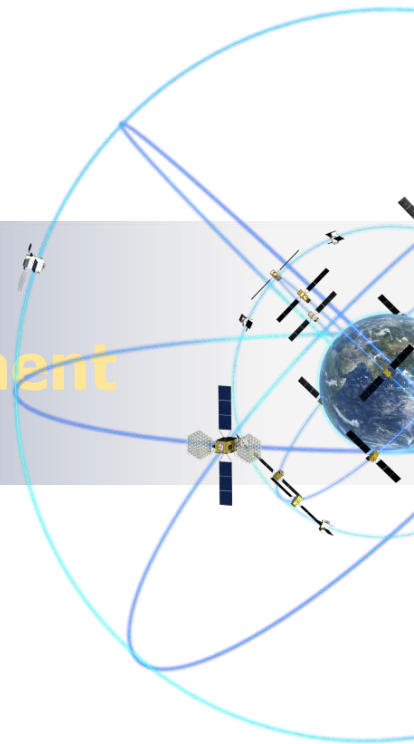




BeiDou Navigation Satellite System Development



LU Jun

China Satellite Navigation Project Center

February, 2022



1

System Status

2

Service Performance

3

Application Promotion

4

Future Plans

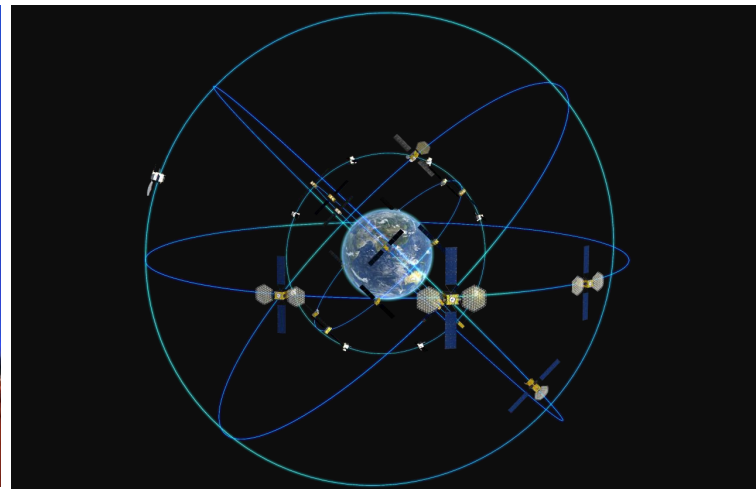
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System Status

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System Status

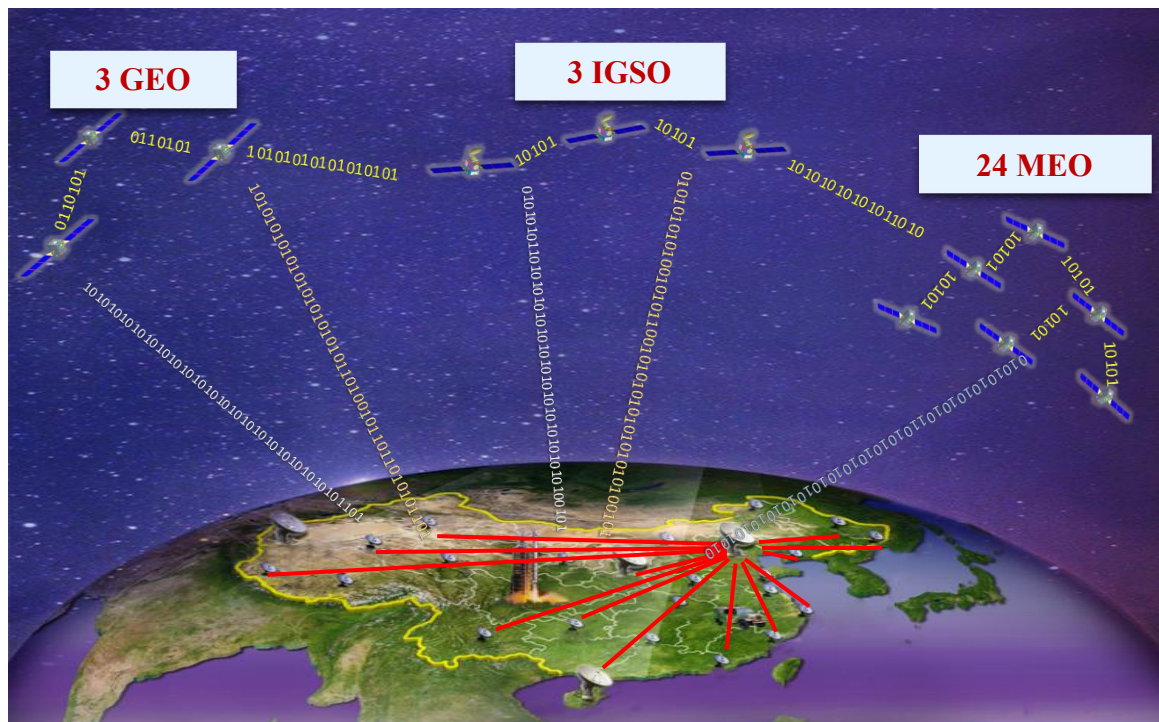
1.1 Completion and Commissioning



On July 31st, 2020, Chinese President XI Jinping announced the completion and commissioning of the BeiDou Navigation Satellite System (BDS-3).

1 System Status

1.2 System Components



3 segments:

- BDS-3 space segment consists of 3 GEO satellites, 3 IGSO satellites, and 24 MEO satellites
- Ground segment consists of various ground stations, including master control stations, time synchronization/uplink stations, monitoring stations
- User segment consists of various kinds of BDS/GNSS terminals

1 System Status

1.3 Information Dissemination

- The latest released documents of Open Service Performance Standard, Signal In Space Interface Control Document are shown as followings.
- More information is available at: en.beidou.gov.cn, csno-tarc.cn/en

| Document | Date |
|---|---------|
| BeiDou Navigation Satellite System Open Service Performance Standard (Version 3.0) | 2021.05 |
| BeiDou Navigation Satellite System Signal In Space Interface Control Document Open Service Signal B2b (Version 1.0) | 2020.08 |
| BeiDou Navigation Satellite System Signal In Space Interface Control Document Precise Point Positioning Service Signal PPP-B2b (Version 1.0) | 2020.08 |
| BeiDou Navigation Satellite System Signal In Space Interface Control Document Satellite Based Augmentation System Service Signal BDSBAS-B1C (Version 1.0) | 2020.08 |
| BeiDou Navigation Satellite System Signal In Space Interface Control Document Search and Rescue Service (Version 1.0) | 2020.08 |
| BeiDou Navigation Satellite System Ground-based Augmentation Service Interface Control Segment | 2020.08 |
| Development of the BeiDou Navigation Satellite System (Version 4.0) | 2019.12 |
| The Application Service Architecture of BeiDou Navigation Satellite System | 2019.12 |

BeiDou Navigation Satellite System
Open Service Performance Standard
(Version 3.0)



China Satellite Navigation Office
May, 2021

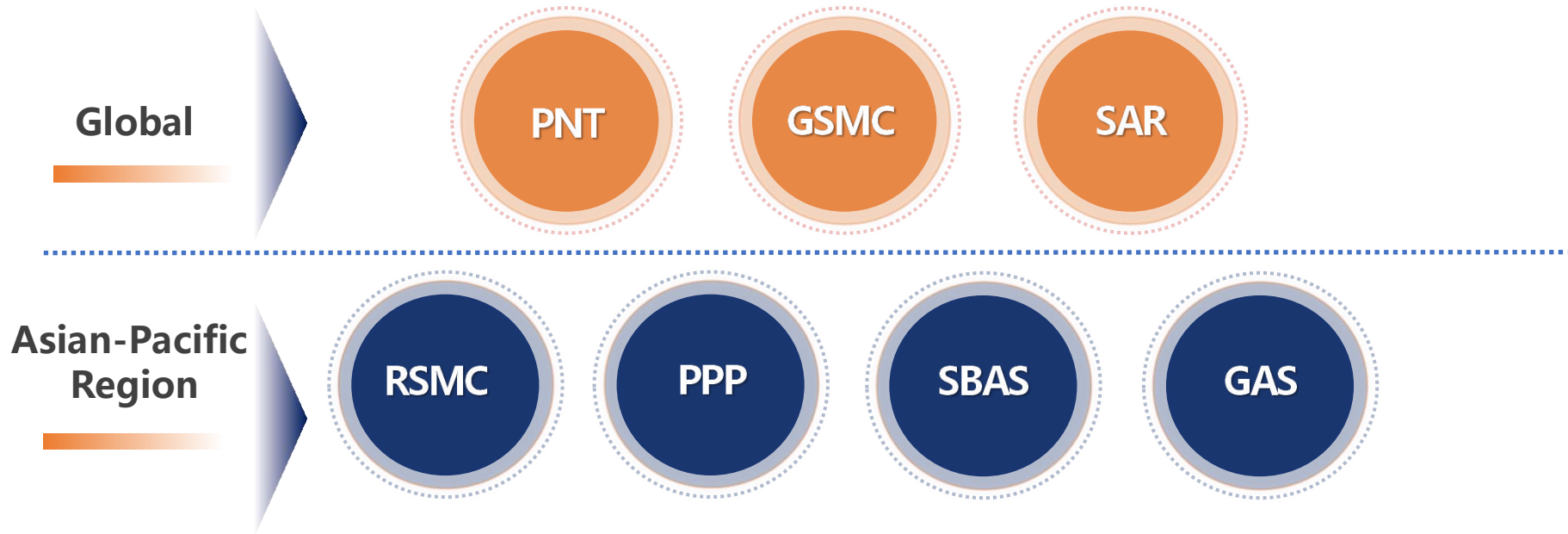
2

Service Performance

2

Service Performance

Various Services with Powerful Functions



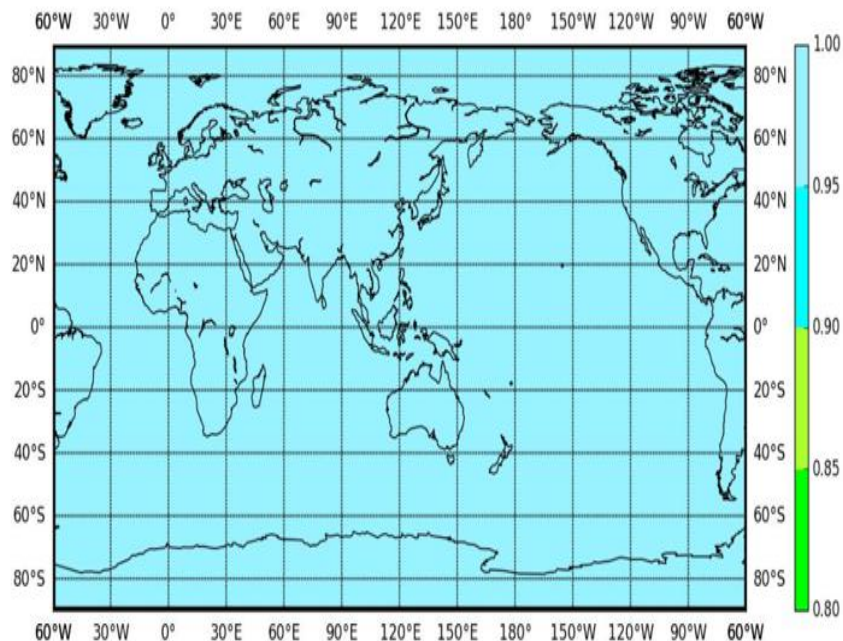
2 Service Performance

2.1 Positioning, Navigation and Timing (PNT)

BDS Service Performance Indicator

| Performance Characteristics | Performance Specification |
|--|--|
| Global Positioning Accuracy (95%) | Horizontal $\leq 2.5\text{m}$ Vertical $\leq 5\text{m}$ |
| Global Velocity Measurement Accuracy (95%) | $\leq 0.2\text{m/s}$ |
| Global Timing Accuracy (95%) | $\leq 20\text{ns}$ |
| SIS (Signal in Space) Continuity | 99.8%/h |
| SIS Availability | $\geq 98\%$ |

BDS Availability (5° Elevation Mask, PDOP ≤ 6)



2 Service Performance

2.1 Positioning, Navigation and Timing (PNT)

State of BDS Satellites

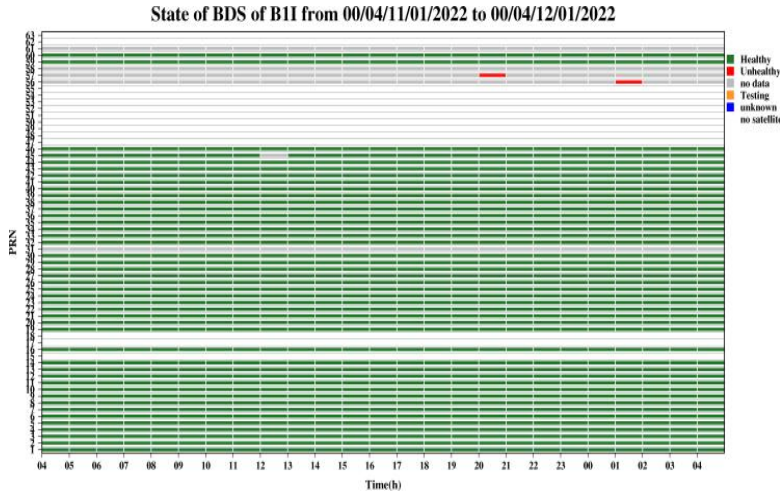


Figure 1 State of BDS from 11th to 12th January, 2022

**Most of the BDS satellites are operating normally in orbit.
The PDOP of BDS is less than 4 in most areas.**

Current PDOP of BDS

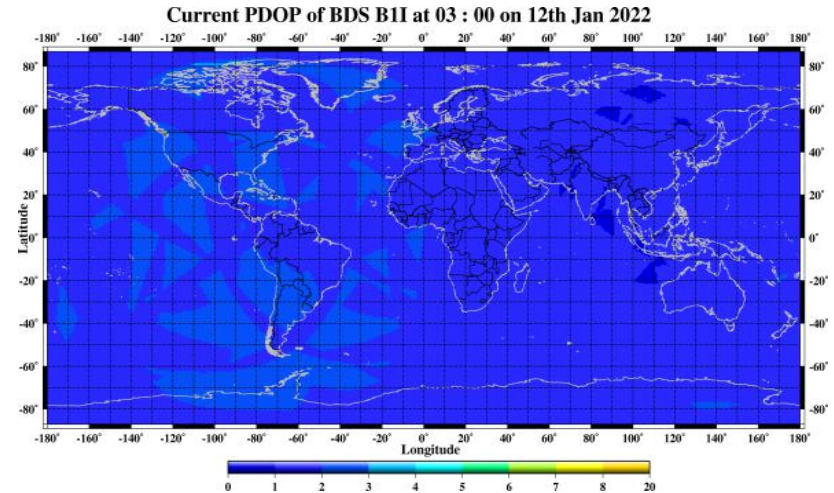
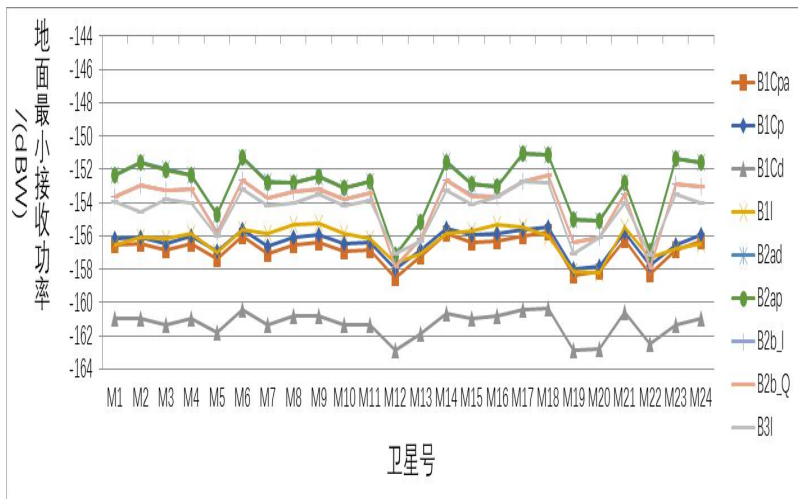


Figure 2 Current PDOP of BDS at 12th January, 2022

2 Service Performance

2.1 Positioning, Navigation and Timing (PNT)

Navigation Signal Quality



SIS Range Error (SISRE)

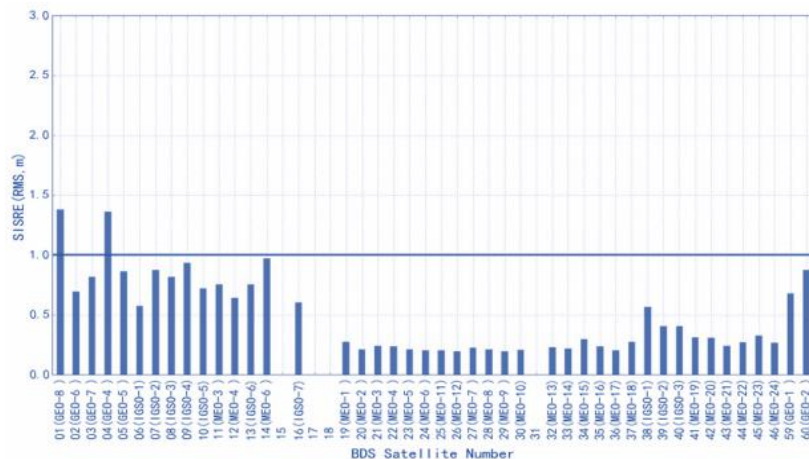


Figure 3 Minimum Ground Received Power of Signal Components

Figure 4 URE of the BDS Satellites

The minimum ground received power of signal components meet the standards.
The SISRE of BDS satellites is better than 0.5m.

2 Service Performance

2.1 Positioning, Navigation and Timing (PNT)

Orbit Accuracy

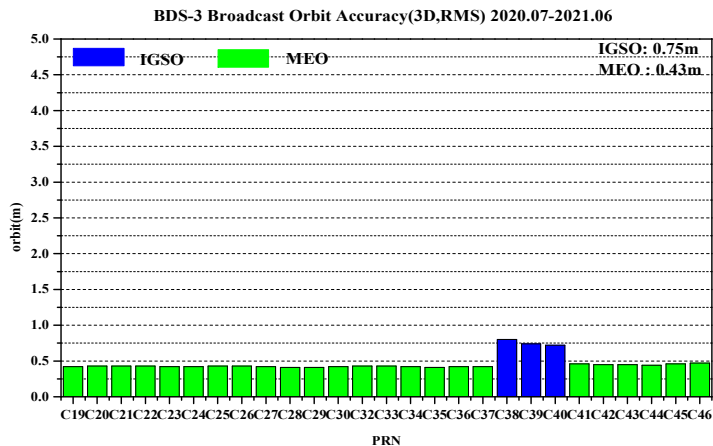


Figure 5 The orbit accuracy of broadcast ephemeris

Clock Accuracy

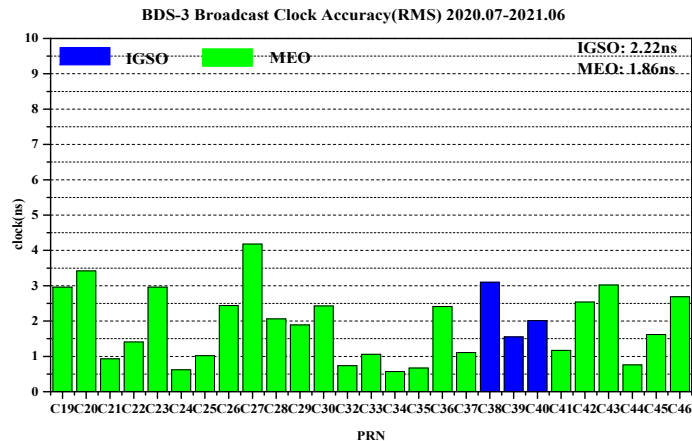


Figure 6 The clock accuracy of broadcast ephemeris

The orbit accuracy of broadcast ephemeris of BDS-3 MEO is within 0.5m.
The clock accuracy of broadcast ephemeris of BDS-3 is always within 5 ns.

2 Service Performance

2.1 Positioning, Navigation and Timing (PNT)

BDS Coordinate Reference Frame

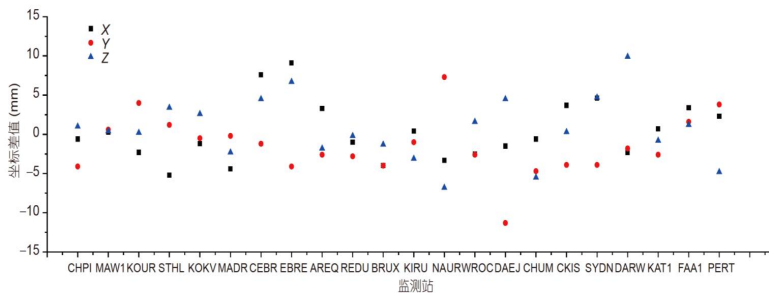


Figure 7 Difference between BDCS and ITRF 2014

The time deviation between BDT and UTC (NTSC) is usually within 26 nanoseconds. The difference between BDCS and ITRF 2014 is usually within 3 centimeters.

Stability of BDT

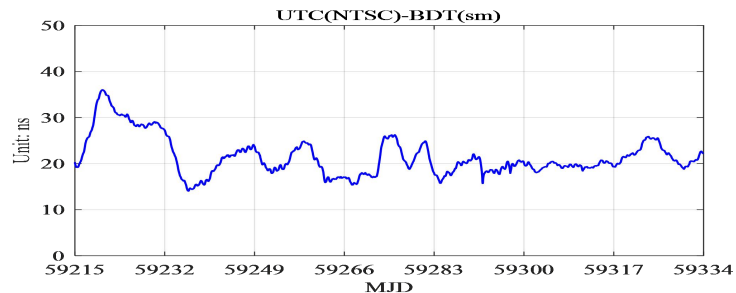


Figure 8 Time Deviation between BDT and UTC(NTSC)

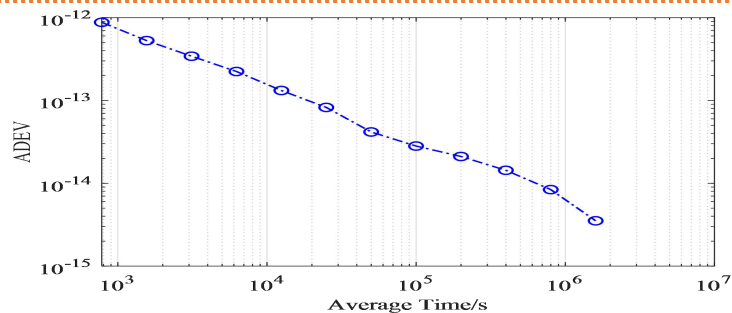
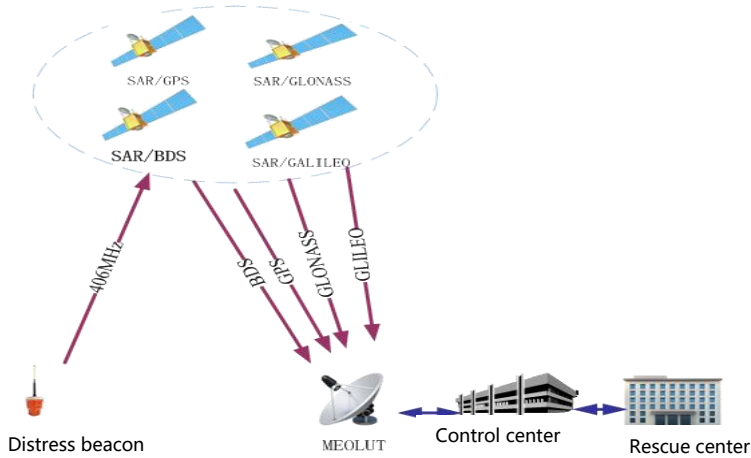


Figure 9 Stability of Clock Bias between BDT and UTC(NTSC)

2

Service Performance

2.2 Search And Rescue (SAR)

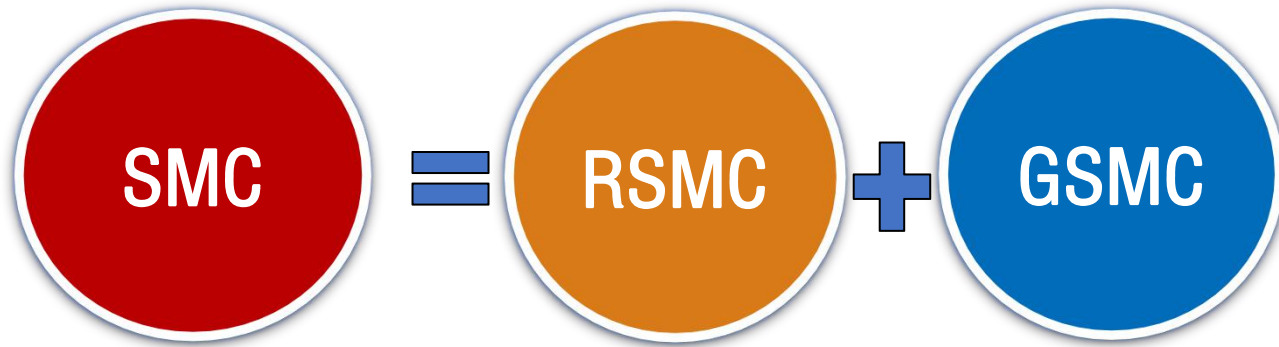


- Coverage: Global
- Space segment: 6 MEO&SAR Payloads
- Standard: COSPAS-SARSAT
- Uplink frequency: 406.05MHz
- Downlink frequency: 1544.21MHz
- Return Link Service

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

BDS Short Message Communication (SMC) Services

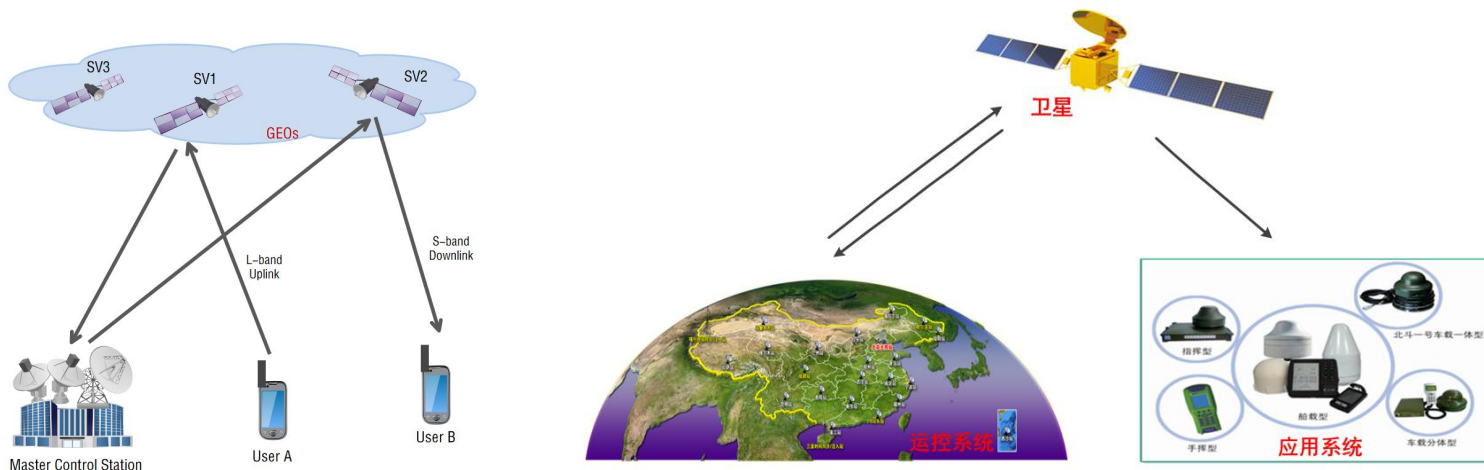
- Featured service
- As a distinctive part of BDS, SMC makes BDS not only a NAV satellite system, but also a NAV+COM satellite system.



2 Service Performance

2.3 Regional Short Message Communication Service (RSMC)

- **Coverage: China & 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**



2

Service Performance

2.4 Global Short Message Communication Service (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)



Benefits of Return-link

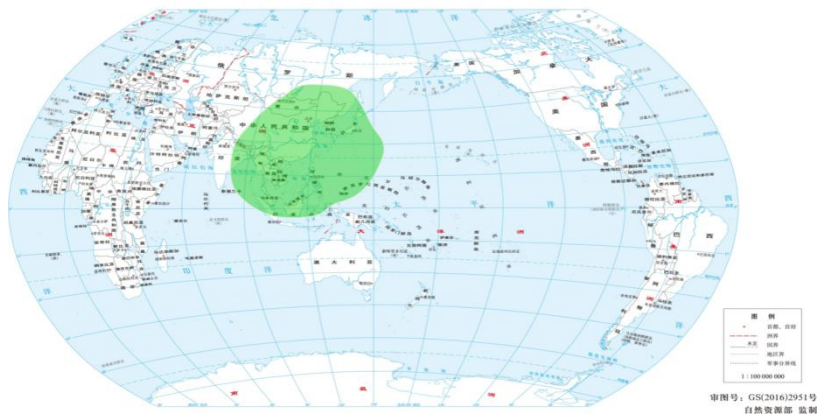
- Quickly confirm responding to the user alert by return-link
- One successful alert, two answers from MCS, RCC respectively
- Reduce invalid repeat and false alarm rate
- Significantly raise the confidence of mariners in distress



2

Service Performance

2.5 Precise Point Positioning (PPP)

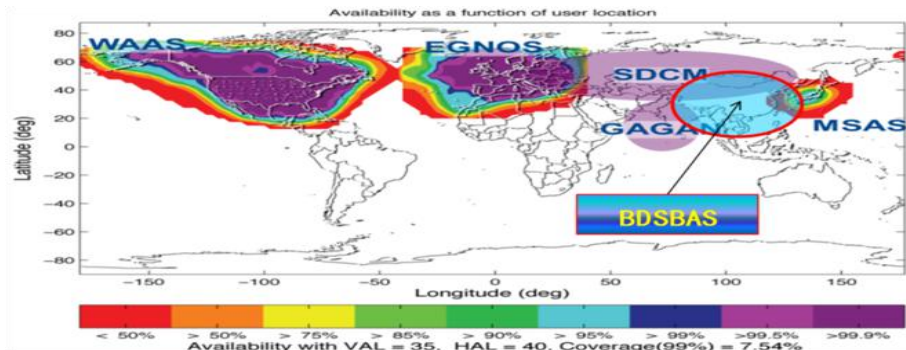


- **Satellites:3 GEO Satellites**
- **Coverage Area: China and surrounding areas**
- **Accuracy: decimeter (dynamic), centimeter (static)**

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

2 Service Performance

2.6 Satellite-Based Augmentation System (SBAS)



- Satellites: 3 GEO Satellites
- Standard: ICAO
- Coverage Area: China and surrounding areas
- Services Mode: Single-Frequency or Dual Frequency Multi-Constellation

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%

2

Service Performance

2.7 Ground-Based Augmentation System (GAS)



- **Service is 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} |

3

Application Promotion

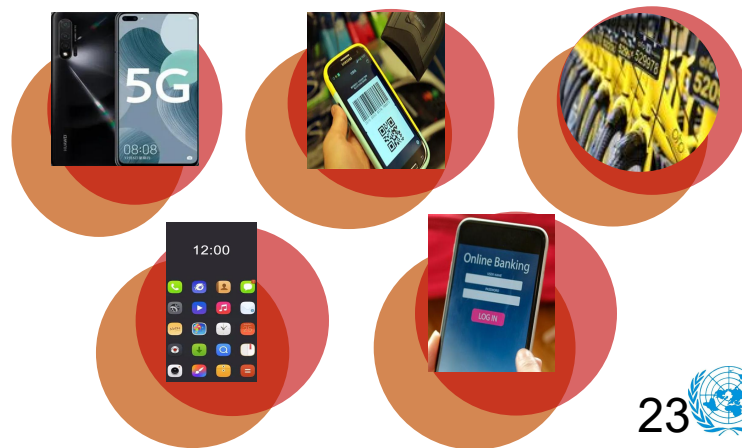
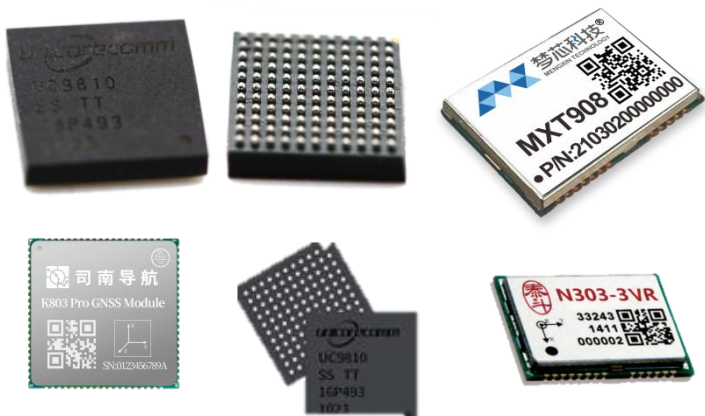
3 Application Promotion

3.1 Establishment of full industrial chain and Entering into Mass Market

Sales volume domestic BDS-supported chips and modules has exceeded **100 million**

79% smart phones sold in China in 2021 supported BDS positioning function

Meter-level positioning is available based on BDS ground based augmentation service signal



3 Application Promotion

3.3 Providing good services for global users



BDS is widely used in ASEAN, Central Asia, Southern Asia, Eastern Europe, Western Asia, Africa in transportation, land ownership confirmation, precision agriculture, intelligent port management, promoting global economic and social development.

4

Future Plans

4

Future Plans

A Comprehensive PNT System will be Established with BDS as the Core Adoption of Standardized Solutions to Meet Common Needs to Realize Full Support for the Future Development

- Positioning precision at decimeter level
- Global integrity services

Satellite Navigation

- Navigation and communication empowers each other
- Communication accessible areas are navigable

Communication

- Acquire PNT information autonomously

Micro autonomous PNT

Deep Integration

Unified Reference

Unified traceability of spatial-temporal reference

Global Coverage

From abysmal sea to deep space, open space to indoor space

High Accuracy

Positioning precision at decimeter level at global surface & near-earth space

High Security

Secure and trusted PNT services

High Intelligence

Intelligent management, operation and maintenance of infrastructure

High Benefits

Realize the unification of high precision and high availability based on low cost handheld terminal





**Thanks for your continuous attention
and support to the BDS development.**

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

<http://www.csno-tarc.cn/en>