Input paper: [[1]](#footnote-1) ENG16- 3.1.3.6

Input paper for the following Committee(s): check as appropriate Purpose of paper:

**□** ARM **🗹** ENG **□** PAP **🗹** Input

**□** ENAV **□** VTS **□** Information

Agenda item [[2]](#footnote-2) 3.1

Technical Domain / Task Number 2 WG3

Author(s) / Submitter(s) CHINA MSA

Introduction of BDS PPP Service

# Summary

G1127(Edition2.0)provides an overview of systems and services enabling high-accuracy positioning or ranging in specific areas such as waterways, traffic separation schemes, traffic zones with limited manoeuvring space, ports and harbours, and congested waters, with increased risks of collisions or groundings. Precise point positioning (PPP) is an important technology for achieving wide area high-precision positioning for a satellite navigation system because of its wide signal coverage, uniform accuracy distribution, and small number of ground reference monitoring stations. BeiDou Navigation Satellite System (BDS) Precise Point Positioning (PPP) service is provided through the PPP-B2b signal broadcast by the three GEO satellites in the BDS-3 nominal constellation. Users can achieve high-precision positioning through this service.

## Purpose of the document

The purpose of the document is providing information for the Committee to review and consider the applications of BDS PPP service as a manner of high-accuracy positioning and ranging system in maritime.

## Related documents

[1] G1127 SYSTEMS AND SERVICES FOR HIGHACCURACY POSITIONING AND RANGING (Edition 2.0)

[2]BeiDou Navigation Satellite System Signal In Space Interface Control Document Precise Point Positioning Service Signal PPP-B2b(Version 1.0), July, 2020

http://www.beidou.gov.cn/xt/gfxz/202008/P020200803362062482940.pdf

[3] BeiDou Navigation Satellite System Open Service Performance Standard (Version 3.0), May, 2021

<http://www.beidou.gov.cn/xt/gfxz/202105/P020210526216231136238.pdf>

[4] Design and implementation of a BDS precise point positioning service, 21 February 2020, ION. DOI: 10.1002/navi.392

# Background

The BeiDou Navigation Satellite System (BDS) has been built and developed in accordance with a "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 inheriting the technically compatible with BDS-1, BDS-2 also added a passive positioning scheme to provide users in the Asia-Pacific regions with positioning, velocity measurement, timing and short message communication services. BDS-3 construction was started from 2009 and fully completed in 2020. On the basis of BDS-2, BDS-3 further improves services performance and expands services functions.

BDS-3 provides various services, including positioning, navigation, timing, global message communication, and international search and rescue services for global users, as well as the satellite-based augmentation, ground augmentation, precise point positioning and regional message communication services for users in China and surrounding areas.

BDS PPP provide service to users in China and its surrounding areas in the scope of 10 ° N~55 ° N, 75 ° E~135 ° E, on the surface of the Earth and its near-earth areas extending within 1,000 kilometres above the Earth surface.

# Discussion

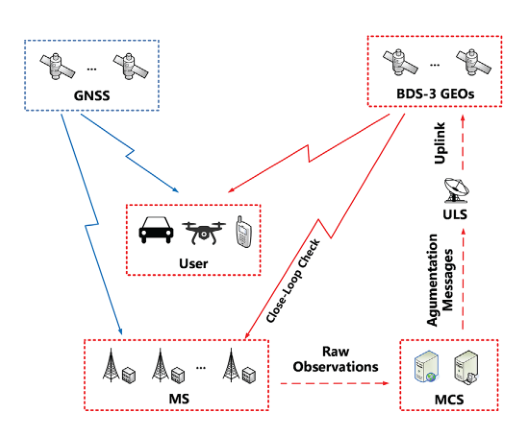
## BDS PPP Service Architecture

the BDS PPP service works by using the space and ground segment facilities of BDS-3.The architecture in show in figure 1.

a) Space segment: three BDS-3GEO located at longitudes 80°, 110.5 °, and 140 ° .

b) Ground segment: consists of the master control station (MCS), uplink stations (ULS), and monitoring stations (MS), which are well distributed in mainland China. The MS carries out continuous monitoring for all the visible satellites of the global navigation satellite systems (GNSS), forming pseudorange and carrier phase observations, and collecting meteorological data. After pre-processing, the raw data are sent to the MCS via a network. The quality verification and accuracy assessment for the raw data are carried out by the MCS for pre-processing. The raw data are compared with historical precise products for the overlapping arcs, and the user differential range error (UDRE) is evaluated. After pre-processing, the precise prediction satellite orbit and clock corrections are solved and fitted based on a dynamical smoothing process. According to the design protocol and format, the corrections and other related parameters such as mask and differential code bias (DCB) are attached to the augmentation navigation messages and then transferred to the ULS. The ULS transmits the augmentation navigation messages to the GEO satellites for broadcasting via PPP-B2b signals. Meanwhile, the MS and MCS retrieve the messages for closed-loop checking.

c)User segment: includes various receivers with PPP-B2b signal reception, augmentation navigation message demodulation, and PPP solution functions.



*Figure 1 The BDS PPP architecture and Data processing flow*

## BDS PPP SIS Interface Characteristics

3.2.1 SIS RF Characteristic

The center frequency of the PPP-B2b signal is 1207.14 MHz, and the bandwidth is 20.46 MHz. The I component of PPP-B2b signal is modulated in BPSK (10), and polarized by RHCP, while the right-hand circularly polarized antenna is 0 dBi gain (or the linearly polarized antenna is 3 dBi gain), the minimum power level that reaches the output of a receiver antenna is -160 dBW. For details, please refer to the "BeiDou Navigation Satellite System Signal-in-Space Interface Control Document: Precise Point Positioning Service Signal PPP-B2b (Version 1.0)".

3.2.2 Characteristics of Navigation Message

The types of messages broadcast by PPP-B2b are shown in Table 1.

* Table 1 The PPP Defined message types

|  |  |
| --- | --- |
| **Message types (in decimal)** | **Information content** |
| 1 | Satellite mask |
| 2 | Satellite orbit correction and user range accuracy |
| 3 | Differential code bias |
| 4 | Satellite clock correction |
| 5 | User range accuracy |
| 6 | Clock correction and orbit correction - combination 1 |
| 7 | Clock correction and orbit correction - combination 2 |
| 8-61 | Reserved |
| 62 | Reserved |
| 63 | Null message |

The NAV message data frame of the I component of PPP-B2b signal employs the reserved flags to indicate the status of the PPP service. The "1" in the highest bit of the reserved flags means the PPP service of this satellite is unavailable and the "0" in the highest bit of the reserved flags means the PPP service of this satellite is available. For details of the navigation messages, please refer to BDS-SIS-ICD-PPP-B2b-1.0.

## BDS PPP Performance Characteristics

3.3.1 Usage Constraint

The PPP service performance are based on the following user constraints:

a) The user receiver meets the relevant technical requirements specified in BDS-SIS-ICD-PPP-B2b-1.0, can track and correctly process the dual-frequency RNSS signals and the PPP-B2b signal, and use the augmentation information to complete the positioning calculation;

b) The service is based on BeiDou Navigation Satellite System Time (BDT) and BeiDou Coordinate System (BDCS);

c) Exclude errors of the signal transmission and the receiving terminal;

d) When the highest bit of the reserved flags is "1", the PPP information broadcast by the satellite should not be used.

3.3.2 Positioning Accuracy and Convergence Time

The main PPP performance standards include the positioning accuracy and the convergence time, etc.

The positioning accuracy refers to the statistical value of the difference between the user’s reference position and the position determined by using the PPP service. The positioning accuracy includes the horizontal and vertical component respectively.

The convergence time is the time to meet the positioning accuracy requirements for the first time, under the condition that the receiver starts meeting the positioning accuracy and continues for 5 minutes.

3.3.3 Service Performance Standard

The augmentation service performance for using BDS only or the dual-system (BDS+GPS) is presented in Table 2.

* Table 2 The PPP Service Performance Standard

| **Constellation** | **Performance**  **Characteristics** | **Performance**  **Standard** | **Constraints** |
| --- | --- | --- | --- |
| BDS | Horizontal Positioning  Accuracy (95%) | ≤0.3m | The correction targets: PPP-B2b information is used to correct the CNAV1 NAV message of the BDS BIC signal and the LNAV NAV message of the GPS L1C/A signal; |
| Vertical Positioning  Accuracy (95%) | ≤0.6m |
| Convergence Time | ≤30min | Requirements for the correction targets: the BDS RNSS service performance meets the requirements of BeiDou Navigation Satellite System Open Service Performance Standard (Version 3.0); GPS service performance meets the requirements of "GPS Standard Positioning Service Performance Standard (Version 5.0)".  Elevation mask is 10 degrees;  Dual-frequency positioning;  The statistical time interval is 7 days, and all points in the service area are averaged. |
| BDS+GPS | Horizontal Positioning Accuracy (95%) | ≤0.2m |
| Vertical Positioning  Accuracy (95%) | ≤0.4m |
| Convergence Time | ≤20min |

# Action requested of the Committee

The Committee is invited:

.1 to note the information provided in the paper; and,

.2 to propose a new guideline of satellite based PPP service together with other HAS providers.

1. Input document number, to be assigned by the Committee Secretary [↑](#footnote-ref-1)
2. Leave open if uncertain [↑](#footnote-ref-2)