BeiDou Navigation Satellite System Signal In Space Interface Control Document

Search and Rescue Service

(Version 1.0)

China Satellite Navigation Office

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1 Statement

China Satellite Navigation Office is responsible for the preparation, revision, distribution, and retention of the BeiDou Navigation Satellite System (BDS) Signal In Space Interface Control Documents (hereinafter referred to as SIS ICD), and reserves the rights for final interpretation of this document.

2 Scope

The construction and development of the BeiDou Navigation Satellite System is divided into three phases: BDS-1, BDS-2, and BDS-3 in sequence.

This document defines the characteristics of the search and rescue service provided by BDS-3. This search and rescue service includes COSPAS-SARSAT compliant Medium Earth Orbit Search and Rescue (MEOSAR) service provided by Medium Earth Orbit (MEO) satellites, as well as B2b signal based Return Link Service (RLS) provide by MEO and Inclined Geo-Synchronous Orbit (IGSO) satellites.

3 BDS Overview

3.1 Space Constellation

The nominal space constellation of BDS-3 consists of 3 Geostationary Earth Orbit (GEO) satellites, 3 IGSO satellites, and 24 MEO satellites. According to actual situation, spare satellites may be deployed in orbit. The GEO satellites operate in orbit at an altitude of 35,786 kilometers and are located at 80°E, 110.5°E, and 140°E respectively. The IGSO satellites operate in orbit at an altitude of 35,786 kilometers and an inclination of the orbital planes of 55 degrees with reference to the equatorial plane. The MEO satellites operate in orbit at an altitude of 21,528 kilometers and an inclination of the orbital planes of 55 degrees with reference to the equatorial plane.

3.2 Coordinate System

BDS adopts the BeiDou Coordinate System (BDCS) whose definition complies with the standards of the International Earth Rotation and Reference System Service (IERS). The definition is also consistent with that of the China Geodetic Coordinate System 2000(CGCS2000). BDCS and CGCS2000 have the same reference ellipsoid parameters, which is defined as follows:

(1) Definition of origin, axis and scale

The origin is located at the Earth’s center of mass. The Z-Axis is the direction of the IERS Reference Pole (IRP). The X-Axis is the intersection of the IERS Reference Meridian (IRM) and the plane passing through the origin and normal to the Z-Axis. The Y-Axis, together with Z-Axis and X-Axis, constitutes a right-handed orthogonal coordinate system.

The length unit is the international system of units (SI) meter.

(2) Definition of the BDCS Reference Ellipsoid

The geometric center of the BDCS Reference Ellipsoid coincides with the Earth’s center of mass, and the rotational axis of the BDCS Reference Ellipsoid is the Z-Axis. The parameters of the BDCS Reference Ellipsoid are shown in Table 3-1.

Table 3-1 Parameters of the BDCS Reference Ellipsoid

No.	Parameter	Definition
1	Semi-major axis	a=6378137.0 m
2	Geocentric gravitational constant	$\mu=3.986004418\times10^{14}\ m^3/s^2$
3	Flattening	f=1/298.257222101
4	Earth's rotation rate	$\dot{\Omega}_e=7.2921150\times10^{-5}$ rad/s

3.3 Time System

The BeiDou Navigation Satellite System Time (BDT) is adopted by the BDS as time reference. BDT adopts the second of the international system of units (SI) as the base unit, and accumulates continuously without leap seconds. The start epoch of BDT is 00:00:00 on January 1, 2006 of Coordinated Universal Time (UTC). BDT connects with UTC via UTC (NTSC), and the deviation of BDT to UTC is maintained within 50 nanoseconds (modulo 1 second). The leap second information is broadcast in the navigation message.

4 Characteristics of the User Alarm Signal

This chapter specifies the characteristics of the up-link user alarm signal at 406 MHz and the down-link BDS MEOSAR payload signal at 1544.21MHz, according to standards of COSPAS-SARSAT.

4.1 Distribution of BDS MEOSAR Payloads

BDS MEOSAR service is provided by 6 MEOSAR payloads mounted on 6 BDS MEO satellites. This is a global service. The distribution of BDS MEO satellite with SAR payloads in MEO constellation is shown in table 4-1.

Table 4-1 Distribution of BDS MEO satellite with SAR payloads in MEO constellation

Slot/Plane	A	B	C
1		M13	
2			
3		M14	M23
4			
5			M24
6	M21		
7			
8	M22		

The corresponding relationship among PRN (Pseudo-Random Noise), NORAD (North American Aerospace Defense Command) ID, satellite name, international designator of these satellites is shown in table 4-2.

Table 4-2 Corresponding relation among PRN, ID and satellite names

PRN	NORAD ID	Satellite Name	International Designator
32	43622	M13	2018-072A
33	43623	M14	2018-072B
45	44543	M23	2019-061B
46	44542	M24	2019-061A
43	44794	M21	2019-078B
44	44793	M22	2019-078A

4.2 Up-link Alarm Signal

There are two types of up-link user alarm signal formats from two types of beacons, i.e. the first-generation beacon and the second-generation beacon. The first-generation beacon uses BPSK modulation method, and the second-generation beacon uses DSSS-OQPSK modulation method.

Major operating parameters of up-link user alarm signal are shown in table 4-3.

Table 4-3 Major parameters of the up-link alarm signal

	Item	First Generation Beacon Parameters	Second Generation Beacon Parameters
1	Frequency	406.0MHz～406.1MHz	406.05 MHz
2	TX power	32dBm～43dBm	33dBm～45dBm
3	Beacon Polarization	Vertical, or RHCP	
4	Modulation method	BPSK	DSSS-OQPSK
5	Modulation Bandwidth	800Hz	76.8kHz
6	Data length	112bits or 144bits	250bits
7	Baud rate	400bps	300bps
8	TX duration	440ms or 520ms	1s
9	Payload mode	50kHz or 90kHz mode	90kHz mode only
10	Payload RX power range	-166dBW～-135dBW	

Please refer to COSPAS-SARSAT document T.001 *Specification for Cospas-Sarsat 406 MHz Distress Beacons*[1] for the detailed structure of the first-generation beacon and COSPAS-SARSAT document T.018 *Specification for Second-Generation Cospas-Sarsat 406-MHz Distress Beacons*[1] for that of the second-generation beacon.

4.3 Down-Link Signal

The downlink signal is used by the COSPAS-SARSAT ground segment. The design of BDS MEOSAR payloads meets the requirement of COSPAS-SARSAT standards, and is compatible with other MEOSAR systems. Major operating parameters of BDS MEOSAR

1 Documents are available at http://www.cospas-sarsat.int/en/documents-pro/system-documents.

payloads are shown in table 4-4.

Table 4-4 Major parameters of BDS MEOSAR payloads

Parameter		**Interoperability Requirement**	**Design result of BDS MEOSAR payloads**
Bandpass characteristics	Normal mode	1dB > 80kHz	1dB > 80kHz
		3dB > 90kHz	3dB > 90kHz
		10dB < 110kHz	10dB < 110kHz
		45dB < 170kHz	45dB < 170kHz
		70dB < 200kHz	70dB < 200kHz
	Narrowband mode	1dB > 50kHz	1dB > 50kHz
		10dB < 75kHz	10dB < 75kHz
		45dB < 130kHz	45dB < 130kHz
		70dB < 160kHz	70dB < 160kHz
Transponder gain modes		/	ALC
Transponder gain		＞180 dB	> 180 dB
Downlink frequency band		/	1544.16～1544.26MHz
Downlink centre frequency	Normal mode	/	1544.21MHz
	Narrowband mode	/	1544.203MHz
Downlink antenna polarization		/	RHCP
Downlink EIRP		>15dBw	＞18.0dBw

Please refer to COSPAS-SARSAT documents R.012 *Cospas-Sarsat 406 MHz MEOSAR Implementation Plan*[1] and T.016 *Description of the 406 MHz Payloads Used in the Cospas-Sarsat MEOSAR System*”[1] for detailed information of downlink signal parameters.

5 Characteristics of the RLM Signal

RLM signals is the downlink user signal that broadcasted from BDS-3 MEO and IGSO satellites via the I-component of B2b signal in the 20.46 MHz frequency band centralized at 1207.14 MHz.

For the signal structure, signal modulation, logic levels, polarization, carrier phase noise, spurious, correlation loss, data/code coherence, signal coherence, receiving power levels on ground and navigation message overview of B2b signal, please refer to *BeiDou Navigation Satellite System Signal In Space Interface Control Document Open Service Signal B2b (Version 1.0).*[2]

5.1 Brief Description of the Navigation Message

RLM is carried by navigation messages formatting in B-CNAV3 as defined in the B2b ICD. The B-CNAV3 navigation message includes basic navigation information and global basic integrity information. Each frame has a length of 1000 symbols, with a symbol rate of 1000sps, therefore the transmission period of each frame lasts for 1 second. The basic frame structure of B-CNAV3 is defined in Figure 5-1.

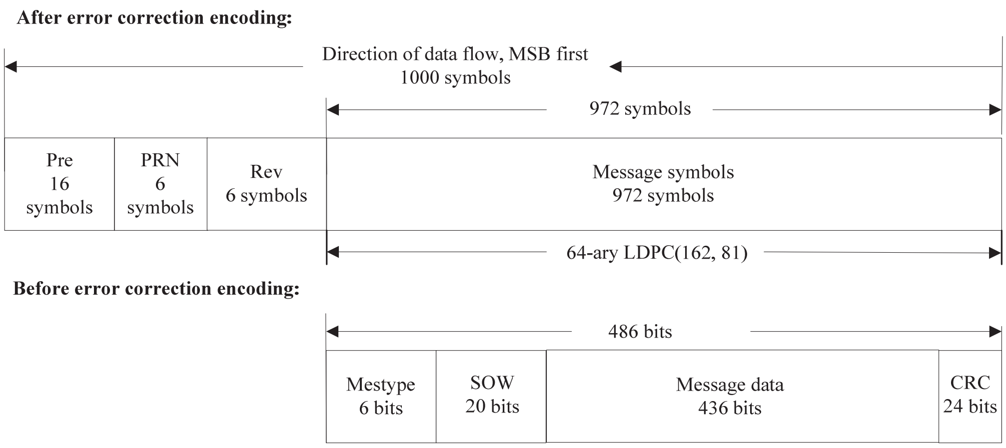

Figure 5-1 B-CNAV3 frame structure

The first 16 symbols of each frame are preambles (Pre) with the value of 0xEB90 in hexadecimal (i.e., 1110 1011 1001 0000 in binary). The MSB is transmitted first. The PRN for

2 ICD is available at http://en.beidou.gov.cn/SYSTEMS/Officialdocument/ .

ranging code is 6 bits with unsigned integer.

Each frame before error correction coding has a length of 486 bits, containing Message Type (Mestype, 6 bits), Seconds Of Week (SOW, 20 bits), message data (436 bits), and CRC check bits (24 bits). MesType, SOW, and message data participate in the CRC calculation. After 64-ary LDPC (162, 81) encoding, the frame length shall be 972 symbols.

For LDPC encoding method, please refer to *BeiDou Navigation Satellite System Signal In Space Interface Control Document Open Service Signal B2b (Version 1.0).*

5.2 RLM Data Format

B-CNAV3 navigation message currently defines several types of valid massage types, among which the Message Type 8 (i.e. ‘001000’, MSB first) is defined to be used for RLM in international search and rescue.

A single frame of a B2b message has 436 bits of message data to contain RLM. At this time, the message length of a single RLM is shorter than 436 bits, hence a single RLM frame could contain multiple RLMs, each of which is independent.

In order to improve interoperability with other GNSS, three RLM formats are currently designed.

• Type 1 RLM (Short RLM, system acknowledgement): When COSPAS-SARSAT ground segment detects and locates the distress from the distress beacon with a BDS RLM request, the distress is sent to the BDS RLSP (Return Link Service Provider). Upon receiving the RLM request, the BDS RLSP automatically sends the RLM to the distress beacon through the BDS Operating and Control Center. Type 1 RLM is used for quick delivery of response RLM.

• Type 2 RLM (Long RLM, rescue coordination center confirmation): In this case, the BDS RLSP only sends out the RLM to the distress beacon after receiving authorization from the responsible rescue coordination center. This confirmation will notify the user that the alarm is being processed. Type 2 RLM is used for delivery of response RLM after the evaluation on the distress by SAR authorities.

• Type 3 RLM: The working mechanism is the same as Type 2, but the actual message field is customized text.

The data formats (bit allocation) of the three types of RLM are shown in Figure 5-2.

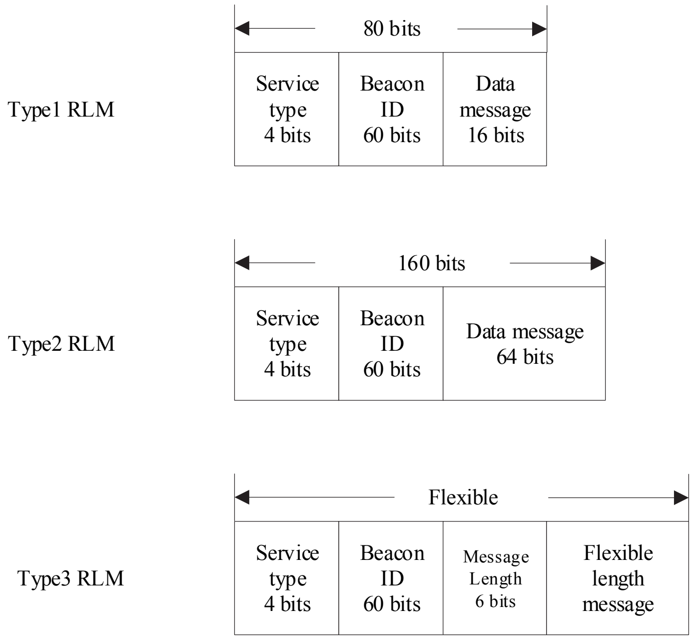

Figure 5-2 Bit allocation for RLM

Service type fields are defined in Table 5-1.

Table 5-1 Service Type Fields Definition

	Data	**Definition**
1	1111	Test Mode
2	0001	Type 1 RLM
3	0010	Type 2 RLM
4	0011	Type 3 RLM

Beacon ID is the unique identification code for beacons in COSPAS-SARAST. According to the beacon ID，distress beacon can identify whether the message is sent to itself or not. The ID of the first-generation beacon is 60 bits, and that of the second-generation beacon is 92 bits, but RLM only contains the first 60 bits.

Actual message fields are still under design.

6 Abbreviations

BDCS	BeiDou Coordinate System
BDS	BeiDou Navigation Satellite System
BDT	BeiDou Navigation Satellite System Time
BPSK	Binary Phase Shift Keying
CGCS2000	China Geodetic Coordinate System 2000
COSPAS-SARSAT	Космическая Система Поиска Аварийных Судов-Search And Rescue Satellite-Aided Tracking
CRC	Cyclic Redundancy Check
DSSS-OQPSK	Direct Sequence Spread Spectrum-Offset Quadrature Phase Shift Keying
GEO	Geostationary Earth Orbit
GNSS	Global Navigation Satellite System
ICD	Interface Control Document
IERS	International Earth Rotation and Reference Systems Service
IGSO	Inclined GeoSynchronous Orbit
IRM	IERS Reference Meridian
IRP	IERS Reference Pole
LDPC	Low Density Parity Check
MEO	Medium Earth Orbit
MEOSAR	Medium Earth Orbit Search And Rescue
MSB	Most Significant Bit
NORAD	North American Aerospace Defense Command
NTSC	National Time Service Center
PRN	Pseudo-Random Noise
RHCP	Right-Hand Circular Polarization
RLS	Return Link Service
RLM	Return Link Message

RLSP	Return Link Service Provider
SOW	Seconds Of Week
UTC	Universal Time Coordinated