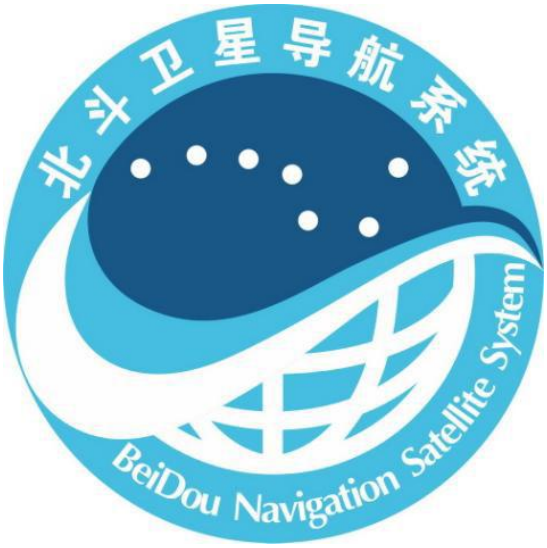
Development of the BeiDou Navigation Satellite System

（Version 4.0）



China Satellite Navigation Office

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Preface

The BeiDou Navigation Satellite System (hereinafter referred to as BDS) has been independently developed and operated by China with an eye on the needs of the country's national security as well as economic and social development. As a temporal-spatial infrastructure of national significance, the BDS provides all-time, all-weather and high-accuracy positioning, navigation and timing services to global users.

China attaches great importance to the BDS construction and development, and has been exploring a path to develop a navigation satellite system suitable for its national conditions since 1980s, and gradually formulated a three-phase development strategy. By 2000, the construction of BDS-1was completed to provide services to China; by 2012, the construction of BDS-2 was completed to provide services to the Asia-Pacific region; the construction of BDS-3 will be completed to provide services worldwide in 2020. With the BDS as core, a more ubiquitous, integrated and intelligent, comprehensive national positioning, navigation and timing (PNT) system is scheduled to be established by 2035.

Many Chinese administrations have been involved in the management processes of the BDS development, operation and application. The China Satellite Navigation Committee and the China Satellite Navigation Office (CSNO) have been jointly established by the related governmental departments of China, to take managerial responsibilities on the construction, applications and international cooperation of BDS. At the same time, expert committees and expert groups have been set up to give full play to the advisory role of expert think tanks and implement scientific and democratic decision-making processes.

China applies the principle that “BDS is developed by China, dedicated to the world, and aiming to be top-class”, and adheres to the BeiDou spirit of “independent innovations, unity and collaboration, overcoming difficulties, and the pursuit of excellence”. BDS provides spatial and temporal information security for economic and social development, and is one of the important achievements in the past 40 years of China’s reform and opening-up, as well as one of the major technical achievements in the past 70 years since the establishment of the People’s Republic of China, and serves as a global public product contributed by China to the world. China is willing to share the outcome of the BDS construction and development with all other countries, to promote global satellite navigation development and make Global Navigation Satellite Systems (GNSS) serve the world and benefit mankind.

I. The BDS Overview

Based on its national conditions, China upholds the principles of "independence, openness, compatibility and gradualness", to steadily push forward the BDS construction and development.

(I) Goals of Development

The BDS development aims to build a world-class navigation satellite system to meet the needs of the country's national security as well as economic and social development; to provide continuous, stable and reliable services for global users; to develop BDS-related industries to support China's economic and social development and to improve people's living standards; and to enhance international cooperation to share the development fruits in the field of satellite navigation to improve the comprehensive application efficiency of global satellite navigation systems..

(II) Principles of Development

- By "independence", it means to the BDS uphold independent construction, development and operation, and to acquire the capability to independently provide satellite navigation services to global users.

- By "openness", it means to provide open satellite navigation services free of charge, and to encourage all-scale, multilevel and high-quality international exchanges and cooperation.

- By "compatibility", it means to enhance compatibility and interoperability with other navigation satellite systems, and to encourage international exchanges and cooperation, so as to provide better services to users.

- By “gradualness”, it means to carry out the BDS project in a phased approach, to enhance BDS service performance, and to boost the healthy, rapid and continuous development of satellite navigation industries.

(III) Main Architecture

BDS is mainly comprised of three segments: A space segment, a ground segment and a user segment.

- The space segment. The BDS space segment consists of a number of satellites located in the Geostationary Earth Orbit (GEO), Inclined Geo-Synchronous Orbit (IGSO) and Medium Earth Orbit (MEO).

- The ground segment. The BDS ground segment consists of various ground stations, including master control stations, time synchronization/uplink stations, monitoring stations, as well as operation and management facilities of the inter-satellite link.

- The user segment. The BDS user segment consists of various kinds of the BDS products, systems, and services as well as those compatible with other navigation systems, including basic products such as chips, modules and antennae, terminals, application systems and application services.

(IV) Three-Step Development Strategy

- The first step is to construct BDS-1. The project started in 1994, and the system was completed and put into operation in 2000 with the two in-orbit GEO satellites. Using an active positioning scheme, the system provided users in China with positioning, timing, wide-area differential and short message communication services. The third GEO satellite was launched in 2003, which further enhanced the system’s performance.

- The second step is to construct BDS-2. The project started in 2004, and by 2012, a total of 14 satellites, including 5 GEO satellites, 5 IGSO satellites and 4 MEO satellites, were launched to complete the space constellation deployment. In addition to a technical scheme compatible with that of BDS-1, BDS-2 further included a passive positioning scheme, and provided users in the Asia-Pacific region with positioning, velocity measurement, timing and short message communication services.

- The third step is to construct BDS-3. The development of BDS-3 started in 2009, and will be comprehensively completed with the launching of 30 satellites by 2020. By inheriting the technical schemes of both active and passive services, BDS-3 can provide global users with basic navigation (including positioning, velocity measurement and to timing), global short message communication, and international search and rescue services, and offer users in China and surrounding areas with regional short message communication, satellite-based augmentation, ground augmentation and precise point positioning services, etc.

(V) The BDS Characteristics

The BDS development follows a model of developing regional service capacities fast, then gradually extending the services globally. This practice has blazed a path for building a satellite navigation system with Chinese characteristics, and enriched the development models for navigation satellite systems worldwide.

BDS possesses the following characteristics: Firstly, its space segment is a hybrid constellation consisting of satellites in three types of orbits. In comparison with other navigation satellite systems, BDS operates more satellites

in high orbits to offer better anti-shielding capabilities, which is particularly observable in terms of performance in the low-latitude areas. Secondly, BDS provides multi-frequency navigation signals, and is able to improve the service accuracy by using combined signals. Third, BDS integrates navigation and communication function, and possesses multiple service capabilities, namely, basic navigation, short message communication, international search and rescue, satellite-based augmentation, ground augmentation and precise point positioning, etc.

II. The Construction Progress

By the end of 2019, 24 BDS-3 MEO satellites have been launched, marking the complete deployment of the core BDS-3 constellation to comprehensively upgrade the system service performance and users' experience, while the BDS services are available worldwide.

(I) System Deployment

- The global constellation deployment has been smoothly accelerated. Twenty-eight (28) constellation satellites (including 1 GEO satellite, 24 MEO satellites and 3 IGSO satellites) have been successfully launched by the end of 2019, stable and reliable inter-satellite links have been established, and the joint networking of inter-satellite and satellite-ground has been completed.

- The ground segment has been upgraded and improved. BDS-3 has established high-precision time and space references, added inter-satellite link operation management facilities, and realized satellite orbit and clock difference measurement based on joint observations using satellite-ground and inter-satellite links. It possesses the capability to provide positioning, navigation, timing services. At the same time, ground facilities for short message communication, international search and rescue, satellite-based augmentation, precise point positioning and other services have also been built.

(II) System Operation

- Constantly improve the accountability system for stable operations. Perfect a normalized multi-party response mechanism for the BDS space segment, ground segment and user segment. Improve the satellite's autonomous

health management, fault response and handling capabilities. Continuously enhance the capability of assurance to manage the operation of large-scale constellations, and promoting the stable operation of the system to become more intelligent.

- Realize the smooth transition between the systems. BDS-3 is forward compatible with BDS-2, and can provide users with continuous, stable and reliable services.

- Innovate risk prevention, control and management measures. Adopt a satellite backup strategy both in-orbit and on-ground to reduce and avoid the effects of emergent in-orbit satellite faults affecting service performance. Redundant and backup design is adopted to enable ground facilities to eliminate weak links, and to enhance system reliability.

- Maintain high-precision time and space references, and improve interoperability with the time and coordinate frameworks of other satellite navigation systems. The BeiDou Navigation Satellite System Time (BDT) is used as the time reference for BDS. BDT adopts International System of Units (SI) second as the basic unit, and accumulates continuously without leap seconds. The initial epoch of BDT was 00:00:00 on January 1, 2006 Coordinated Universal Time (UTC). BDT is related to UTC through UTC(NTSC), which is maintained by National Time Service Center, Chinese Academy of Sciences. The offset between BDT and UTC is less than 50ns (modulo 1 second). The leap second information between BDT and UTC is broadcasted in the navigation message. BDS adopts the BeiDou Coordinate System (BDCS). The BDCS definition is in accordance with the International Earth Rotation Service Organization (IERS) specification and is consistent with

the definition of the China Geodetic Coordinate System 2000 (CGCS2000) with identical reference ellipsoid parameters, aligned with the latest International Earth Reference Framework (ITRF), and is updated annually.

- Establish a GNSS monitoring and assessment network. Extensively exploit international resources to construct a network of monitoring and assessment stations and various types of centers, including data centers, analysis centers, monitoring and assessment centers, synthetic product and service centers, operation and management centers, etc., to carry out monitoring and assessment of the constellation status, signal accuracy, signal quality and service performance of major GNSS providers, to offer raw data, fundamental products and information services, and to provide references for users' applications.

(III) Service Performances

The BDS positioning, navigation and timing service performance standards are as follows:

- System service coverage: global;
- Positioning accuracy: 10 meters horizontally, 10 meters vertically (95%);
- Velocity measurement accuracy: 0.2 m/s (95%);
- Timing accuracy: 20 nanoseconds (95%);
- System service availability: better than 95%.

In the Asia-Pacific region, the positioning accuracies are 5 meters horizontally and 5 meters vertically (95%).

According to the results of the actual measurement, the BDS service capabilities have achieved and are better than above standards in an all-round way.

(IV) Future Development

By the end of June 2020, another 2 BDS-3 GEO satellites will be launched. In the future, BDS will continue to improve service performance, expand service functions, and guarantee continuous and stable operation, to further improve global basic navigation and regional short message communication service capabilities, and to provide the global short message communication, satellite-based augmentation, ground augmentation, international search and rescue, and precise point positioning services, etc. BDS is planned to provide following services in 2020.

Table Services to be provided by the BDS in 2020

Service Types		Signal(s)/Band(s)	Broadcast Satellites
Worldwide	Positioning, Navigation and Timing (RNSS)	B1I, B3I	3GEO+3IGSO+24MEO
		B1C, B2a, B2b	3IGSO+24MEO
	Global Short Message Communication (GSMC)	Uplink: L Downlink: GSMC-B2b	Uplink: 14MEO Downlink: 3IGSO+24MEO
	International Search And Rescue (SAR)	Uplink: UHF Downlink: SAR-B2b	Uplink: 6MEO Downlink: 3IGSO+24MEO
China and Surrounding Areas	Satellite-based Augmentation System (SBAS)	BDSBAS-B1C, BDSBAS-B2a	3GEO
	Ground Augmentation System (GAS)	2G, 3G, 4G, 5G	Mobile communication networks, Internet
	Precise Point Positioning (PPP)	PPP-B2b	3GEO
	Regional Short Message Communication (RSMC)	Uplink: L Downlink: S	3GEO
Note: China and surrounding areas means 75°E to 135 °E, 10°N to 55°N			

- Basic navigation services. Basic navigation services are available for global users. The signal-in-space (SIS) accuracy is superior to 0.5m. The global

positioning accuracy is better than 10 meters, the velocity measurement accuracy is better than 0.2 m/s, the timing accuracy is better than 20 nanoseconds. The overall performance will be greatly improved in the Asia-Pacific region, with the positioning accuracy better than 5 meters, the velocity measurement accuracy better than 0.1 m/s, and the timing accuracy better than 10 ns.

- Short message communication services. As for short message communication services in China and surrounding areas, the service volume will be increased to 10 million times per hour and the receiver transmit power will be reduced to 1-3W, with capability as 1,000 Chinese characters per message (14,000 bytes). As for global short message communication services, the service capability is 40 Chinese characters per message (560 bytes).

- Satellite-based augmentation services. The satellite-based augmentation services will be provided to users in China and surrounding areas, in accordance with the standards of the International Civil Aviation Organization (ICAO), supporting single frequency and Dual Frequency Multi-Constellation (DFMC) formats, and meeting the ICAO performance requirements.

The BeiDou ground-based augmentation system. Since provision of services in July 2017, the BeiDou ground-based augmentation system has been providing augmented positioning services, including real-time precision positioning and navigation services at meter, decimeter and centimeter level, and post-processing services at millimeter-level.

- International search and rescue services. The international search and rescue services will be provided to global users. This function will be offered by a global MEOSAR system jointly supported by BDS and other navigation

satellite systems in accordance with the COSPAS-SARSAT standards. Distress alert services based on return-links will also be provided, which will greatly enhance the efficiency and capability of search and rescue services.

- Precise Point Positioning service. The precise point positioning (PPP) service will serve users in China and surrounding areas, with the dynamic precise position service accuracy at decimeter level and static precise position service accuracy at centimeter level.

III. Application and Industrialization

China strives to develop satellite navigation application industries, in an effort to build a BDS industrial chain which comprises the basic products, application terminals, application systems and operational services, keeps strengthening BDS-related industrial support, promotion and innovation systems, continuously improves the industrial environment, expands the application scale for integrated development, and increases the comprehensive benefits of the satellite navigation industry.

(I) Fundamental Products and Facilities

- BDS/GNSS fundamental products have been applied in a massive scale and the technology has advanced to a world-class level. The BDS-3 chips with the 28nm ASIC technology have been extensively applied in the fields of Internet of Things and consumer electronics. The 22nm dual-frequency positioning chips are ready to come into market, The full-frequency high-precision integrated chips have been put into production. The performance of BDS chips have been pushed a step forward. By the end of 2019, the sales volume of domestically produced BDS-enabled navigation chips and modules has exceeded 100 million pieces, while the quarterly sales volume has exceeded 10 million pieces. The BDS navigation products, including chips, modules, high-precision OEM boards and antenna have been exported to more than 100 countries and regions.

(II) Industrial and Regional Applications

Since provision of services, BDS has been widely used in transportation,

agriculture, forestry, fisheries, hydrological monitoring, meteorological forecasting, communication, power dispatching, disaster relief, public security and other fields, and has been serving national significant infrastructures, thereby resulting in remarkable economic and social benefits.

- In the field of transportation, BDS has been widely used in the monitoring and management of priority transportation, highway infrastructure safety, port scheduling, and real-time high-precision positioning. By the end of 2019, more than 6.5 million road operating vehicles, 40 thousand postal and express delivery vehicles, 80 thousand buses in 36 central cities, 3.2 thousand inland navigation facilities, and 2.9 thousand marine navigation facilities, have adopted BDS, which forms the world's largest dynamic monitoring system for road operating vehicles. It is advancing in-depth the management of railway transportation, inland navigation, ocean navigation, air transportation and transportation infrastructure construction, In recent years, \the number of major accidents and the death toll in the field of road transportation have both been decreased by 50%.

- In the fields of agriculture, forestry and fishery, BDS-based automatic driving systems have been equipped on more than 20 thousand sets of agricultural machinery and equipment, saving 50% of the labor cost. BDS-based agricultural machinery operation supervision platforms and IoT platforms provide services for more than 100 thousand sets of agricultural machinery equipment, greatly improving management and operation efficiency. As for forestry, the BDS positioning and short message communication functions are widely applied in forest fire prevention, natural forest protection and survey, extermination of disease and insect pest, and other scenarios. As for fishery,

BDS provides services for ship positioning and monitoring, emergency rescue, information release, and fishing vessel management. BDS-enable terminals have been installed by more than 70 thousand fishing boats and law enforcement vessels across China. With the BDS-based maritime applications, more than 10,000 lives have been saved.

- In the field of hydrological monitoring, BDS has been successfully applied at the real-time transmission of hydrological forecast information in mountainous regions, which has improved the accuracy of the disaster forecasting, and helped the planning and scheduling programs for the flood and drought control.

- In the field of weather forecasting, a series of BDS-based terminals, equipment have been developed for weather forecast, and various application solutions have been worked out, to improve the observation accuracy, the automatic capacity and emergency response capabilities.

- In the field of time synchronization for telecommunication systems, the BDS one-way and two-way timing demonstration program has achieved breakthroughs in some key technical areas such as long distant fiber technology, and an integrated satellite-based timing system has been developed.

- In the field of power distribution, power system time synchronization has been implemented based on BDS, which has created a basis for high precision applications such as the electric accident analysis, the electricity early warning and protection systems.

- In the field of disaster relief and mitigation, the BDS navigation, positioning, short message communications and position reporting capabilities have provided services for the nationwide real-time disaster relief commanding

and dispatching, emergency communications, rapid reporting and sharing of disaster information, which has significantly improved the rapid response of the disaster emergency relief and decision-making capability. A tri-level platform covering the national ministries, the provinces, and cities and counties has been built to offer six-tier application services, with more than 45,000 terminals using BDS. The BDS/GNSS high-precision technologies have been applied in the field of geological disaster monitoring, while the landslides in Gansu province have been successfully forecast repeatedly, with time accuracy at the second level and deformation accuracy at the millimeter level.

- In the field of public security, a tri-level public security application system covering the national ministries, the provinces, and cities and counties has been built, more than 400 thousand BDS terminals for the policemen have been connected to a location service platform. The time reference for public security network has been synchronized based on the BDS timing services. BDS has played an important role in safeguarding major events, such as the Asia-Pacific Economic Cooperation (APEC) Meeting and the G20 Summit, etc.

(III) Mass Market Applications

The mass market BDS applications enjoy broad prospects. The BDS-based navigation services have been widely adopted by e-commerce enterprises, manufacturers of intelligent mobile terminals and location-based services providers. The services have extensively entered into the fields of mass consumption, share economies, and those related to people's livelihood With the arrival of the 5G commercial era, BDS is accelerating the integration with new technologies such as the new generation of mobile communication, block-chain, artificial intelligence, etc. New modes, business forms and economy of the BDS

applications are emerging, profoundly changing people's production and life.

- In the field of e-commerce, logistics trucks and delivery personnel of many e-commerce companies in China are using the BDS-based vehicle-borne and handheld terminals, to dispatch vehicles, deliverymen and goods at real time.

- In the field of smart phones, mainstream chip manufacturers both at home and abroad have introduced integrated chips, which are compatible with BDS. By the third quarter of 2019, more than 400 models of smart phones sold in China are supporting positioning functions, among which about 300 models are supporting BDS.

- In the field of smart portable devices, a variety of BDS-enabled smart wearable devices such as watches and cards, are emerging in social services and caring for vulnerable groups, and have already been widely used by students, seniors and many others.

(IV) Policies and Industrial Development

- Continuously promote the development of a satellite navigation legal system. The Chinese government attaches great importance to and comprehensively accelerates the legal rules in the field of satellite navigation, actively promotes the legislative process of “the Regulations of the People's Republic of China on Satellite Navigation”, to safeguard the healthy, rapid and sustainable development of the satellite navigation industry.

- Formulate policies and plans at the national level. In 2013, “the Medium and Long-Term Development Plan for the National Satellite Navigation Industry” was released, to making overall arrangement for medium and long-term satellite navigation industrial development, and to provide the macro policy guidance. of In 2016, a governmental White Paper entitled “China’s BeiDou Satellite

Navigation System" was released, to introduce the BDS development methods and policies.

- Release the guidance documents for industrial and regional applications. The National Development and Reform Commission, the Ministry of Science and Technology, the Ministry of Industry and Information Technology, the Ministry of Public Security, the Ministry of Transport, the Ministry of Agriculture and Rural Affairs, and administrations in more than 30 provinces, autonomous regions, independent municipalities and regions, have introduced a series of policies and specific initiatives to advocate the BDS applications.

- Preliminary achievements have been made in aspects of intellectual property rights and standardization. China attaches importance to the generation, utilization, management and protection of intellectual property rights related to BDS. In recent years, domestic applications of satellite navigation patents have increased rapidly, and the number has been added up to 70,000, ranking the first place worldwide. The National Technical Committee on the BDS satellite navigation standardization (SAC/TC 544) has been established. National and industrial standards related to BDS have been released, and the BDS industrial and applications environment has been improving gradually.

- Satellite navigation is an important area for the development of strategic emerging industries. China will further promote the technological integration between BDS and mobile communications, cloud computing, Internet of Things, industry internet, big data and block chain, promote the integration between the satellite navigation industry and high-end manufacturing, software, integrated data and modern service industries, and continue to promote the BDS applications and industrial development, so as to serve the country's

modernization construction and daily life of the people, and to make contributions to the global scientific, technological, economic and social development.

IV. International Exchanges and Cooperation

As one of the four major GNSS providers, BDS persists in open cooperation and resource sharing, actively carries out international exchanges and cooperation, and promotes the development of global satellite navigation.

(I) Coordination and Cooperation with Other Navigation Satellite Systems

BDS keeps carrying out coordination and cooperation with other navigation satellite systems, and promotes compatibility and interoperability among systems to jointly provide higher quality services for global users.

- China-Russia cooperation on satellite navigation. Within the framework of the China-Russia Prime Ministerial Regular Meeting Committee, the China-Russia Satellite Navigation Cooperation Project Commission was established, and a series of milestone documents have been signed and come into force, including the *Agreement between the Government of the People's Republic of China and the Russian Federation on Cooperation in the Field of the Use of BDS and GLONASS for Peaceful Purposes*, *Joint statement on Compatibility and Interoperability of the China's BDS and the Russia's GLONASS*, as well as the *Joint Statement on Navigation Technologies Applications Cooperation based on Peaceful Use of BDS and GLONASS*. Joint working groups have been established in the areas of compatibility and interoperability, augmentation systems, construction of ground stations, service monitoring and assessment, joint applications, to carry out practical cooperation, and to push forward ten typical cooperation projects. The China-Russia satellite navigation monitoring and assessment platform has been built and put into operation. The complementarity and integrated development of BDS and GLONASS will be

facilitated.

- China-US cooperation on satellite navigation. China and the United States have set up a dialogue mechanism for the satellite navigation cooperation. A joint statement, “the China-US statement on Civil GNSS Cooperation between the BeiDou Navigation Satellite System (BDS) and the Global Positioning System (GPS)”, was signed. “The Joint Statement of BDS and GPS Signal Compatibility and Interoperability” was signed, which indicated that the two systems are radio-frequency compatible, and the BDS B1C civil signal and the GPS L1C civil signal have achieved interoperability. Joint working groups have been be set up in the areas of compatibility and interoperability, augmentation systems and civil services, etc., to promote exchanges and cooperation.

- China-Europe cooperation on satellite navigation. A working group on compatibility and interoperability between BDS and Galileo has been set up, to hold several rounds of meetings, and to continuously promote frequency coordination. Extensive exchanges have been carried out under the China-EU dialogue mechanism on space science and technology cooperation.

(II) Multilateral Cooperation on Satellite Navigation

China has taken part in international activities organized by the United Nations and other relevant international organizations, within the framework of relevant multilateral mechanisms.

- Under the ITU framework, the satellite network information was submitted in accordance with the BDS construction plan and progress. International frequency coordination activities have been conducted. China has taken part in the ITU World Radio-communication Conference and the meetings

of the ITU study groups and working groups, promoted to extend the radio-determination satellite service (space-to-earth) allocations in the S-band, and successfully pushed forward the S-band (2483.5-2500 MHz) as an alternative band for navigation satellites, under joint efforts with delegates from other countries.

- As a members of the International Committee on Global Navigation Satellite Systems (ICG) and its Providers' Forum, China actively participated in the meetings held by the United Nations Committee on the Peaceful Uses of Outer Space, and the seminars organized by the United Nations Office for Outer Space Affairs. The BDS experts serve as co-chairs of a number working groups, sub-working groups and task forces of ICG, promoting mechanism reform, launching international initiatives, proposing Chinese proposals and offering wisdom. China successfully hosted the Seventh ICG Meeting in 2012, and released the Joint Statement of Global Navigation Satellite Systems for the first time. In 2018, China successfully hosted the Thirteenth ICG Meeting. Chinese President Xi Jinping sent a congratulatory letter to the Meeting, and expressed that China was willing to share the BDS achievements with other countries, and to promote the development of global satellite navigation systems. The Meeting issued a booklet on the interoperability of the GNSS space service volume, and released the Xi'an Initiative to advocate joint development of satellite navigation. During the 62nd session of the Committee on the Peaceful Uses of Outer Space in June 2019, an exhibition on ancient Chinese navigation technologies was held at the Vienna International Center with the theme "From Compass to BeiDou".

- The China Satellite Navigation Conference has been held annually, with more than 3,000 attendees every year. China actively established interaction

mechanisms with navigation meetings of the United States, Russia and Europe, participated in, organized and hosted international academic exchange activities of satellite navigation.

- Under the framework of the Asia-Pacific Space Cooperation Organization (APSCO), a number of cooperative projects are being implemented, including monitoring and assessment, research and applications of BeiDou/GNSS compatible terminals in disaster reduction, development of BeiDou/GNSS software receivers, and education and training on satellite navigation.

(III) Ratification of the BDS by International Standards

Continuous efforts have been devoted to advance the ratification of BDS by international organizations, such as International Civil Aviation Organization (ICAO), International Maritime Organization (IMO), Third and Fourth-Generation Mobile Communication Standard Partnership Project (3GPPP/4GPPP), COSPAS-SARSAT, International Electrotechnical Commission (IEC) and others.

- In the field of international civil aviation, positive efforts have been made to draft the BDS standards under the ICAO framework. The technical specification validations of B1C, B2a and B1I signals have been preliminarily completed. It is planned to complete the ratification of BDS by the ICAO Standard and Recommended Practices (SARPs) in 2020.

- In the field of international maritime, BDS has been recognized by the IMO as the third World-Wide Radio Navigation System (WRNSS). BDS is advancing the drafting and revision on the SBAS standards under the International Association of Marine Aids to Navigation and Lighthouse

Authorities (IALA).

- In the field of mobile communication, 26 BDS B1I signal international mobile communication standards have been formulated, including the related series test standards for the independent positioning and network auxiliary positioning function; mobile communication standards supporting high-precision BDS applications are being developed; the first 5G standard supporting the BDS B1C signal has been approved and will be released in 2020.

- In the field of international search and rescue, efforts are made to include technical parameters and specification information about the BDS SAR payload into relevant documents of COSPAS-SARSAT. The first batch of SAR payloads have completed the construction and in-orbit tests, and are carrying out commissioning tests as planned.

- In the field of International Electrotechnical Commission, the first BDS-based ship-borne equipment testing standard has been reviewed and approved by the IEC, and is planned to be issued in 2020.

- In the field of general data formats of receivers, An independent data exchange protocol, differential data protocol and positioning result output protocol supporting the BDS high-precision positioning applications have been officially released.

(VI) The BDS International Application Promotion

BDS-enabled products have been exported to more than 100 countries, providing users with a variety of choices and enhanced application experiences. BDS-based solutions have been successfully adopted in different regions and fields, such as land registration, precise agriculture, digital construction, monitoring and management on vehicles and ships, intelligent port management,

in Southeast Asia, South Asia, East Europe, West Asia and Africa, etc.

- BDS has been strengthening exchanges and training on satellite navigation, etc.

- China has carried out satellite navigation cooperation and exchanges with many countries and international organizations, in the League of Arab States, ASEAN, South Asia, Central Asia, Africa and other regions, established cooperation mechanisms, signed cooperation documents and implemented cooperation projects.

- China has hosted the BDS Cooperation Forum under the framework of the China-Central Asia Cooperation Forum, signed cooperation documents, and promoted BDS to serve the construction of countries in Central Asia.

- China has hosted the China-Arab States BeiDou Cooperation Forum and satellite navigation seminars, established a China-Arab States BDS/GNSS Center, and promoted BDS to serve the construction of Arab states.

- China has established the BeiDou International Exchange and Training Center, supported the construction of the Regional Center for Space Science and Technology Education in Asia and the Pacific (China) Affiliated to the United Nations, and facilitated the partner countries to train talents in the field of satellite navigation.

- The BeiDou global user experience and evaluation activity has been launched. The participation of global users and equipment suppliers is welcomed to experience the BDS services, evaluate the BDS performance, and to provide input for the BDS improvements and upgrades.

Conclusion

The BDS construction and development have benefited from the significant increase in China's overall national strength, sustained and stable economic development, and significant enhancement in scientific and technological innovation capacity since the reform and opening up. China will continue to promote the construction and industrial development of satellite navigation systems, encourage the use of new satellite navigation technologies, continually expand application areas to meet the ever-growing diverse needs of people, and actively promote international exchanges and cooperation, so as to achieve compatibility and interoperability with other satellite navigation systems in the world and provide global users with higher performance, more reliable and multiple services.

Annex1: Launch Record of the BDS Satellites

(as of December 27, 2019)

Satellite	Launch Date	Type	Status
1st BeiDou Navigation Experiment Satellite	2000.10.31	GEO	Decommissioned
2nd BeiDou Navigation Experiment Satellite	2000.12.21	GEO	Decommissioned
3rd BeiDou Navigation Experiment Satellite	2003.05.25	GEO	Decommissioned
4th BeiDou Navigation Experiment Satellite	2007.02.03	GEO	Decommissioned
1st BeiDou Navigation Satellite	2007.04.14	MEO	Decommissioned
2nd BeiDou Navigation Satellite	2009.04.15	GEO	Decommissioned
3rd BeiDou Navigation Satellite	2010.01.17	GEO	Operational
4th BeiDou Navigation Satellite	2010.06.02	GEO	In-orbit Maintenance
5th BeiDou Navigation Satellite	2010.08.01	IGSO	Operational
6th BeiDou Navigation Satellite	2010.11.1	GEO	Operational
7th BeiDou Navigation Satellite	2010.12.18	IGSO	Operational
8th BeiDou Navigation Satellite	2011.04.10	IGSO	Operational
9th BeiDou Navigation Satellite	2011.07.27	IGSO	Operational
10th BeiDou Navigation Satellite	2011.12.02	IGSO	Operational
11th BeiDou Navigation Satellite	2012.20.25	GEO	Operational
12th and 13th BeiDou Navigation Satellite	2012.40.30	MEO	Operational
14th BeiDou Navigation Satellite	2012.09.19	MEO	Decommissioned
15th BeiDou Navigation Satellite	2012.09.19	MEO	Operational
16th BeiDou Navigation Satellite	2012.10.25	GEO	Operational
17th BeiDou Navigation Satellite	2015.03.30	IGSO	In-orbit Experiment
18th and19th BeiDou Navigation Satellite	2015.07.25	MEO	In-orbit Experiment
20th BeiDou Navigation Satellite	2015.09.30	IGSO	In-orbit Experiment
21st BeiDou Navigation Satellite	2016.02.01	MEO	In-orbit Experiment

Satellite	Launch Date	Type	Status
22nd BeiDou Navigation Satellite	2016.03.30	IGSO	Operational
23rd BeiDou Navigation Satellite	2016.06.12	GEO	Operational
24th and 25th BeiDou Navigation Satellite	2017.11.05	MEO	Operational
26th and 27th BeiDou Navigation Satellite	2018.01.12	MEO	Operational
28th and 29th BeiDou Navigation Satellite	2018.02.11	MEO	Operational
30th and 31st BeiDou Navigation Satellite	2018.03.30	MEO	Operational
32nd BeiDou Navigation Satellite	2018.07.10	IGSO	Operational
33rd and 34th BeiDou Navigation Satellite	2018.07.29	MEO	Operational
35th and 36th BeiDou Navigation Satellite	2018.08.25	MEO	Operational
37th and 38th BeiDou Navigation Satellite	2018.09.19	MEO	Operational
39th and 40th BeiDou Navigation Satellite	2018.10.15	MEO	Operational
41st BeiDou Navigation Satellite	2018.11.01	GEO	In-orbit Test
42nd and 43rd BeiDou Navigation Satellite	2018.11.19	MEO	Operational
44th BeiDou Navigation Satellite	2019.04.20	IGSO	Operational
45th BeiDou Navigation Satellite	2019.05.17	GEO	In-orbit Test
46th BeiDou Navigation Satellite	2019.06.25	IGSO	Operational
47th and 48th BeiDou Navigation Satellite	2019.09.23	MEO	In-orbit Test
49th BeiDou Navigation Satellite	2019.11.05	IGSO	In-orbit Test
50th and 51st BeiDou Navigation Satellite	2019.11.23	MEO	In-orbit Test
52nd and 53rd BeiDou Navigation Satellite	2019.12.16	MEO	In-orbit Test

Annex2: List of Released Documents on the BDS

December 2011, BeiDou Navigation Satellite System Signal In Space Interface Control Document Open Service Signal B1C (Test Version);

December 2012, BeiDou Navigation Satellite System Signal In Space Interface Control Document Open Service Signal B1I (Version 1.0);

December 2013, BeiDou Navigation Satellite System Signal In Space Interface Control Document Open Service Signal (Version 2.0), BeiDou Navigation Satellite System Open Service Performance Standard (Version 1.0);

June 2016, China's BeiDou Navigation Satellite System;

November 2016, BeiDou Navigation Satellite System Signal In Space Interface Control Document Open Service Signal (Version 2.1);

August 2017, BeiDou Navigation Satellite System Signal In Space Interface Control Document Open Service Signal B1C, B2a (Test Version);

December 2017, BeiDou Navigation Satellite System Signal In Space Interface Control Document Open Service Signal B1C (Version 1.0), BeiDou Navigation Satellite System Signal In Space Interface Control Document Open Service Signal B2a (Version 1.0);

February 2018, BeiDou Navigation Satellite System Signal In Space Interface Control Document Open Service Signal B3I (Version 1.0);

December 2018, BeiDou Navigation Satellite System Open Service Performance Standard (Version 2.0);

December 2019, BeiDou Navigation Satellite System Signal In Space Interface Control Document Open Service Signal B2b (Beta Version); BeiDou Navigation Satellite System Signal In Space Interface Control Document Precise

Point Positioning Service Signal PPP-B2b (Beta Version); The Application Service Architecture of BeiDou Navigation Satellite System (Version 1.0).

The BDS official website: http://beidou.gov.cn;http://en.beidou.gov.cn