*International Civil Aviation Organization*

**Twenty Fourth Meeting of the Communications/ Navigation and Surveillance Sub-group (CNS SG/24) of APANPIRG**

Web-conference, 30 November – 4 December 2020

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**Agenda Item 5:** Navigation

5.5 Other navigation related issues

# BDSBAS STATUS UPDATE REPORT

(Presented by China)

**SUMMARY**

This information paper provides the updates of BDSBAS, including the BDSBAS architecture, the GEO satellite status, the BDSBAS B1C ICD, the service testing results and the certification plan.

## 1. INTRODUCTION

1.1 The BeiDou Navigation Satellite System (BDS) was formally commissioned on July 31st, 2020. As an important part of BDS, the BeiDou Satellite-based Augmentation System (BDSBAS) will provide Single-Frequency (SF) and Dual-Frequency Multi-Constellation (DFMC) services, in accordance with the International Civil Aviation Organization (ICAO) standards. BDSBAS will serve users in China and surrounding areas, and aim to achieve APV-I and CAT-I precision approach capabilities.

## 2. THE BDSBAS ARCHITECTURE

2.1 BDSBAS is comprised of space segment, ground segment and user segment. The BDSBAS architecture is shown as Figure 1.

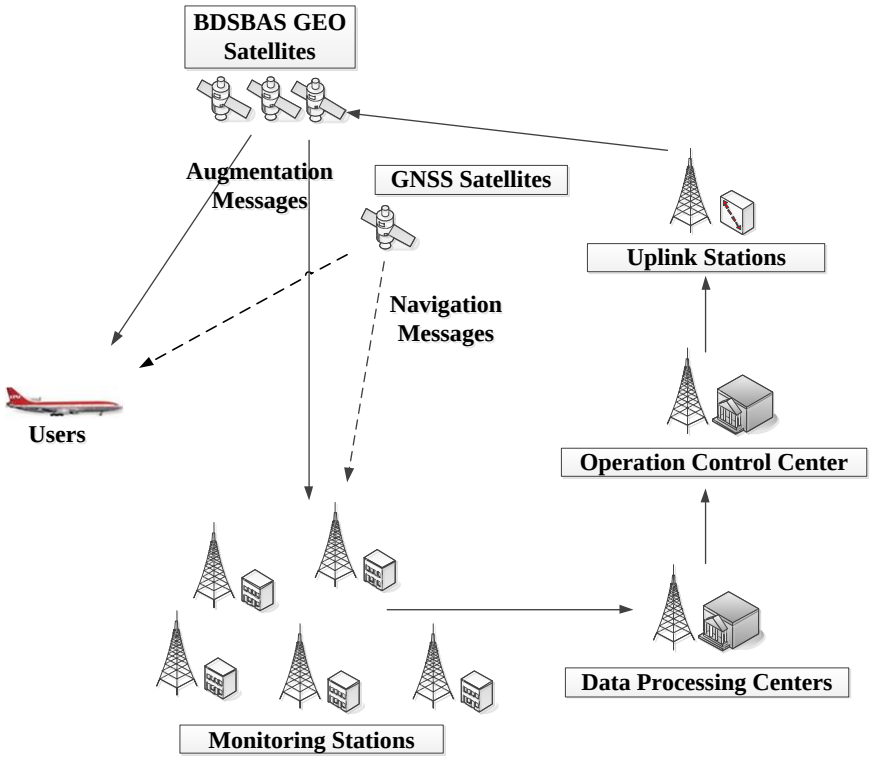


Figure 1 The BDSBAS Architecture

## 2.2 The BDSBAS SPACE SEGMENT

2.2.1 The BDSBAS space segment includes 3 Geostationary Earth Orbit (GEO) satellites, and the corresponding orbital slots are 80°E, 110.5°E and 140°E, respectively. All 3 GEOs have been successfully launched, with the coverage areas as shown in Figure 2.

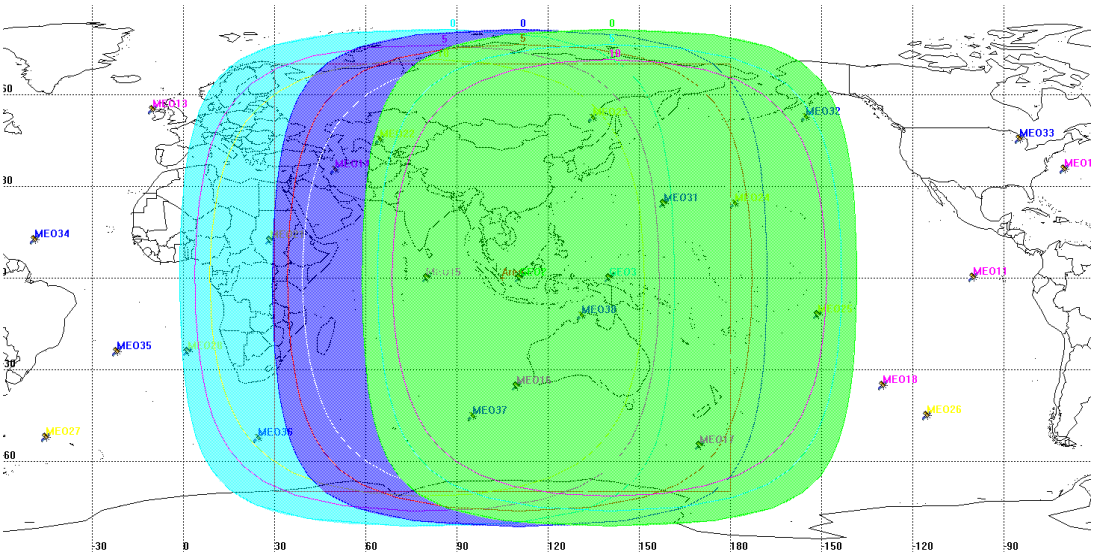

Figure 2 The BDSBAS Coverage Area

2.2.2 On October 12, 2017, three "Temporary" PRN codes (130, 143, and 144) were assigned to the three BDSBAS GEOs. On August 13, 2020, the PRN codes (130, 143 and 144) with the "Final" status were assigned to BDSBAS and will be effective through August 2030, as shown at Table 1.

**Table 1 The BDSBAS PRN codes and the orbital slots**

| L1 C/A PRN Code Number | C/A | | | System (Satellite) | Orbital Slot | Effective Through | Assignment Type |
|---|---|---|---|---|---|---|---|
| | G2 Delay (chips) | Initial G2 Setting (Octal) | First 10 Chips (Octal) | | | | |
| 130 | 355 | 0341 | 1436 | BDSBAS (GEO-1) | 140E | Aug 2030 | Final |
| 143 | 307 | 1312 | 0465 | BDSBAS (GEO-3) | 110.5E | Aug 2030 | Final |
| 144 | 127 | 1060 | 0717 | BDSBAS (GEO-2) | 80E | Aug 2030 | Final |

| L5 PRN Code Number | XB Code Advance (Chips) | | Initial XB Code State (Octal) | | System (Satellite) | Orbital Slot | Effective Through | Assignment Type |
|---|---|---|---|---|---|---|---|---|
| | I5 | Q5 | I5 | Q5 | | | | |
| 130 | 1224 | 1092 | 17754 | 12737 | BDSBAS (GEO-1) | 140E | Aug 2030 | Final |
| 143 | 3745 | 8126 | 05474 | 15167 | BDSBAS (GEO-3) | 110.5E | Aug 2030 | Final |
| 144 | 4723 | 7017 | 02275 | 16761 | BDSBAS (GEO-2) | 80E | Aug 2030 | Final |

2.3 THE BDSBAS GROUND SEGMENT

2.3.1 The BDSBAS ground segment consists of 30 Monitoring Stations (MS), 2 Data Processing Centers (DPC), 1 Operation Control Center (OCC) and 3 Uplink Stations (US).

2.3.2 The MSs monitor GNSS satellites continuously, collect observation and meteorological data, and send these data to DPC.

2.3.3 Having received data, the DPCs first process satellite orbit and clock information, then generate ionospheric delay differential information, satellite differential information (the ephemeris correction and the clock correction) and the integrity information (UDRE, GIVE, DFRE etc.), and send the information to the OCC.

2.3.4 The OCC generates augmentation messages using the information from the DPCs, and sends the messages to the USs.

2.3.5 The USs uplink the messages to the BDSBAS GEOs, which will broadcast the messages to the users within China and surrounding areas.

2.4 The BDSBAS USER SEGMENT

2.4.1 The BDSBAS user segment refers to the SBAS terminals used in civil aviation, maritime and railway applications etc.

## 3. THE BDSBAS GEO SATELLITES STATUS

3.1 The ground tests of the BDSBAS GEO-1 satellite was carried out in February 2018, and the ground test of the BDSBAS GEO-2 and GEO-3 satellites were carried out in March and May 2019, respectively. According to the test results, the B1C and B2a RF characteristics of the three GEOs are

shown in Table 2 and Table 3, respectively. The B1C RF characteristics indicate that the signal-in-space performance of GEO-1, GEO-2 and GEO-3 met the requirements of ICAO SARPs. The B2a RF characteristics show that the signal-in-space performance of GEO-1, GEO-2 and GEO-3 satisfies the requirements of the draft ICAO DFMC SBAS SARPs.

**Table 2 The B1C RF characteristics of the BDSBAS GEO-1, GEO-2 and GEO-3**

| NO | Item | ICAO requirements | GEO-1 RF characteristics | GEO-2 RF characteristics | GEO-3 RF characteristics |
|---|---|---|---|---|---|
| 1. | Carrier Frequency | 1575.42MHz | 1575.42MHz | 1575.42MHz | 1575.42MHz |
| 2. | Spurious | ≤-40dBc | -56.66 | -62.52 | -58.34 |
| 3. | Modulation | BPSK（1）symbol rate 500sps code length 1023 Chip rate 1.023Mchip/s | BPSK（1）symbol rate 500sps code length 1023 Chip rate 1.023Mchip/s | BPSK（1）symbol rate 500sps code length 1023 Chip rate 1.023Mchip/s | BPSK（1）symbol rate 500sps code length 1023 Chip rate 1.023Mchip/s |
| 4. | Phase Noise | PLL of 10 Hz one-sided noise bandwidth is able to track the carrier with an accuracy of 0.1 radian | 0.00578 rad | 0.00630 rad | 0.00598rad |
| 5. | Spectrum | At least 95% of the broadcast power will be contained within 12 MHz bandwidth | Band wide：±18.414MHz | Band wide：±18.414MHz | Band wide：±18.414MHz |
| 6. | Frequency Stability | <5e-11(1s~10s) | 1.5e-12/1s | 1.37e-12/1s | 1.40e-12/1s |
| 7. | Coherence of Code & Carrier | Short-term：< 0.15m | 0.12m | 0.08m | 0.10m |
| | | Long-term：< 0.19m | 0.133m | 0.09m | 0.11m |
| | | Long-term：<0.255m | 0.16m | 0.11m | 0.15m |
| 8. | Coherent of L1 | Short-term：<0.2m Long-term：<0.255m | Short-term：0.13m Long-term：0.178m | Short-term：0.04m Long-term：0.078m | Short-term：0.08m Long-term：0.103m |

**Table 3 The B2a RF characteristics of the BDSBAS GEO-1, GEO-2 and GEO-3**

| NO | Item | ICAO requirements | GEO-1 RF characteristics | GEO-2 RF characteristics | GEO-3 RF characteristics |
|---|---|---|---|---|---|
| 1. | Carrier Frequency | 1176.45MHz | 1176.45MHz | 1176.45MHz | 1176.45MHz |
| 2. | Spurious | ≤-40dBc | -62.34 | -54.38 | -58.55 |
| 3. | Modulation | BPSK（10）symbol rate 500sps code length 10230 Chip rate 10.23Mchip/s | BPSK（10）symbol rate 500sps code length 10230 Chip rate 10.23Mchip/s | BPSK（10）symbol rate 500sps code length 10230 Chip rate 10.23Mchip/s | BPSK（10）symbol rate 500sps code length 10230 Chip rate 10.23Mchip/s |

| | | | | | |
|---|---|---|---|---|---|
| 4. | Phase Noise | PLL of 10 Hz one-sided noise bandwidth is able to track the carrier with an accuracy of 0.1 radian | 0.00578 rad | 0.00630 rad | 0.00598rad |
| 5. | Spectrum | At least 95% of the broadcast power will be contained within 3 dB bandwidth | Band wide: ±35.805MHz | Band wide: ±35.805MHz | Band wide: ±35.805MHz |
| 6. | Frequency Stability | <6.7e-11(1s~10s) | 5.2e-13/10s | 4.77e-13/10s | 4.9e-13/10s |
| 7. | Coherence of Code & Carrier | Short-term: <0.2m | 0.1m | 0.09m | 0.09m |
| | | Long-term: <0.255m | 0.16m | 0.11m | 0.15m |
| 8. | Coherent of L5 | Short-term: <0.2m<br>Long-term: <0.255m | Short-term: 0.13m<br>Long-term: 0.178m | Short-term: 0.04m<br>Long-term: 0.078m | Short-term: 0.08m<br>Long-term: 0.103m |

## 4. BDSBAS B1C ICD

4.1 The interface control document (ICD) of BDSBAS B1C has been published by China Satellite Navigation Office in July, 2020. The file can be downloaded from the official BDS website at www.beidou.gov.cn/xt/gfxz/202008/P020200803362065480963.pdf.

## 5. TEST RESULTS OF BDSBAS SF SERVICE

5.1 The performance of BDSBAS SF service, which augments GPS, was tested by using the SF augmentation messages broadcast from BDSBAS GEOs B1C and the measurements from Beijing, Shanghai and Changsha.

5.2 The tests of BDSBAS SF service were carried out in three stages. 1) From November 27 to December 4, 2019, only GEO-1 broadcasted signals; 2) From June 15 to 21, 2020, both GEO-1 and GEO-2 broadcasted signals; 3) From September 14 to 20, 2020, all 3 GEOs have been broadcasting signals.

5.3 The testing results of positioning accuracy in that three stages are shown in Table 4, Table 5 and Table 6, respectively. As shown in the three tables, the BDSBAS SF service performance has been constantly improving.

**Table 4 The positioning accuracy in the first stage**

| **Site** | **Beijing** | | **Shanghai** | | **Changsha** | |
|---|---|---|---|---|---|---|
| **Positioning Accuracy (95%)** | Horizontal | Vertical | Horizontal | Vertical | Horizontal | Vertical |
| | 2.23m | 3.83m | 2.89m | 3.89m | 2.46m | 3.91m |

**Table 5 The positioning accuracy in the second stage**

| **Site** | **Beijing** | | **Shanghai** | | **Changsha** | |
|---|---|---|---|---|---|---|
| **Positioning Accuracy (95%)** | Horizontal | Vertical | Horizontal | Vertical | Horizontal | Vertical |
| | 0.91m | 2.33m | 1.28m | 2.67m | 0.95m | 2.92m |

**Table 6 The positioning accuracy in the third stage**

| **Site** | **Beijing** | | **Shanghai** | | **Changsha** | |
|---|---|---|---|---|---|---|
| **Positioning Accuracy (95%)** | Horizontal | Vertical | Horizontal | Vertical | Horizontal | Vertical |
| | 0.80m | 1.89m | 1.15m | 2.26m | 0.79m | 2.39m |

5.4 The testing results of the safety index (calculated at the moment when the positioning error was worst) in the three stages are listed in Table 7, Table 8 and Table 9. As shown in the tables, both of the horizontal and vertical safety indexes are larger than 1, which means no appearance of the integrity risk during the test periods.

**Table 7 The safety index in the first stage**

| **Site** | **Horizontal Safety Index HPL/HPE** | **Vertical Safety Index VPL/VPE** |
|---|---|---|
| **Beijing** | 3.29 | 2.90 |
| **Shanghai** | 1.59 | 1.72 |
| **Changsha** | 1.91 | 5.08 |

**Table 8 The safety index in the second stage**

| **Site** | **Horizontal Safety Index HPL/HPE** | **Vertical Safety Index VPL/VPE** |
|---|---|---|
| **Beijing** | 3.02 | 5.29 |
| **Shanghai** | 3.37 | 2.45 |
| **Changsha** | 4.48 | 9.81 |

**Table 9 The safety index in the third stage**

| **Site** | **Horizontal Safety Index HPL/HPE** | **Vertical Safety Index VPL/VPE** |
|---|---|---|
| **Beijing** | 4.96 | 6.98 |
| **Shanghai** | 7.25 | 3.69 |
| **Changsha** | 9.05 | 3.87 |

## 6. CERTIFICATION PLAN

6.1 According to plan, BDSBAS system will be completed and have the capability to broadcast SF test signals based on ICAO SARPs and BDSBAS B1C ICD by the end of 2020. And the certification process of BDSBAS SF service will be carried out accordingly, and last for at least 3 years.

6.2 The certification work will be carried out by a specific working group established by CAAC and led by the Technical Centre of the ATMB, CAAC.

6.3 BDSBAS certification work consists of three parts: technical review, system test and initial operation. The technical review includes reviewing the documents of the system design and construction, to check the compliance with the operational requirements of the BDSBAS system; the system test includes a long-term (over two years) wide-area performance monitoring and evaluation of BDSBAS , flight test, and flight validation; and after BDSBAS has the initial operating capability, long-term performance monitoring will be continued, and the system application will be promoted. The scheme of certification is shown as Figure 3.

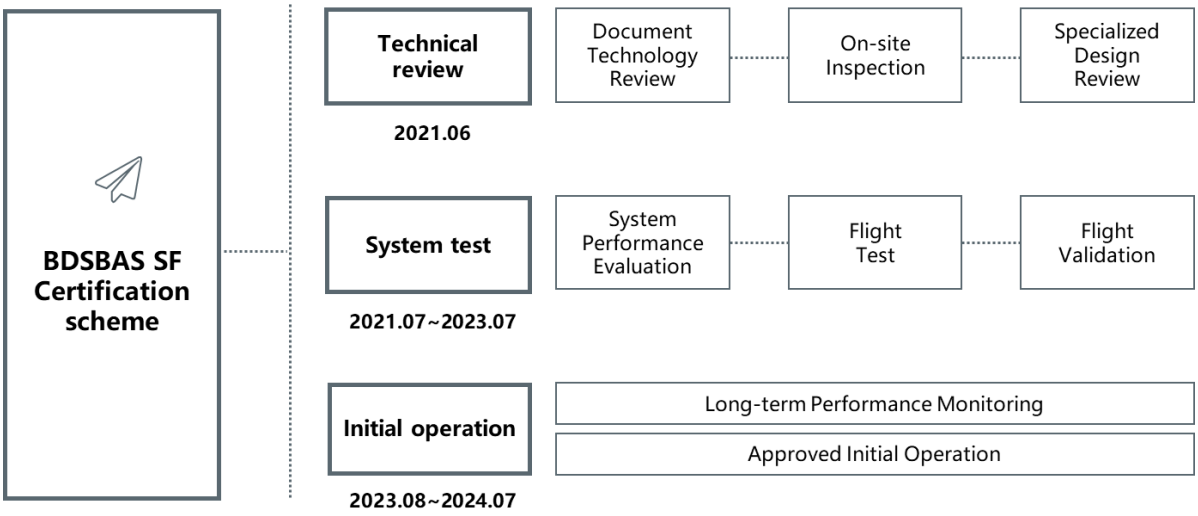


Figure 3 BDSBAS SF Certification Scheme

## 7. ACTION BY THE MEETING

7.1 The meeting is invited to:

a) note the information regarding BDSBAS implementation status in China and future plans of BDSBAS up-gradation and certification.

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