未来导航
FUTURE NAVIGATION

CENTISPACE™ System Experimental Satellites PPP Application Test

October, 2023

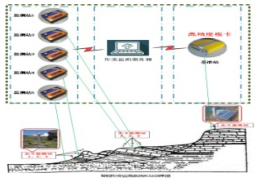
Beijing Future Navigation Technology Co., Ltd.

PART 01: Brief Introduction of CENTISPACE™

■ **With the rapid growth of modern information industries like 5G, mobile internet, autonomous driving, and artificial intelligence, traditional meter-level precision navigation services are no longer sufficient to meet user demands. There is a rising demand for high-precision navigation services in various sectors.**

Traditional Professions

Surveying, mapping, disaster monitoring, smart grid, communication network, ocean engineering, and more, with demands ranging from sub-meter to millimeter level.

UAV Applications

With an Annual Shipment Volume of Nearly 4 Million Units, Fundamental Demand for Low-Cost and High-Precision Satellite Navigation.



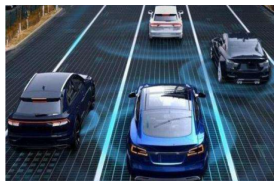
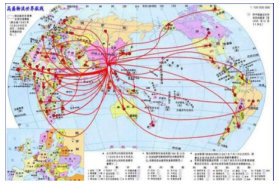

Consumer Electronics

With over 5 billion smartphones worldwide, real-time dynamic positioning accuracy of better than 0.3m is essential for pedestrian navigation, and interactive gaming.




Internet of Vehicles, Internet of Things

- Global vehicle market: 2 billion vehicles require real-time lane-level navigation accuracy better than 0.3m; autonomous driving demands 10cm.
- Global terminal device network: 50 billion devices require positioning accuracy of 0.05-0.5m for IoT.

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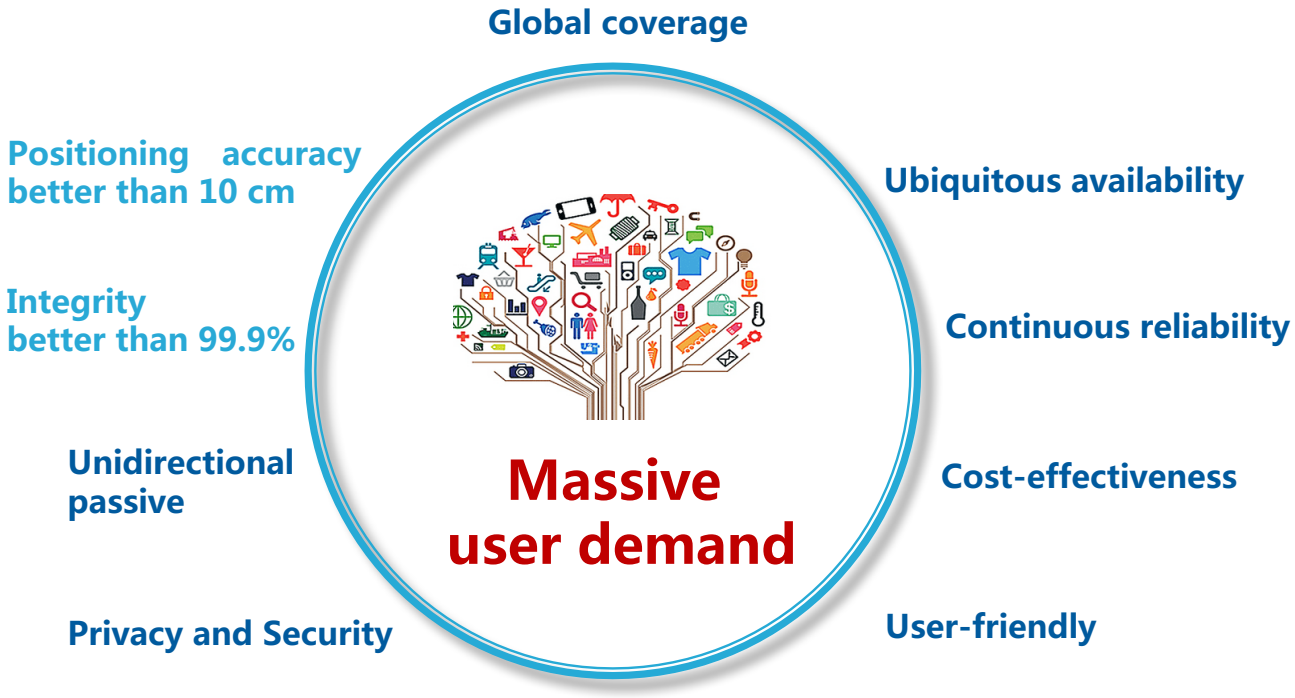
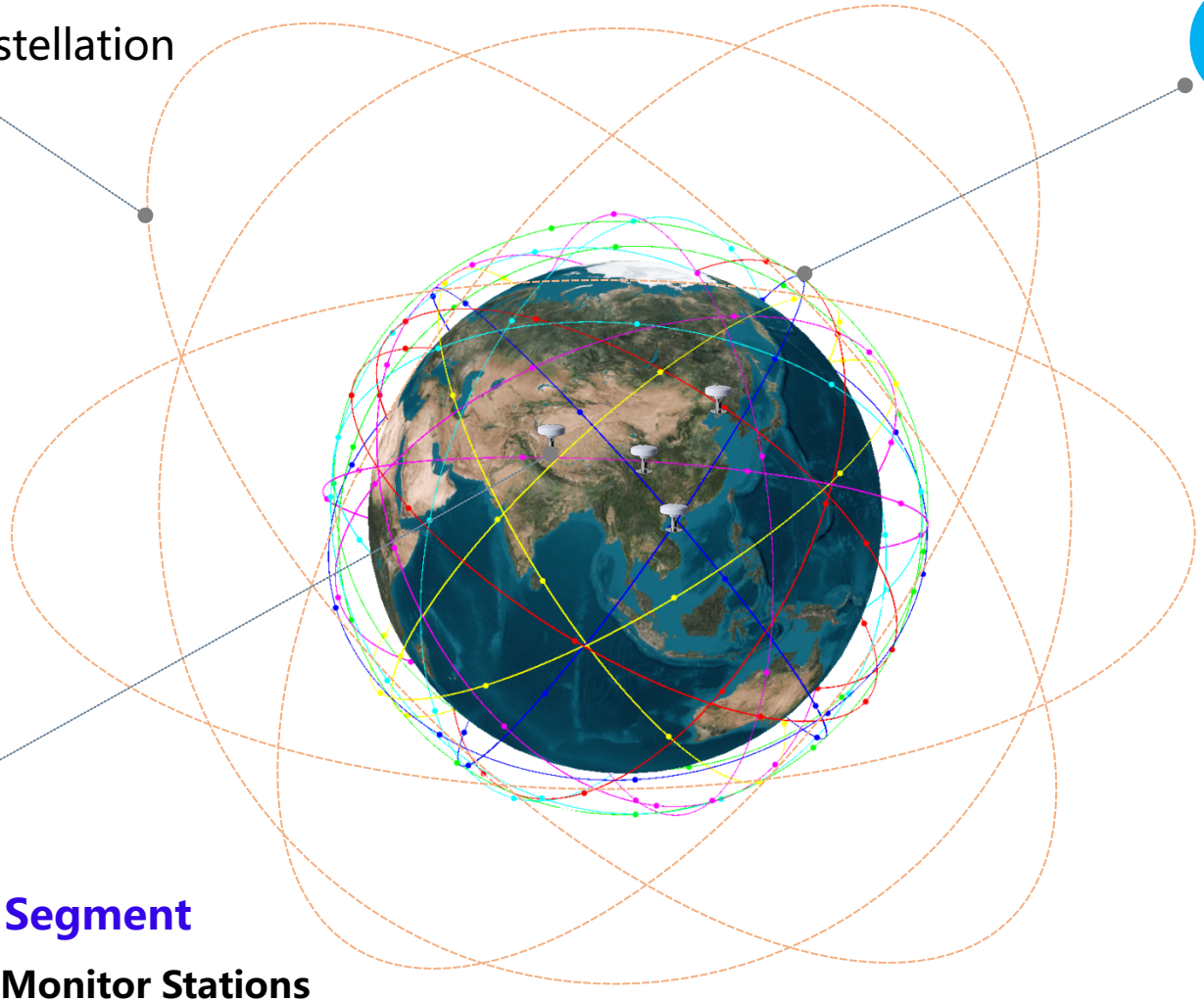


A centralized system is needed with the **SERVICE FEATURE:**
As convenient as basic navigation services, high-accuracy.

The CENTISPACE System has two main segments:

GNSS Constellation



Space Segment

190 LEO satellites

- **Sub-constellation I**
  - Constellation : WALKER120/12/1
  - Orbit altitude : 975km
  - Inclination : 55°
- **Sub-constellation II**
  - Constellation : WALKER 30/3/1
  - Orbit altitude : 1100km
  - Inclination : 87.4°
- **Sub-constellation III**
  - Constellation : WALKER 40/4/1
  - Orbit altitude : 1100km
  - Inclination : 30°

Ground Segment

Multiple Monitor Stations

During the Signal Design Process, the Following Factors Were Considered:

- **Lower user device complexity :**

  Common hardware (antenna, filter, A/D, etc.)

- **Interoperability with MEO system :**

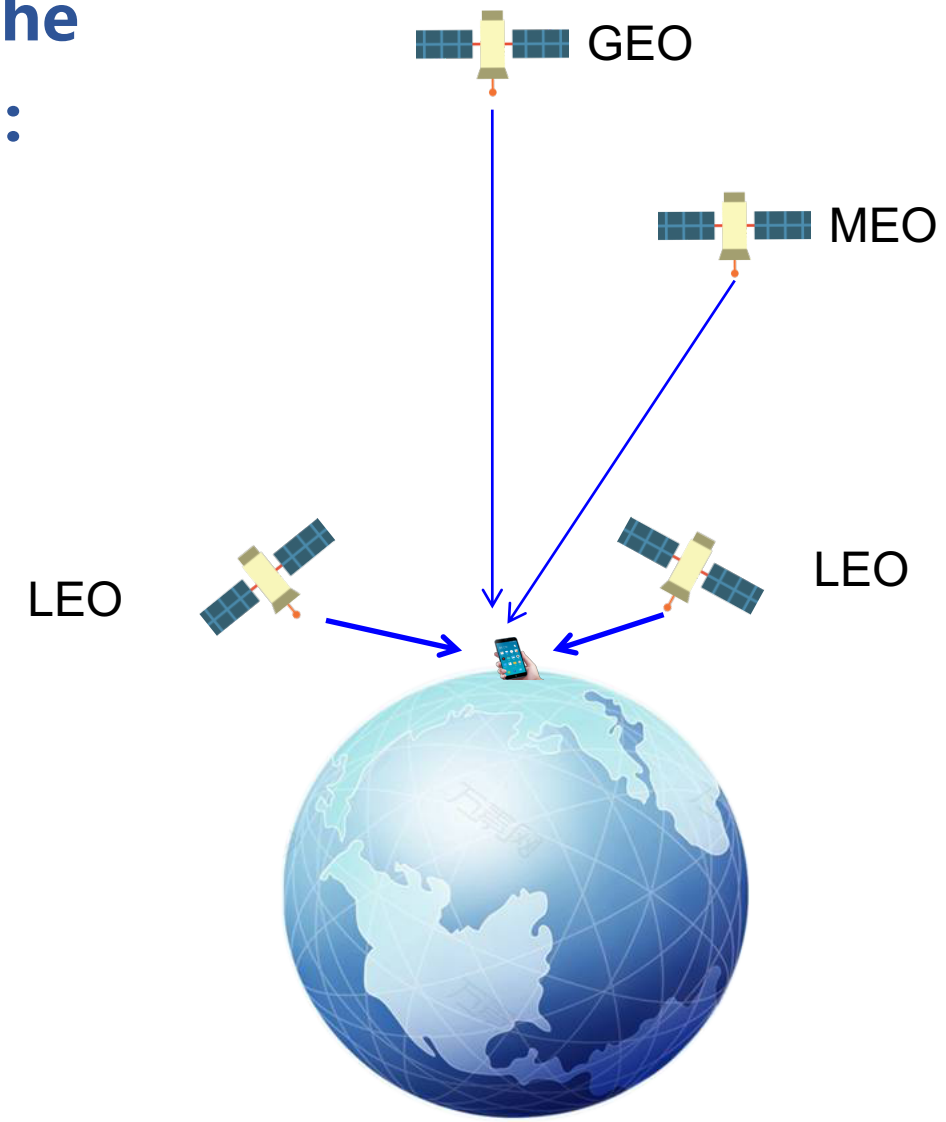
  Common frequency band and reference frame

- **Interoperability with GEO augmentation system:**

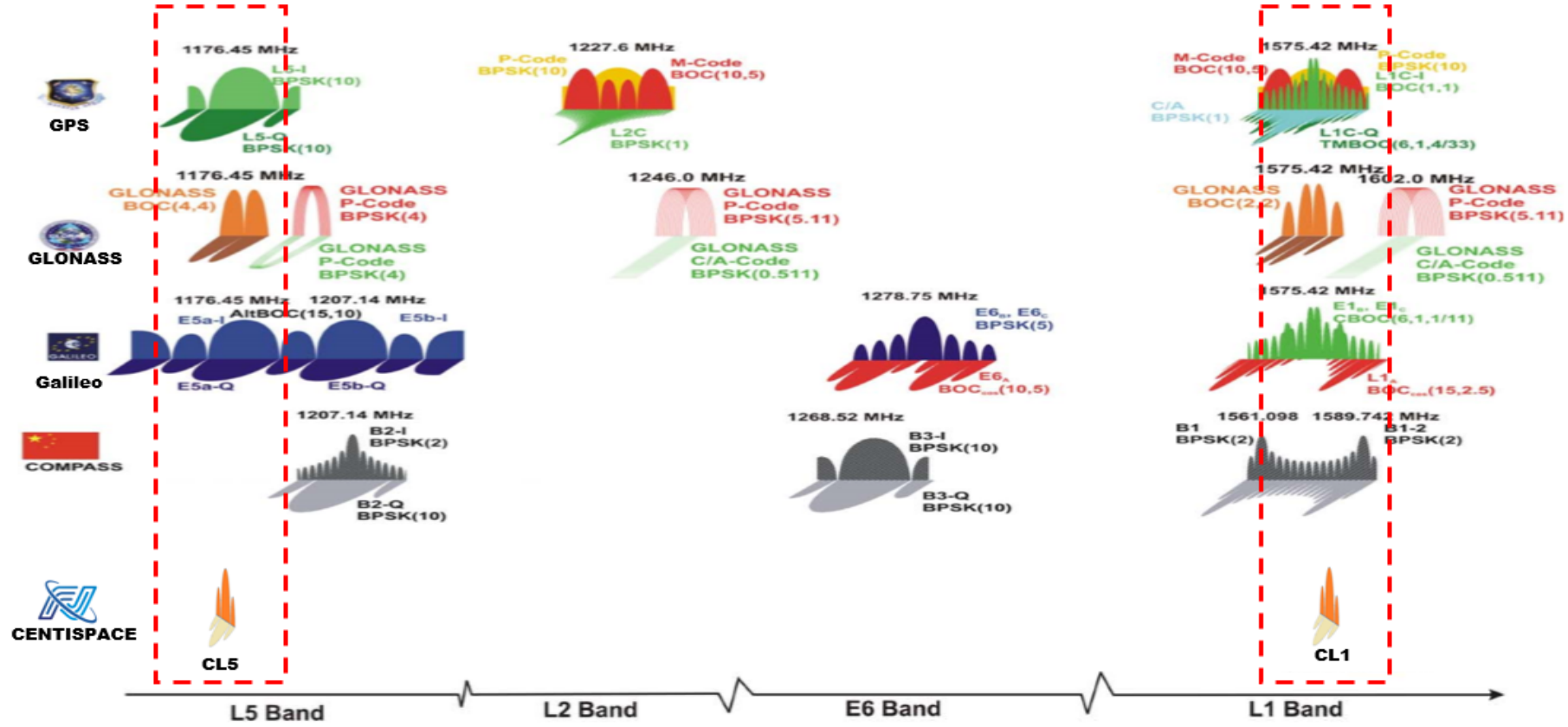
  Common frequency band and reference frame

- **Compatibility with MEO and GEO systems :**

  No signal interference



Signal Frequency



Finally, the combination of L1 and L5 bands is the preferred option.

Signal Frequency

- **Our ITU filings**

table/worksheet
Nongeolist

SATELLTIE NAME	CATEGORY	ADM	NTWK ORG	DATE OF PROTECTION	STATUS	WIC
CENTISPACE-1	A	CHN		See TSUM	50	2891
CENTISPACE-1	C	CHN		See TSUM	50	2898
CENTISPACE-2	A	CHN		See TSUM	50	2896
CENTISPACE-2	C	CHN		See TSUM	50	2913
CENTISPACE-3	A	CHN		See TSUM	50	2953
CENTISPACE-3	C	CHN		See TSUM	50	2965
CENTISPACE-4	C	CHN		See TSUM	50	3001
CENTISPACE-4	A	CHN		See TSUM	50	3002
TOTAL:						8

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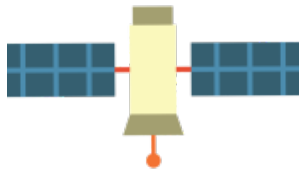
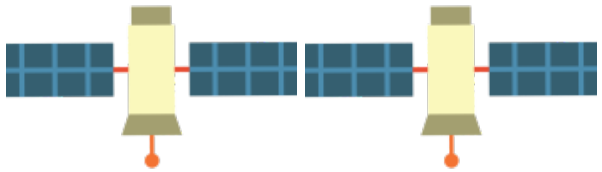
Space Segment

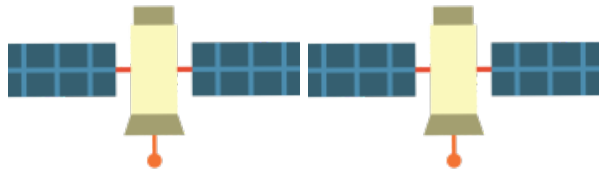
- Currently, we have 5 experimental satellites in orbit.
- Platform and payload experiments have been successfully conducted.
- As the testing is still in progress, the data presented in this report is derived from two of these satellites.



CENTISPACE-S1
(Launch: 29 Sep 2018)



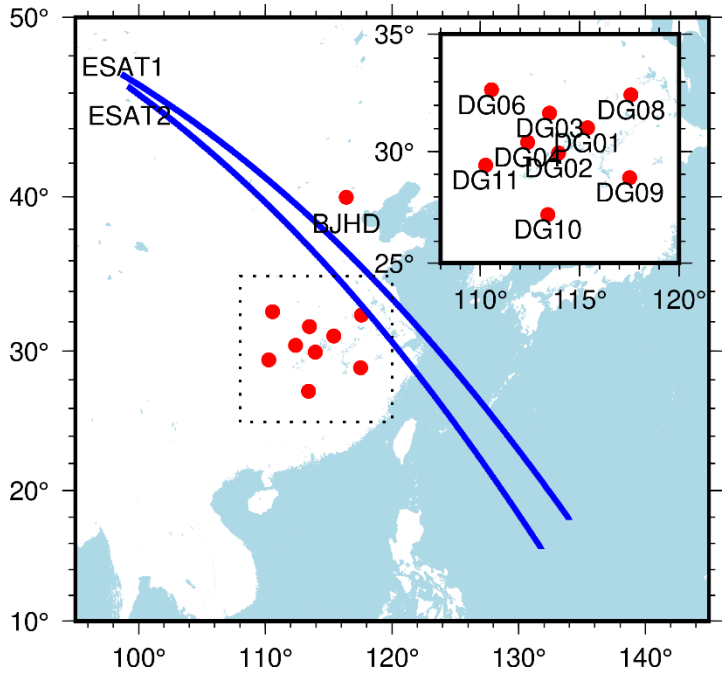
CENTISPACE-S3/S4
(Launch: 6 Sep 2022)



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

Ground Segment

- We have constructed 10 monitor stations.
- For the PPP demonstration，two stations(DG03 and BJHD) are selected.



Distribution of the ground stations

Ground tracks of ESAT1 and ESAT2 experimental satellites during 03:40:00-03:50:00 on April 1, 2023.

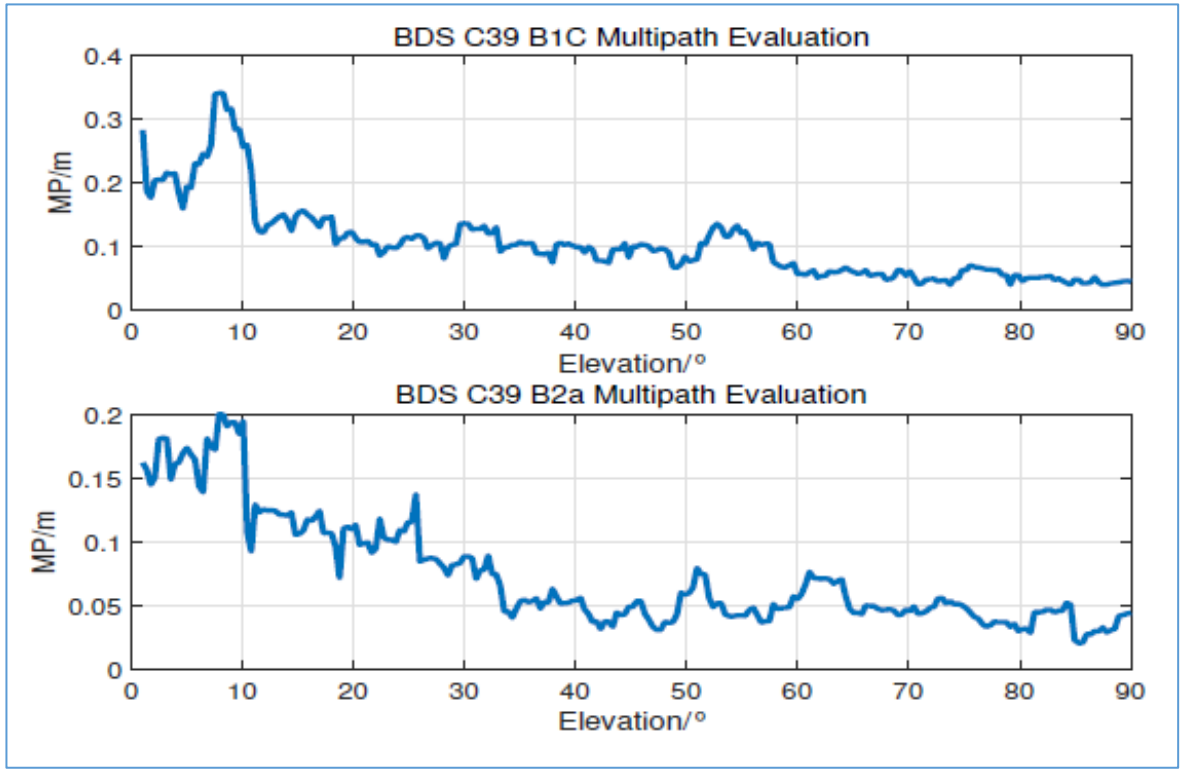
Signal Receive Test

Static Test

Dynamic Test

GNSS Observation Quality for BDS satellites

- **Multipath statistical results:**
  - **For B1C signal: 0.027-0.482m.**
  - **For B2a signal: 0.019-0.332m.**
- **Are both within the acceptable range of 0.5m.**

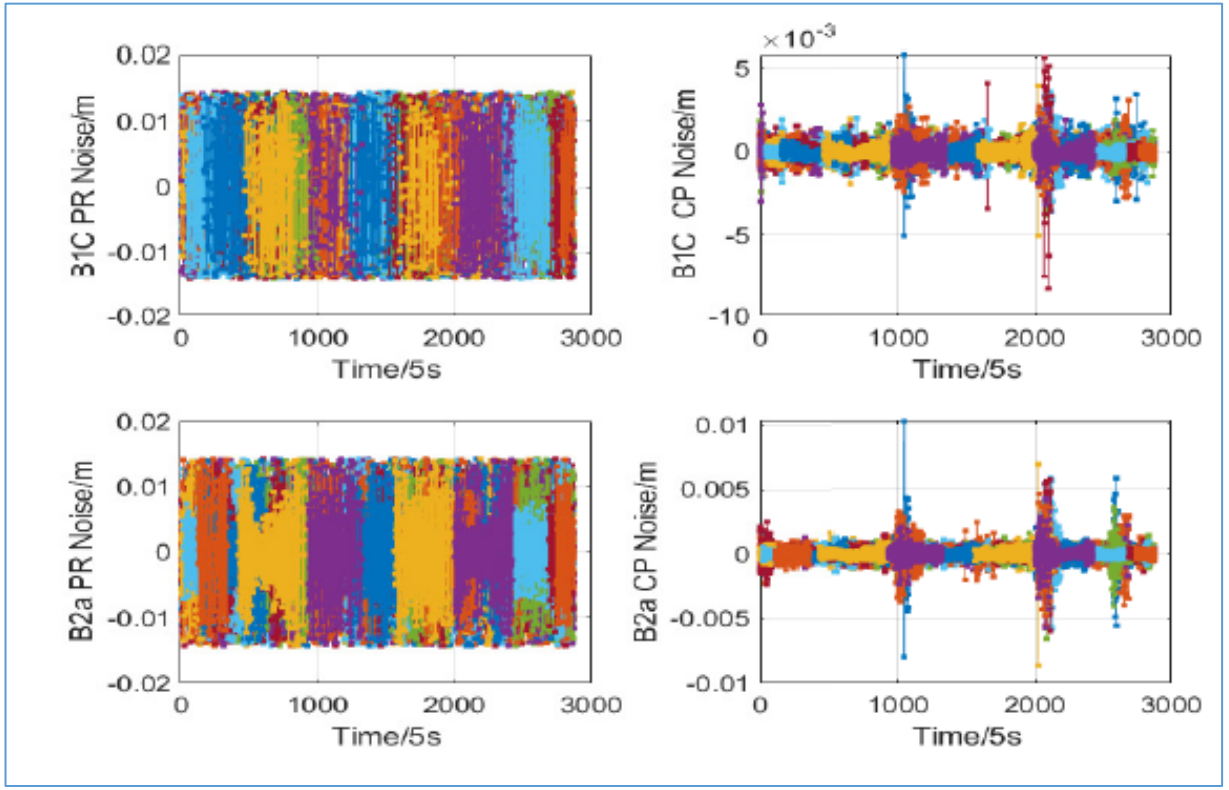


Multipath Evaluation for BDS C39

These findings align with the results from iGMAS tracking stations.

GNSS Observation Quality for BDS satellites

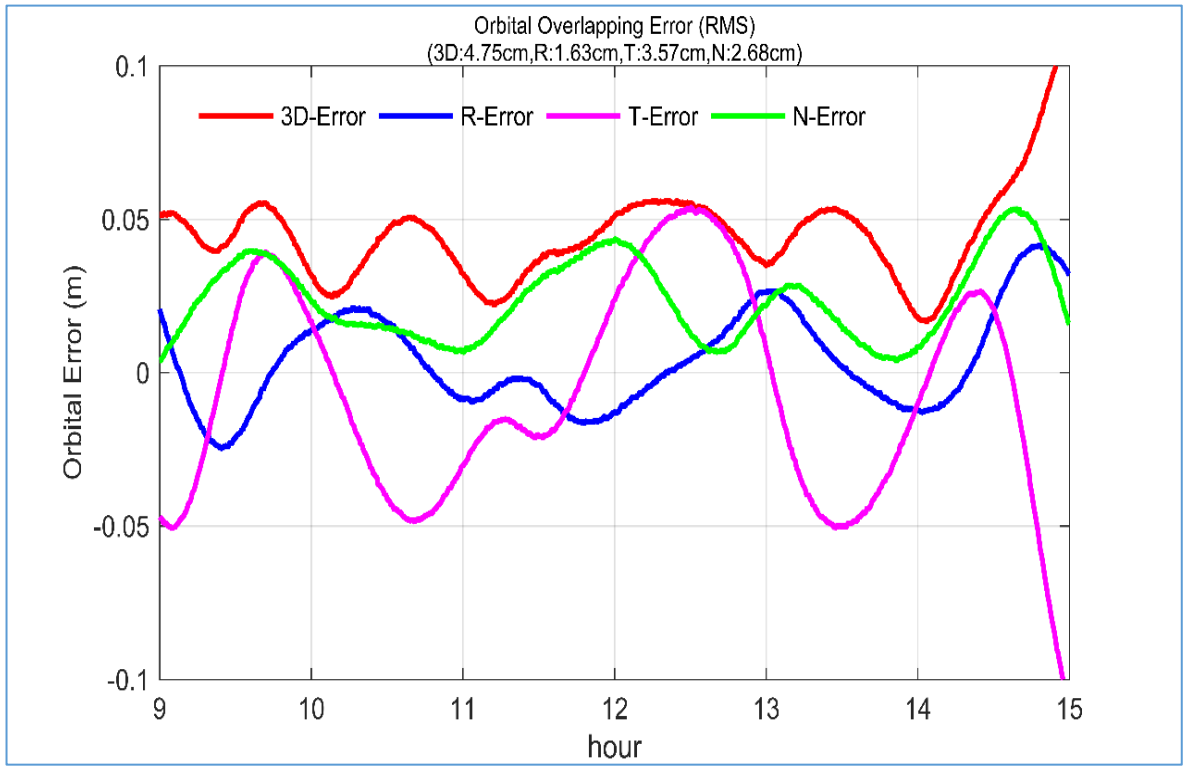
- **Pseudo range noise measurement for BDS signals: <8cm.**
- **Carrier phase noise measurement for BDS signals: <2mm.**



BDS Measurement Noise
Observed by Space-borne GNSS Receiver

These results demonstrate the high precision of our GNSS observations for BDS signals.

Precise Orbit Determination: Results of BDS Satellites

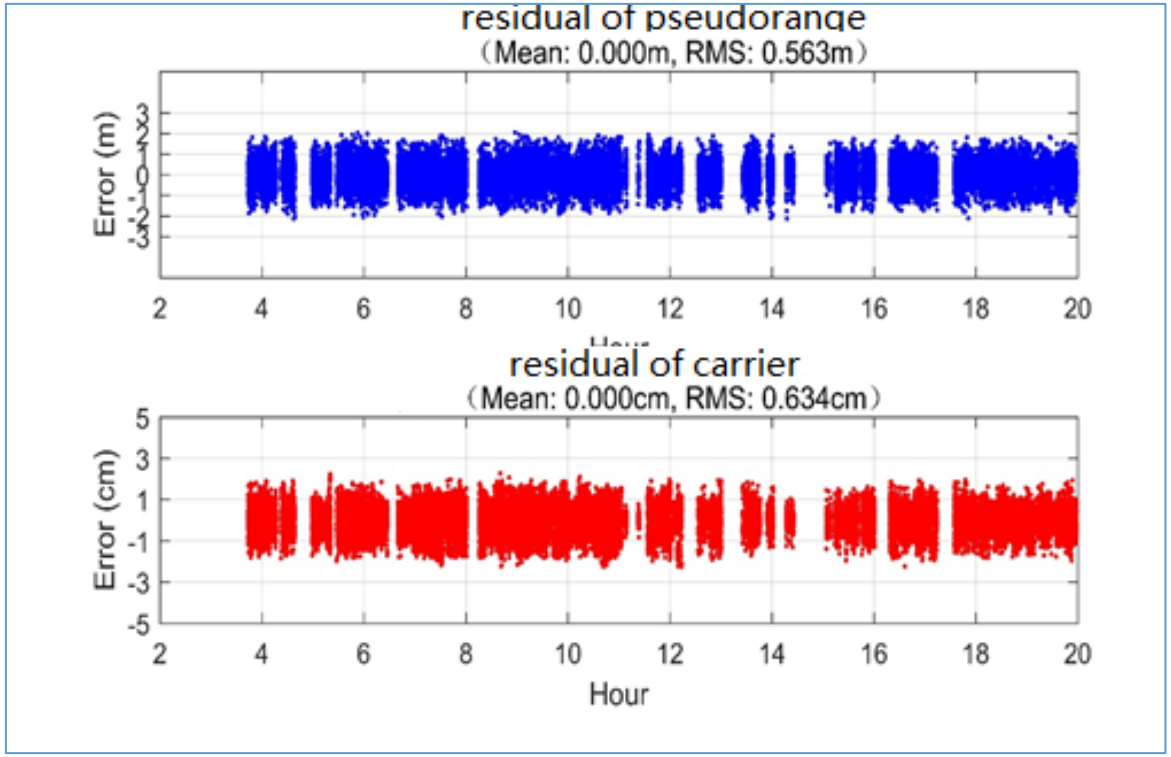


Precision orbit determination results based on BDS observation, about 5cm.

Precise Orbit Determination: Results of LEO Satellites

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

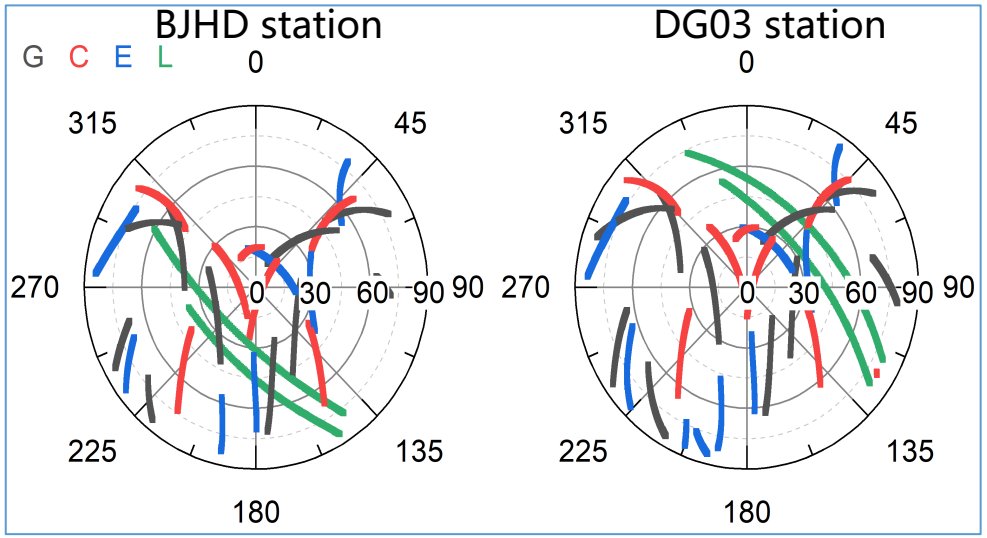
- **LEO satellites orbit determination residual of carrier phase: 0.634cm (RMS) .**



LEO precision orbit determination residual

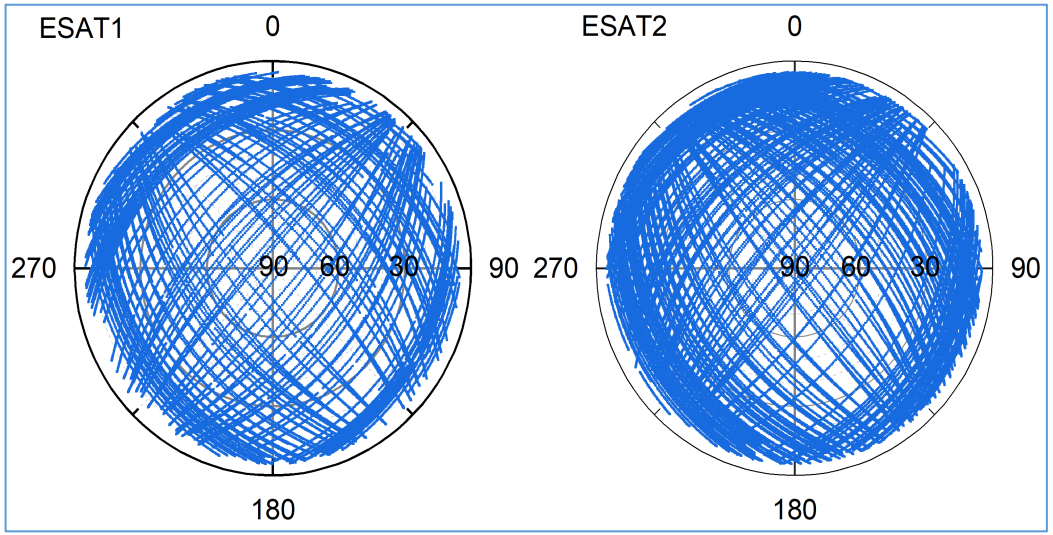
These results demonstrate the high precision achieved.

Augmentation of Two LEO Satellites: Track Compare



Sky-view tracks in one orbit arc

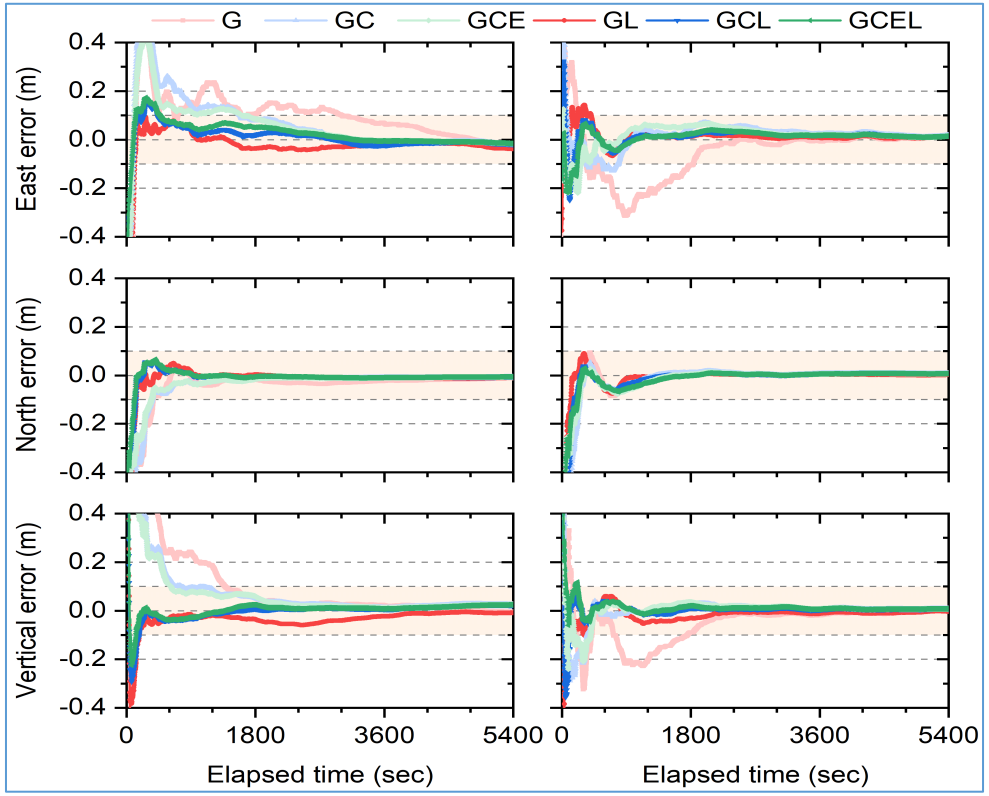
(black lines: GPS, red lines: BDS, blue lines: Galileo, green lines: LEO)



Sky-view tracks of two LEO satellites in 20 days

A longer track indicates faster movement, and can provide more information for the PPP algorithm.

Augmentation of Two LEO Satellites: Potential for PPP



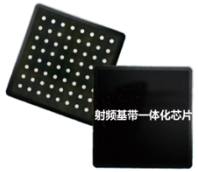
- **Compared in different scenarios, with and without LEO augmentation.**
- **Benefits of LEO augmentation:**
  - **Reduced Convergence Time(about 50% for this data)**
  - **Improved Positioning Precision**

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

These findings highlight the potential of LEO augmentation, and larger improvements can be achieved with more LEO satellites to be deployed in the future.

Accelerate the Development of LEO-augmented Navigation Basic Products utilizing Existing Application Industries

- **Upgrade products quickly:** To achieve rapid development, we collaborate with chip manufacturers for quick product upgrades.
- **Expand to various fields:** Expand LEO augmentation to various fields, may starting with drones and lane-level navigation.

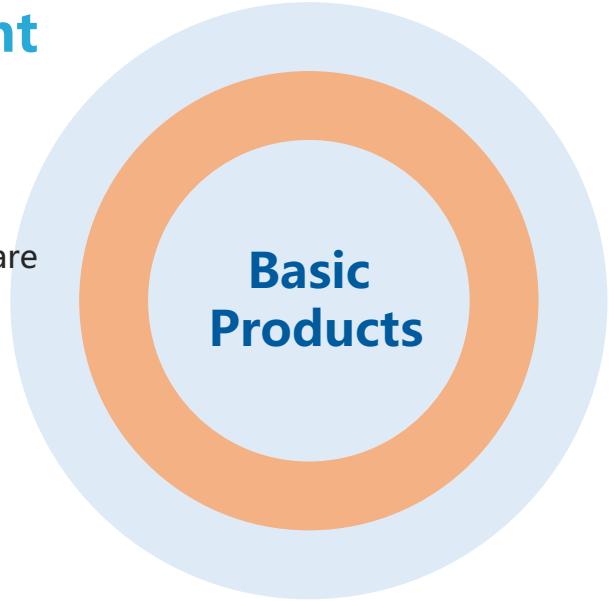


Chip development

The functionality of LEO augmentation can be added through software upgrades while utilizing existing hardware resources.

Antenna development

Simultaneous reception of navigation signal and LEO enhanced signal with similar frequencies.



Board/module development

Can be designed for integrated use in various professional devices through chip customization.

Terminal integration

Customizing User-Oriented Terminal Machines with Added Communication and Storage Modules.

Upgrading and Expansion of Application Solutions with LEO Augmentation

Traditional high-precision

Such as surveying and mapping, can be empowered with LEO augmentation.

Emerging high-precision

LEO augmentation can be expanded into new fields like IoT, leading industry development and tapping into potential demand.

Transportation industry

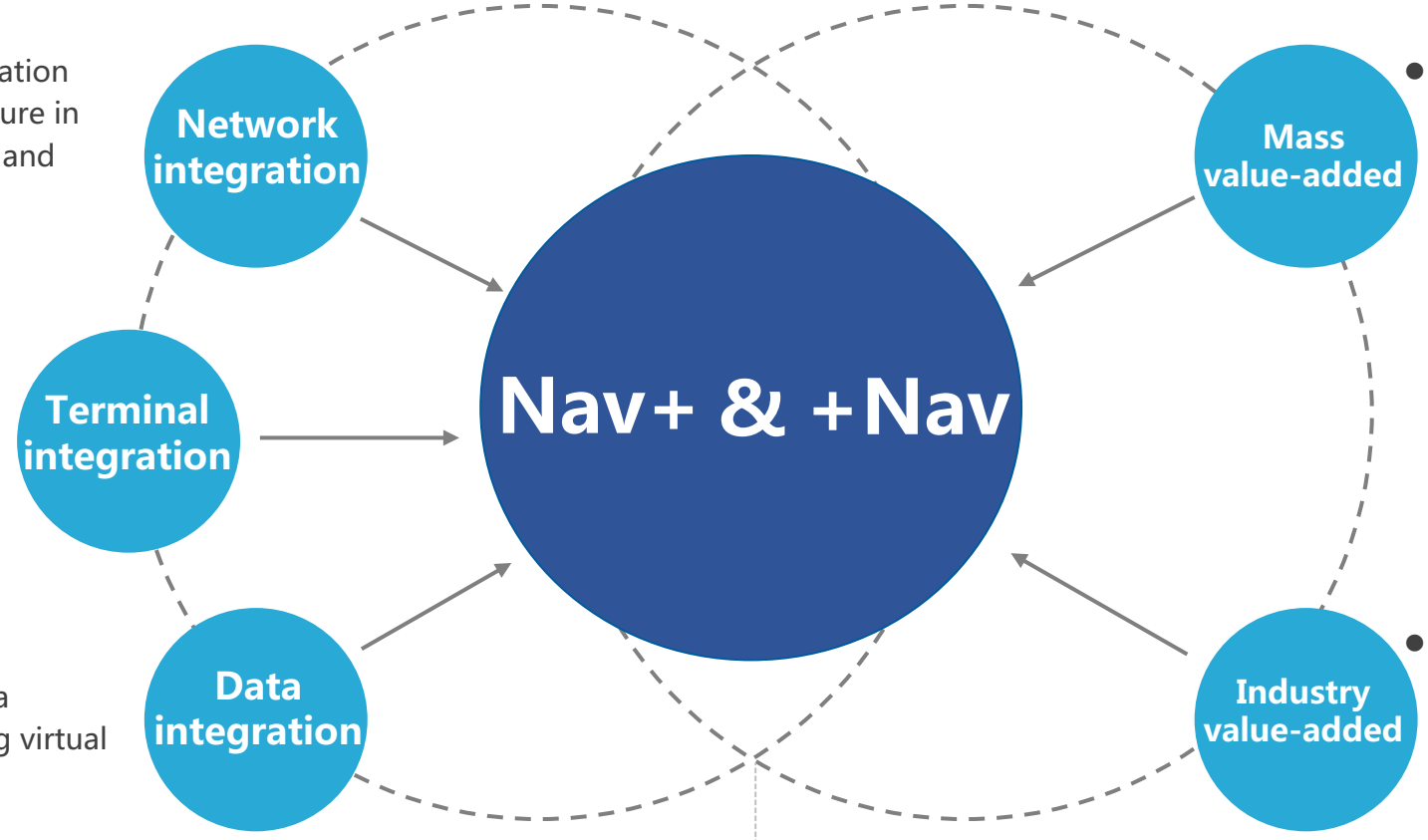
LEO augmentation can enhance its capabilities to meet new demands like autonomous driving and lane-level navigation.

Mass consumption

LEO augmentation offers advantages such as low cost, convenient use, and integration into mobile devices.

Wide Construction of Service Platforms to Promote LEO Augmented Value-Added Applications

- Integrate LEO augmentation with existing infrastructure in IoT, 5G, transportation, and power grids.
- Achieve embedded development through technological innovation.
- Provide spatiotemporal information for big data applications, connecting virtual and real worlds.



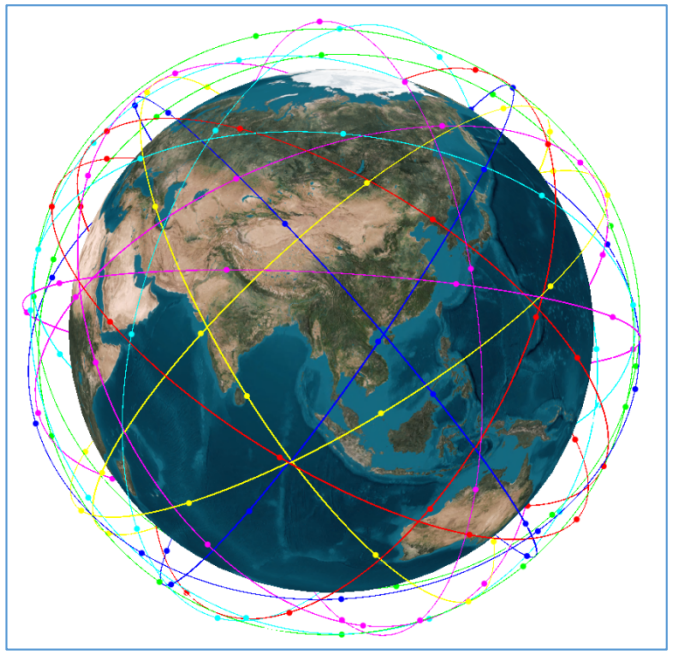
- Utilize location-based services in consumer devices for gaming and social scenarios.
- Expand navigation capabilities in various industries, offering value-added services.

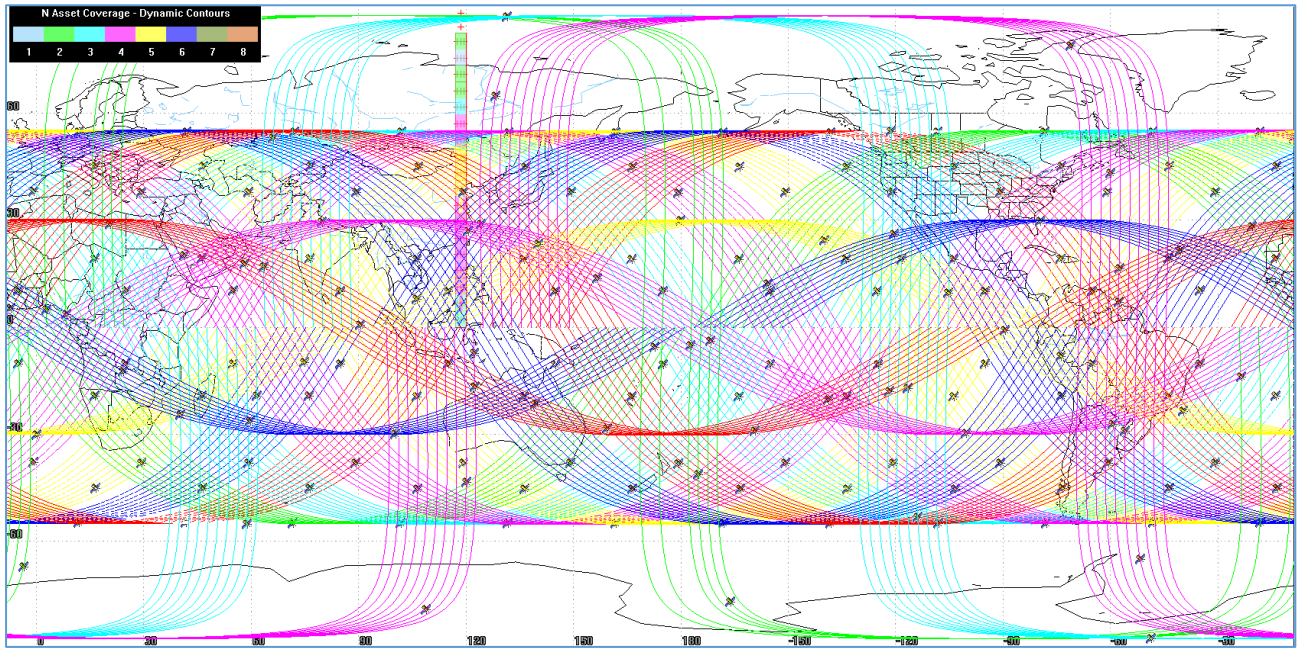
Focuses on the navigation industry.

Focuses on enterprises outside the navigation industry.

Next Steps

- Complete the construction of the entire constellation within several years.
- Provide worldwide augmentation navigation services.
- This will augment existing navigation systems and provide precise positioning.





THANK YOU
FOR YOUR ATTENTION!

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