



Development of BeiDou Navigation Satellite System



LU Xiaochun

International Cooperation Center, China Satellite Navigation Office

Oct. 16, 2023

Constellation Status

A total of 46 satellites operational in orbit

The 1th BDS-3 back-up satellite launched on May 17, 2023

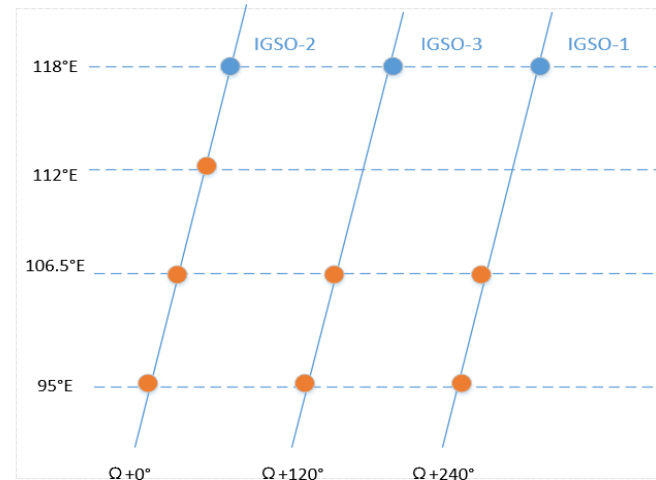
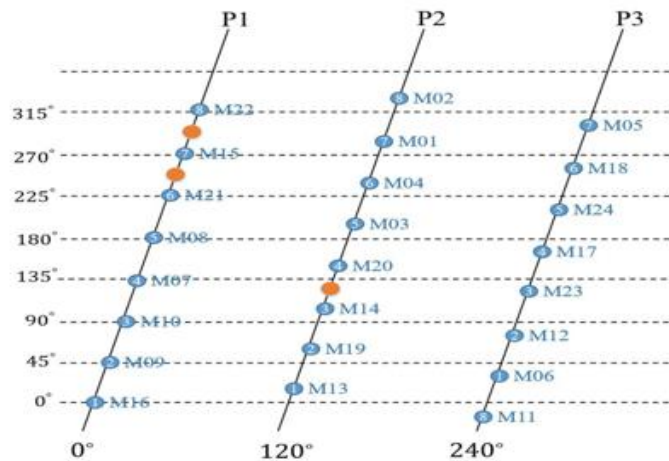
Including:

15 BDS-2 Satellites

31 BDS-3 Satellites (30 networking satellites and 1 back-up satellite)



The 56th satellite for China's BeiDou Navigation Satellite System (BDS) was launched at Xichang



- Constellation availability and stability promoted
- Communication capacity of the system's regional short-messaging function expanded by 1/3
- Positioning accuracy of satellite-based augmentation and precise point positioning enhanced and quick high-accuracy positioning realized
- In-Orbit test and assessment of GEO-4 finished

New

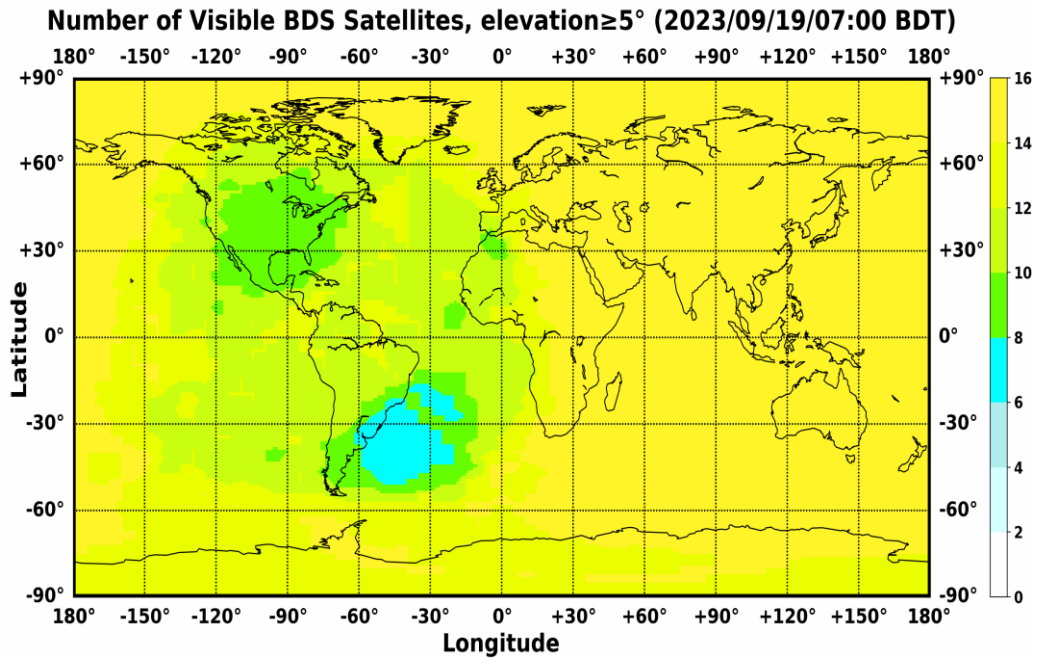


Diversified Services

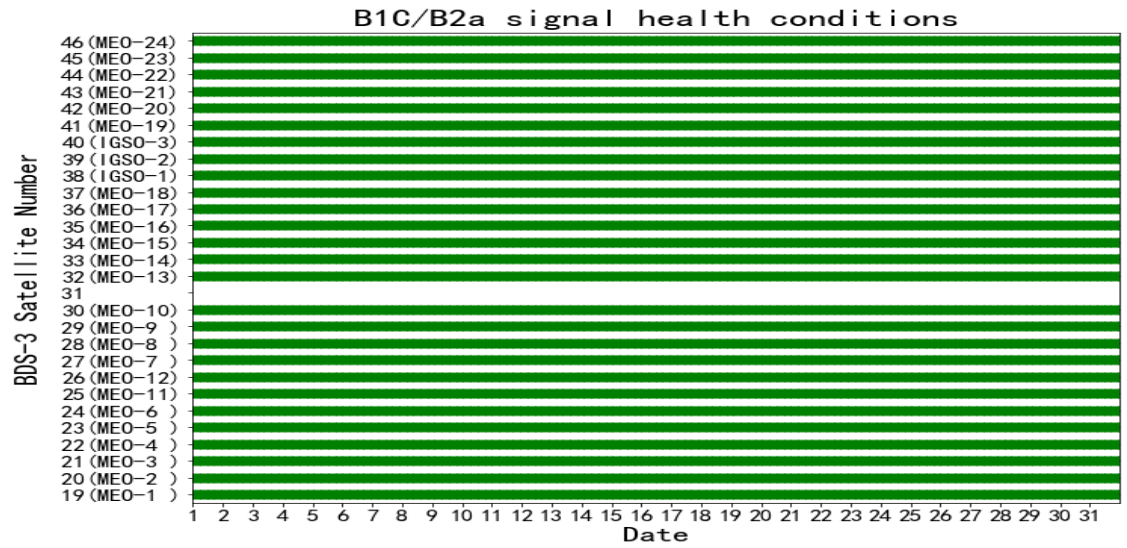
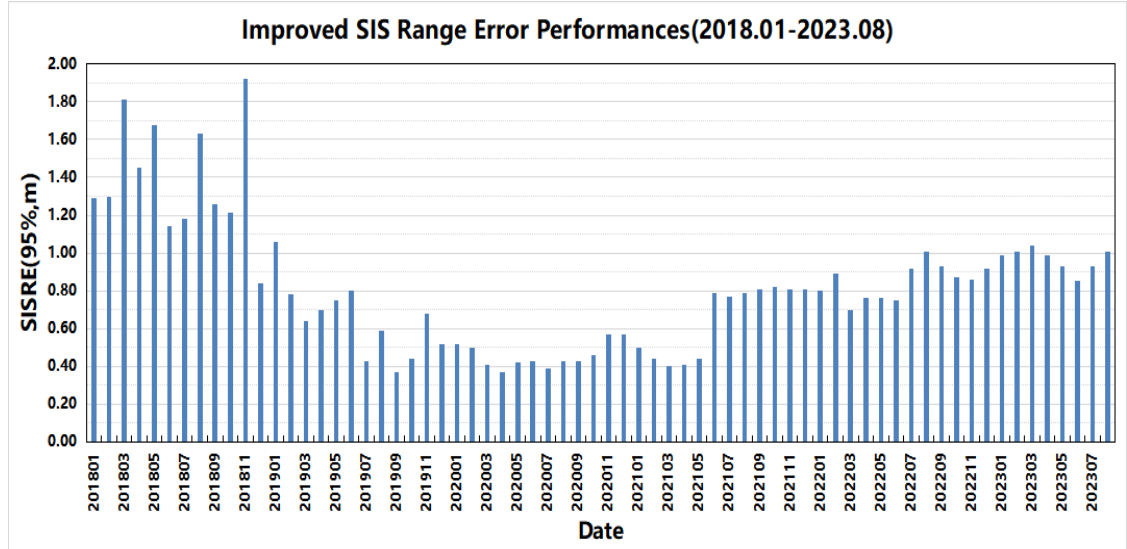
	RNSS	GSMC	SAR	RSMC	PPP	SBAS	GAS
Channel	24MEO+3GEO +3IGSO	Up:14MEO Down: 3IGSO+24MEO	Up: 6MEO Down: 3IGSO+24MEO	3GEO	3GEO	3GEO	Mobile Communication & Internet
Frequency	B1I,B3I,B2a, B1C,B2b	L, B2b	UHF, B2b	L, S	B2b	B1C, B2a	
Information Provided	GNSS	Short Message	Alarming Message	Short Message	Corrections	Error Corrections and integrity	Differential Corrections
Functions	Positioning, Navigation, Timing	Location Reporting, Emergency Rescue, Short Message Communication	Warning & Alarming	Communication	Precise Positioning Point	Augmentation and Integrity	RTK
Performances	Horizontal 9m Vertical 10m	Maximum length of a single message: 560 bits	Return link delay: ≤2mins Return link success rate: ≥95%	Maximum length of a single message: 14000 bits	Horizontal 0.3m Vertical 0.6m Convergence time 30 mins	Positioning, warning time, integrity risk	Real-time cm- level, post- processing mm- level
Service Area		Global				Asia-Pacific Region	



RNSS Service Performances

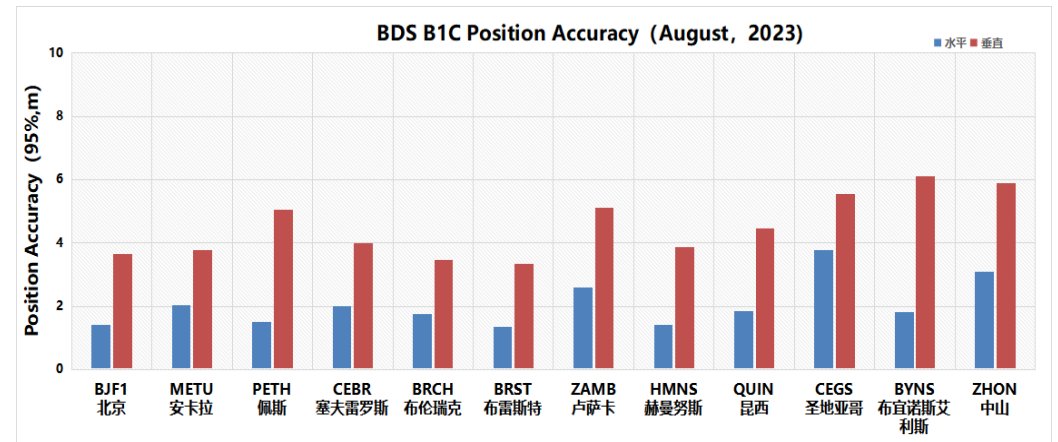
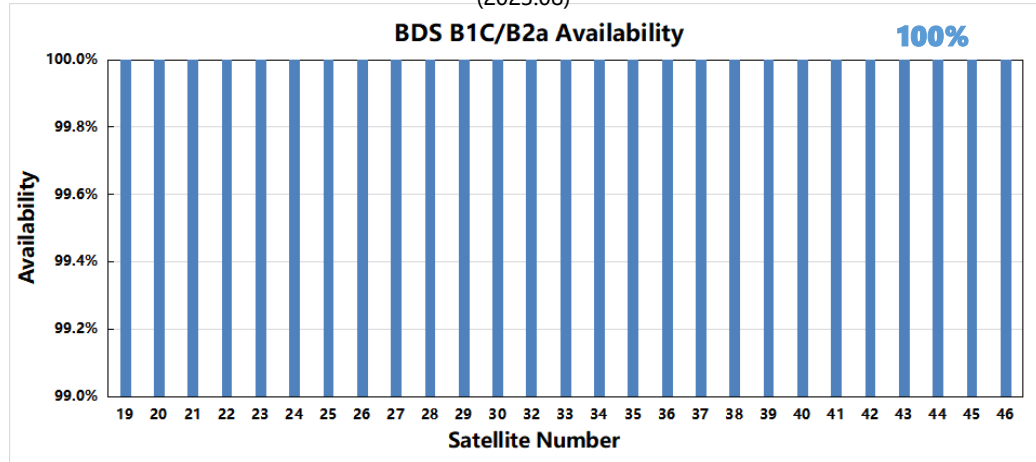
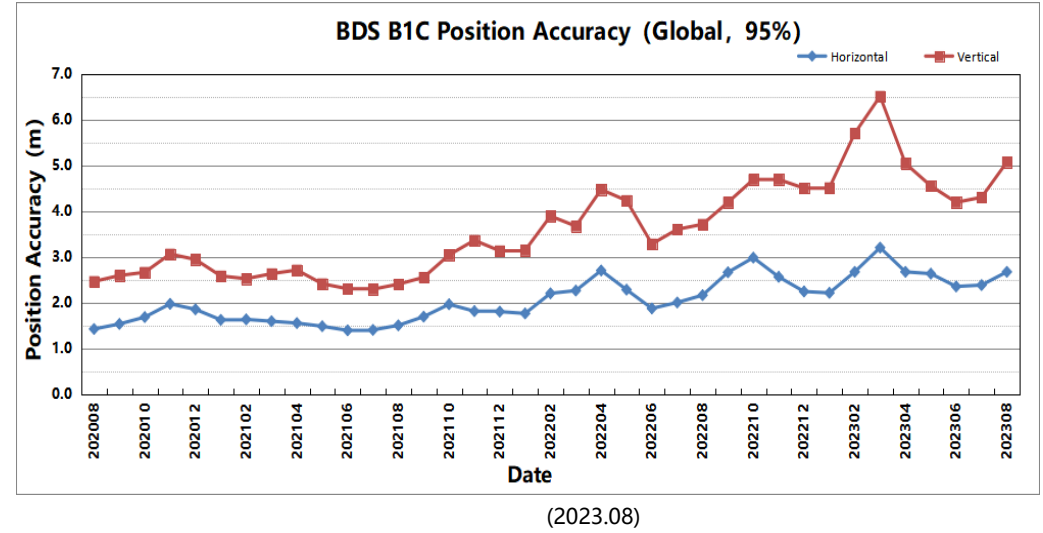
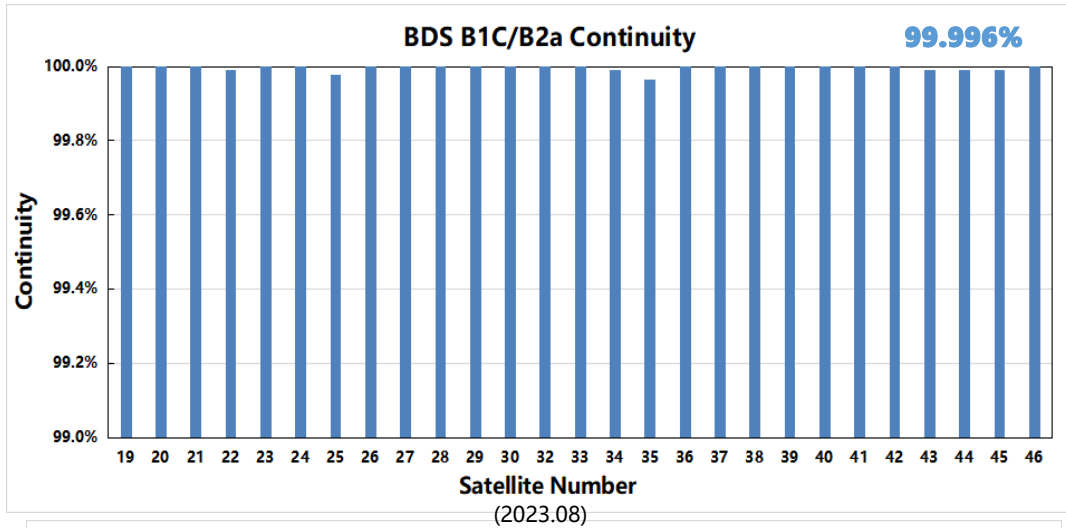


- BDS-3 system and service performances fully better than indicator requirements by ICD.
- Intelligent operation and management, in-orbit software refactoring, real-time monitoring and assessment, stable operation and better performances realized since officially commissioned.





RNSS Service Performances



Short Message Communication Service

Global Short Message Communication

- Coverage: Global
- Space Segment: 14 MEO satellites support up link; 3 ISGO and 24 MEO support down link;
- Maximum length of a single message: About 560 bits (40 Chinese characters per message)

Regional Short Message Communication

- Coverage: China and surrounding area
- Space Segment: 3 GEO satellites at 80°E, 110.5°E, 140°E
- Maximum length of a single message : 14,000 bits (around 1,000 Chinese characters)
- Main functions: search & rescue, location report, short message communication, etc.



Available for Authorized Users



HUAWEI Mate X3



HUAWEI P60 系列



HUAWEI Mate50 系列



HUAWEI Mate Xs 2

In 2023, two-way BDS short message communication service is realized on some domestic smart phone brands. "Directly-connected to satellite" has become the standard of some domestic series products, and the number of social units has exceeded 10 million.



Missing people sent distress messages and positioning coordinates through the short message communication function on mobile phone and were successfully rescued.

Search and Rescue Service

Monitoring and assessment was carried out in accordance with the guidelines for monitoring and assessment. The assessment results in May, 2023 showed that:

MEO SAR meets technical requirement, six BDS SAR payloads meet standards, and have the ability to transmit distress signals

The return-link service meets the technical requirements. Within 2 minutes, 99% of the return-link messages should be broadcast.

MEOSAR

MEOSAR	
Positioning Accuracy	4.38km
Detection Probability	99.2%
Availability	99%

RLS

RLS	
Time Delay	15s
Service Success Rate	99%



Beijing

RLS (from ground-based supporting system to user terminals)

Average Delay 9.1s

London

RLS (from ground-based supporting system to user terminals)

Average Delay 34s

RLS Delay Test and Assessment

Unscripted Maritime Search and Rescue Exercise



Danger Scene Simulation: A boat flipped over by strong wind and 11 people missing on the sea

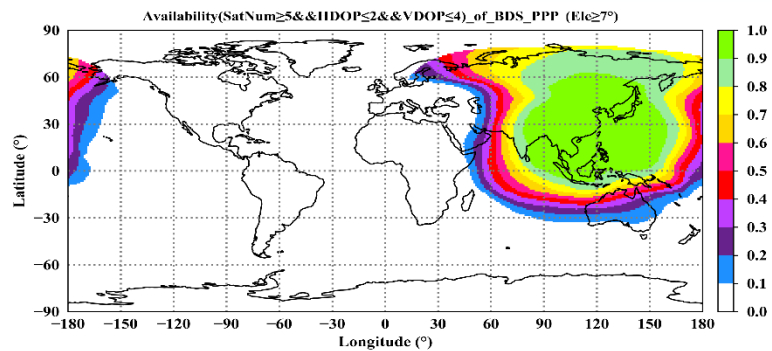
Hebei Province Maritime Search and Rescue Center coordinates and directs the national professional rescue vessels, fisheries and other public vessels, and social rescue forces for interaction.

BDS search and rescue beacons, and integrates new technologies and equipment such as rescue helicopters, drones, underwater robots and intelligent unmanned boats utilized.

SAR performances tested in real maritime environment, distress alert procedure review carried out for all-services, a comprehensive search and rescue network covering sea-land-air and space established.

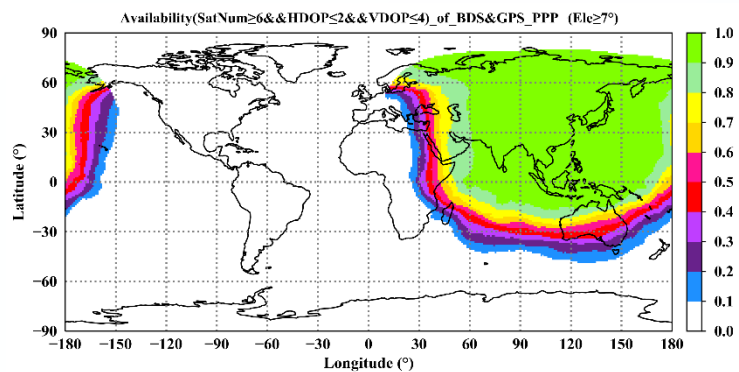
PPP-B2b Service Performance

Coverage



BDS PPP service availability

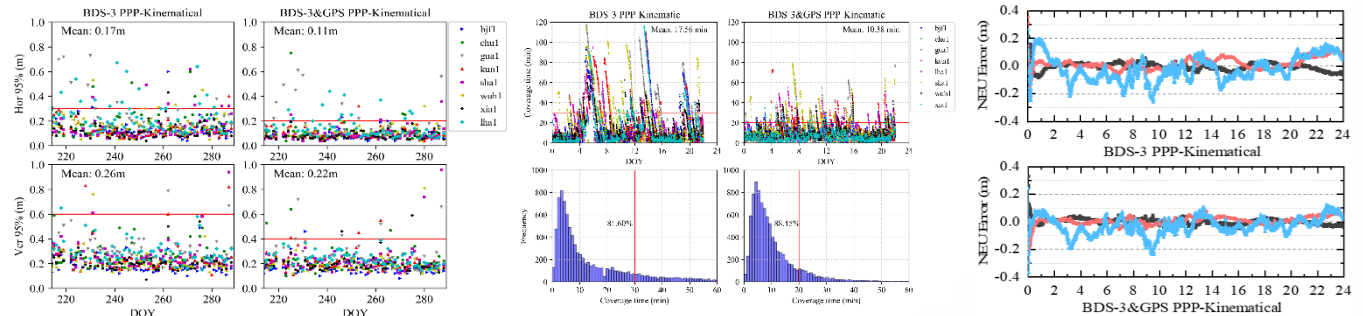
Sat numbers ≥ 5 , HDOP ≤ 2 & VDOP ≤ 4



BDS+GPS PPP service availability

Sat numbers ≥ 6 , HDOP ≤ 2 & VDOP ≤ 4

Positioning accuracy and convergence time



Station	BDS-3 PPP			BDS-3&GPS PPP		
	Hor/m	Ver/m	convergence time/min	Hor/m	Ver/m	convergence time/min
BJF1	0.14	0.19	15.6	0.09	0.17	11.2
CHU1	0.21	0.30	18.7	0.13	0.26	12.8
GUA1	0.23	0.30	22.0	0.14	0.25	13.2
KUN1	0.12	0.25	18.1	0.10	0.25	9.8
LHA1	0.24	0.30	22.8	0.14	0.24	10.9
SHA1	0.15	0.27	12.7	0.10	0.23	9.4
WUH1	0.16	0.21	15.8	0.11	0.19	8.1
XIA1	0.13	0.22	14.5	0.09	0.20	8.8
Mean value	0.17	0.26	17.5	0.11	0.22	10.4

BDS

•Positioning accuracy:

• Horizontal (95%) 17cm, Vertical (95%) 26cm

•Convergence time:

• 17min (H \leq 30cm, V \leq 60cm)

BDS+GPS

•Positioning accuracy:

• Horizontal (95%) 11cm, Vertical (95%) 22cm

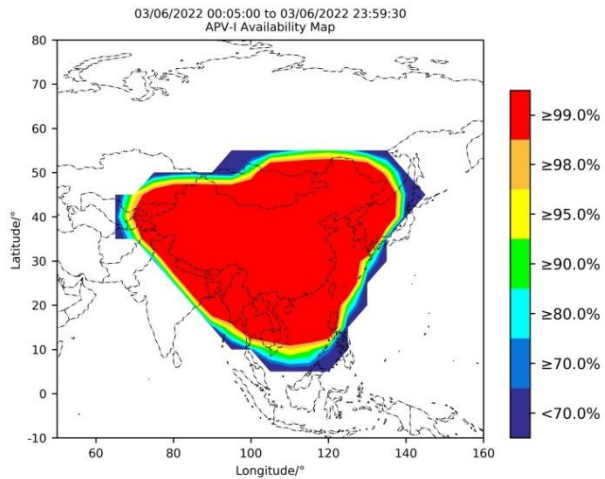
•Convergence time:

• 10min (H \leq 20cm, V \leq 40cm)

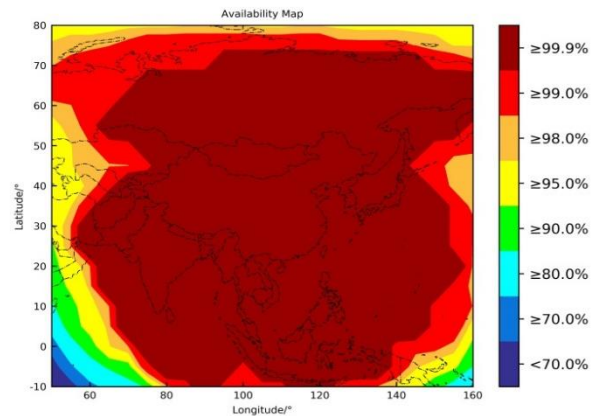
Indicator	Requirement	
Position Accuracy (95%)	Horizontal	≤ 30 cm
Position Accuracy (95%)	Vertical	≤ 60 cm
Convergence Time	≤ 20 min	

Satellite-Based Augmentation Service

Indicator Requirement



APV-I availability of BDSBAS SF service



APV-I availability of BDSBAS DFMC service

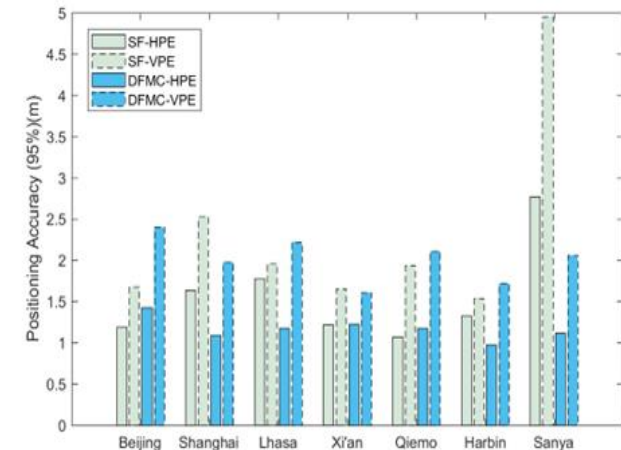
Performance requirements		BDSABS	
		SF service	DFMC service
Augmentation Objects		GPS L1C/A	BDS B1C/B2a GPS L1C/A/L5
Frequency		BDS GEO B1C	BDS GEO B2a
Accuracy		H: 16m, V: 20m	H: 16m, V: 4m
Integrity	Time-to-alert	10s	6s
	Integrity risk	$2 \times 10^{-7}/150s$	
	Alert limit	HAL: 40 m VAL: 50 m	HAL: 40 m VAL: 10 m
Continuity		$1-8 \times 10^{-6}/15s$	
Availability		Better than 99%	Better than 99.9%

- BDSBAS positioning accuracy (average)

SF service: HPE(95%)=1.82m,
VPE(95%)=2.32m;

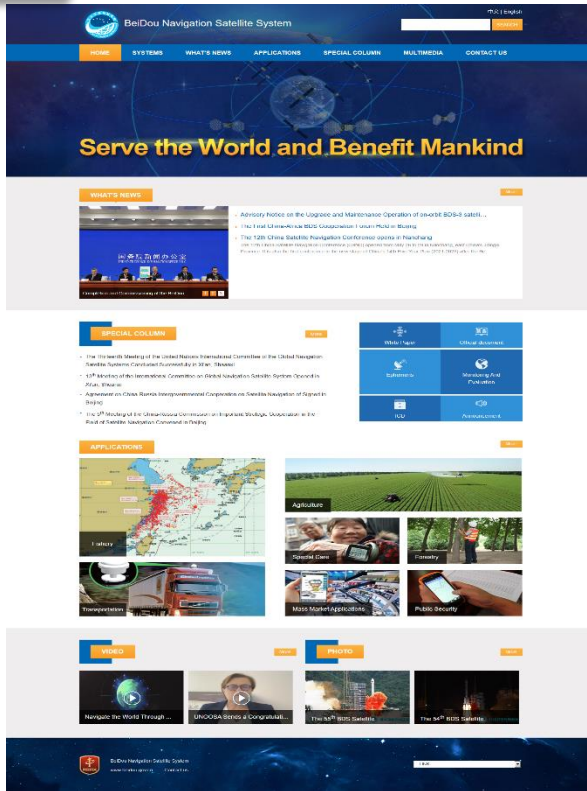
DFMC service: HPE(95%)=1.17m,
VPE(95%)=1.91m;

- During the evaluation period, no HMI occurred;
- Availability better than 99.99%.





BDS User Access

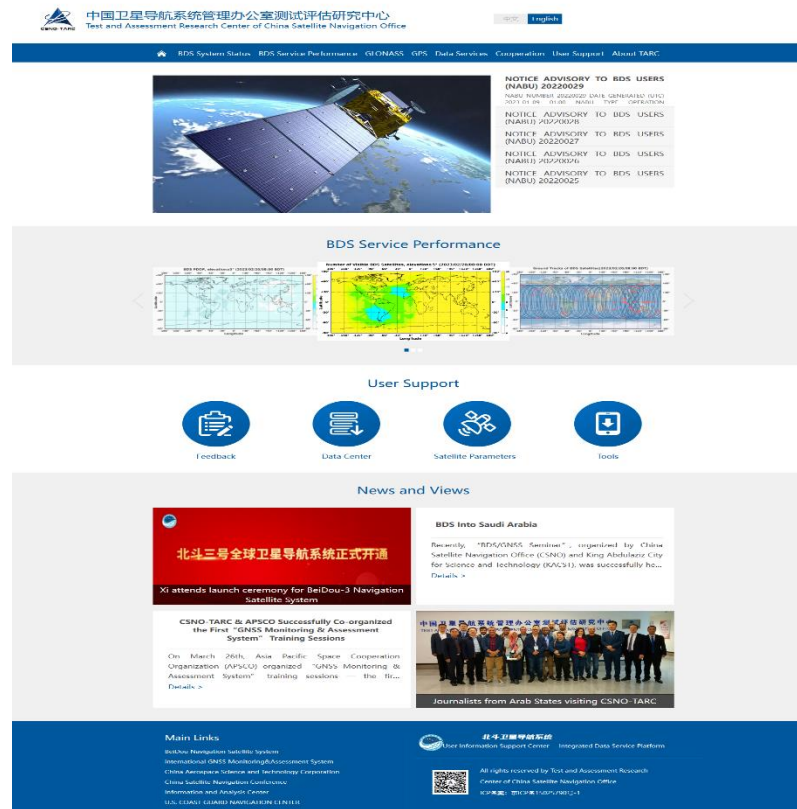


URL: www.beidou.gov.cn

Official plan, strategy, documents

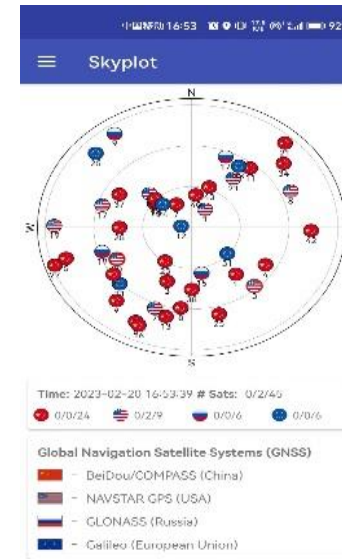


bdservices@beidou.gov.cn beidouicd@beidou.gov.cn bdsfeedback@csno-tarc.cn



URL: www.csno-tarc.cn

System status, performance, NABU



APP: navsat

For Android and Harmony OS



BDS/GNSS Applications

BeiDou Applications Empowering Various Industries and Sectors

- Overall scale of BDS space-time information application steadily increasing
- Industrial applications going further and deeper
- Efforts done in applications in the key areas



Smart Transportation
Comprehensively raise information level of transportation and help to smart city management



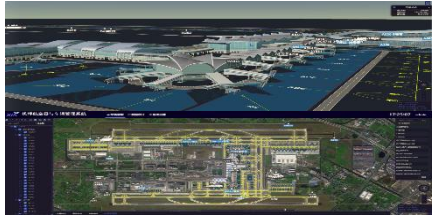
Agriculture, Forestry and Fisheries
Realizing cross-domain operating data integration, greatly improving operation management efficiency



Electric Power
Continuing to contribute BDS-based wisdom to the digitization of power grid



Express Delivery Logistics
99% accuracy, achieving faster delivery and higher efficiency



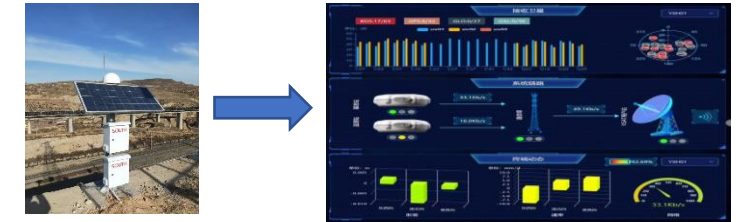
Traffic in Airport
Reducing accident risk in airport and enhancing operation and management efficiency



Smart Resources
Realizing smart operation and maintenance of photovoltaic hydropower stations



Emergency Management
Share emergency information and upgrade emergency response efficiency



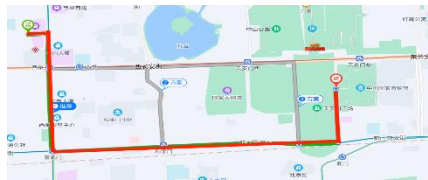
Smart Construction Safeguarding life security, improving the quality and efficiency of construction



Deformation Monitoring
High accuracy Safeguarding for the dam in Sarez Lake



Mass Consumption
Becoming the standard configuration of smart phones, mobile phones supporting BDS accounted for 98.5%



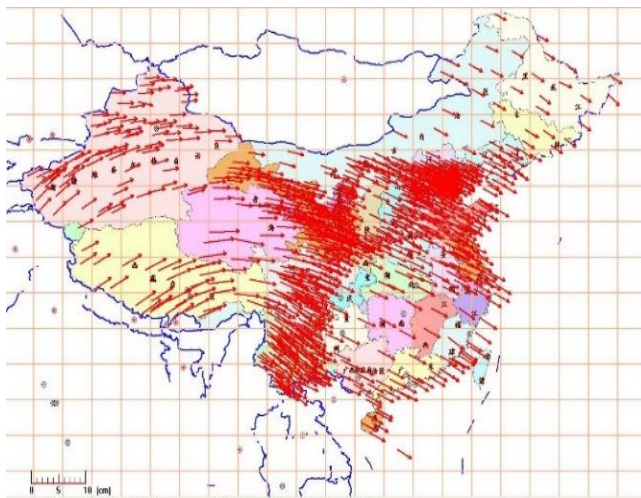
Mobile Map
Daily use of BDS positioning service exceeding 360 billion times by mainstream map applications in China.



International Scale Applications
Raising the level of international application and ensuring the fruits of development benefit the whole world

BDS/GNSS Applications

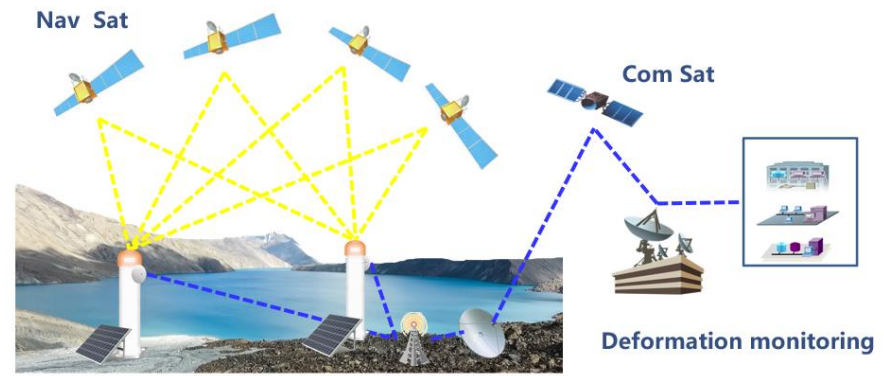
High Accuracy Application——Terrain Monitoring



- BDS successfully used in national coordinate framework monitoring and plate movement monitoring with accuracy better than 3mm
- In landslide and deformation monitoring, **BDSMC used for transferring alert information**
- “BDS + Smart Monitoring and Early Warning Cloud Platform” being applied in more than 600 buildings and structures in different areas in China and gave alarm 600 times, with 8000+ monitoring points distributed



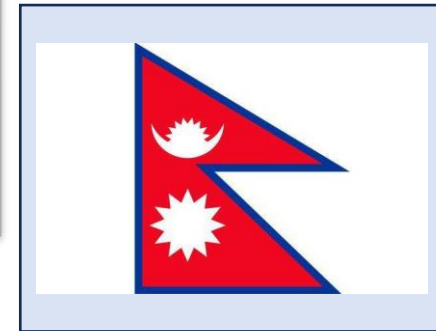
In June 2017, UN secretary general, Antonio Guterres personally led a team to inspect Sarez lake



- 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.

BDS/GNSS Applications

High Accuracy Application—Mount Everest Height Measurement



- Based on BDSBAS PPP, real-time decimeter-level measurement and downlink information realized
- BDS location report covered the whole height measurement procedure

China and Nepal announced the Mount Everest stands at 8848.46m (about 29,032 feet) on December 8, 2020.

International Cooperation

Compatibility and Openness through Bilateral and Multilateral Exchange



- Continuing to carry out compatibility and interoperability coordination and cooperation with providers including GPS, GLONASS, Galileo, QZSS, NavIC, etc.
- Joint discussion and platform construction with The Belt and Road countries, promoting global satellite navigation industry development together.



ICG-7 in Beijing



ICG-13 in Xi'an



ICG-16 BDS Update Presentation



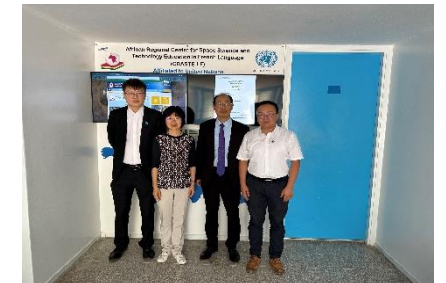
ICG-16 Chinese Delegation (in Abu Dhabi)



ICG-16 Chinese Delegation (in Beijing)



Participation of ICG-17 Second Planning Meeting in Vienna



Participation of ICG-17 WG-S Intersessional Meeting in Rabat

Deeply and continuously engaged in activities under multi-lateral framework such as UNOOSA, held ICG annual meetings twice in 2012 and 2018, participated the ICG-16 in Abu Dhabi, UAE in Oct. 2022, ICG-17 planning meetings to promote compatibility and mutual development with other systems and better serve the world.

International Cooperation

Active Participation to Academic Exchange



Successfully held International Training Workshop on BeiDou Technologies and Applications in the Belt and Road Countries and Regions, Training Courses on the Satellite Navigation and Remote Sensing Applications in China and South Africa, and 13th China Satellite Navigation Conference, actively participated International Navigation Forum, Munich Satellite Navigation Summit, Multi-GNSS Asia Annual Conference.



International Cooperation

Ratification by International Standards to Better Serve the World



In Nov. 2022, BeiDou has been adopted as the third operator to provide tracking systems for ships after being given a certificate by the International Maritime Organization (IMO).



In Nov. 2022, China formally becomes the provider of COSPAS-SARSAT space segment



In June 2022, BDS B2a and B31 signal technology standard proposals passed 3GPP deliberations. BDS positioning technology standards, which are supported by the Fourth- and Fifth-generation mobile communication system network, have been officially released



BDS technical indicators have been verified by ICAO and meet the standards. It has the ability to provide PNT services for global civil aviation users.





Future Visions

- ① 1-3 back-up satellites for BDS-3 constellation will be launched in 2023, to further improve the stability and availability.
- ② Continuously improve the intelligent operation and services of BDS ground segment, to ensure the steady operation and to upgrade performance.
- ③ Further promote marketization, industrialization, and internationalization of BDS scale applications.



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

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