



TWELFTH AIR NAVIGATION CONFERENCE

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Agenda Item 6: Future direction

6.1: Implementation plans and methodologies

THE DEVELOPMENT AND APPLICATION OF BEIDOU SATELLITE NAVIGATION SYSTEM

(Presented by China)

EXECUTIVE SUMMARY

This paper provides the latest development of China's BeiDou Satellite Navigation System (BeiDou), the principles and prospects of the application of BeiDou, and describes China's future efforts to support the initiative proposed by ICAO on developing a multi-constellation GNSS to enhance safety and benefit of global air navigation system.

1. INTRODUCTION

1.1 So far, the Global Navigation Satellite Systems (GNSS) have become the foundation of ICAO's air navigation service system, being used widely in civil aviation. GNSS' positioning, navigation and timing (PNT) service is the core technical measure for the aviation system block upgrades (ASBU). So the accuracy, integrity, availability and continuity of the services provided by GNSS have been the common concerns of ICAO and global aviation users.

1.2 BeiDou is a global navigation satellite system constructed and operated by China. It is announced that BeiDou will provide free PNT service for all users all over the world including aviation users. At the 37th Session of the ICAO Assembly, BeiDou was accepted for incorporation into ICAO's GNSS framework and involved with the formulation of technical documents relating to Standards and Recommended Practices (SARPs).

1.3 China is engaging in the construction of BeiDou as planned. By November 2012, the second phase networking had been completed, and regional coverage and service capability had been achieved. According to the construction schedule, the deployment of the global navigation constellation will be completed by 2020.

¹ English and Chinese translation provided by China.

2. BEIDOU SYSTEM DEVELOPMENT AND APPLICATION

2.1 Development objectives

2.1.1 It is aimed to build a high performance, reliability and benefits BeiDou system to provide around-the-clock positioning, navigation and timing services for global users.

2.2 Basic principles

- a) *Openness*: BeiDou will provide high quality open services free of charge from direct users, and worldwide use of BeiDou is encouraged.
- b) *Independency*: China will develop and operate BeiDou system independently.
- c) *Compatibility*: BeiDou will pursue solutions to realize compatibility and interoperability with other satellite navigation systems, thus enabling users to experience better services by using interoperable signals.
- d) *Gradualness*: In consideration of technical and economic risks, the construction of the BeiDou system follows a step-by-step pattern based on technical and economic evolution in China.

2.3 Basic tasks

2.3.1 The basic tasks are:

- a) to deploy a global constellation consisting of five GEO satellites and thirty non-GEO satellites and construct a ground operation control system including main control stations, injection stations and monitoring stations; and
- b) to achieve regional services coverage by 2012 and global services coverage by 2020 and provide open, authorization, wide area differential and short text messages services.

2.4 Development roadmap

2.4.1 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:

- a) initiate the construction of BeiDou demonstration system in 1994 and Provided RDSS (Radio Determination Satellite Service) from 2000;
- b) start the construction of BeiDou system in 2004, and provide RNSS (Radio Navigation Satellite Service) for users in China and its surrounding areas from 2012; and
- c) further the construction of the BeiDou system from 2013 and provide global services coverage RNSS in 2020.

2.5 Policies

2.5.1 Providing continuous space-based services for global users free of charge; and continue system maintenance and complement in order to enhance service performance.

2.5.2 Formulating industrial plan and national standard of satellite navigation application, and to promote the worldwide service utilization and industry development of BeiDou.

2.5.3 Strengthening international cooperation, including advocating for international GNSS monitoring and assessment, achieving compatibility and interoperability between BeiDou and other GNSS, and ensuring BeiDou diversified applications.

2.6 Latest progress and capability

Constellation network

2.6.1 As of November 2012, fourteen working satellites in orbit are available for BeiDou, including five GEO satellites, five IGSO satellites and four MEO satellites, which have been ready for providing operational services. The service covers 55 degree south to north latitude and 55 to 180 degree east longitude.

Basic benchmark and ground operation control facilities

2.6.2 So far, the constructions of master control station, uplink station and several monitoring stations have been finished. At the same time, BeiDou Time (BDT) System and China Geodetic Coordinate System (CGCS2000) have also been created as the time and coordinate benchmark for BeiDou.

Service capacity test and assessment

2.6.3 Through practical test, the positioning accuracy is better than 10 m horizontally and 15 m vertically, while the velocity accuracy is better than 0.2 m/s.

2.6.4 Satellite broadcast ephemeris URE is better than 1.5 m, while clock bias is better than 5 nanoseconds.

2.6.5 Orbit determination precision is better than 10 m, while time synchronization precision is better than 2 nanoseconds.

2.6.6 Ionospheric correction of Klobuchar-8 model is about 80 per cent.

2.6.7 For the satellite atom clock, according to in-orbit test results, the frequency accuracy of the master clock of GEO is $1.62\text{E-}12$, drift is $3.05\text{E-}14$, and ten thousand seconds stability is $6.59\text{E-}14$.

Application

2.6.8 The application of BeiDou has been carried out in many fields, such as land, water transportation, fishery, forestry and meteorological observation, etc. In the field of civil aviation, the Civil Aviation Administration of China (CAAC) has described clearly in the PBN roadmap and related documents that BeiDou will be used and CAAC is planning to perform testing, assessment and application relating to BeiDou.

2.7 International cooperation and coordination

2.7.1 China has participated in many campaigns held by the International Committee on Global Navigation Satellite Systems (ICG) of the United Nations Office for Outer Space Affairs and hosted China satellite navigation academic annual meetings to strengthen international academic exchange. Besides, China has advocated to launch international GNSS monitoring and assessment service (iGMAS), BeiDou/GNSS Application Demonstration and Experience Campaign (BADEC) and initiated to create workgroups for international monitoring/assessment and application, serving as the one of chairmanship members. According to the Radio Regulations of International Telecommunications Union (ITU), China will be engaged in bilateral frequency coordination with related countries and share frequency and orbit resources.

2.8 Response to the decisions made at the 37th Session of the ICAO Assembly

2.8.1 In October, 2011, CAAC and China Satellite Navigation System Office were invited to introduce and discuss the BeiDou system in ICAO's GNSS briefing meeting, and promised that BeiDou was going to provide open, stable, continual and free service. According to ICAO Council's Resolution 37-12 –“*Develop SARPs to Support the Implementation of the BeiDou (COMPASS) Navigation System of China into the Global Framework*”, a working procedure has been initiated for the incorporation with support from ICAO. Supported by ICAO's Navigation Specialist Panel (NSP), China is now undertaking the research on and drafting of technical documents for SARPs, making the preparation for providing qualified service for global civil aviation users.

3. CONCLUSION

3.1 The construction of BeiDou is in progress as scheduled. The second-stage construction has been finished, based on which a regional service system has been created, allowing to provide PNT service for China and the surrounding Asia/Pacific Region constantly.

3.2 From 2013, China will carry out the third-stage construction with the target to realize a global constellation deployment by 2020.

3.3 China's BeiDou will be dedicated to providing continuous, open, safe and high-quality PNT service with considering the challenges and problems with respect to accuracy, integrity, availability and continuity of satellite navigation service. China supports ICAO's recommendation to use multi-constellation /multi-frequency GNSS to reduce the vulnerability of GNSS. Under the working framework of ICAO, China will enhance research and preparation of related SARPs, conduct related research to reduce the vulnerability, promote aligned application of BeiDou and other navigation satellite systems and launch wider international cooperation to promote international monitoring, assessment and multi-system application.

3.4 China encourages and welcomes all ICAO members to conduct assessment, utilization and cooperation activities with the BeiDou system.

3.5 The Conference is invited to note the information provided in this paper.