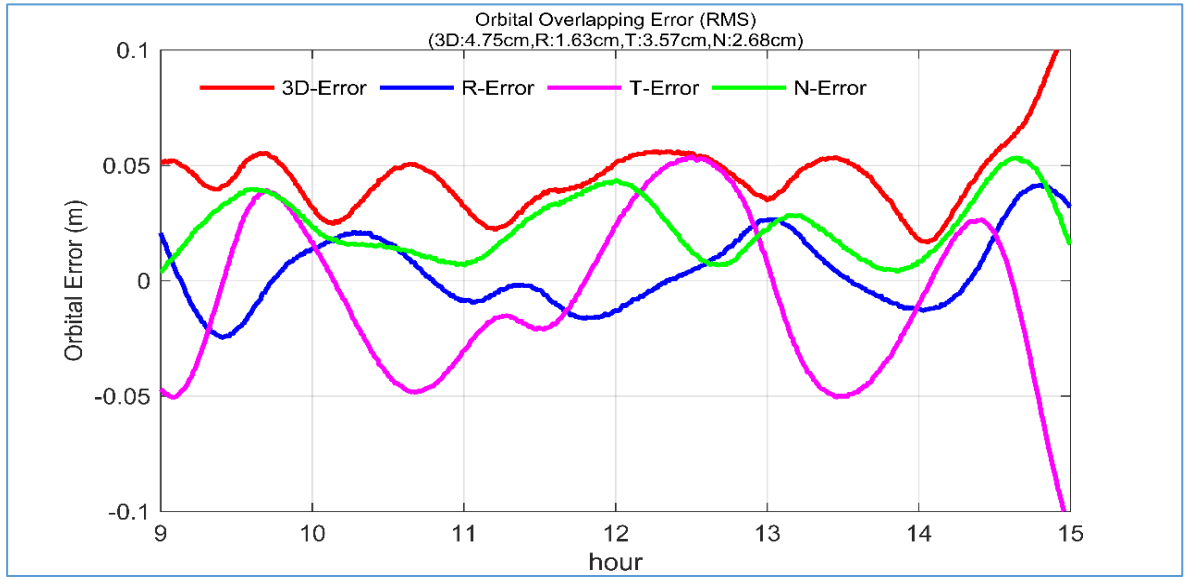
Onboard GNSS Observation Quality Test

- The measurement value of pseudo range noise for BDS signals: <8cm.
- The measurement value of carrier phase noise for BDS signals: <2mm.



BDS Measurement Noise Observed by Space-borne GNSS Receiver

Precise Orbit Determination



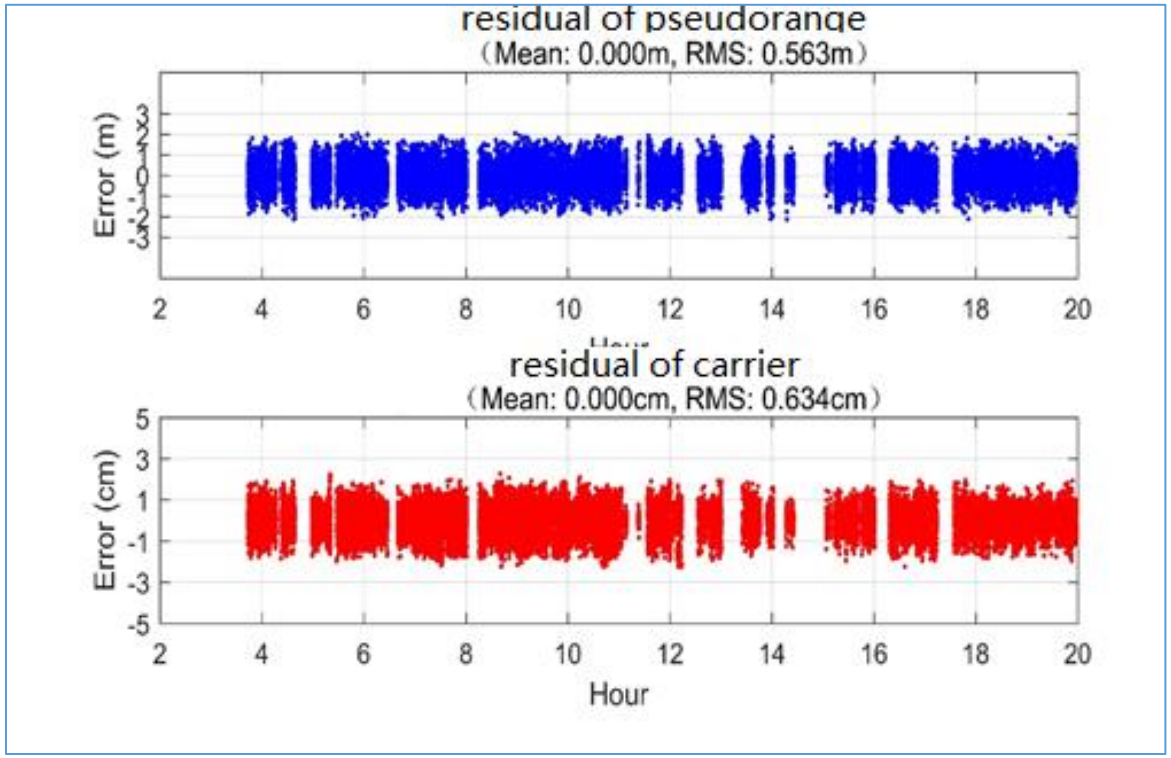
Difference of Subsequent Orbit Arc Overlap

- **Precise orbit determination error with BDS signals: <5cm.**

2. In-orbit Testing Results

Precise Orbit Determination

- LEO satellites orbit determination residual of pseudo range: **0.563m（RMS）.**
- LEO satellites orbit determination residual of carrier phase: **0.634cm（RMS）.**



LEO precision orbit determination ranging residual (Based on BDS observation data)

2. In-orbit Testing Results

Ranging Signal Test Setup

High Gain Antenna

Static Test Receiver

Kinematic Test Vehicle

2. In-orbit Testing Results

Ranging Signal Quality

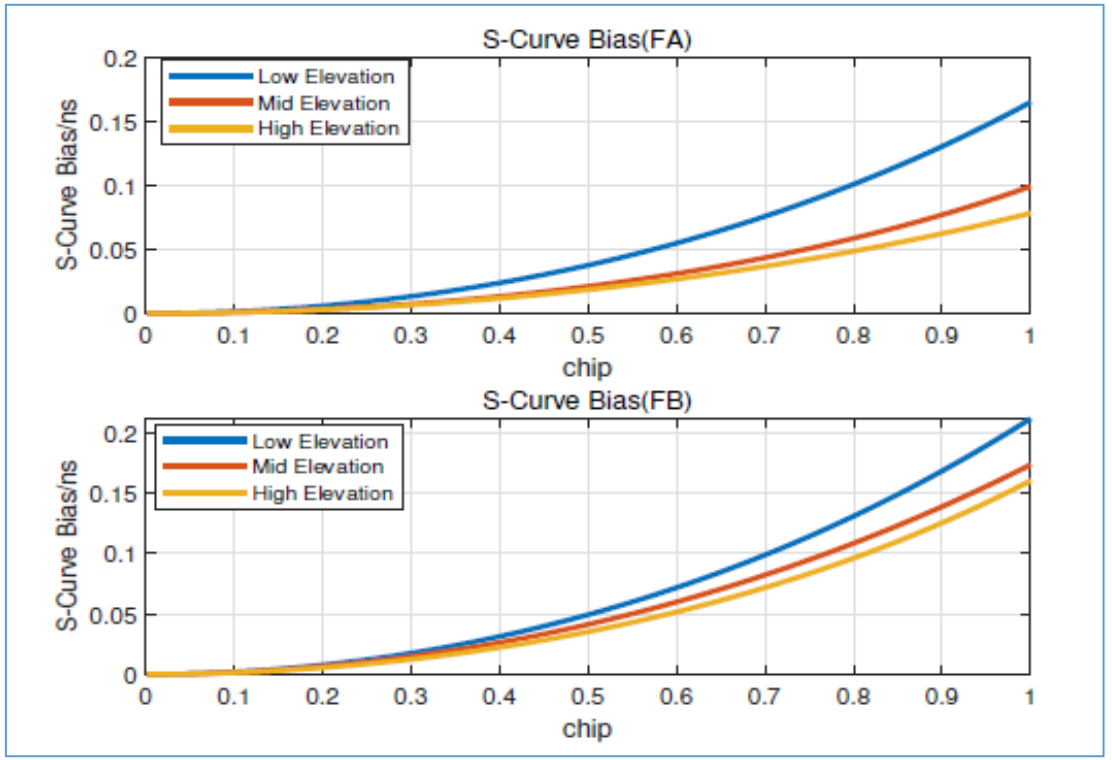
I/Q Orthogonality

Signal	High Elevation	Mid Elevation	Low Elevation
FA (1577MHz)	0.38˚	0.37˚	1.69˚
FB (1174MHz)	0.32˚	0.35˚	1.45˚

Correlation Loss

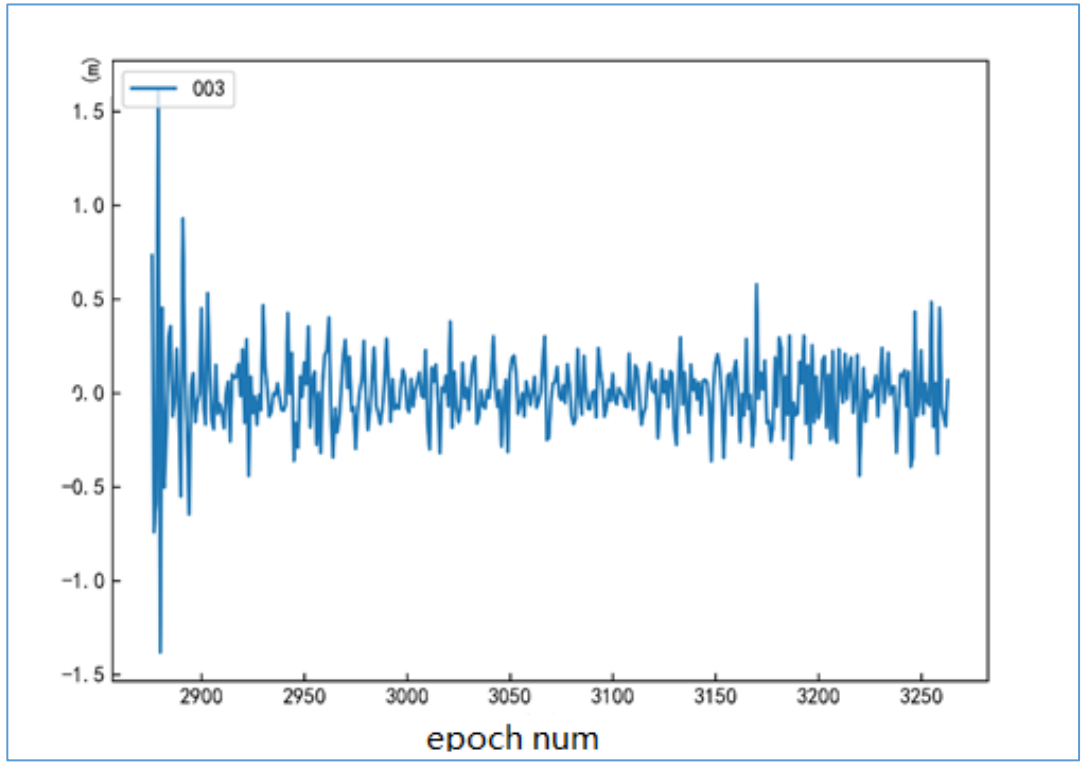
Signal		High Elevation	Mid Elevation	Low Elevation
FA	I	0.25dB	0.26dB	0.34dB
	Q	0.23dB	0.29dB	0.31dB
FB	I	0.17dB	0.19dB	0.29dB
	Q	0.20dB	0.22dB	0.25dB

S-Curve Bias

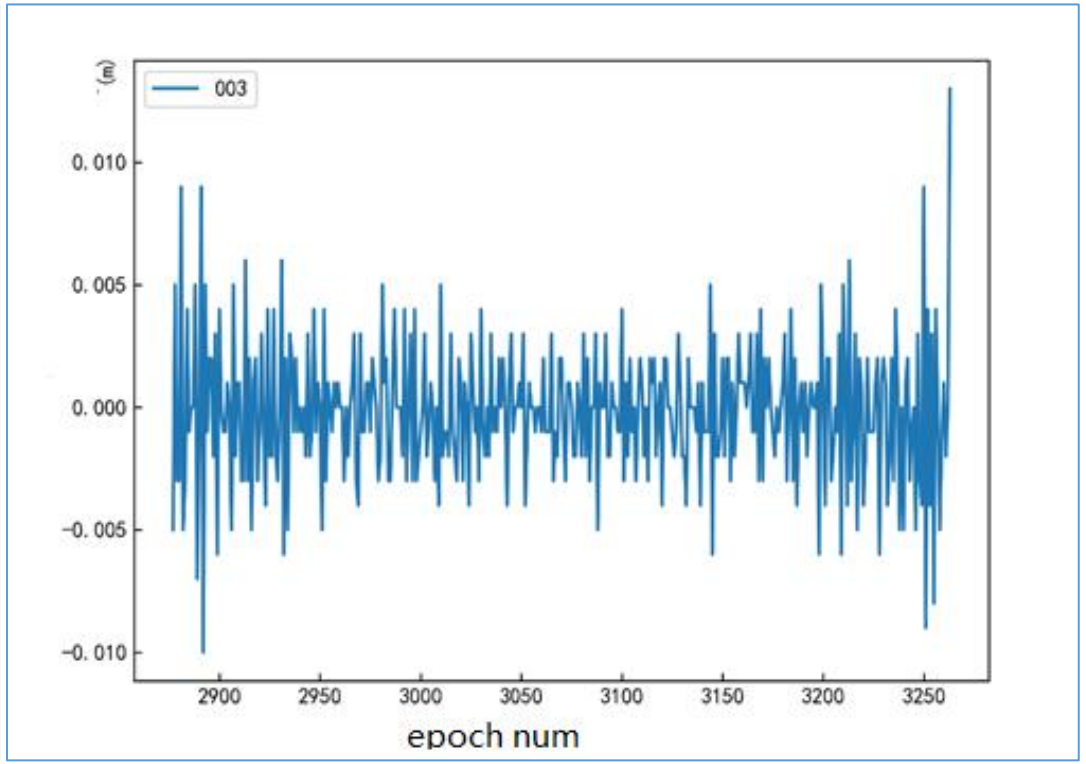


2. In-orbit Testing Results

Ranging Signal Quality

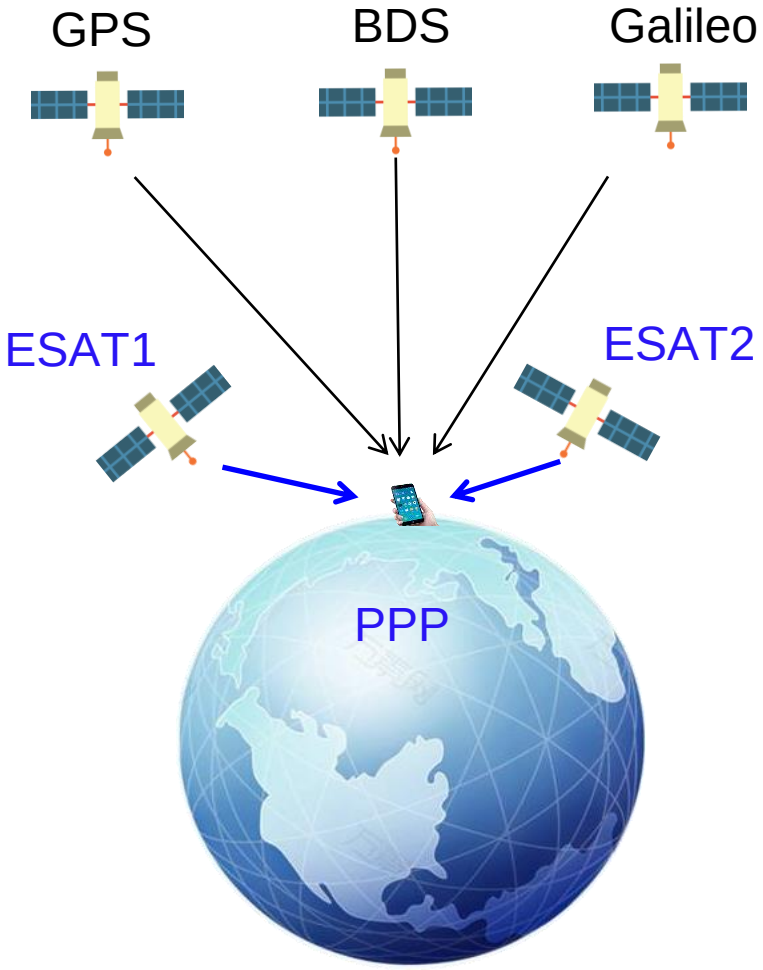


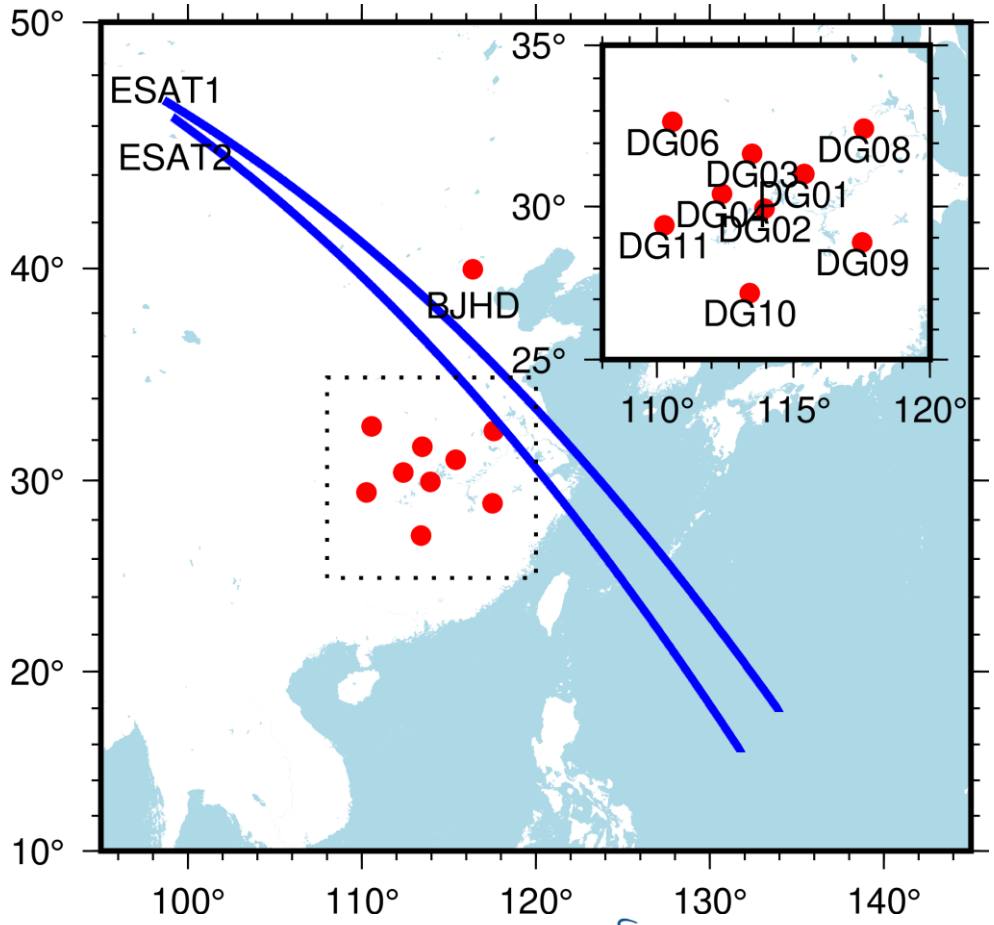
DD of Pseudorange GF Combination
（RMS：3.2cm）



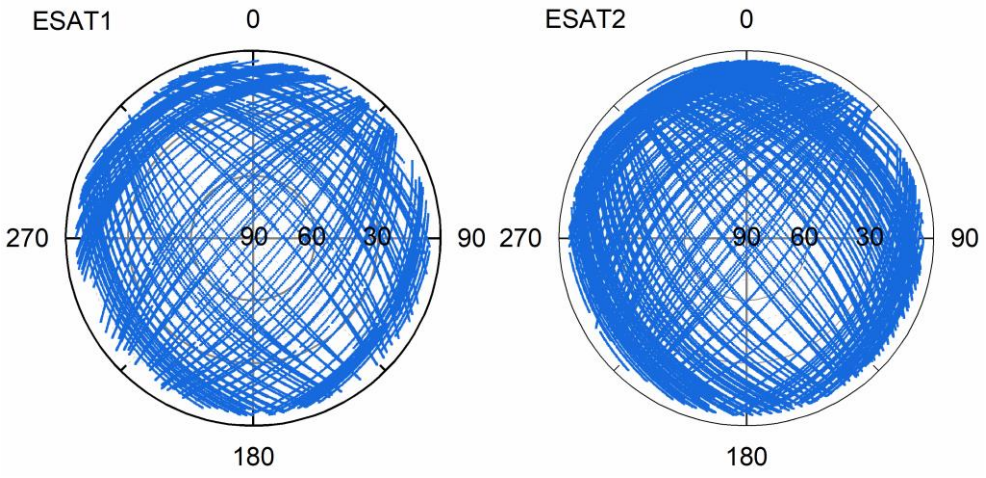
DD of Phase GF Combination
（RMS:0.4mm）

Two LEOs Augmentation PPP Experiment

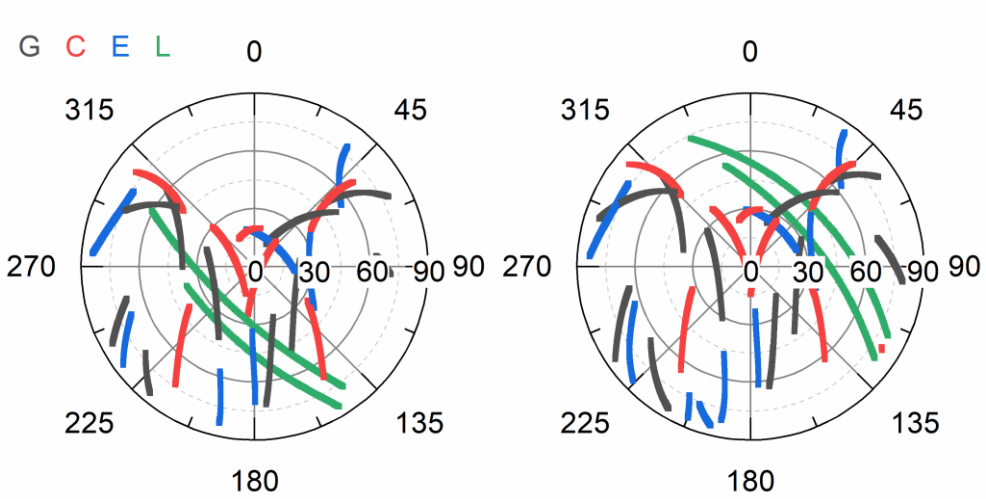




Two LEOs Augmentation PPP Experiment



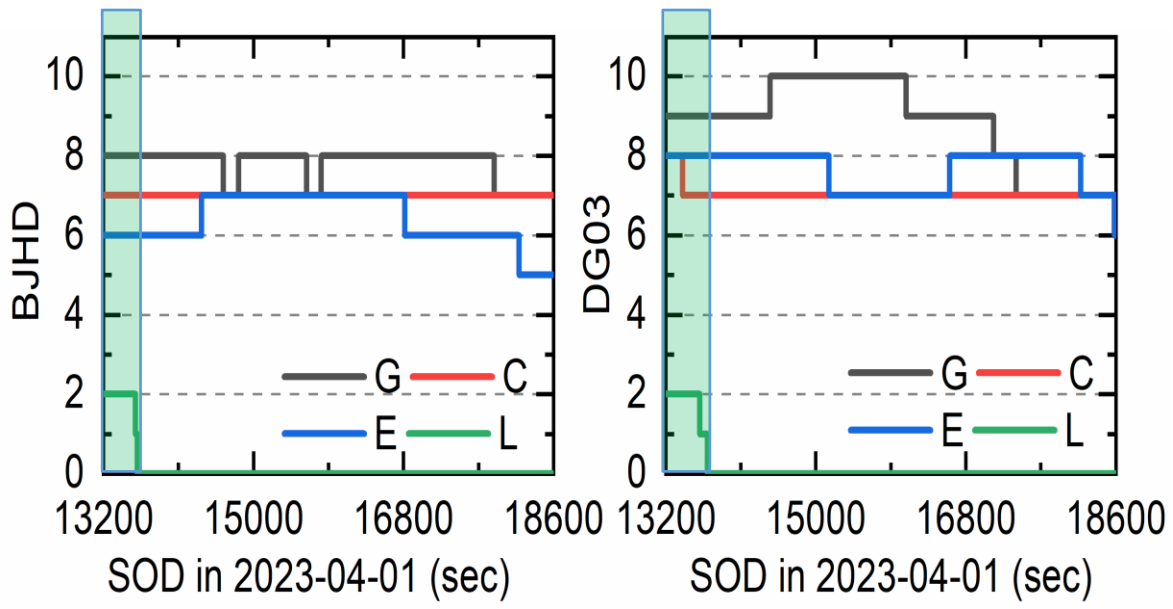
Tracks Plot of Two LEOs in 20 Days



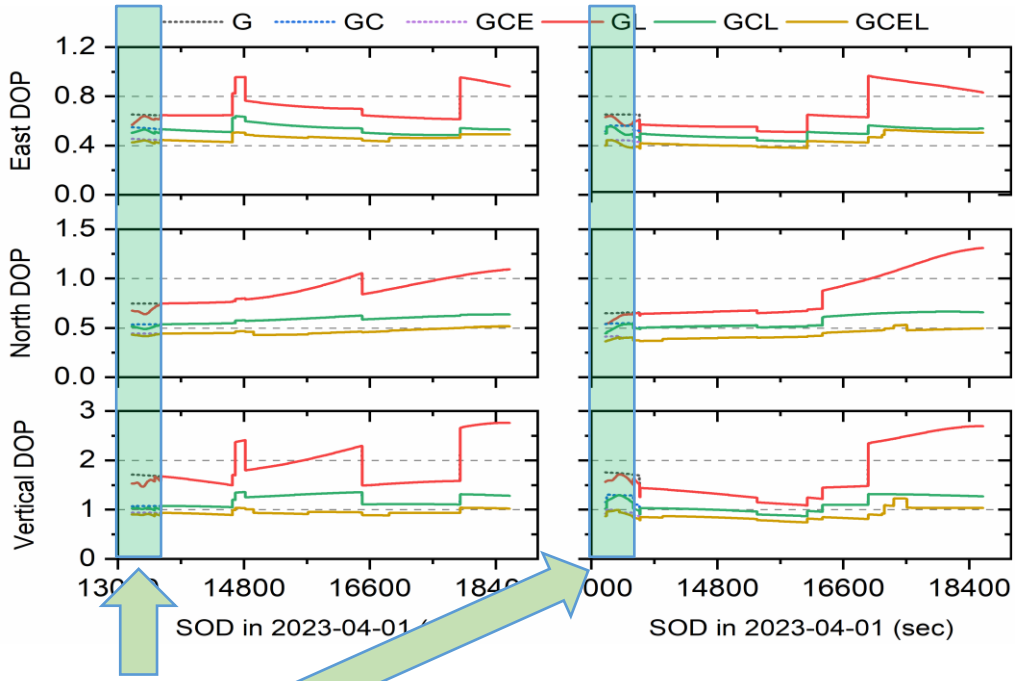
Tracks Plot of 90 Minutes

2. In-orbit Testing Results

Two LEOs Augmentation PPP Experiment



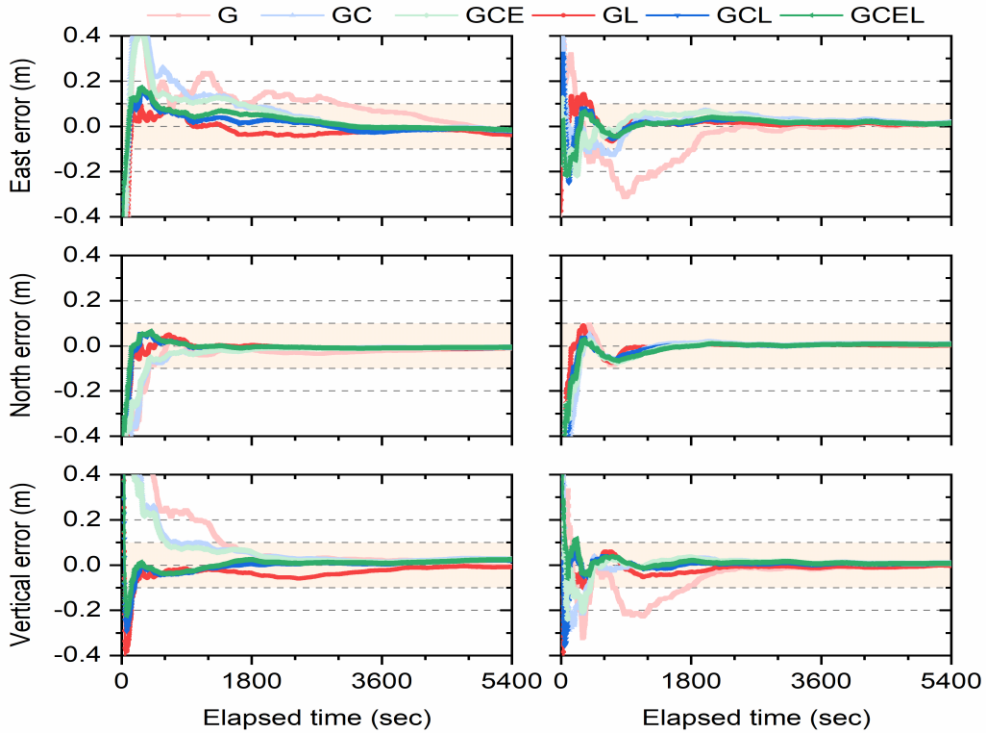
Number of Satellites



Rapiad Variation of DOPs

DOPs of 2 Sites

Two LEOs Augmentation PPP Experiment



Statistical Data of Two LEOs Augmentation PPP
(based on 14 kinds of constellation combinations and 42 sets of PPP results)

GNSS system number	W/O LEO		With LEO	
	Convergence time (min)	3D precision (cm)	Convergence time (min)	3D precision (cm)
1	32.7	6.1	16.7	5.2
2	17.9	4.6	8.9	3.9
3	14.2	4.6	5.7	3.8

Outline

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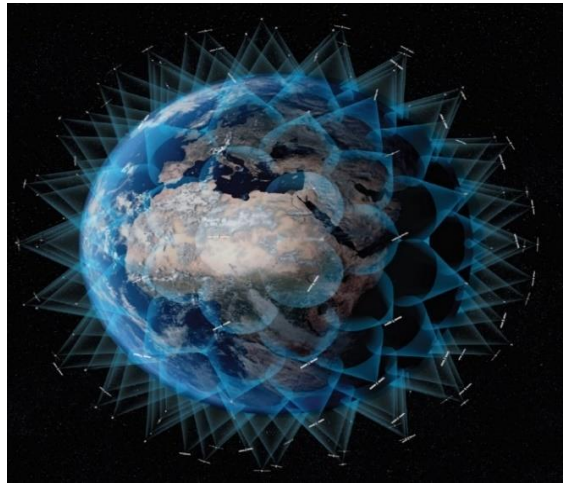
Next Steps

- Complete the construction of whole constellation
- Provide high accuracy navigation services globally




THANK YOU FOR YOUR ATTENTION !
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