Development of BeiDou Navigation Satellite System

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23 October, 2023

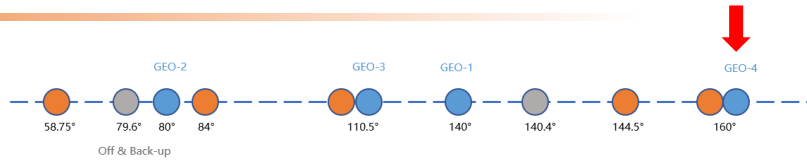## A total of 46 satellites operational in orbit

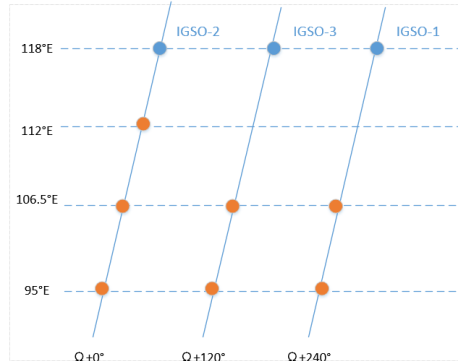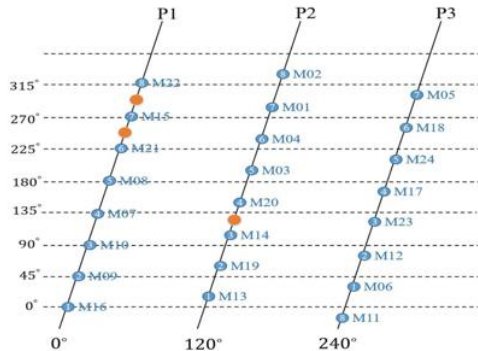The 1th BDS-3 back-up satellite launched on May 17, 2023

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

- To promote the network's availability and stability
- To expand the communication capacity of the system's regional short-messaging function by 1/3
- To enhance positioning accuracy of satellite-based augmentation and precise point positioning and realize quick high-accuracy positioning
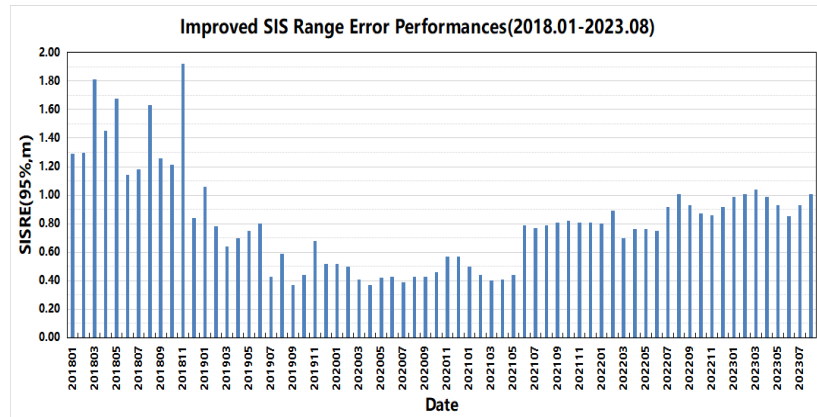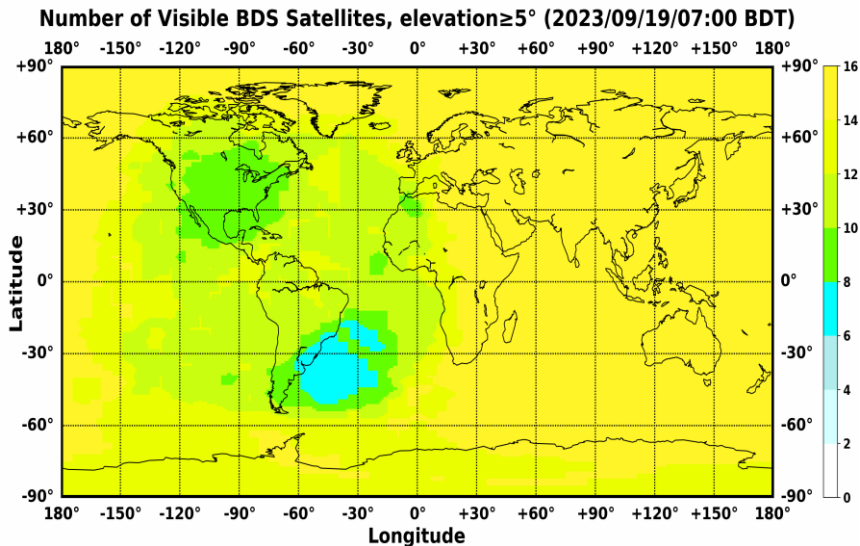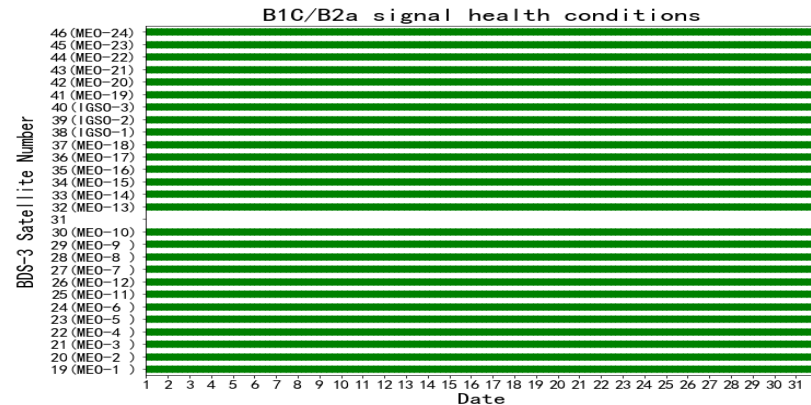- **In-Orbit test and assessment of GEO-4 finished**

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		

Ref.: China's BeiDou Navigation Satellite System in the New Era   (scio.gov.cn)

Number of Visible BDS Satellites, elevation≥5° (2023/09/19/07:00 BDT)

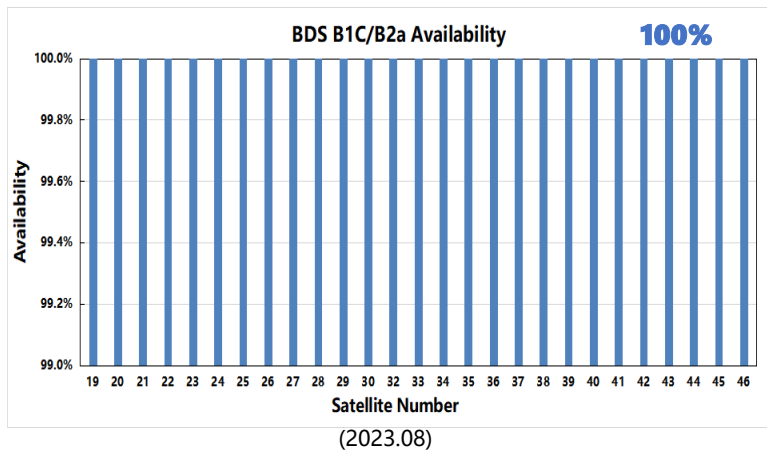Improved SIS Range Error Performances(2018.01-2023.08)

B1C/B2a signal health conditions

- 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.

BDS B1C/B2a Continuity

99.996%

(2023.08)

BDS B1C Position Accuracy (Global, 95%)

(2023.08)

BDS B1C/B2a Availability

100%

(2023.08)

BDS B1C Position Accuracy (August, 2023)
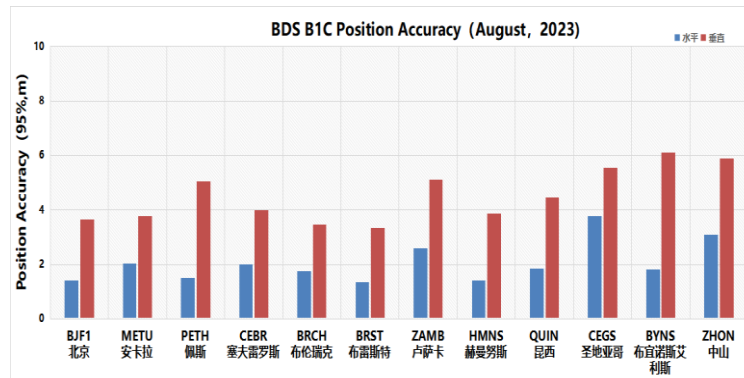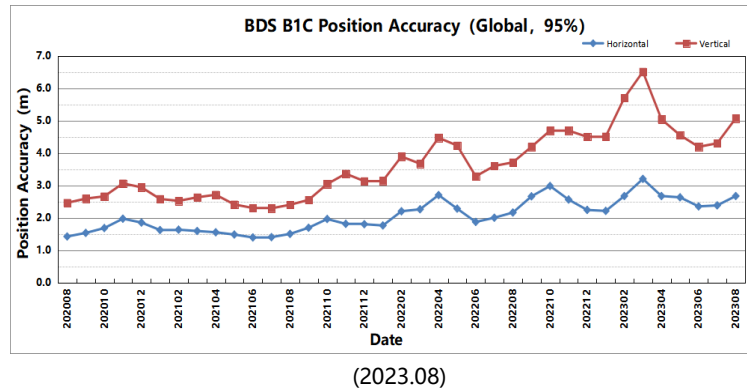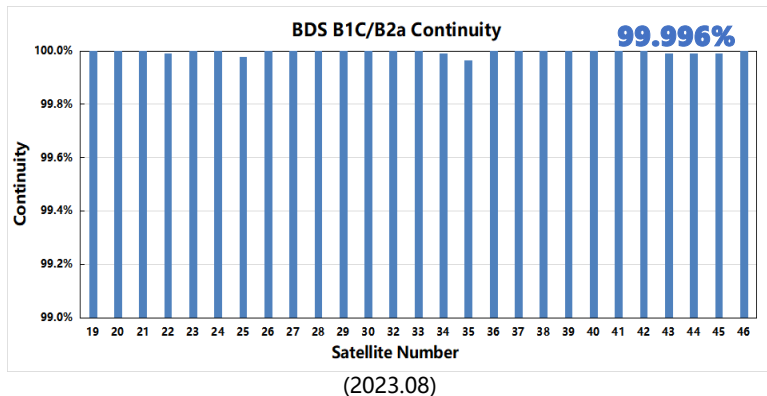
Short Message Communication Service

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)

Global 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

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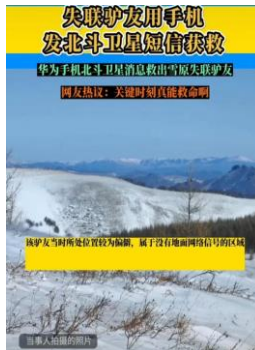
Missing people sent distress messages and positioning coordinates through the short message communication function on mobile phone and were successfully rescued.

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%

RLS Delay Test and Assessment

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

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.
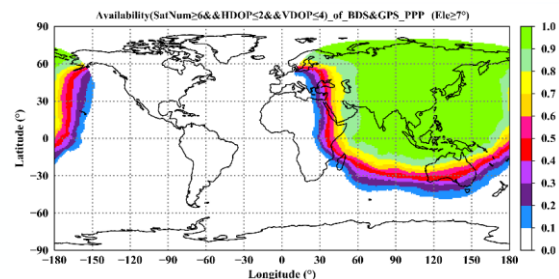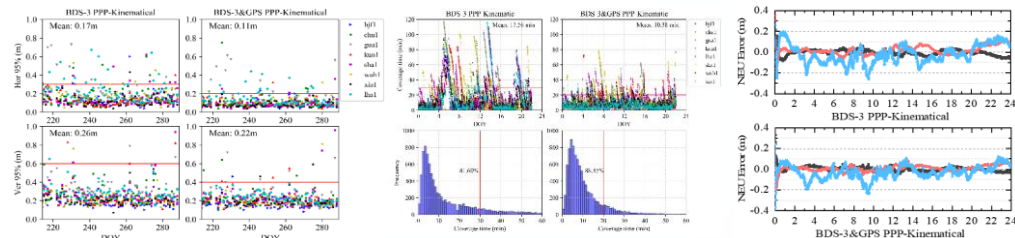
PPP-B2b Service Performance

Coverage

Availability(SatNum≥5&&HDOP≤2&&VDOP≤4)_of_BDS_PPP (Ele≥7°)
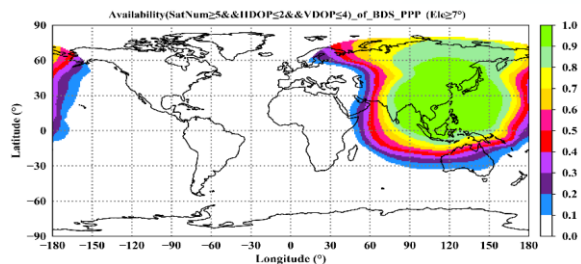
BDS PPP service availability
Sat numbers≥5，HDOP≤2 & VDOP ≤ 4

Availability(SatNum≥6&&HDOP≤2&&VDOP≤4)_of_BDS&GPS_PPP (Ele≥7°)

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≤30cm, V≤60cm)

BDS+GPS
·Positioning accuracy:
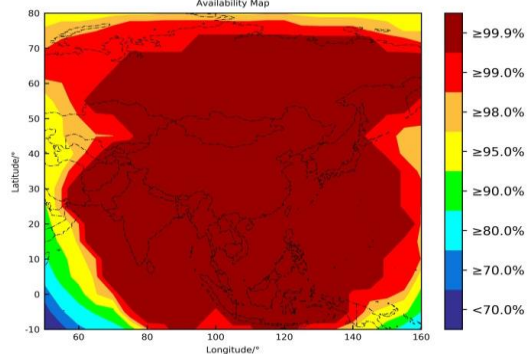•Horizontal (95%) 11cm, Vertical (95%) 22cm
·Convergence time:
•10min (H≤20cm, V≤40cm)

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

Satellite-Based Augmentation Service

03/06/2022 00:05:00 to 03/06/2022 23:59:30
APV-I Availability Map
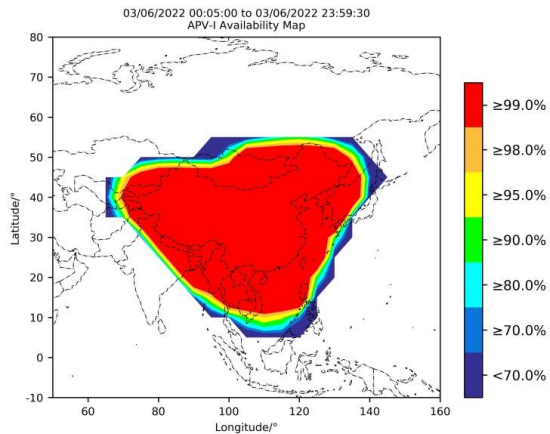
APV-I availability of BDSBAS SF service

Availability Map

APV-I availability of BDSBAS DFMC service

Indicator Requirement

| 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	2×10^{-7}/150s	
	Alert limit	HAL: 40 m VAL: 50 m	HAL: 40 m VAL: 10 m
Continuity		$1-8\times10^{-6}$/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%.
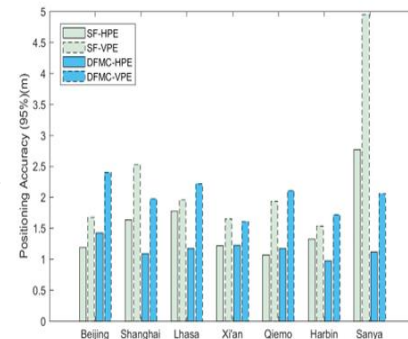
BDS Product Steady Growth

BDS Basic Product

- A complete industrial chain of chips, modules, antennas, boards formed, software and algorithms are completely independently developed, forming a sound development trend.

- By the end of 2022, the accumulated sales volume of chips and modules compatible with BDS exceed **300 million**, quantity of terminals supporting BDS positioning (including smart phone) is over **1.28 billion.**
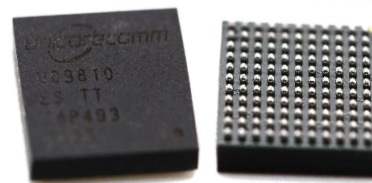
BDS Terminals

- Based on GNSS/LBS Association of China, the sales volume of terminals supporting BDS was **376 million** in 2022, including **264 million** smart phones, **12 million** onboard navigators, and more than **100 million** IoT, wearable, and onboard high accuracy terminals.

BDS/GNSS Applications in Precision Agriculture

## Automatic Driving of Farm Machinery

- Accuracy of 2.5 cm, 30% increase in machinery scheduling efficiency, 5% enhancement in crop production, 10% saving in fuel consumption
- Over 1.6 million intelligent agricultural machineries supporting auto-steering and remote management put into application, and all supporting 62 reference stations are established and in operation

Plant Protection UAV

- Based on RTK-based centimeter-level high-precision, autonomous flight of the plant protection UAV realized according to the route generated by pre-mapping and the parameters set. It can adjust the translation distance and flight speed on the set regional route, to control the flight operation spray range and improve the operation efficiency.
- To spray 300 to 500 acres of land/ per day, and the operation efficiency is 60 to 80 times that of manual labor.

Heat Map Based on BDS-based Statistics in Harvest Time
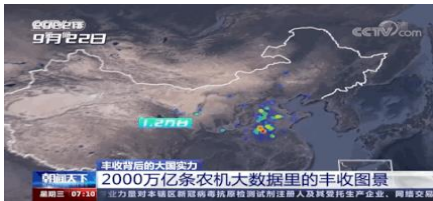
- Agricultural Machineries equipped with BDS terminals played important role in grain production in summer and autumn harvests.
- Trillions of big data statistics were generated.

Annual cumulative operation area reached 10 million acres, significantly improving agricultural production efficiency

BDS/GNSS Applications in Transportation

Intelligent Analysis of Heavy Truck Pollution and Environmental Protection Information

BDS used in driving monitoring, infrastructure and facility safety monitoring, and environmental protection monitoring of heavy trucks. By the end of 2022, more than 8 million BDS-supporting terminals registered in one of the largest dynamic transportation monitoring systems, realizing the 100% coverage in business areas such as public service vessel and costal navigation equipment.

Real-time pollution emission assessment and intelligent monitoring system of heavy trucks collects multi-source real-time data including BDS-based positioning monitoring in urban area and carries out intelligent real-time analysis

BDS installed in

More than 8 million road transport vehicles nationwide	More than 90,000 express vehicles nationwide	More than 48,000 vessels nationwide	More than 13,000 costal navigation aid facilities

BDS/GNSS Application in Power Industry

Digitalization Construction of Power Grid Infrastructure

High Precision Unmanned Powerline Inspection

Safety Management of Employees

Real-time Monitoring of Power Grid Operation

BeiDou Services including PNT, Timing and Frequency, and Short Message Communication all fully applied in the field, with more than 380,000 devices and terminals.

● Safety management of employees ensured based on BDS-based electronic fence, crane arm alarming and protection and other sub-systems,.

● High precision positioning based UAV supports automatic correction of deviation and powerline inspection. Employees check the extent of damage with the UAVs which can inspect powerline according to presuppose settings.

● BDS short message communication also can be used for safe transmission of relevant data information and control instruction.

100% **Power Regulation, Information Management**
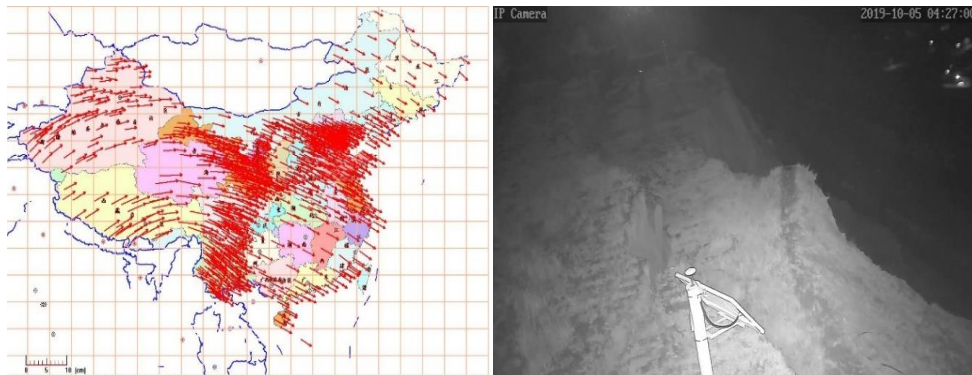All applying BDS Timing Signals

100% **Frequency Synchronization Backbone Network**
All receiving BDS Frequencies

100% **Vehicles in Power Industry**
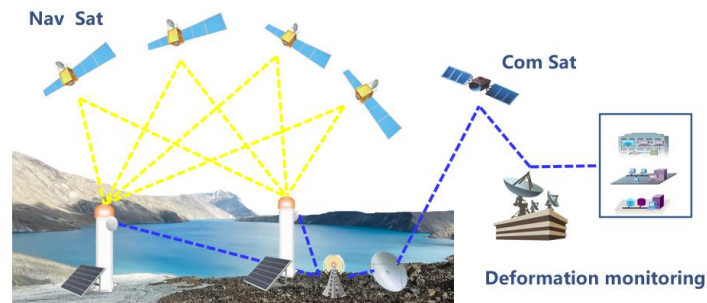All equipped BDS Terminals

BDS/GNSS Applications

High Accuracy Application——Terrain Monitoring

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

➢ 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

➢ 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 in Height Measurement
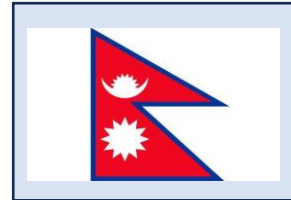
➤ Based on BDSBAS PPP, real-time decimeter-level measurement and downlink information realized

➤ BDS location report covered the whole height measurement procedure

China and Nepal announced the Mount Everest stands at 8848.46m (about 29032 feet) on

December 8, 2020.

# BDS/GNSS Applications in Special Industries

Disaster Relief

BDS Security Monitoring and Alarming Platform

Workers installed BeiDou monitoring equipment at risky sites of geological disasters

"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.

Resource Management
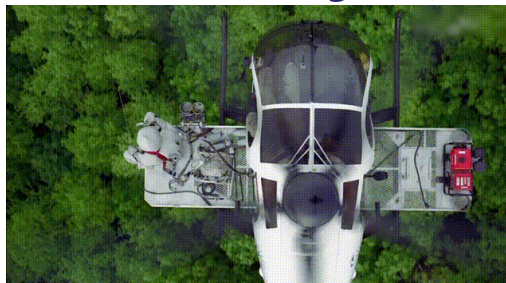
Forestry inspection and Management

Forest rangers used BDS-based forestry patrol terminal to carry out inspection

More than 110,000 BDS terminals applied in forestry and grassland fire prevention, forestry inspection and management, realizing route planning and navigation, positioning for vehicles, disaster monitoring, and personnel safety management.

Public Security

BDS-based Coastal Joint-Control and Management Application Platform

Public security vehicles equipped with BDS terminals

The public security industry has promoted and applied more than 4.5 million BDS terminals in information collection, mobile policing, communication support, and command and dispatch.

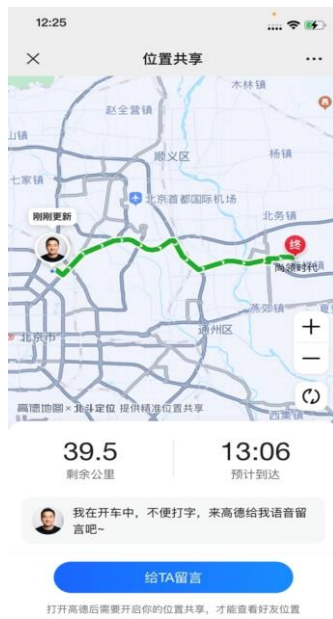# BDS/GNSS Applications in Location-based Industry

Mobile Map

Detailed Information of BDS satellites shown in interface

Lane-Level Navigation/ Traffic Light Reminder

Real-time Location Sharing

BDS-based location service industries remains active, becoming the most important engine for the development of China's satellite navigation and location service industry, significantly improving travel experience of users

Shared Bicycles

The number of shared bike users exceeds 300 million. The average daily order volume exceeds 45 million.
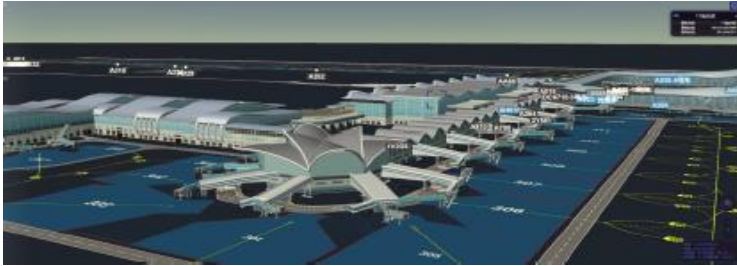
Online Taxi-Hailing

In 2022, a total of more than 5 million online car driver licenses were issued across the country, and 6.96 billion orders were completed throughout the year.

BDS/GNSS Applications in Civil Aviation

Vehicle Management in Airport

- BDS+5G+Multi-Sensors, high-accuracy/active secure onboard terminal and management platform in different airports established in China
- Lane-level positioning, tracing and management realized in every corner of airport
- Comprehensive visual monitoring of vehicles moving in airport realized

Reduce accident risk in airport and enhance operation and management efficiency

Civil Aviation Tracking and Positioning

- Consist of BDS tracking and positioning device, BDS system, BDS main positioning station, and data receiving stations
- Real-time positioning and tracking, also monitoring on speed, direction, height, angle, fuel quantity realized
- Accumulated 19,000 hours for 9,700 flights with 1.05 million data on flight, success rate of data report within 1 minute reaching 97%

Meet 4D/15 tracking requirement by ICAO

BDS/GNSS Overseas Applications

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

BDS basic products have been applied in more than half of the world's countries and regions, with more diverse models and constantly expanding fields. BDS products, technologies, and services are gaining more recognition from international users.

International Cooperation

Compatibility and Openness through Bilateral and Multilateral Exchange

ICG-7 in Beijing

ICG-13 in Xi'an
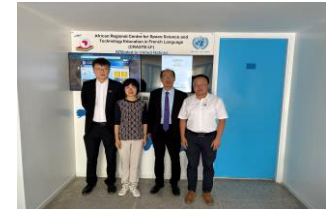

ICG-16 BDS Update Presentation

ICG-16 Chinese Delegation (in Abu Dahbi)

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

- 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.

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

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 B3I 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

- ①1-3 back-up satellites for BDS-3 constellation will be launched in 2023, to further improve the stability and availability.

- ②Continuously improve the intelligent operation and services of BDS ground segment, to ensure the steady operation and to upgrade performance.

- ③Further 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