



Update on BeiDou Navigation Satellite System

China Satellite Navigation Office



Twelfth Meeting of the International Committee on Global Navigation Satellite Systems
2-7 December 2017 Kyoto, Japan



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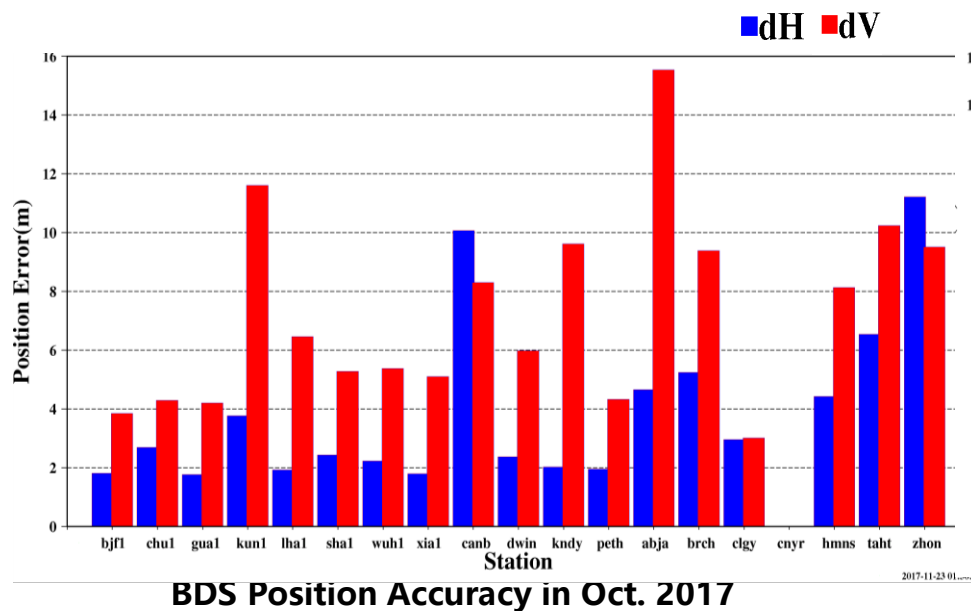
**BDS
Development**

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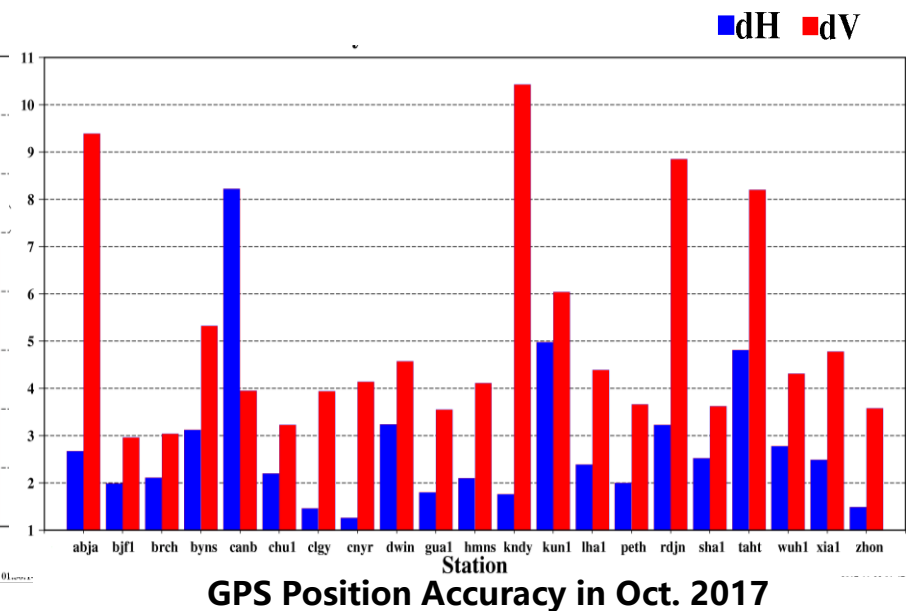
**Near-term
Plans**

BD-2 System

- FOC services from December, 2012 (5GEO+5IGSO+4MEO)
- Two on-orbit backup satellites launched in 2016 (1 IGSO+1 GEO)
- Further improve the stability and availability of BD-2 constellation
- Position accuracy meets with the nominal specification within service area (10 m), and the mean value is 2.3 m (Horizontal) and 5.7m (Vertical), according to the iGMAS analysis data



BDS Position Accuracy in Oct. 2017

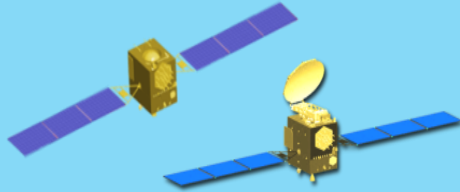


GPS Position Accuracy in Oct. 2017



BD-3 System

Space Segment



- 3 GEO
- 3 IGSO
- 24 MEO

Ground Segment



- Master Control Station
- Uplink Stations
- Monitoring Stations

User Segment



- BDS terminal
- Terminal compatible with other navigation systems

Development Steps of BD-3 System

Step III : Complete System
(24 MEO+3 GEO+3 IGSO)
Global services before Dec. 2020

Step II : Basic System
(18 MEO+1 GEO)
RNSS services before Dec. 2018

Step I: Experimental System
(2 IGSO+3 MEO)
Already completed



BS-3 Experimental System

- **5 BD-3 experimental satellites were launched (2 IGSO+3 MEO)**
- **Test 4 frequencies and signals of RNSS signals**
 - B1 (1575.420MHz); B2 (1191.795MHz)
 - B3 (1268.520MHz); Bs (2492.028 MHz)
- **Add Ka-band inter-satellite-link**
- **New Hydrogen and Rubidium clocks**
- **Verification of**
 - **inter-satellite-link**
 - **timing system**
 - **precision orbit determination and prediction**
 - **PVT specifications assessment**



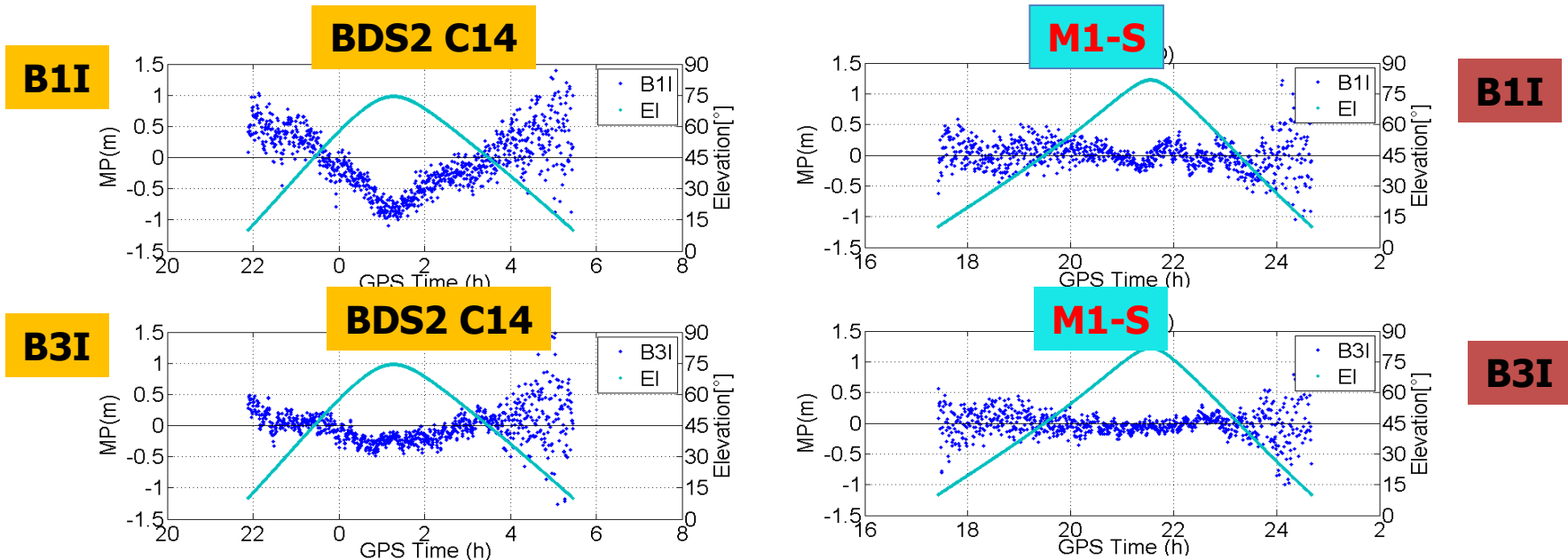
BS-3 Experimental System Performance

- **Based on the results of experiments and verifications, BD-3 signal status has been solidified**
- **BD-3 System performance is much better than that of BD-2**
 - **frequency accuracy has been improved from $5E^{-13}$ to $6E^{-14}$**
 - **frequency stability has been improved from $2E^{-14}(1d)$ to $6E^{-15}(1d)$**
 - **inter-satellite-link supports the high-precision determination and prediction of satellite orbit and clock offset**
 - **stability of rubidium atomic clock: E^{-14}**
 - **stability of hydrogen atomic clock: E^{-15}**
 - **Time synchronization accuracy: 0.14ns**
 - **Multipath effect and pseudo range noise is greatly improved**



BS-3 Experimental System Performance

Multipath -- Comparison btw BDS-2 & test system

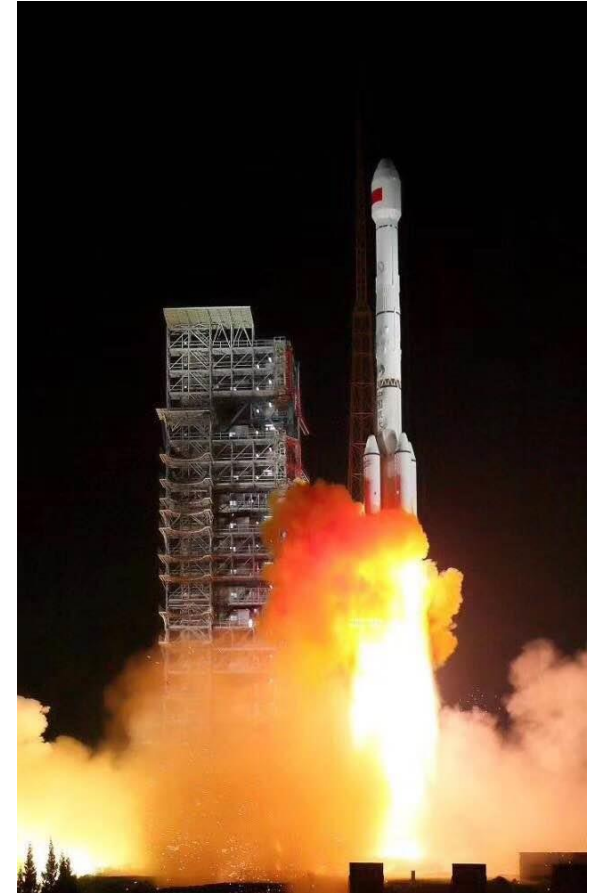


Time series of pseudo-range errors

- Pseudo-range multipath of BDS2 has the elevation angle related systematic effects, especially in B1I signal
- In the new test constellation, however, the elevation angle related multipath is significantly decreased

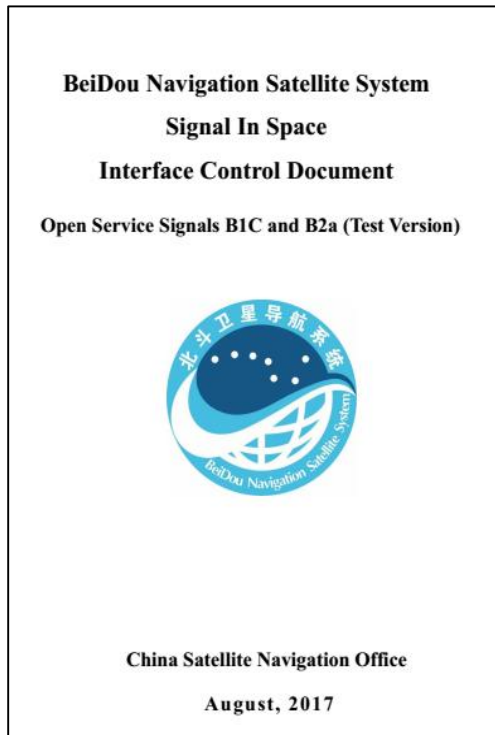
BS-3 Global Constellation

- **On November 5, 2017, the first pair of the 24 BD-3 MEO satellites was successfully launched**
- **These two satellites are operating in-orbit normally, will provide services after tests and networking validation, and accelerate the global coverage of BDS**
- **By utilizing new technologies, the signal-in-space (SIS) accuracy will be superior to 0.5m, the position accuracy will be doubled or quadrupled, and reach 2.5m to 5m**



Information Dissemination

- **The BDS Signal In Space Interface Control Document Open Service Signals B1C and B2a (test version) has been released on website <http://en.beidou.gov.cn>**
- **The official version will be released by the end of 2017**



Other Disseminations	Date of Release
BDS SIS ICD(beta version)	Dec. 2011
BDS SIS ICD (V 1.0)	Dec. 2012
BDS Open Service Performance Standard(V 1.0)	Dec. 2012
BDS SIS ICD Open Service Signal (V 2.0)	Dec. 2013
BDS SIS ICD Open Service Signal (V 2.1)	Nov. 2016

Planning of BD-3 Services

Service type		Signal frequency	Satellite
RNSS	Open	B1I, B3I, B1C, B2a, B2b	3GEO+3IGSO +24MEO
	Authorized	B1A, B3Q, B3A	
SBAS	Open	B1C, B2a	3GEO
	Authorized	B1A	
Regional short message communication services	Authorized	L(Inbound), S(Outbound)	3GEO
Global short message communication services		L (uplink), B2b (downlink)	14MEO
International SAR service		uplink: 406MHz downlink: 1544-1545MHz	6MEO
Transmission of precise positioning information		B2b	3GEO



Planning of BD-3 Services

Service type	Service area	Nominal Specification	Remarks
RNSS	Global	Positioning accuracy < 10m Timing accuracy < 20ns Velocity accuracy < 0.2m/s	In the Asia-Pacific region, services are improved by the GEO and IGSO satellites Timing accuracy < 10ns Velocity accuracy < 0.1m/s
short message communication services	China and the surrounding areas	Regional communication ability < 1000 Chinese characters per time	RDSS, GEO satellites
	Global	Trial communication ability < 40 Chinese characters per time	Communication + RNSS, MEO satellites
Transmission of precise positioning information	China and the surrounding areas	Transmission of decimeter-level precise positioning information (1kbps)	B2b signal of GEO satellites

Progress of BDSBAS

- **In October 2017, 3 PRN codes (No. 130, 143, 144) at L1C/A and L5 for the BDSBAS were assigned**
- **BDSBAS has been recognized as an official SBAS provider in the ICAO family**
 - **The SBAS service provider identifier has been assigned**
 - **The UTC standard identifier has also been assigned by the ICAO**
- **Above progress has laid foundation for the follow-up construction of BDSBAS, as well as its provision of standard navigation services for the civil aviation sector**



Planning of BDSBAS

➤ Space Segment

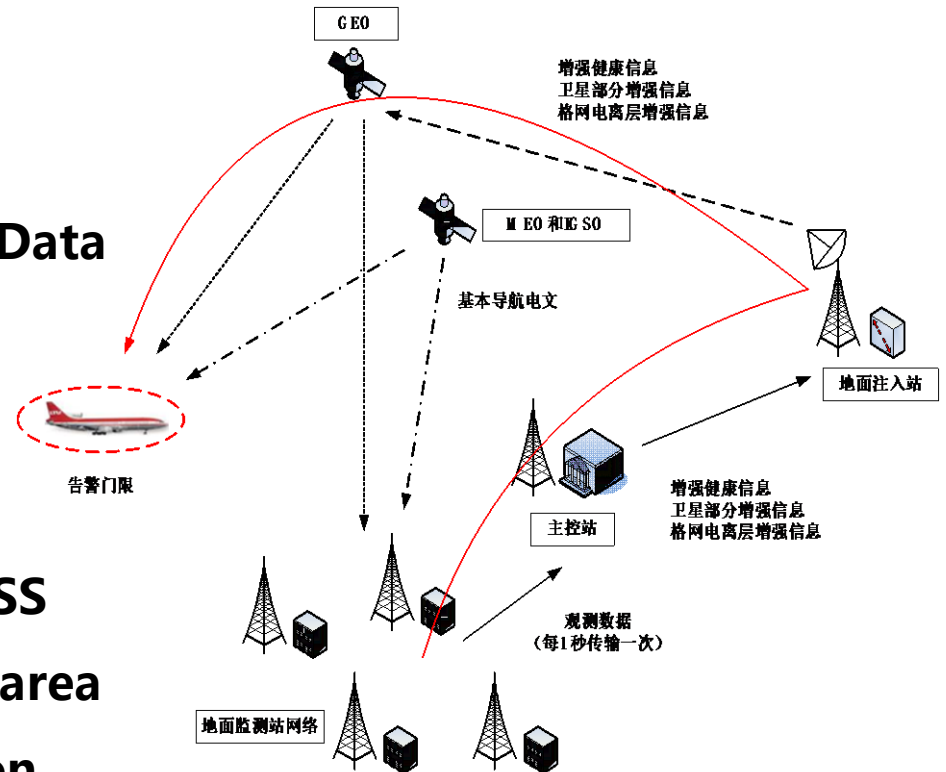
- Three BD-3 GEO satellites (80°E , 110.5°E , 140°E)

➤ Ground Segment

- Operation and Control Center, Data Centers, Uplink Stations, Monitoring Stations

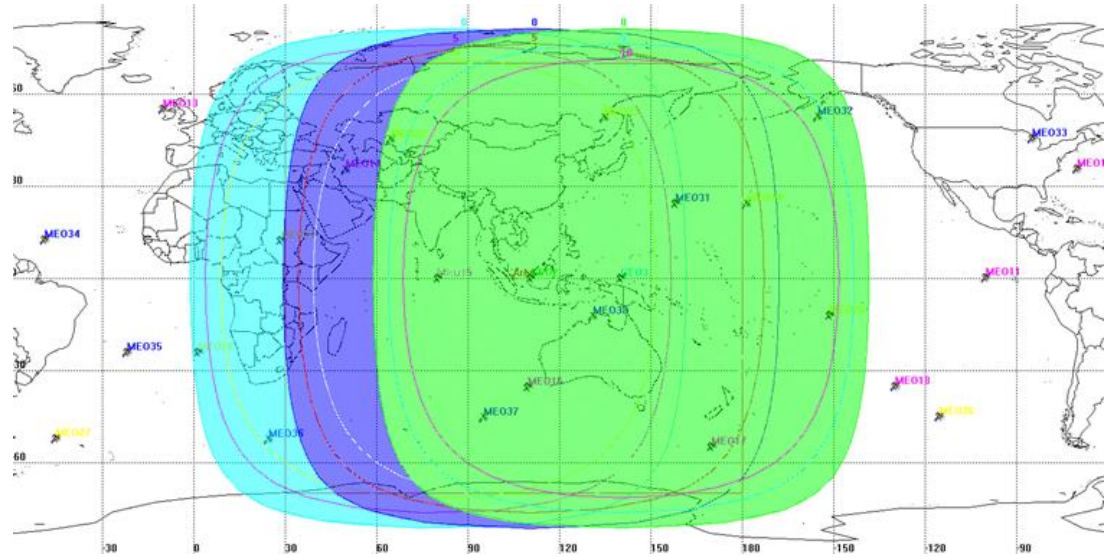
➤ User Segment

- SBAS terminals can receive RNSS navigation messages and wide area differential integrity information broadcast by GEO satellites



Planning of BDSBAS

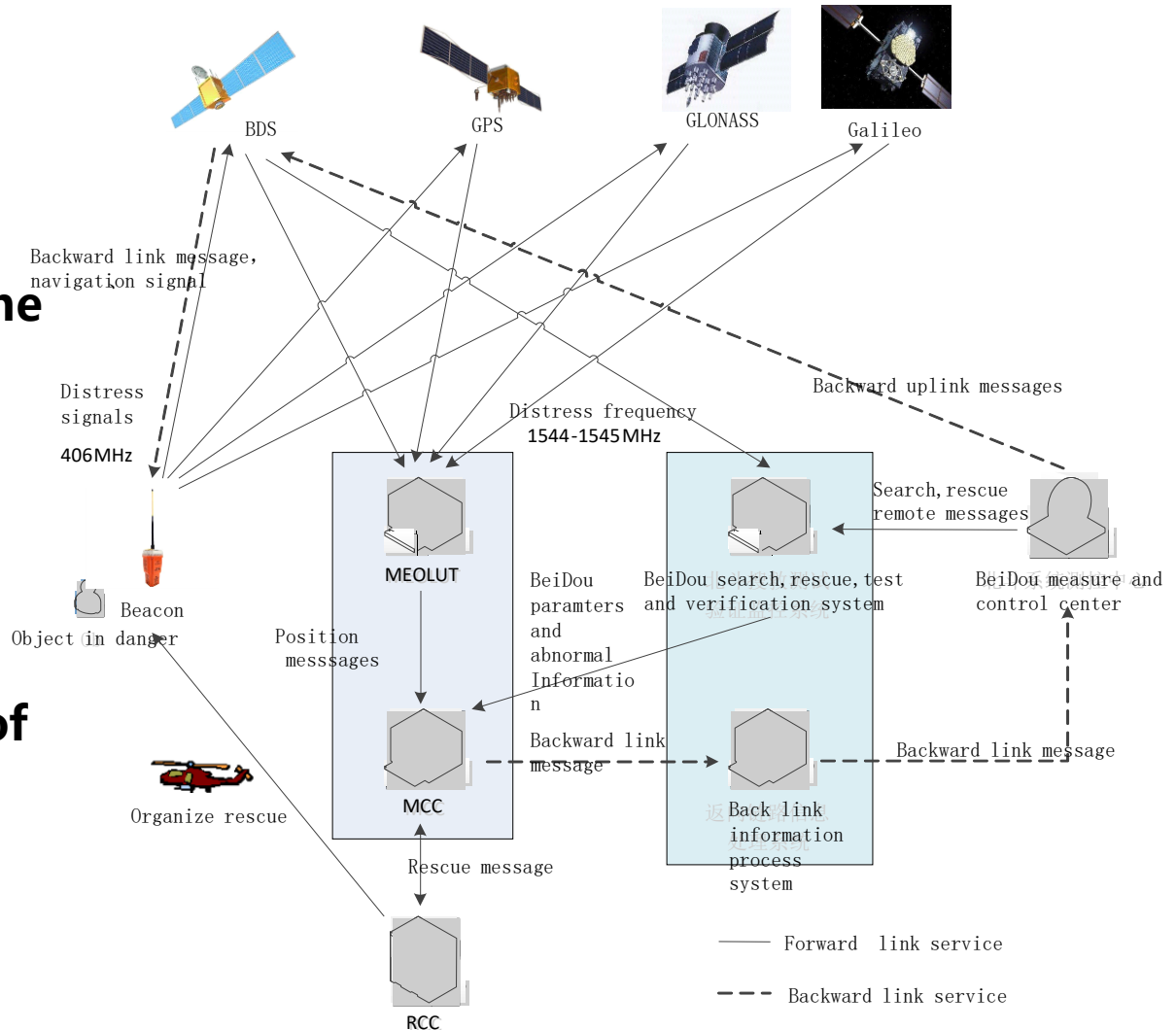
- Following the ICAO standards
- Service area: China and surrounding areas
- Providing CAI-I service



Service accuracy(95%)	Positioning accuracy	Single frequency	Double frequency
		H < 2.5m, V < 4.0m	H < 1.5m, V < 2.0m
	Timing accuracy	10ns	
	Velocity accuracy	0.1m/s	
Service reliability	Availability	>99%	
	Integrity	Alarm time: 6s Risk probability: 10 ⁻⁷ /approach (threshold: H 40m, V 10-15m)	
	Continuity	Risk probability: 10 ⁻⁶ /15s	

Planning of SAR Services

- Six MEO satellites with SAR payloads
- Following the IMO standards to serve the global users
- Providing reliable distress alert
- Meeting with the basic requirements of joining in COSPAS-SARSAT



BDS Applications

- **The domestic output value of BDS-related industry in 2016 surpassed RMB 210 billion, of which BDS contributed more than 70%**
- **By October 2017, the sales volume of BDS navigation chips and modules exceeded 50 million pieces, and that of high-precision surveying boards and navigation antenna captured 30% and 90% of market shares respectively**
- **At present, BDS has already covered more than 50 countries and over 3 billion people. BDS-related products have accessed to the markets of over 70 countries and regions**
- **With the release of the first Chinese in-house developed meter-level fast positioning BDS chip, BDS applications have begun to embrace the era of meter-level positioning**



BDS Applications

- **BDS has been widely applied in the transportation, logistics, marine fishing, precision agriculture, land mapping, deformation monitoring, emergency rescue, and other industries and fields:**
 - **In traffic management industry, the amount of major accidents has decreased by 46.7%, and the death toll has reduced by 48.9%**
 - **With the BDS-based maritime applications, over 10,000 lives have been saved**
 - **The production of precision agriculture has increased by 5%, and the oil consumption by agricultural machine has decreased by 10%**
 - **The time for surveying and mapping of national land is shortened from a few days to several seconds**



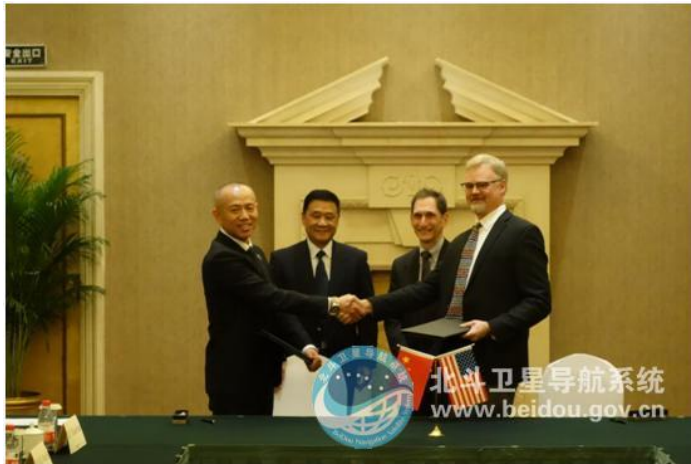
BDS Applications

- **BDS has been fully put into mass applications**
- **The BDS-based navigation services has been adopted by various enterprises in the fields of manufacturing of mobile and smart terminals, location-based services (LBS), e-commerce, and so on**
- **BDS-based LBS have been widely applied in mass consumption sector and people's livelihood, and many innovative applications have emerged, such as caring for the seniors and children, shared vehicles, BDS-based logistics, and so on, which have been changing people's life and providing more convenience for the public**



International Cooperation of BDS

- The Joint Statement on Civil Signal Compatibility and Interoperability between the GPS and the BDS was signed in November 2017
- The Fourth Meeting of China-Russia Cooperation Program Committee on Satellite Navigation was held in October 2017, while the joint iGMAS service statement was signed, and the service platform was kicked off
- In March 2017, a multi-system (GPS/GLONASS/BDS) ship-borne receiver standard was approved by the IMO
- BDS has been included in the PNT guidelines of maritime applications



International Academic Exchanges

- The 9th China Satellite Navigation Conference will be held between May 23rd and 25th, 2018, in Harbin, Heilongjiang Province
- China will host the ICG-13 meeting from Nov. 4th to 9th, 2018, in Xi'an, Shaanxi Province, after the precedent organization of ICG-7 in





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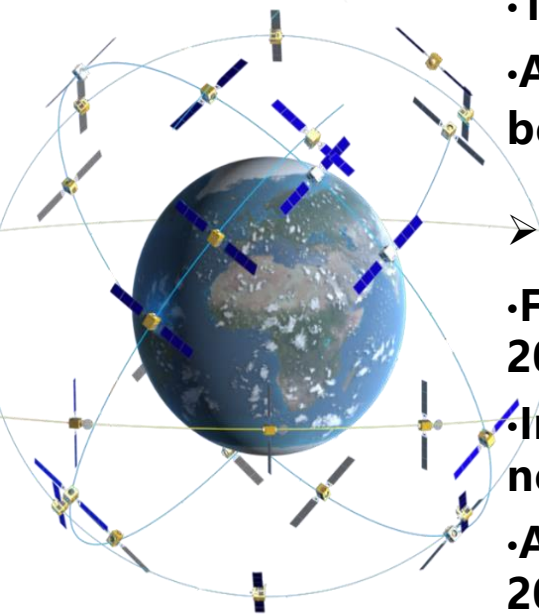
**BDS
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**Near-term
Plans**



Near-term Plans



➤ Deployment of BD-3 System

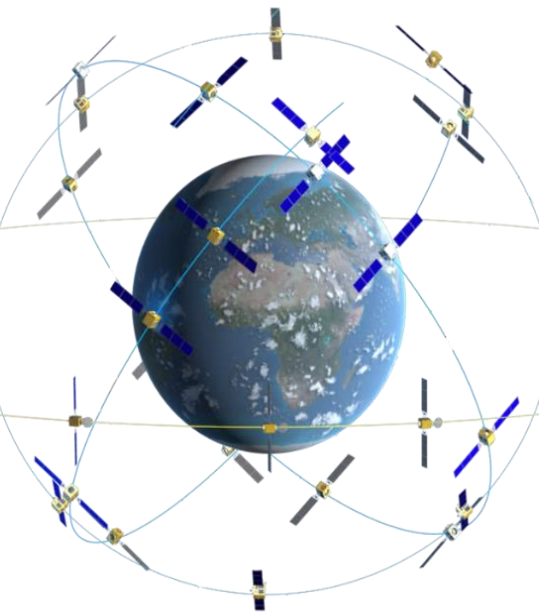
- 16 MEO+1 GEO satellites to be launched in 2018
- Another 6 MEO+3 IGSO+2 GEO satellites to be launched between 2019 and 2020

➤ Construction of BDSBAS

- First GEO satellite with BDSBAS payload to be launched in 2018, to implement system integration and test
 - Improve the construction of ground monitoring stations network in 2019
 - Another two GEO satellites with BDSBAS to be launched in 2020, to form initial operational capability
- ## ➤ Make plans to build a BDS-based PNT system
- Covering indoor, underwater, space and other special areas
 - Looking forward to sharing proposals and experience with relevant countries regarding building a PNT system



Near-term Plans



➤ **Continue to promote integrated applications and development of related industries**

• **Bring GNSS high-precision services in combination with cloud computing, Internet of Things, big data and other technologies**

• **Push forward the integration between BDS-related industries and high-end manufacturing, software, integrated data industries**

➤ **The domestic output value of BDS-related industry in 2020 will exceed 400 billion**

➤ **Keep enhancing cooperation and communication with other navigation satellite systems, and provide better services to the users along the “Belt and Road” area, and all over the world**





**Thanks for your attention and support for
BDS!**

China Satellite Navigation Office
<http://en.beidou.gov.cn>



iGMAS APP