

The Application Service Architecture of BeiDou Navigation Satellite System

(Version 1.0)



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1 Overview

The BeiDou Navigation Satellite System (BDS) has been built and developed in accordance with the "three-step" strategy. BDS-1 construction was started from 1994 and put into use in 2000. It adopted an active positioning scheme to provide Chinese users with positioning, timing, wide-area differential and short message communication services. BDS-2 construction was started from 2004 and put into use in 2012. Besides being technically compatible with BDS-1, BDS-2 also added a passive positioning scheme, to provide users in the Asia-Pacific region with positioning, velocity measurement, timing and short message communication services. BDS-3 construction was started from 2009. On the basis of BDS-2, BDS-3 further improves services performance and expands services functions, with the successful launch of 30 constellation satellites. It is planned to fully complete the BDS-3 by 2020, and to provide global users with high-quality services including navigation, positioning and data communication.

The BDS-3 construction has been rapidly accelerated since 2018. By December 2018, 18 MEO satellites and 1 GEO satellite had been launched, and the BDS-3 Preliminary System had been completed to offer global services. By December 2019, the core constellation has been fully deployed with the additional launch of 6 MEO satellites and 3 IGSO satellites. In 2020, two more GEO satellites will be launched and the BDS will be completed to realize full constellation operation. At present, BDS services are jointly provided by BDS-2 and BDS-3, which will be smoothly transitted to the services mainly provided by BDS-3 after 2020.

In order to let global users to better know, understand and use BDS, and to enable the high-quality BDS services better benefit the world, a BDS application service architecture is developed. This document specifies the BDS service plan with a systematic introduction of the BDS service types and indicators, and service guarantee system including the service documents, information dissemination and feedback mechanisms, etc. In the future, with the BDS construction and development, the service support capacity and this application service architecture will be further improved to offer global users with first-class services derived from BDS in the new era.

2 Service Plan

2.1 Service Types

BDS has two functions including navigation and positioning as well as data communication, and provides seven kinds of services. Specifically, it provides three kinds of global services including positioning, navigation and timing (RNSS), global short message communication (GSMC) and international search and rescue (SAR). Meanwhile, the satellite-based augmentation system (SBAS), ground augmentation system (GAS), precise point positioning (PPP) and regional short message communication (RSMC) services are provided in China and surrounding areas, as shown in Table 1. Among them, the RNSS services have been launched worldwide in December 2018, the GSMC, SAR and GAS services are already available in December 2019, and SBAS, PPP and RSMC services will be available in 2020.

Table 1 The BDS Service Plan

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

2.2 Performance Standard

(1) RNSS Performance Standard

BDS-3 utilizes 3 GEO satellites, 3 IGSO satellites and 24 MEO satellites to provide free RNSS services to global users located on or 1,000 kilometers above the earth's surface. The

main performance indicators are shown in Table 2.

Table 2 Main BDS RNSS Performance Indicators

Performance Characteristics		Performance Indicators
Service Accuracy (95%)	Positioning Accuracy	Horizontal $\leq 10\text{m}$, Vertical $\leq 10\text{m}$
	Timing Accuracy	$\leq 20\text{ns}$
	Velocity Measurement Accuracy	$\leq 0.2\text{m/s}$
Service Availability		$\geq 99\%$

(2) SBAS Service Performance Standard

BDS utilizes GEO satellites to provide free single-frequency augmentation and dual-frequency multi-constellation augmentation services in accordance with the International Civil Aviation Organization (ICAO) standards to users in China and surrounding areas, aiming to achieve APV-I and the CAT-I precision approach.

(3) GAS Service Performance Standard

BDS utilizes mobile communication networks or the Internet to provide users within the coverage area of reference station network, with high-precision positioning services at the meter, decimeter, centimeter and millimeter levels. The main performance indicators are shown in Table 3.

Table 3 Main BDGAS Service Performance Indicators

Performance Characteristics	Performance Indicators				
	Single-Frequency Ranging Augmentation Service	Single Carrier Phase Augmentation Service	Dual-Frequency Carrier Phase Augmentation Service	Dual-Frequency Carrier Phase Augmentation Service (Network RTK)	BDS/GNSS Baseline Post-Process with Accuracy at Millimeter Level
Target System	BDS	BDS	BDS	BDS/GNSS	BDS/GNSS
Positioning Accuracy (95%)	Horizontal $\leq 2\text{m}$ Vertical $\leq 3\text{m}$	Horizontal $\leq 1.2\text{m}$ Vertical $\leq 2\text{m}$	Horizontal $\leq 0.5\text{m}$ Vertical $\leq 1\text{m}$	Horizontal $\leq 5\text{cm}$ Vertical $\leq 10\text{cm}$	Horizontal $\leq 5\text{mm} \pm 1 \times 10^{-6} \times D$ Vertical $\leq 10\text{mm} \pm 2 \times 10^{-6} \times D$ (D means baseline length in kilometers)
Initiating Time	Seconds	$\leq 20\text{min}$	$\leq 40\text{min}$	$\leq 60\text{s}$	-

(4) PPP Service Performance Standard

BDS utilizes GEO satellites to provide users in China and surrounding areas with free

precise point positioning services. The main performance indicators are shown in Table 4.

Table 4 Main BDS PPP Service Performance Indicators

Performance Characteristics	Performance Indicators	
	Phase I (Year 2020)	Phase II (After 2020)
Broadcast Data Rate	500bps	It will be extended to enhance multiple global navigation systems, to improve broadcast data rate, to expand satellite service area according to the situation, and to improve positioning accuracy and shorten convergence time.
Positioning Accuracy (95%)	Horizontal \leq 0.3m Vertical \leq 0.6m	
Convergency Time	\leq 30min	

(5) RSMC Service Performance Standard

BDS utilizes GEO satellites to provide the regional short message communication service to users in China and surrounding areas. The main performance indicators are shown in Table 5.

Table 5 Main BDS RSMC Service Performance Indicators

Performance Characteristics	Performance Indicators	
Service Success Rate	\geq 95%	
Service Frequency	Normally once every 30 seconds, maximumly once per second	
Response Time	\leq 1s	
Terminal Transmission Power	\leq 3w	
Service Capacity	Uplink	12,000,000 times per hour
	Downlink	6,000,000 times per hour
Maximum Length of a Single Message	14,000 bits (approximately equivalent to 1,000 Chinese characters)	
Positioning Accuracy (95%)	RDSS	Horizontal \leq 20m, Vertical \leq 20m
	CRDSS	Horizontal \leq 10m, Vertical \leq 10m
Two-Way Timing Accuracy	\leq 10ns	
Usage Constraints and Remarks	If a user's radial velocity relative to the satellite is greater than 1000km/h, the adaptive Doppler compensation is required.	

(6) GSMC Service Performance Standard

BDS utilizes MEO satellites to provide global short message communication services to authorized users located on or 1,000 kilometers above the earth's surface. The main performance indicators are shown in Table 6.

Table 6 Main BDS GSMC Service Performance Indicators

Performance Characteristics		Performance Indicators
Service Success Rate		$\geq 95\%$
Response Time		Normally better than 1min
Terminal Transmission Power		$\leq 10\text{w}$
Service Capacity	Uplink	300,000 times per hour
	Downlink	200,000 times per hour
Maximum Length of a Single Message		560 bits (approximately equivalent to 40 Chinese characters)
Usage Constraints and Remarks		A user needs to carry out adaptive Doppler compensation, and after the compensation, the frequency offset of the uplink signal arriving at the satellite should be less than 1,000 Hz.

(7) SAR Service Performance Standard

BDS utilizes MEO satellites to provide free distress warning services in accordance with the COSPAS-SARSAT standards, to maritime, aviation and land users around the world in conjunction with other search and rescue satellite systems. It is capable of confirming the service by using a return link. The main performance indicators are shown in Table 7.

Table 7 Main BDS International SAR Service Performance Indicators

Performance Characteristics	Performance Indicators
Detection Probability	$\geq 99\%$
Independent Positioning Probability	$\geq 98\%$
Independent Positioning Accuracy	$\leq 5\text{km}$
Ground Receiving Bit Error Rate	$\leq 5 \times 10^{-5}$
Availability	$\geq 99.5\%$

3 Service Guarantee System

3.1 Service Documents

Service documents refer to relevant technical and guidance documents, which are used for developing user terminals, introducing the system service performance and facilitating utilization of the system. Specifically, those include interface control documents, usage guidance for interface control documents, service performance standards and user guide manuals, etc.

3.1.1 Interface Control Documents

Interface control documents mainly define the signal characteristics, ranging code characteristics, message structures, message parameters and algorithms, which can be upgraded in parallel as the system construction and development progresses.

(1) RNSS

The interface control documents are issued according to different signals. The BDS RNSS signal interface control documents are shown in Table 8.

Table 8 The BDS RNSS Signal Interface Control Documents

Index	Title	Signal	Issue Date
1	BeiDou Navigation Satellite System Signal In Space Interface Control Document Open Service Signal B1C (Version 1.0)	B1C	2017.12
2	BeiDou Navigation Satellite System Signal In Space Interface Control Document Open Service Signal B2a (Version 1.0)	B2a	2017.12
3	BeiDou Navigation Satellite System Signal In Space Interface Control Document Open Service Signal B3I (Version 1.0)	B3I	2018.02
4	BeiDou Navigation Satellite System Signal In Space Interface Control Document Open Service Signal B1I (Version 3.0)	B1I	2019.02
5	BeiDou Navigation Satellite System Signal In Space Interface Control Document Open Service Signal B2b (Beta Version)	B2b	2019.12

(2) SBAS Service

The interface control documents are issued according to different signals. Users can refer the official website of the ICAO (www.icao.org) for more information. The BDSBAS service signal interface control documents will be issued, as shown in Table 9.

Table 9 The BDSBAS Service Signal Interface Control Documents

Index	Title	Signal	Issue Date
1	BeiDou Navigation Satellite System Signal In Space Interface Control Document Satellite Based Augmentation System Service Signal BDSBAS-B1C (Beta Version)	BDSBAS-B1C	2020.06
2	BeiDou Navigation Satellite System Signal In Space Interface Control Document Satellite Based Augmentation System Service Signal BDSBAS-B2a (Beta Version)	BDSBAS-B2a	2020.06

(3) PPP Service

The interface control documents are issued according to different signals. The BDS PPP service signal PPP-B2b interface control document is shown in Table 10.

Table 10 The BDS PPP Service Interface Control Document

Index	Title	Signal	Issue Date
1	BeiDou Navigation Satellite System Signal In Space Interface Control Document Precise Point Positioning Service Signal PPP-B2b (Beta Version)	PPP-B2b	2019.12

(4) RSMC Service

The interface control documents are released according to service types. The BDS RSMC service interface control document will be issued, as shown in Table 11.

Table 11 The BDS RSMC Service Interface Control Document

Index	Title	Issue Date
1	BeiDou Navigation Satellite System Regional Short Message Communication Service Signal In Space Interface Control Document (Beta Version)	2020.06

(5) GSMC Service

The interface control documents are issued according to service types. The BDS GSMC service interface control document will be issued, as shown in Table 12.

Table 12 The BDS GSMC Service Interface Control Document

Index	Title	Issue Date
1	BeiDou Navigation Satellite System Global Short Message Communication Service Signal In Space Interface Control Document (Beta Version)	2020.06

(6) SAR Service

Interface control documents (with return link) are issued according to service types. The BDS international SAR service interface control document will be issued, as shown in Table 13. Users can refer the official website of the COSPAS-SARSAT (<http://cospas-sarsat.int/en/>) for more information.

Table 13 The BDS International SAR Service Interface Control Document

Index	Title	Issue Date
1	BeiDou Navigation Satellite System Search And Rescue Service Signal In Space Interface Control Document (Beta Version)	2020.06

3.1.2 Usage Guidance for Interface Control Documents

In order to help users to better understand and use the interface control documents, the usage guidance serves as an interpretation of RNSS, SBAS and PPP services interface control documents, and will be upgraded correspondingly. The usage guidance for BDS services interface control documents will be issued, as shown in Table 14.

Table 14 The Usage Guidance for BDS Services Interface Control Documents

Index	Title	Signal	Issue Date
1	Usage Guidance for BeiDou Navigation Satellite System Open Service Signal In Space Interface Control Documents (Version 1.0)	B1C, B2a, B1I, B3I, B2b	2020.06
2	Usage Guidance for BeiDou Navigation Satellite System Satellite-Based Augmentation System Service Signal In Space Interface Control Documents (Version 1.0)	BDSBAS_B1C BDSBAS_B2a	2020.06
3	Usage Guidance for BeiDou Navigation Satellite System Precise Point Positioning Service Signal In Space Interface Control Documents (Version 1.0)	PPP-B2b	2020.06

3.1.3 Service Performance Standards

Service performance standards mainly specify the service performance characteristics and performance indicators of various system services. The BDS services performance standard documents will be upgraded according to the system construction and development, as shown in Table 15.

Table 15 The BDS Services Performance Standard Documents

Index	Service Types	Title	Issue Date
1	RNSS	BeiDou Navigation Satellite System Open Service Performance Standard (Version 1.0)	2013.12
2		BeiDou Navigation Satellite System Open Service Performance Standard (Version 2.0)	2018.12
3		BeiDou Navigation Satellite System Open Service Performance Standard (Version 3.0)	2020.12
4	SBAS	BeiDou Satellite-Based Augmentation System Performance Standard (Version 1.0)	2020.12
5	GAS	National BDS Augmentation System Service Performance Standard (Version 1.0)	2017.07
6		BeiDou Ground Augmentation System Performance Standard (Version 2.0)	2020.12
7	PPP	BeiDou Navigation Satellite System Precise Point Positioning Service Performance Standard (Version 1.0)	2020.12
8	RSMC	BeiDou Navigation Satellite System Regional Short Message Communication Service Performance Standard (Version 1.0)	2020.12
9	GSMC	BeiDou Navigation Satellite System Global Short Message Communication Service Performance Standard (Version 1.0)	2020.12
10	SAR	BeiDou Navigation Satellite System Search And Rescue Service Performance Standard (Version 1.0)	2020.12

3.1.4 User Guide Manuals

User guide manuals are mainly used to help users understand the use of the RSMC and GSMC service procedures, to guide users to complete the application, registration and utilization of services. The user guide manuals for BDS services will be upgraded according to the system construction and development, as shown in Table 16.

Table 16 The User Guide Manuals for BDS Services

Index	Service Types	Title	Issue Date
1	RSMC	The User Guide Manual for BeiDou Navigation Satellite System Regional Short Message Communication Service (Version 1.0)	2020.12
2	GSMC	The User Guide Manual for BeiDou Navigation Satellite System Global Short Message Communication Service (Version 1.0)	2020.12

3.1.5 Other Important System Information

According to the development and actual operation status of the system construction, the system construction and development plan, system constellation status, parameters required for high-precision applications, etc, will be timely released. Planned and unplanned interruptions of the in-orbit satellites and other relevant information will be timely notified.

3.2 Information Dissemination

The BDS interface control documents, usage guidance for service interface control documents, service performance standards, user guide manuals, and other important information of the system will be timely released on the official BDS website (www.beidou.gov.cn).

3.3 Feedback Mechanism

The BDS service user feedback mechanism is being established, and a designated E-mail box (BDSServices@beidou.gov.cn) is set up to receive the feedback, comments and suggestions. BDS will respond to global users' needs in a timely manner, continuously improve service capability and user response mechanism, so as to provide the best BDS application service experience for global users.

Appendix: Acronyms

APV-I	Approach Procedure with Vertical Guidance I
BDS	BeiDou Navigation Satellite System
CAT-I	Category I Precision Approach
CRDSS	Comprehensive Radio Determination Satellite Service
GAS	Ground Augmentation System
GEO	Geostationary Earth Orbit
GNSS	Global Navigation Satellite System
GSMC	Global Short Message Communication
IGSO	Inclined Geosynchronous Orbit
MEO	Medium Earth Orbit
PPP	Precise Point Positioning
RDSS	Radio Determination Satellite Service
RNSS	Radio Navigation Satellite Service
RSMC	Regional Short Message Communication
RTK	Real-time Kinematic
SAR	Search And Rescue
SBAS	Satellite-Based Augmentation System