



16th Meeting of the International Committee on
Global Navigation Satellite Systems



BeiDou Navigation Satellite System Construction and Development

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China Satellite Navigation Office
Oct. 10, 2022

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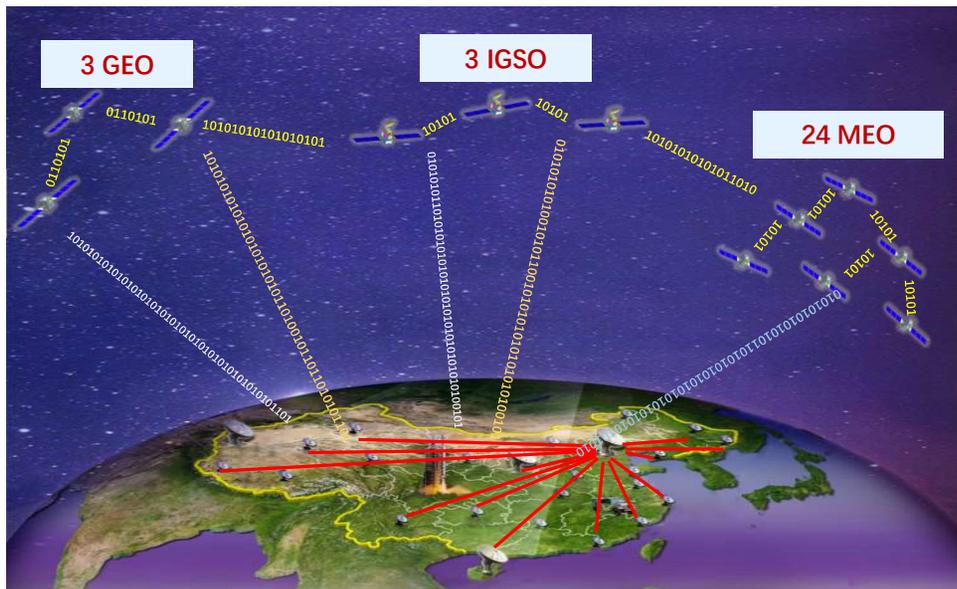


System Construction

01

BDS System Construction

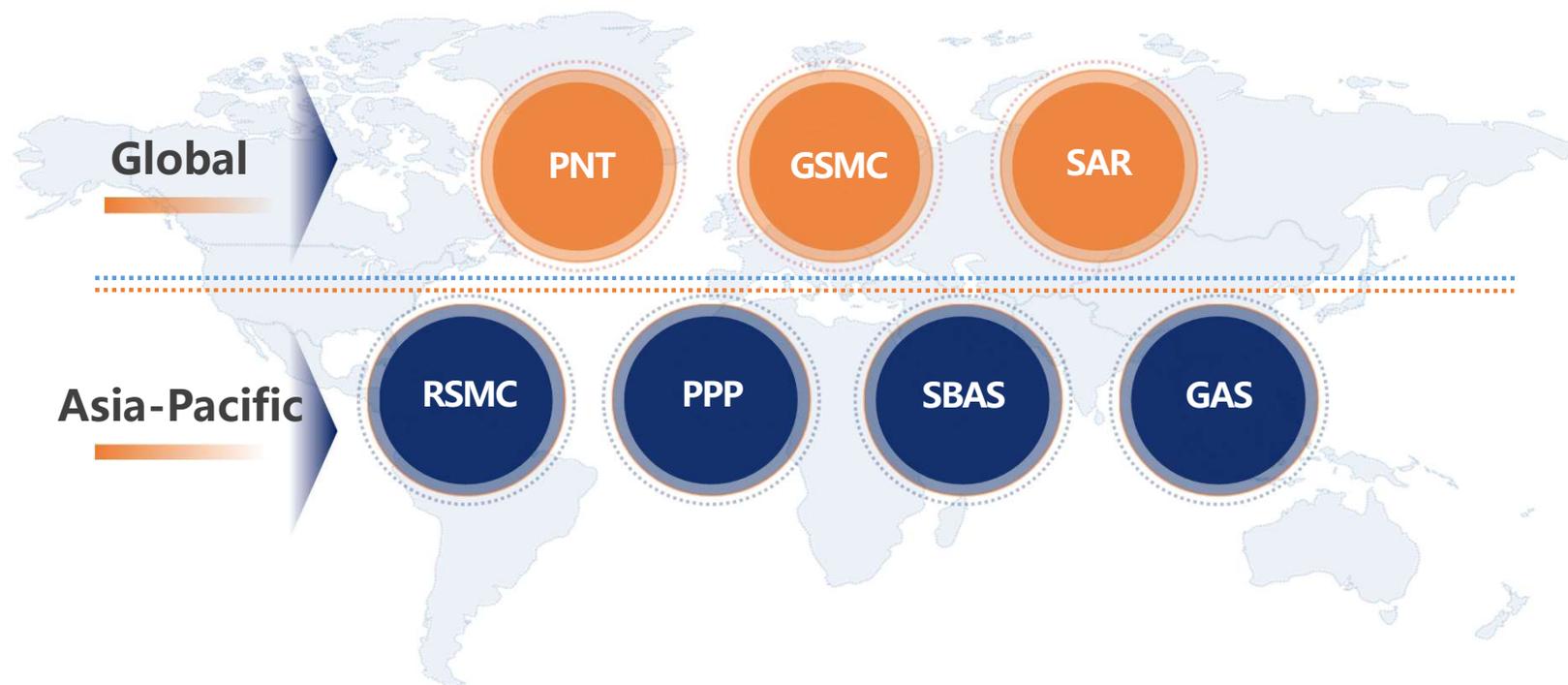
System Components



- BDS is mainly comprised of three segments: Space Segment, Ground Segment, User Segment.
- Up to now, BDS-3 constellation consists of 3 GEO satellites, 3 IGSO satellites, and 24 MEO satellites.

O1 System Construction

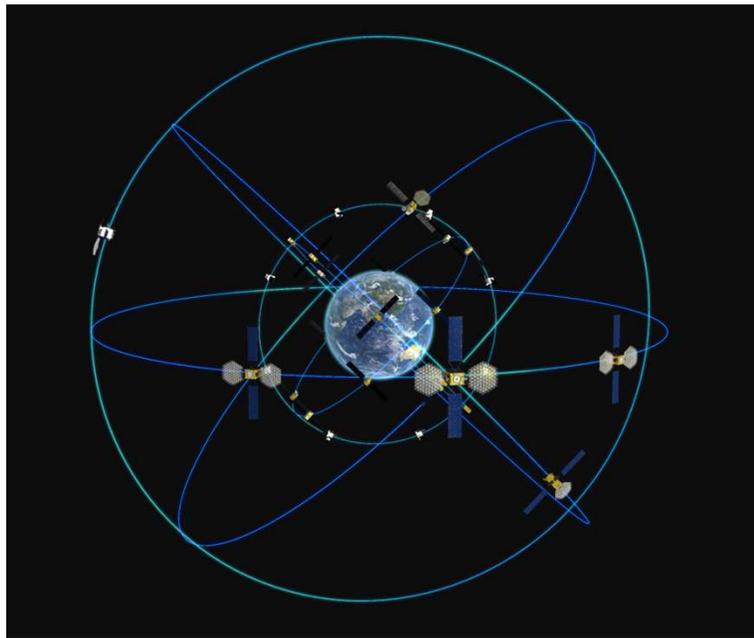
System Services



01 System Construction

Positioning, Navigation, and Timing (PNT)

International GNSS Monitoring & Assessment System (iGMAS) Test Results and Comparison with Specification



Items	Test Results	Specification
Global Positioning Accuracy (95%)	horizontal 2.5m vertical 5.0m	horizontal 9m vertical 10m
Global Velocity Measurement Accuracy (95%)	better than 0.1m/s	better than 0.2m/s
Global Timing Accuracy (95%)	better than 20ns	better than 20ns
SIS Continuity	99.996%	better than 99.8%
SIS Availability	99%	better than 98%

01 System Construction

Positioning, Navigation, and Timing (PNT)

Status of BDS Satellites

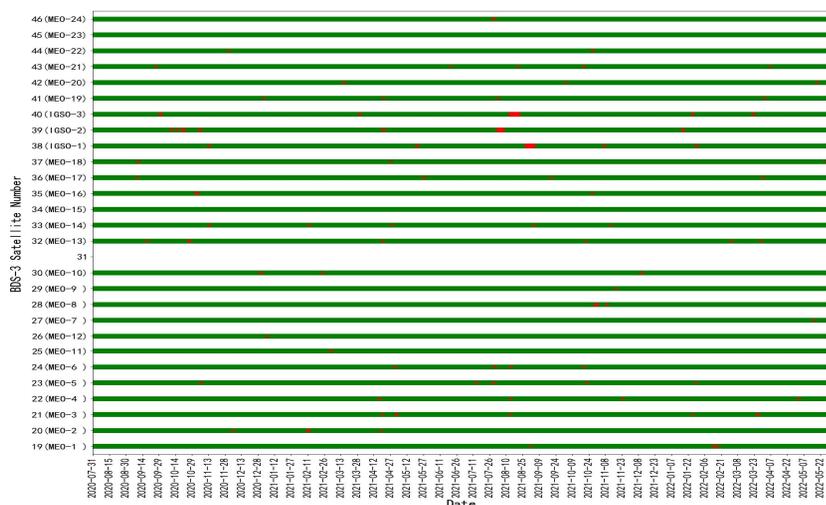


Figure 1: Status of BDS Satellites

BDS Positioning Precision Performances

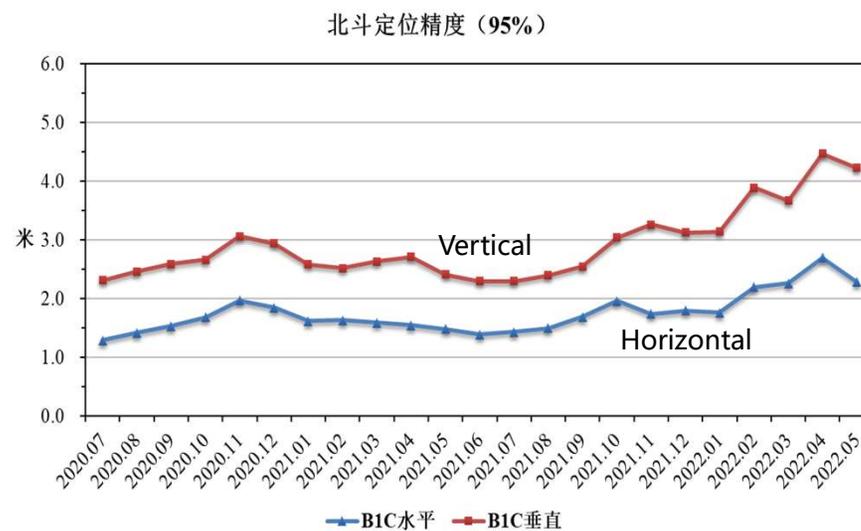


Figure 2: BDS Positioning Accuracy Performances

O1 System Construction

Positioning, Navigation, and Timing (PNT)

Navigation Signal Quality

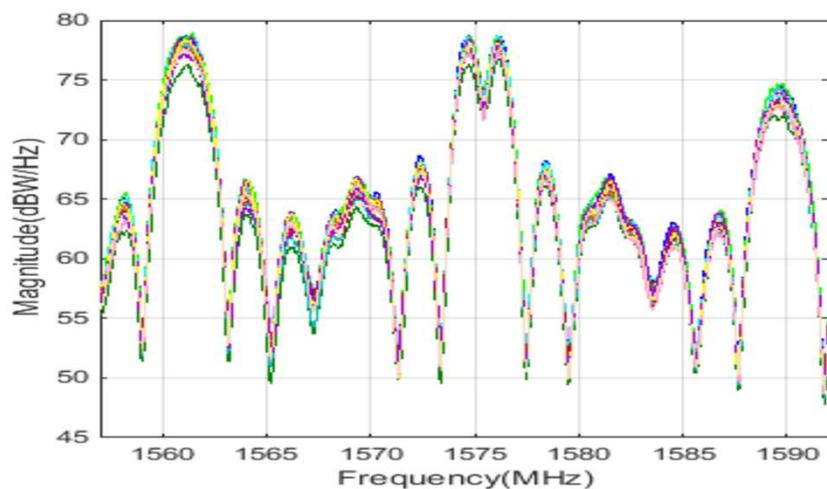


Figure 3: Power spectrum Density of BDS

SIS Accuracy

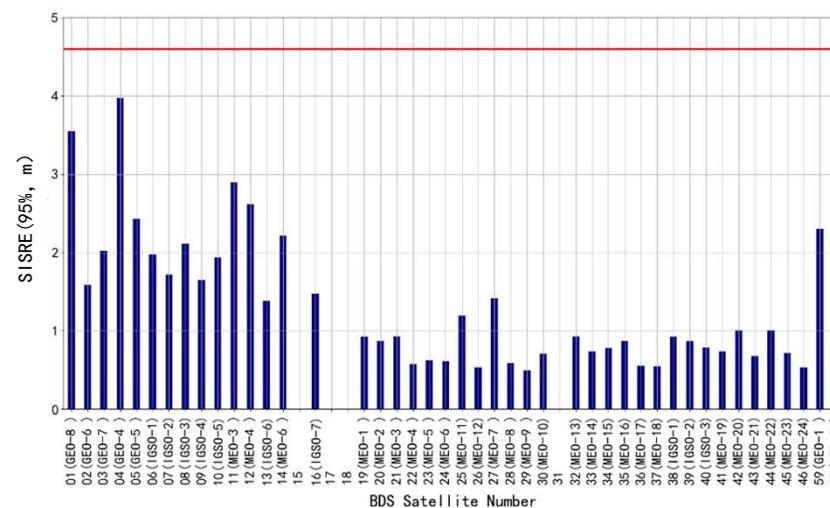


Figure 4: SISRE of BDS Satellites

BDS System Construction

Positioning, Navigation, and Timing (PNT)

Orbit Accuracy

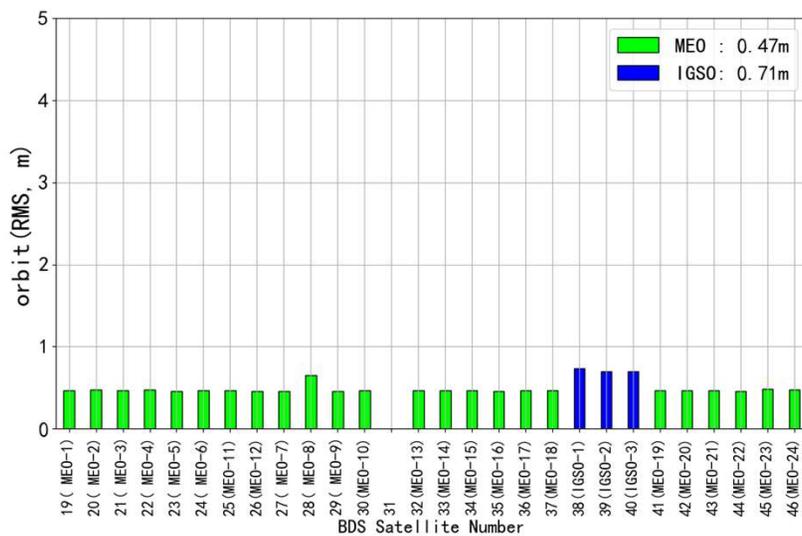


Figure 5 The orbit accuracy of broadcast ephemeris

Clock Accuracy

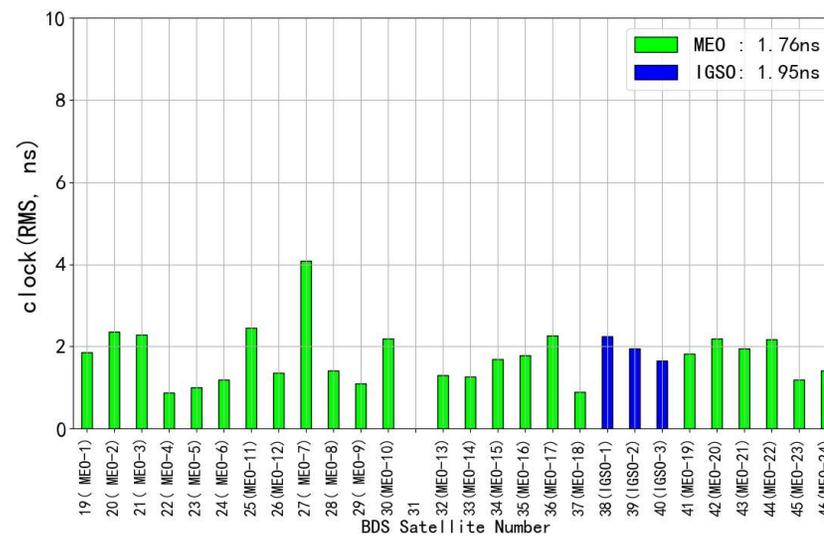


Figure 6 The clock accuracy of broadcast ephemeris

O1 System Construction

Global Short Message Communication (GSMC)

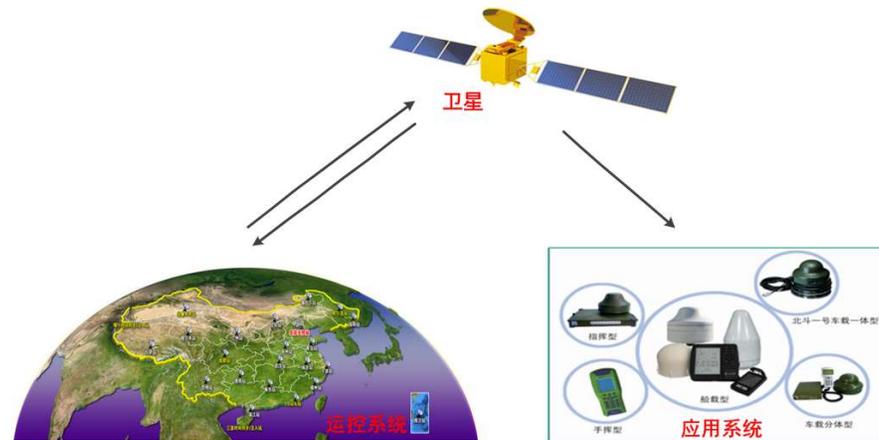
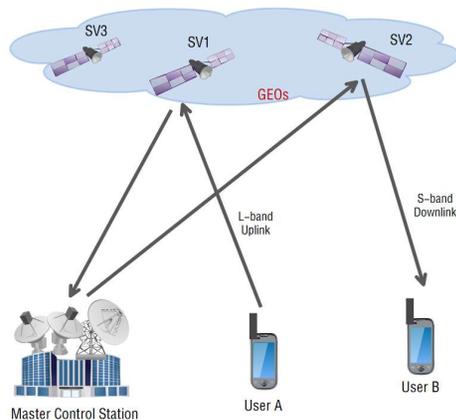
- **Coverage: Global Random Access**
- **Space Segment: 14 MEOs for up-link, 3 IGSOs + 24 MEOs for down-link**
- **Maximum length of a single message: 560 bits (40 Chinese characters per message)**



01 System Construction

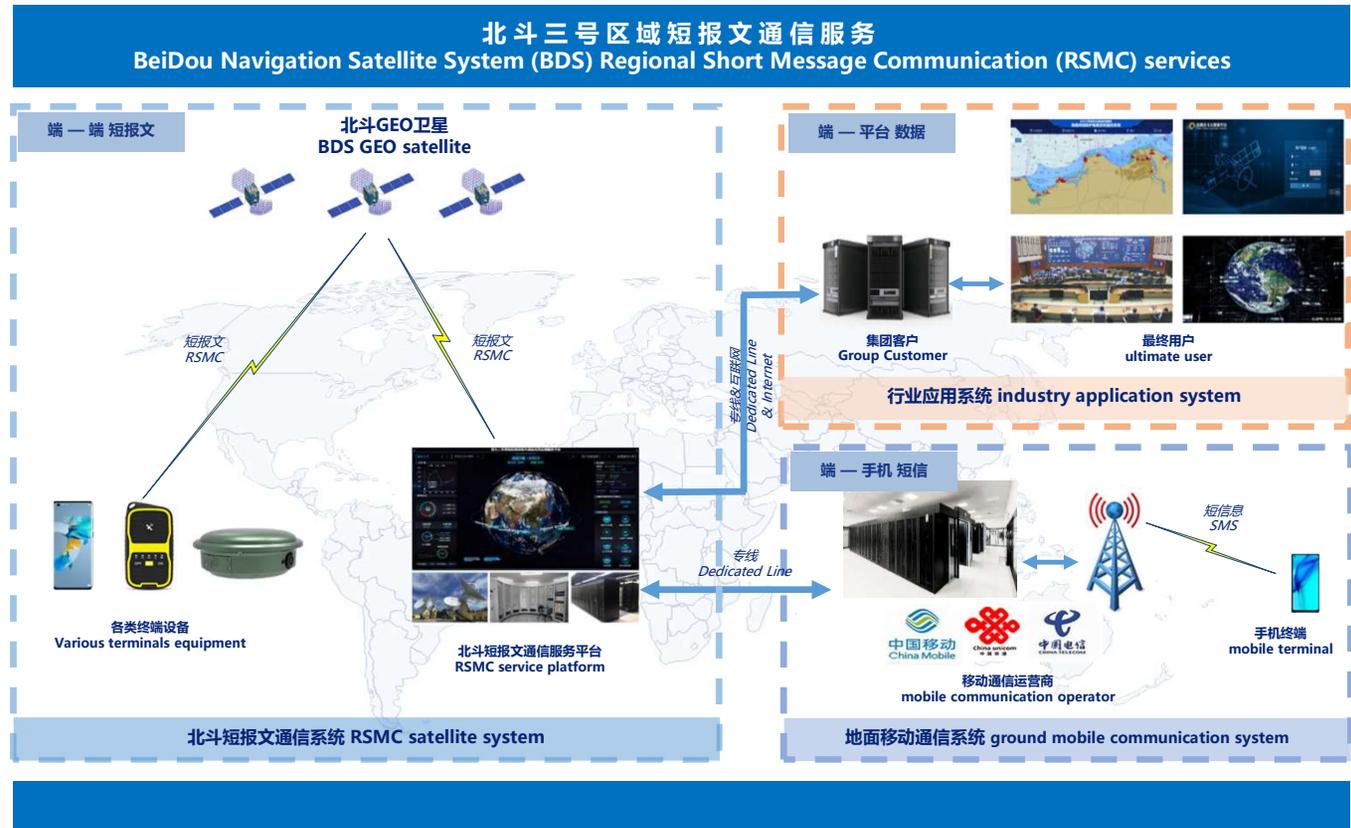
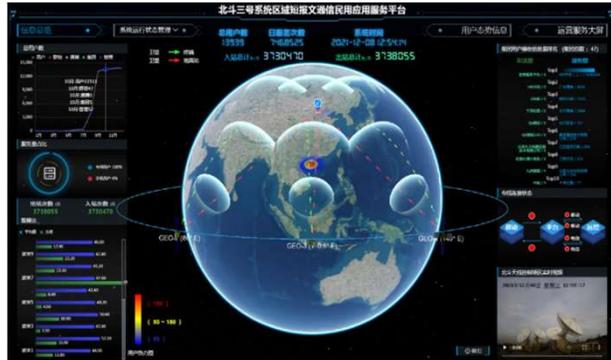
Regional Short Message Communication (RSMC)

- **Coverage: China and surrounding areas**
- **Space Segment: 3 GEO satellites, 80°E, 110.5°E, 140°E**
- **Maximum length of a single message: 14000 bits (1000 Chinese characters per message)**
- **Main functions: Search & Rescue, Position Report, Messaging**



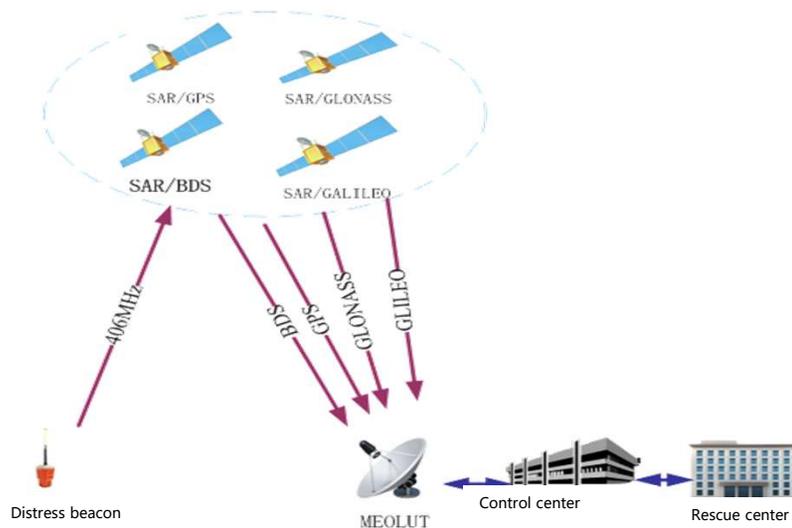
01 System Construction

Short Message Communication Civil Use Service Platform



01 System Construction

Search and Rescue (SAR)



- **Space segment: 6 MEO&SAR Payloads**
- **Return Link Service (RLS)**
- **On-orbit Testing and Authentication finished**
- **COSPAS-SARSAT technical review passed**

Performance Characteristics	Performance Specification
Positioning Accuracy	≤5km
Detection Probability	≥99%
Availability	≥99%
Return Link Time Delay	≤2 min
Return Link Success Rate	≥95%



01 System Construction

Search and Rescue (SAR)

2017

2018

2019

2020

2021

2022

JC-31

Promote BDS into C/S

Complete BDS - GALILEO

Frequency coordinate

1544.21MHz, RHCP

JC-33

Submit PROPOSED BDS AMENDMENTS TO DOCUMENT C/S T.016, T.017, T.019(JC-33/04/04,JC-33/04/05 andJC-33/05/05). e.g C/S T.016 "Description of the 406 MHz Payloads Used in the COSPAS-SARSAT MEOSAR System" .

JC-34

submit DESCRIPTION OF RLS/BDS INFORMATION IN DOCUMENTS C/S T.001, C/S T.018, C/S R.012 (JC-34/Inf.36, JC-34/Inf.37) . e.g C/S T.001" Specification for COSPAS-SARSAT 406 MHz Distress Beacons"

EWG-5C/2021

BDS SATELLITE 632,633,643,644,645,646(BD-3 M13, M14, M21, M22,M23,M24) SAR REPEATER COMMISSIONING REPORT

JC-36

Submit PROPOSED BDS-RELATED AMENDMENTS TO DOCUMENT C/S T.007 T.014,T.016, T.021,etc.

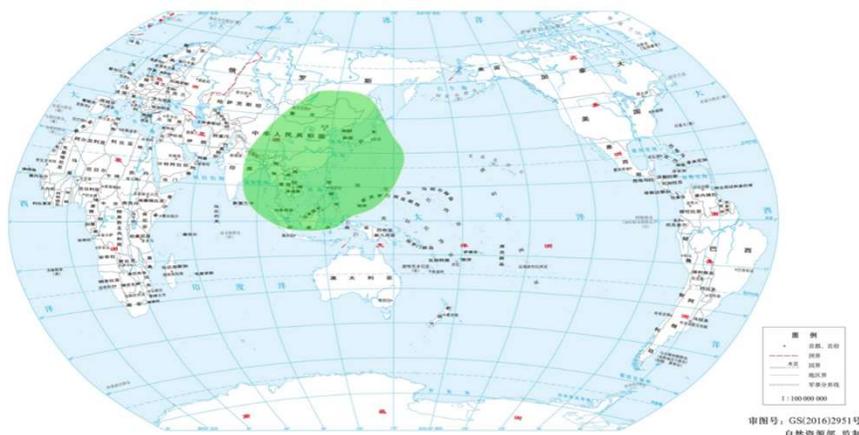
DOI (Declaration of Intent between C/S and China)

Commissioning reports of SAR/BDS satellites M13, M14, M21, M22, M23 were complete and no further information was required.



01 System Construction

Precise Point Positioning (PPP)

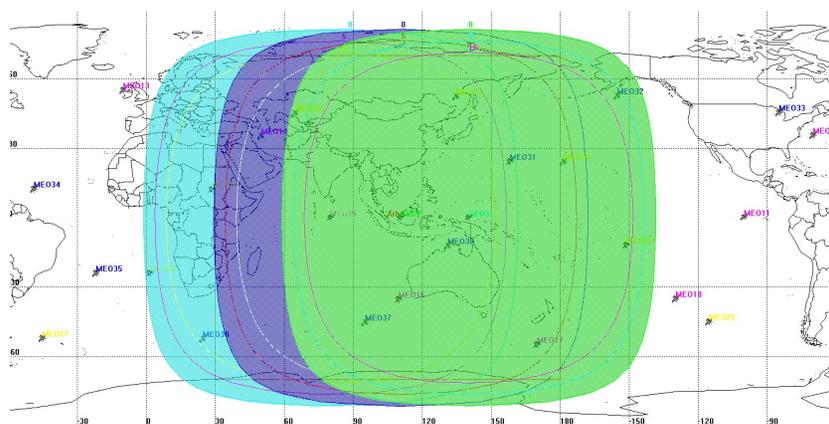


- **Satellites:3 GEO Satellites**
- **Coverage Area: China and surrounding areas**
- **Accuracy: decimeter (dynamic), centimeter (static)**

Performance Characteristics	Performance Specification	
Accuracy (95%)	Horizontal	≤20cm
Accuracy (95%)	Vertical	≤35cm
Convergence Time	≤20 min	

01 System Construction

Satellite-based Augmentation System (SBAS)



- **Satellites: 3 GEO Satellites**
- **Standard: ICAO Requirements**
- **Coverage Area: China and its surrounding areas**
- **Services Mode: SF or DFMC**

Performance Characteristics	Performance Specification
Dual-Frequency Positioning Accuracy for Civil Use (95%)	Horizontal 1m Vertical 1.5m
Warning Time	Single Frequency for Civil Use 10s Dual Frequency for Civil Use 6s
Integrity Risk	$2 \times 10^{-7} / 150s$
Continuity	$1 - 8 \times 10^{-6} / 15s (99.992\%)$
Availability	99%

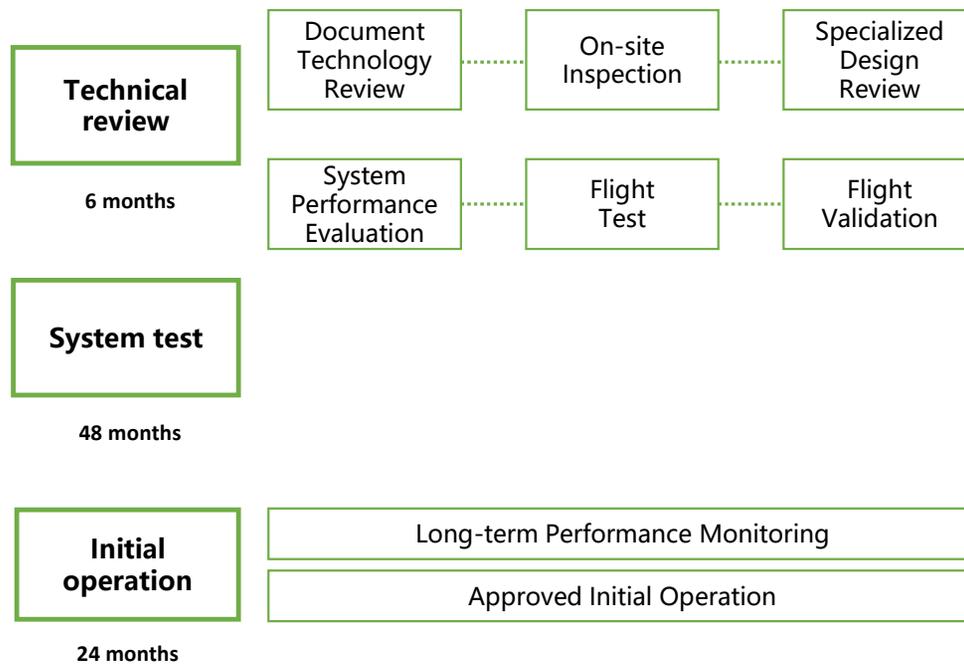
01 System Construction

Satellite-based Augmentation System (SBAS)

Monitoring Stations of BDSBAS



BDSBAS SF Certification Scheme



O1 System Construction

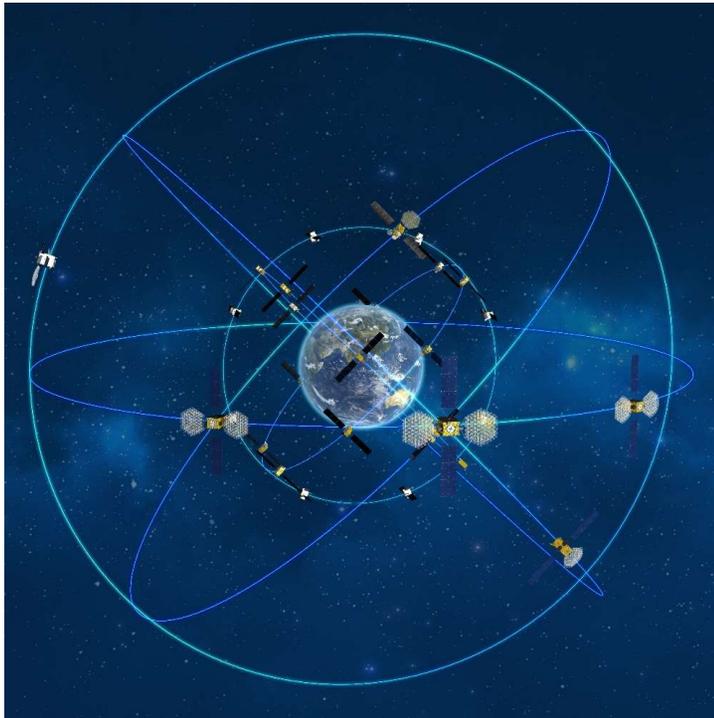
Ground-based Augmentation System (GAS)



- **Service provided through mobile communication networks or the Internet, with positioning accuracy at meter, decimeter, centimeter and millimeter levels**

Dual-Frequency Static Post-Processing Service	Performance Specification
Horizontal Positioning Accuracy (RMS)	$\leq 5\text{mm} + 1\text{mm} \times 10^{-6} \times D$ D means baseline length.
Vertical Positioning Accuracy (RMS)	$\leq 10\text{mm} + 2\text{mm} \times 10^{-6} \times D$ D means baseline length.
Relative positioning accuracy of repeated baseline length measurements	better than 3×10^{-8}

01 System Construction



- BDS has been enjoying a stable and continuous operation with system performances increased since its commissioning.
- We are also paying attention to soft environment construction of satellite navigation undertaking, including the protection of intellectual property, product testing certification system construction, industrial assessment system construction, standardization construction, etc.



Application Cases

02

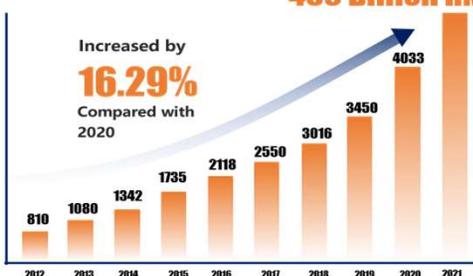
02 Application Cases

New High of Output Value

- The overall output value of China's satellite navigation and location-based service industry increased

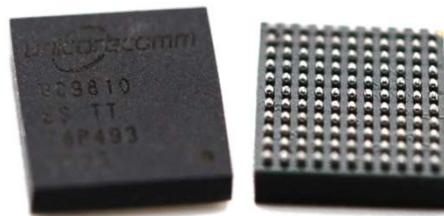
2021

Domestic output value of satellite navigation and location-based service industries: **469 Billion RMB**



Healthy Development of Industry

- Making breakthroughs in the key technologies of basic products, a full product chain established



Mass Market Applications

- Making breakthrough in mass market with smart phone as representative products
- More than 130 million, also 98.5% shipments of smart phones in China supported BDS positioning function in the first half year of 2022



02 Application Cases



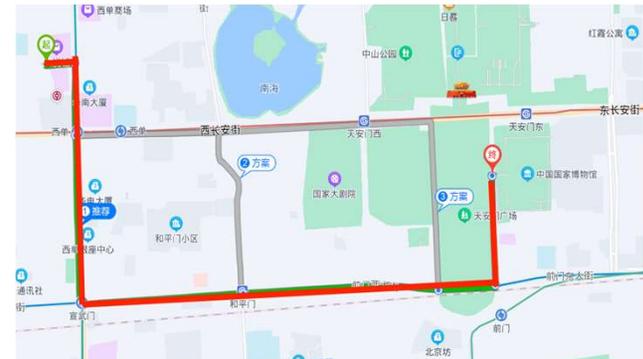
Transportation

- 8.3 million BDS-based devices equipped in transportation vehicles, with more than 7.84 million operating vehicles



Map Data

- BDS-based "Baidu Positioning Open Service Platform" with more than 100 billion times used per day



02 Application Cases



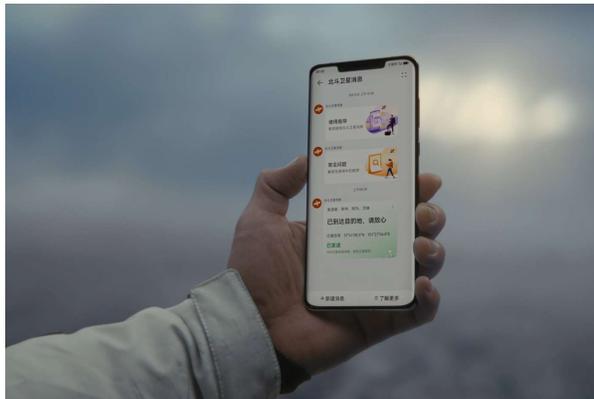
Availability of SMC for mobiles

- BDS Short Message Communication applied to Smart phones without changing devices in July
- BDS Short Message Communication entering Actual Test phase



Sender

Receiver



02 Application Cases



Precision Agriculture and Auto-Steering

- Accuracy of 2.5 cm, 30% increase in machinery scheduling efficiency, 5% enhancement in crop production, 10% saving in fuel consumption

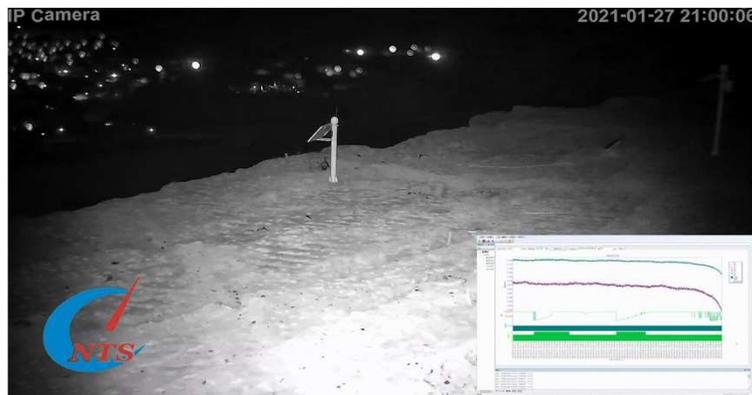
Requirement	Solutions	Effects
Precise Positioning	Satellite-based Positioning	Provide high-accuracy real-time location information for machinery
Precise Quantification	Satellite-based Positioning & Field Information Collecting Techniques	Realize collecting and analyzing field situation
Precise Timing	Satellite-based Positioning	Work without limitation of time and weather



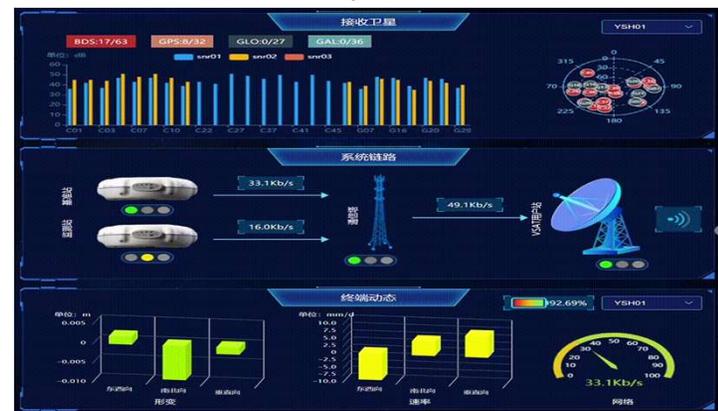
02 Application Cases

High Precision Deformation Monitoring

- BDS high-precision based early warning and monitoring system released landslide warning 7 minutes ahead, whose scale is as large as a hundred thousand cubic meters, and successfully prevented casualties.



- Confronted with the threat of potential natural disaster in Sarez Lake in Tajikistan, China and Tajikistan utilized BDS to undertake the deformation monitoring and disaster warning in surrounding area in millimeter-level accuracy, providing important scientific and technological reference for the safety of the dam.



02 Application Cases

BDS Overseas Applications

- BDS-based products have been exported to and used in more than half countries and regions in the world. BDS has been widely used in ASEAN, Southern Asia, Eastern Europe, Western Asia, Africa in land ownership confirmation, precision agriculture, intelligent port management, etc., promoting local economic and social development.





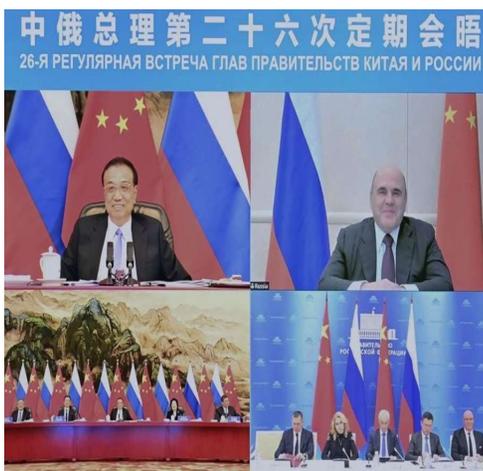
International Cooperation

03

03 International Cooperation

Compatibility and Openness to Provide Better Service (Bilateral)

China-Russia



Cooperation in joint test, station construction, and precision agriculture under the China-Russia Satellite Navigation Key Strategic Cooperation Project Committee framework

China-U.S.



Fostered the cooperation in compatibility and interoperability, SBAS, and civil use industries

China-EU



Coordinated with EU to foster a communication mechanism between Galileo and BeiDou, and frequency coordination communication was conducted

03 International Cooperation

Compatibility and Openness to Provide Better Service (Bilateral)

中国卫星导航系统管理办公室与阿根廷国家空间活动委员会合作谅解备忘录在线签署仪式
 Ceremonia de firma virtual del MOU entre CONAE y CSNO

CSNO and CONAE has built a kind of normal cooperation mechanism in satellite and navigation, and will carry out cooperation in joint applications, test and assessment, education and training, etc., to accelerate economic and social development in Argentina.

中国—南非北斗/GNSS应用研讨会
 Workshop on BDS/GNSS Applications in China and South Africa
 2021年12月1日 December 1st, 2021

In order to promote national construction and social and economic development for both countries and enhance cooperation and communication in the satellite navigation field, CSNO and SANSA signed the MOU at the workshop on BDS/GNSS Applications in China and South Africa.

03 International Cooperation

Joint Discussion, Construction and Sharing with The Belt and Road countries (Multilateral)



**3rd China-Arab States
BDS
Cooperation Forum**
Dec. 8, 2021



**2nd China-Central Asia
BDS
Cooperation Forum**
Oct. 13, 2021



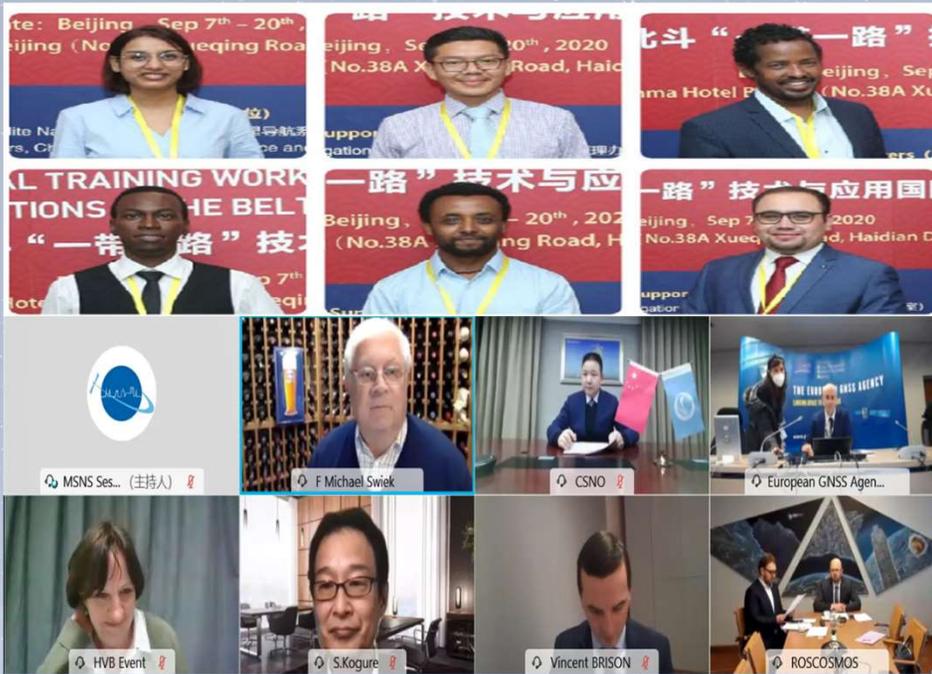
**1st China-Africa BDS
Cooperation Forum**
Nov. 5, 2021



**EXPO 2020
Dubai
BeiDou
Showcase**
Oct. 2, 2021

03 International Cooperation

Chinese Wisdom and Contribution through Multilateral Exchanges (Multilateral)



China actively participated in programs and activities under the ICG framework to promote GNSS compatibility and interoperability, and held education and training activities in Asia-Pacific regions based on United Nation Education and Training Center.



03 International Cooperation

Host of China Satellite Navigation Conference and Extensive Exchanges



The thirteenth China Satellite Navigation Conference (CSNC), is going to be held in Beijing on November 16th.



03 International Cooperation

Ratification by International Standards



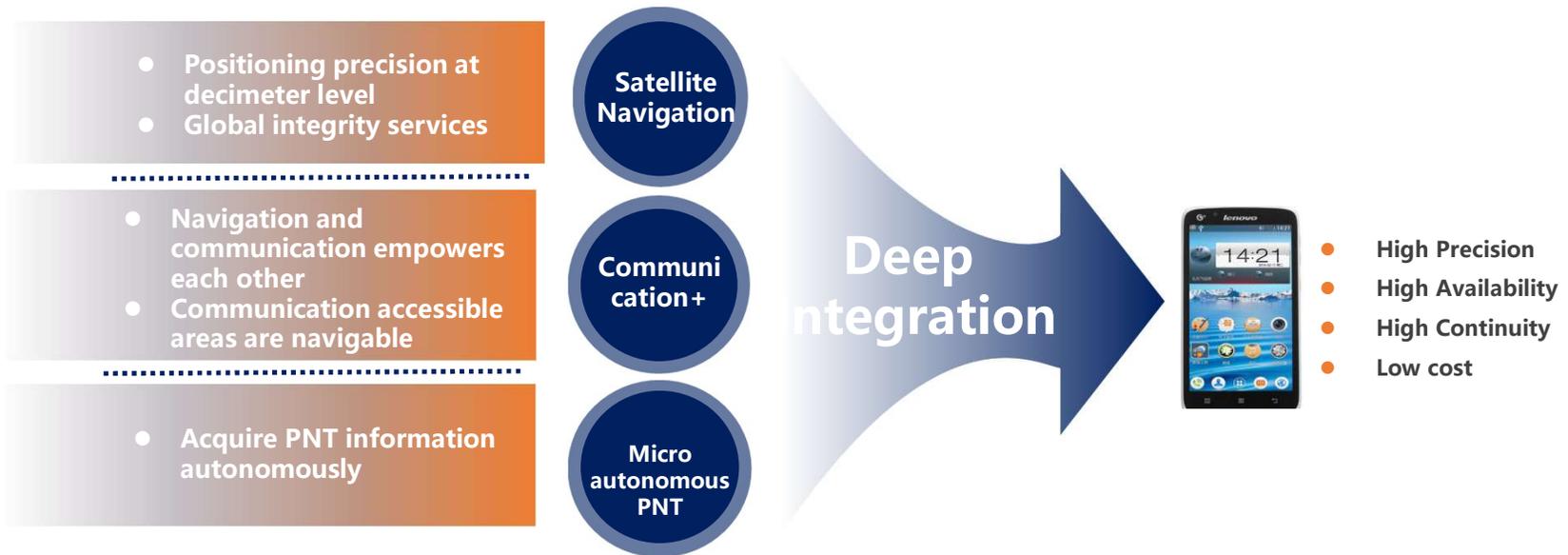


Future Plans

04

04 Future Plans

1. Development of Back-up Satellites, Optimize Production and Status to Ensure the Stable and continuous Operation
2. Adoption of Standardized Solutions to Meet Common Needs
3. A Comprehensive PNT System will be Established with BDS as the Core



A large blue rectangular area containing a diagram of the BeiDou Navigation Satellite System (BDS) constellation. The Earth is at the center, surrounded by several orbits. Numerous satellites are shown in various positions along these orbits, connected by thin lines. The background is a dark blue with faint grid lines.

Thanks for your continuous attention and support to the BDS development!

<http://en.beidou.gov.cn>