Report on the Development of BeiDou（COMPASS）
Navigation Satellite System
(V1.0)

China Satellite Navigation Office
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Preface

Navigation satellite systems can provide all time, all weather and high accuracy positioning, navigation and timing services to users on the earth surface or in the near-earth space. It is an important space infrastructure, which extends people’s range of activities and promotes social development. Satellite navigation is bringing up revolutionary changes to the world politics, economy, military, technology and culture.

With a long history and a splendid culture, China is one of the important cradles of early human civilization. In ancient times, Chinese people used the Big Dipper (Beidou) for identifying directions, and invented the world’s first navigation device, the ancient compass (Sinan), which was a great contribution to the development of world civilization. In modern society, the Chinese-built BeiDou (COMPASS) system will become another contribution to the mankind.

In early 1980s, China began to actively study the navigation satellite systems in line with China’s conditions. In 2000, BeiDou Navigation Demonstration System is basically established, which made China the third nation in possession of an independent navigation satellite system following the United States and Russia. At present, China is steadily accelerating the construction of the BeiDou Navigation Satellite System, and has already successfully launched 9 satellites so far. It is planned to provide preliminary operation service capacity for Asia-Pacific users (within service area).

The BeiDou system will meet the demands of China’s national security, economic development, technological advances and social progress, safeguard national interests and enhance the comprehensive national strength. The BeiDou system will commit
to providing stable, reliable and quality satellite navigation services for global users. Along with other GNSS suppliers, the BeiDou system will jointly promote the development of satellite navigation industry, make contributions to human civilization and social development, serve the world and benefit the mankind.
I. System Description

The BeiDou system is comprised of three major components: space constellation, ground control segment and user terminals. The space constellation consists of five GEO satellites and 30 non-GEO satellites. The GEO satellites are positioned at 58.75°E, 80°E, 110.5°E, 140°E and 160°E respectively. The non-GEO satellites include 27 MEO satellites and three IGSO satellites. The MEO satellites are operating in an orbit with an altitude of 21,500 km and an inclination of 55°, which are evenly distributed in three orbital planes. The IGSO satellites are operating in an orbit with an altitude of 36,000 km and an inclination of 55°, which are evenly distributed in three inclined geo-synchronous orbital planes. The subsatellite track for the three IGSO satellites are coincided while the longitude of the intersection point is at 118°E, with a phase difference of 120°.

Ground control segment consists of several Master Control Stations (MCS), Upload Stations (US) and a network of globally distributed Monitor Stations (MS). The main tasks of MCS are to collect observing data from each MS, to process data, to generate satellite navigation messages, wide area differential data and integrity information, to perform mission planning and scheduling, and to conduct system operation and control. The main tasks of Upload Stations include completing the upload of satellite navigation messages, wide area differential data and integrity information, controlling and managing the payload. The tasks of Monitor Stations include continuous tracking and monitoring of navigation satellites, receiving navigation signals, sending observational data to the Master Control Station for the satellites orbit determination and time synchronization.

The user terminals include various BeiDou user terminals, and terminals compatible with other navigation satellite systems, to meet
different application requirements from different fields and industries.

The time reference for the BeiDou Navigation Satellite System uses BeiDou Time (BDT). BDT’s length of second is a SI second. BDT was zero at 0:00:00 on January 1, 2006 Coordinated Universal Time (UTC). BDT is a continuous system, traceable to the UTC time maintained by the National Time Service Center (NTSC) of Chinese Academy of Sciences, which is referred to as UTC (NTSC). The leap seconds with UTC information is broadcasted in the navigation messages. The difference between BDT and UTC maintains within 100ns.

The coordinate framework of BeiDou system adopts China Geodetic Coordinate System 2000 (CGCS2000).

Upon the full system completion, the BeiDou Navigation Satellite System can provide positioning, navigation and timing services to worldwide users. It can also provide wide area differential services with the accuracy of 1m and short messages services with the capacity of 120 Chinese characters each time.

- Main functions: positioning, velocity measurement, one-way and two-way timing, short messages
  - Service area: global
  - Positioning accuracy: better than 10m
  - Velocity accuracy: better than 0.2m/s
  - Timing accuracy: 20ns
II. System Development

The BeiDou system has followed the development concept of starting with regional services first and expanding to global services later. A three-step development strategy has been taken, with specifics as follows:

Phase I: BeiDou Navigation Satellite Demonstration System. In 1994, China started the construction of BeiDou Navigation Satellite Demonstration System. In 2000, two BeiDou navigation experiment satellites were launched, and the BeiDou Navigation Satellite Demonstration System was basically established. In 2003, the third BeiDou navigation experiment satellite was launched, further enhancing the performance of the BeiDou Navigation Satellite Demonstration System.

BeiDou Navigation Satellite Demonstration System consists of three major components: space constellation, ground control segment and user terminals. The space constellation includes three geostationary orbit (GEO) satellites, positioned at longitude of 80 degrees East, 110.5 degrees East and 140 degrees East respectively above the equator. Ground control segment consists of the ground control center and a number of calibration stations. The ground control center is to complete satellite orbit determination, ionospheric correction, user location determination and user short message information exchange and processing. The calibration ground control stations are mainly to provide the distance measurement and correction parameters to the ground control center.

The user terminals include the hand-held type, vehicle type, command type and other types of terminals, capable of position service application, location coordinates information receiving and other functions.
The main functions and performance specifications of the BeiDou Navigation Satellite Demonstration System are as follows:

- Main functions: positioning, one-way and two-way timing, short message communications;
- Service Area: China and the surrounding areas;
- Positioning Accuracy: better than 20 meters;
- Timing Accuracy: 100 ns one-way, two-way 20 ns;
- Short message communications: 120 Chinese characters per time.

Phase II: BeiDou Navigation Satellite (regional) System. In 2004, China started construction of BeiDou Navigation Satellite System. In 2007, the first satellite, a round medium earth orbit satellite (COMPASS-M1) was launched. By 2012, the BeiDou system will consist of 14 satellites, including five GEO satellites, five IGSO satellites (two in-orbit spares), and four MEO satellites.

The functions and performance parameters of BeiDou Navigation Satellite (regional) System are as follows:

- Main functions: positioning, velocity measurement, one-way and two-way timing, short message communications;
- Service Area: China and part of Asia-Pacific region;
- Positioning Accuracy: better than 10 meters;
- Velocity Accuracy: better than 0.2 m/s;
- Timing Accuracy: 50 ns;
- Short message communications: 120 Chinese characters per message.

Phase III: BeiDou Navigation Satellite System will completely be established by 2020.
III. System Applications

Since it was officially brought into service in 2003, the BeiDou Navigation Satellite Demonstration System has been widely used in transportation, marine fisheries, hydrological monitoring, weather forecasting, forest fire prevention, timing for communication systems, power distribution, disaster mitigation, national security, and many other fields, which has been resulting in significant social and economic benefits. Particularly, the system has played an important role in the South China frozen disaster, earthquake relief in Wenchuan, Sichuan Province and Yushu, Qinghai Province, the Beijing Olympic Games, and the Shanghai World Expo.

—In the field of transportation, built on the Beidou Navigation Satellite Demonstration System, applications such as Xinjiang Satellite Navigation Monitoring System of Public Transport, the Highway Infrastructure Safety Monitoring System, and the Port Scheduling High-precision Real-time Position Monitoring System, have promoted the BeiDou system and achieved a good demonstration effect.

—In marine fisheries, built on the BeiDou Navigation Satellite Demonstration System, the marine fisheries integrated information service platform has provided vessel position monitoring, emergency rescue, information distribution, fishing boats in and out of port management and other services to the fishery administration departments.

—The hydrological monitoring system, based on the BeiDou Navigation Satellite Demonstration System, has realized the real-time transmission of hydrological forecast information in mountainous regions, which has improved the accuracy of the disaster forecasting and has helped the planning and scheduling programs for the flood and drought control.
In the field of weather forecasting, a series of BeiDou terminal equipment have been developed for weather forecast, and various practical and feasible system solutions have been worked out to address the automatic data transmission issues for the China Meteorological Administration and a number of local weather centers and stations.

In the field of forest fire prevention, the BeiDou Navigation Satellite Demonstration System has been successfully used in forest fire prevention system. Its positioning and short message communication services have achieved good results.

In the field of time synchronization for communication systems, the successful implementation of BeiDou 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, built on the BeiDou Navigation Satellite Demonstration System, the successful implementation of power system time synchronization demonstration program has created basis for the high precision applications such as the electric accident analysis, the electric power early warning and protection systems.

In the field of disaster mitigation, the navigation, positioning, short message communications and position reporting capabilities of the BeiDou Navigation Satellite Demonstration System 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.

Upon the full completion, the BeiDou Navigation Satellite System will provide more high-performance positioning, navigation, timing and short-message communication services for civil aviation, shipping, railways, finance, postal and other industries.
IV. International Exchange and Cooperation

The international exchange and cooperation for the BeiDou Navigation Satellite System will be carried out in an active and pragmatic way, which is in line with China’s foreign policies, focusing on China's basic tasks and strategic objectives for the construction of navigation satellite systems, using the domestic and international markets and resources in a coordinated way. The international exchange and cooperation will be proceeded in a phased, focus-centered, non-discriminatory and selective approach in accordance with the overall development plan of China's navigation satellite system. It will be built upon the basis of equality, mutual benefit, mutual complementarity, peaceful utilization and mutual development and the generally accepted principles of the international laws.

The BeiDou Navigation Satellite System adheres to the open and friendly attitude, and has already carried out extensive exchanges and consultation with the countries that have navigation satellite systems, to promote navigation satellite system compatibility and interoperability globally. Through the exchange and cooperation with countries that do not have a navigation satellite system, we also support their use of the existing resources globally and share the benefits of the satellite navigation development.

China's international exchange and cooperation in the field of satellite navigation started in the 1990s. In nearly 20 years, various forms of activities have been carried out with extensive results.

In 1994, under the framework of International Telecommunication Union (ITU), China started the BeiDou Navigation Satellite System frequency coordination activities. Satellite network information was submitted in accordance with the BeiDou system construction plan and progress. International
frequency coordination has been carried out in a phased, step by step, focus-centered approach. China has actively participated bilateral frequency coordination activities with Europe, the United States and Russia, and has actively taken part in the World Radiocommunication Conference and the meetings of ITU study groups and working groups.

China, as an important member of the International Committee on Global Navigation Satellite Systems (ICG), has participated in every ICG General Assembly Meeting and the ICG Providers Forum. In 2007, China became one of the four core providers designated by the organization. Focusing on compatibility and interoperability, China has carried out the extensive exchange and cooperation with the other navigation satellite systems in the world. The Technical Working Group (TWG) on compatibility and interoperability between BeiDou and Galileo was established. Until now, seven TWG meetings have been held.

China actively participates, organizes and hosts international academic exchanges on satellite navigation, which include the American Institute of Navigation (ION) Conferences, the International Symposium on GPS/GNSS (ISGNSS), Munich Satellite Navigation Summit and other international conferences and forums. The China academic conference on satellite navigation is held annually, together with many other forums and seminars.

China encourages and supports domestic research institutions, industrial enterprises, universities and social organizations, under the guidance of the government policy, to carry out international exchanges, coordination and cooperation activities with other countries and international organizations in the fields of the compatibility and interoperability, satellite navigation standards, coordinates frame, time reference, application development and scientific research. China has been actively engaged in international activities in terms of monitoring and assessment of open service for GNSS to promote the BeiDou Navigation Satellite System better serving the global customers, and to promote the development of satellite navigation technology.
Conclusion

The rapid development of the BeiDou Navigation Satellite System is attributed to China's reform and opening-up policy as well as the sustainable development of economy. As always, China will continue to promote the Global Navigation Satellite System construction and industrial development, to encourage the use of new satellite navigation technologies to provide new services, meeting the growing diversified needs of the people. By actively propelling international exchanges and cooperation, China will realize the compatibility and interoperability between the BeiDou Navigation Satellite System and other navigation satellite systems in the world. China will provide global customers with high performance and highly reliable positioning, navigation and timing services.
Annex

The Launch Record of BeiDou Navigation Satellites

- October 31, 2000, launch of 1st BeiDou navigation experiment satellite.
- December 21, 2000, launch of 2nd BeiDou navigation experiment satellite.
- May 25, 2003, launch of the 3rd BeiDou navigation experiment satellite.
- February 3, 2007, launch of the 4th BeiDou navigation experiment satellite.
- April 14, 2007, launch of the 1st BeiDou navigation satellite.
- April 15, 2009, launch of the 2nd Beidou navigation satellite.
- January 17, 2010, launch of the 3rd BeiDou navigation satellite.
- June 2, 2010, launch of the 4th BeiDou navigation satellite.
- August 1, 2010, launch of the 5th BeiDou navigation satellite.
- November 1, 2010, launch of the 6th BeiDou navigation satellite.
- December 18, 2010, launch of the 7th BeiDou navigation satellite.
- April 10, 2011, launch of the 8th BeiDou navigation satellite.