Quasi-Zenith Satellite System

Interface Specification

Centimeter Level Augmentation Service

(IS-QZSS-L6-001)

(November 5, 2018)

Cabinet Office

Disclaimer of Liability

The Cabinet Office, Government of Japan ("CAO") and Quasi-Zenith Satellite System Services Inc. make the User Interface Specification (IS-QZSS) ("Document") available to the public to promote the services using Quasi-Zenith Satellite System ("QZSS") by development of receivers, applications and so on, and also are aiming for high accuracy and convenience with respect to satellite positioning services and message services of QZSS (collectively "Services"). The Services are freely available to any user. However, the receivers and/or applications developed based on this Document may not receive signals or may receive incorrect signals due to no warranty of the Services. You are therefore highly recommended to ensure appropriate measures to avoid accidents such as redundancy, backup and fail-safe, if you develop receivers and/or applications using the Services for the purpose that will possibly give an impact to human life, body and properties. The Services may be suspended or changed without prior notice in accordance with the decision by Government of Japan. This Document and the Services are available subject to the following terms and conditions. You may use this Document only if you agree to such terms and conditions. You shall be deemed to agree such terms and conditions by using this Document.

(1) With respect to this Document and the information included in this Document, the Cabinet Office, Government of Japan ("CAO") and Quasi-Zenith Satellite System Services Inc. ("QSS") disclaim all warranties of any kind, express or implied, including but not limited to, the followings:
 i) warranty of accuracy, completeness, usefulness, and fitness for a particular request or purpose;
 ii) warranty that this Document and the information included in this Document will not be changed in to the future; and
 iii) warranty that this Document and the information included in this Document do not infringe any third party's intellectual property rights.

(2) With respect to satellite positioning services and message services (collectively "Services"), CAO and QSS disclaim all warranties of any kind, express or implied, from any cause whether it is related to Quasi-Zenith Satellite System, other outside systems or not, including but not limited to, the followings:
 i) warranty as to service area, accuracy, availability, continuity, and integrity described in this Document;
 ii) warranty of usefulness, and fitness for a particular request or purpose; and
 iii) warranty that the use of Services does not infringe any third party's intellectual property rights.

(3) To the extent permitted by applicable laws, CAO and QSS shall not be responsible and liable for any damages and losses, including but not limited to, direct, indirect, incidental, special or consequential damages, whether under contractual liability, product liability, strict liability, tort liability or otherwise (including intent or negligence), caused by the use of this Document, the information included in this Document and the Services, the inability to use the Services, or the change of this Document and the information included in this Document.

Document subject to the disclaimer of liability

Revision History

Rev. No.	Date	Page	Revisions
001 Draft Edition	March 25, 2016		Draft edition
	July 12, 2016	-	Adds Disclaimer of Liability
	March 28,2017	1	Adds description of Centimeter Level Augmentation Service for Experiment
		2	Fixed applicable document (1), (3) Adds reference document (5), (6)
		20	Corrects description of (3) L6 Message Type ID Updates Message Generation Facility ID in Table 4.1.2-2
		22	Updates No. of Bit for Compact SSR GNSS Satellite Code and Phase Bias Message
		24	Fixed the definition of (5) multiple message indicator
		34-37	Updates header of MT4073,6
		39-40	Corrects DF range of C00 in MT4073,8
		65-68	Adds subsection for L6E message.
	September 15,2017	2	Fixed applicable document (3) Adds reference document (5), (6)
		34-36	Updates data structure of header part for Compact SSR GNSS Satellite Code and Phase Bias Message in Figure 4.1.2-8 and Table 4.1.12-19~20
		40	Adds description of SSR STEC Quality Indicator in 4.1.2.2.9 (4) Corrects description of λ_0 in 4.1.2.2.9 (5)
		43	Adds description for Tropospheric Delay Quality Indicator Adds definition for constant offset of tropospheric wet vertical delay in 4.1.2.2.10 (5)
		45-51	Updates nominal transmission pattern in Table 4.1.2-30
		58-63	Updates definition of GRID in Table 4.1.4-1 Adds a support file "*clas_grid.def*" as appendix
		73	Adds description for reference table of the SSR troposphere quality indicator
		79	Adds subsection of GNSS Code/Phase Bias
		81, 83	Adds description for interpolation method
		82-83	Adds troposphere vertical delay wet variation value term Fixed subscript of mapping function
		84	Adds subsection for user dependent errors
	April 3,2018	2	Updates applicable document (3) Replaces reference document (8) with an updated one. Adds reference document (9)
		3-4	Adds contents of section 2.3 and 2.4
		20	Adds description to clarify the meaning of nominal validity period in 4.1.1.2 (4)
		23	Changes the PPP-RTK form RTK-PPP
		22, 69	Corrects description of subframe indicator in Table 4.1.2-2 and 4.2.2-2
		24	Adds description for user algorithm in 4.1.2.2.1
		28	Updates Compact SSR signal mask in Table 4.1.2-9

Document subject to the disclaimer of liability

		33	Adds description for Compact SSR Code Bias in 4.1.2.2.5 (1)
		49-54	Updates Subtype transmission pattern in Figure 4.1.2-12
		60-65	Updates definition of GRID (Table 4.1.4-1 Compact network ID and coordinates)
		68, 70	Updates reference source page of reference document (8)
		71	Adds description for integrity information
		80	Adds description regarding velocity calculation of a GEO satellite
		81-82	Adds description of rigorous compensating method for "Network Bias correction" Remove description for phase wind up from section 5.5.3.2 to 5.5.6
		84, 86	Adds description of interpolation/extrapolation method with three grids
		87	Adds description for receiver inter system bias in 5.5.5.6
		88	Adds subsection for calculation of Observation Space Representation in 5.5.5.7
	August 31,2018	19	Adds Nominal Update Interval of Compact SSR GNSS Combined Correction in Table 4.1.1-1
		20	Adds Nominal Validity Period of Compact SSR GNSS Combined Correction in Table 4.1.1-2
		24	Adds Sub type 11, and updates Sub Type 6 in Table 4.1.2-3
		47,48	Adds subsection for Sub Type 11 in 4.1.2.2.12
		49-55	Updates Sub Type transmission pattern in 4.1.2.2.13
		62-67	Updates definition of GRID (Table 4.1.4-1 Compact network ID and coordinates) Updates a support file "*clas_grid.def*"
		84	Fixed equation of $\delta BIAS$' calculation
		87	Adds note for STEC Network correction
001	November 5, 2018	2	Updates applicable document (3)
		22	Adds description of user algorithm for different Message Generation Facility ID
		46	Corrects total data size in Figure 4.1.2-12
		48-54	Updates Sub Type transmission pattern in 4.1.2.2.13
		55	Adds description for validity interval
		61-66	Updates definition of GRID (Table 4.1.4-1 Compact network ID and coordinates) Updates a support file "*clas_grid.def*"
		72	Adds description for usage of integrity information in 5.4
		86	Corrects suffix of equation of ionosphere slant delay in 5.5.4.2

"TBD" is an abbreviation for "To be determined." Those items marked "TBD" have not yet been determined but will be determined in the future.

Document subject to the disclaimer of liability

Table of Contents

Document subject to the disclaimer of liability

1. Scope

This interface specification document describes the interface specification between the Quasi-Zenith Satellite System (QZSS) and users of the Centimeter-Level Augmentation Service (CLAS). The interface specification includes the signal characteristic, message specification, and user algorithm.

The service introduction and the performance characteristics such as the service area, accuracy, availability, continuity and integrity are described in the applicable document (1) PS-QZSS-001, Performance Standard of QZSS.

Moreover, the service introduction and performance characteristics such as the service area, accuracy with regard to Centimeter Level Augmentation Service for Experiment (CLAS-E) are described in the reference document (7) SLI-CLAS-E, Service Level Information for Centimeter Level Augmentation Service for Experiment of QZSS.

2. Reference and Terminology

2.1. Applicable Documents

The cited parts of the following documents are recognized as being part of this document. This document may be updated when these applicable documents are updated.

(1) PS-QZSS, Quasi-Zenith Satellite System Performance Standard.

(2) RTCM STANDARD 10403.2 DIFFRENTIAL GNSS (GLOBAL NAVIGATION SATELLITE SYSTEMS) SERVICE –VERSION3, RTCM SPECIAL COMMITTEE NO.104, 1-FEB-2013.

(3) RTCM Paper, Specification of Compact SSR Messages for Satellite Based Augmentation Service, Version 0.5, 18-OCT-2018.

2.2. Reference Documents

The following documents are referred on the creation of this document. This document might be updated when these reference documents are updated.

(1) Global Positioning Systems Directorate Systems Engineering & Integration Interface Specification IS-GPS-200, Navstar GPS Space Segment/Navigation User Interfaces, Revision H, 24-SEP-2013

(2) Survey Act (Act No. 188 of June 3, 1950, Japan)

(3) Working Rules for Operating Specifications (Notice 413, Ministry of Land, Infrastructure, Transport and Tourism, 2008)

(4) Niell, A. E., Global mapping functions for the atmosphere delay at radio wavelengths, J. Geophys. Res., 101, 3227-3246, 1996.

(5) Wu, J.T., S.C. Wu, G.A. Hajj, W.I. Bertiger, S.M. Lichten., Effects of Antenna Orientation on GPS Carrier Phase, Manuscripta Geodaetica, 18, 91-98, 1993.

(6) G.Petit and B.Luzum (eds.), IERS Technical Note No.36, IERS Conventions (2010), 2010.

(7) SLI-CLAS-E, Quasi-Zenith Satellite System Service Level Information for Centimeter Level Augmentation Service for Experiment

(8) Global Positioning Augmentation Service Corporation, Correction Data on Centimeter Level Augmentation Service for Experiment Data Format Specification 1st Edition, 2017.

(9) Multi GNSS survey manual (draft) - Utilization of modernized GPS, Galileo etc. - Commentary, Geospatial Information Authority of JAPAN (GSI), 2015.

2.3. Terms and Definitions

Terms	Definitions
alert flag	See Section 5.4.1 If the service stops due to an error occurring in the ground or satellite system, an alert flag is notified to the user that the service is not available.
Compact SSR (CSSR)	See Section 4.1.2.2 Bandwidth efficient State Space Representation (SSR) format for Precise Point Positioning - Real Time Kinematic (PPP-RTK) service defined as a proprietary message in the applicable document (2)
PPP-RTK	PPP-RTK is a conventional RTK using range corrections converted from SSR messages, which is defined in applicable document (3). Note that this method is called RTK-PPP in (2).

2.4. Abbreviation

-A-

-B-

bps	bits per second
BPSK	Binary Phase Shift Keying

-C-

CDMA	Code Division Multiple Access
CLAS	Centimeter Level Augmentation Service
CSK	Code Shift Keying
CSSR	Compact State Space Representation

-D-

-E-

ECEF	Earth Centered Earth Fixed

-F-

-G-

GEO	Geostationary Orbits
GEONET	GNSS Earth Observation Network System
GLONASS	Global Navigation Satellite System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GPST	GPS Time
GRS	Geodetic Reference System
GSI	Geospatial Information Authority of Japan

-H-

-I-

IGS	International GNSS Service
IOD	Issue Of Data
IODE	Issue of Data Ephemeris
ITRF	International Terrestrial Reference Frame
I/NAV	Integrity Navigation Message

Document subject to the disclaimer of liability

-J-

    JGD   Japanese Geodetic Datum

-K-

-L-

    LNAV   Legacy NAVigation

    LSB   Least Significant Bit

-M-

    MCS   Master Control Station

    MSB   Most Significant Bit

    MT   Message Type

-N-

-O-

    OSR   Observation Space Representation

-P-

    PPP-RTK   Precise Point Positioning - Real-Time Kinematic

    PRN   Pseudorandom Noise

-Q-

    QZO   Quasi-Zenith Orbits

    QZS   Quasi-Zenith Satellite

    QZSS   Quasi-Zenith Satellite System

    QZSST   QZSS Time

-R-

    RMS   Root Mean Square

    RS   Reed-Solomon

    RTCM   Radio Technical Commission for Maritime Services

    RTK-PPP   Real-Time Kinematic - Precise Point Positioning

-S-

    SIR-URE   Signal-In-Reference User Range Error

    sps   symbols par second

    SSR   State Space Representation

    ST   Sub Type

    STEC   Slant Total Electron Content

    SV   Space Vehicle

-T-

    TAI   International Atomic Time

-U-

    URA   User Range Accuracy

-V-

-W-

-X-

-Y-

-Z-

3. Signal Properties

3.1. RF Signal Characteristic

3.1.1. Signal Structure

Table 3.1.1-1 and Table 3.1.1-2 define the signal structure. Table 3.1.1-3 and Table 3.1.1-4 list the PRN code characteristics. Table 3.1.1-5 lists the message characteristics.

Table 3.1.1-1 Signal structure (Block I)

Frequency band	Signal name	Modulation	PRN code name	Overlay code name	Message name
L6	L61	BPSK *1	L6 (code 1)	-	L6D
			L6 (code 2)*2	-	-

*1: This bit string is generated by two types of bit strings, *code 1* and *code2* (corresponding to two channels), that are selected alternately in chip-by-chip multiplexing.

*2: L6 (code 2) is dataless. (i.e., no data is modulated onto this signal)

Table 3.1.1-2 Signal structure (Block II)

Frequency band	Signal name	Modulation	PRN code name	Overlay code name	Message name
L6	L62	BPSK *1	L6 (code 1)	-	L6D
			L6 (code 2)	-	L6E

*1: This bit string is generated by two types of bit strings, *code 1* and *code2* (corresponding to two channels), that are selected alternately in a chip-by-chip multiplexing.

Table 3.1.1-3 PRN code characteristics (Block I)

PRN code name	Chip rate	Length	Period	Overlay code
L61 (code1)	2.5575 Mcps	10,230 chip	4 ms	-
L61 (code 2)	2.5575 Mcps	1,048,575 chip	410 ms	-

Table 3.1.1-4 PRN code characteristics (Block II)

PRN code name	Chip rate	Length	Period	Overlay code
L62 (code 1)	2.5575 Mcps	10,230 chip	4 ms	-
L62 (code 2)	2.5575 Mcps	10,230 chip	4 ms	-

Table 3.1.1-5 Message characteristics

Message name	bit rate	Symbol rate	Period (minimum frame size)	Coding system
L6D	2,000 bps	250 sps	1 s	RS (255,223)
L6E*1	2,000 bps	250 sps	1 s	RS (255,223)

*1 Centimeter-level augmentation message for experiments (L6E) is available in Block II only.

3.1.2. Frequency

Table 3.1.2-1 shows the frequency and bandwidth. The operational QZS frequency, f_s, is offset with respect to the reference frequency of $f_0 = 10.23$ [MHz], in order to provide compensation for the relativistic effect to which the QZS satellites are subjected due to their orbital motion. The frequency is as follows: L6 band offsets -0.690397Hz.

Table 3.1.2-1 Frequency and bandwidth

Frequency band	Block I	Block II
L6 band nominal center frequency : 1278.75 MHz = 125 x f_0	39.0 MHz (±19.5 MHz)	42.0 MHz (± 21.0 MHz)

3.1.3. Configurations

3.1.3.1   L6 Signal Configuration

As shown in Figure 3.1.3-1 and Figure 3.1.3-2, the L6 baseband signal is generated with a chipping rate of 5.115 Mchip/s by interleaving the following two 2.5575-Mcps bit streams.

For L61, the two streams consist of a 4-ms PRN short code modulated by means of code shift keying (CSK) by the Reed-Solomon encoded navigation message, and a 410-ms PRN long code modulated by a square wave with a period of 820 [ms], beginning from 0 ("010101...").

For L62, the two streams consist of two 4-ms PRN short codes modulated by means of code shift keying (CSK) by the Reed-Solomon encoded messages.

As defined in Figure 3.1.3-3, CSK modulation shifts the phase of the PRN code by the number of chips indicated by the 8-bit encoded navigational message symbol.
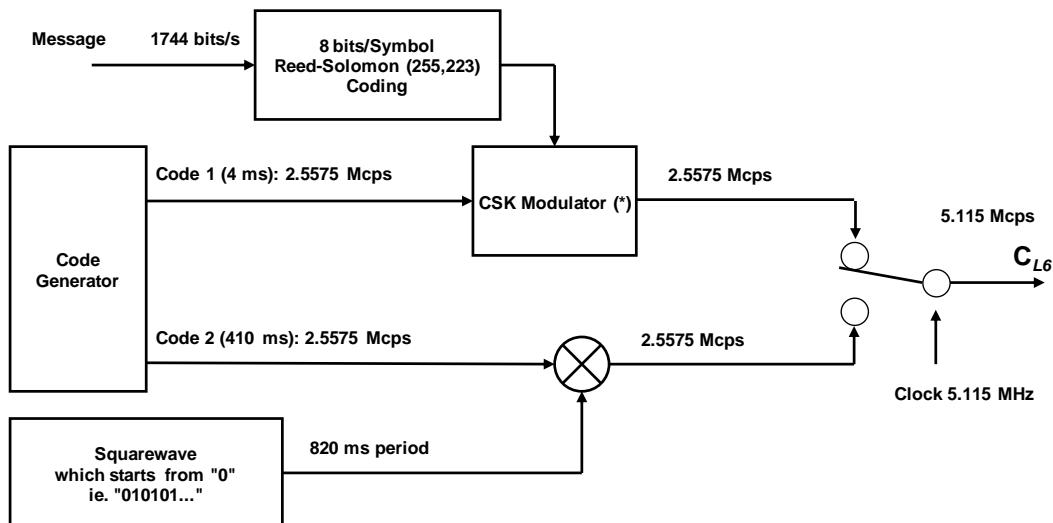
Figure 3.1.3-1 L61 signal structure
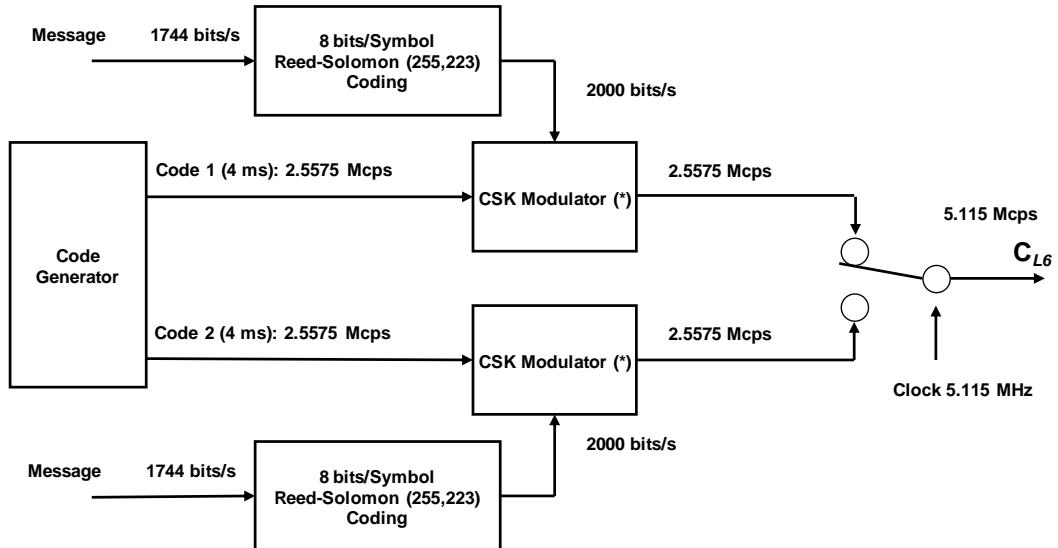
Figure 3.1.3-2 L62 Signal structure
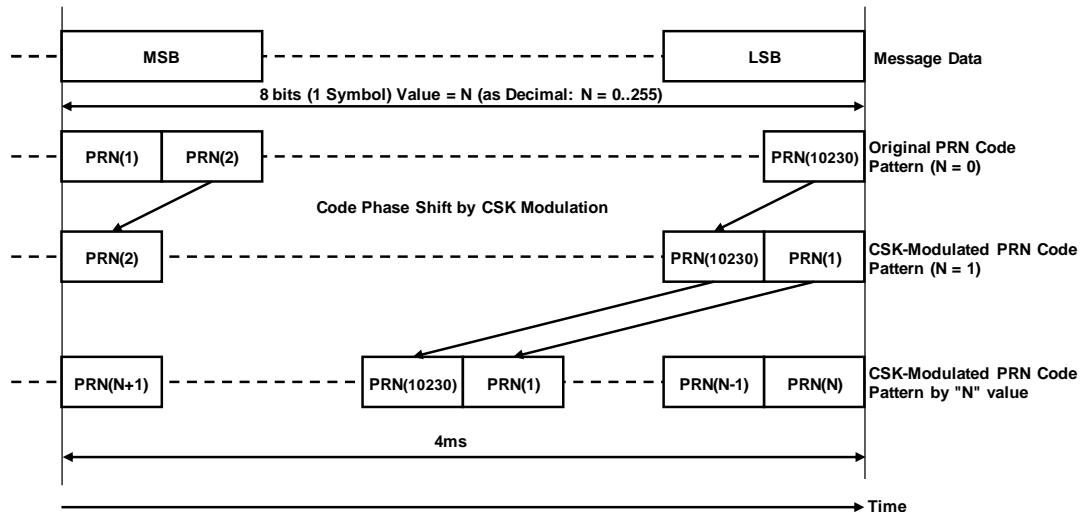
Figure 3.1.3-3 CSK modulation

3.1.3.2   Signal Timing

For L61, the initialization period for each code generator is 4 ms in the case of the Code 1 generator and 410 ms in the case of the Code 2 generator. Both the Short Code generator and the Long Code generator are initialized at the end/beginning of the week. Figure 3.1.3-4, shows the timing relationship between Code 1 and Code 2.

For L62, the initialization period for the code generators are 4 ms for both the Code 1 generator and Code 2 generator. Figure 3.1.3-5 shows the timing relationship between Code 1 and Code 2.
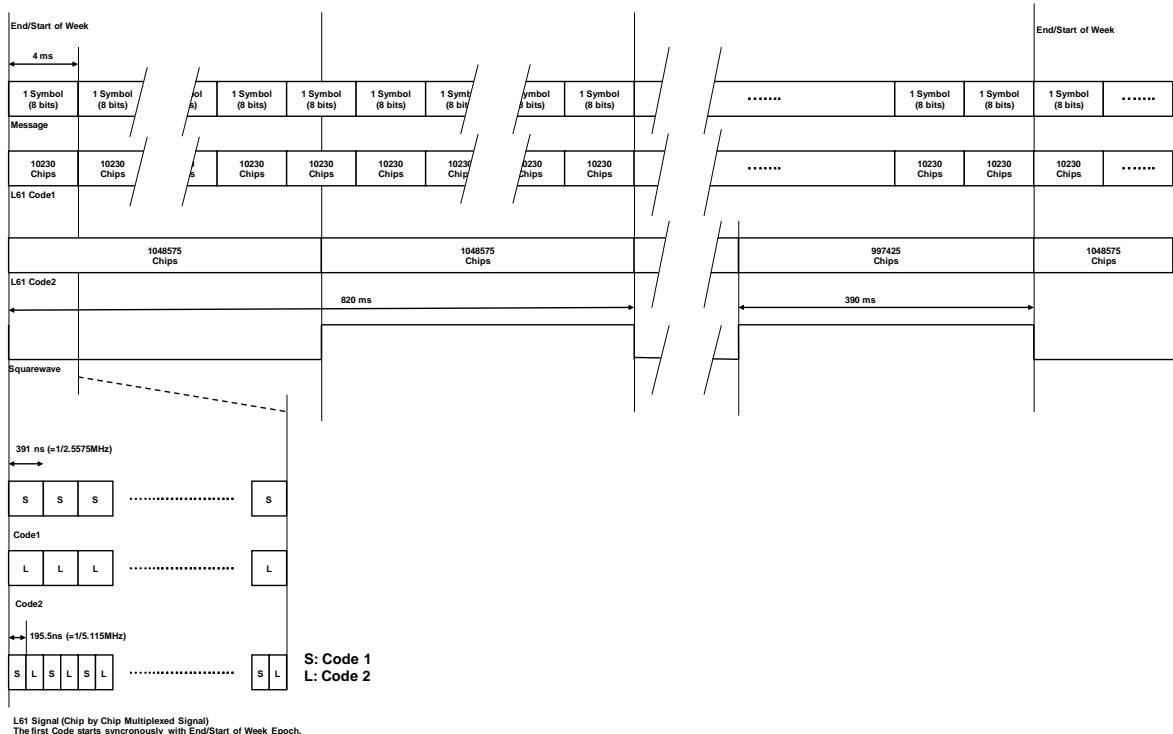
Figure 3.1.3-4 Signal timing (L61)
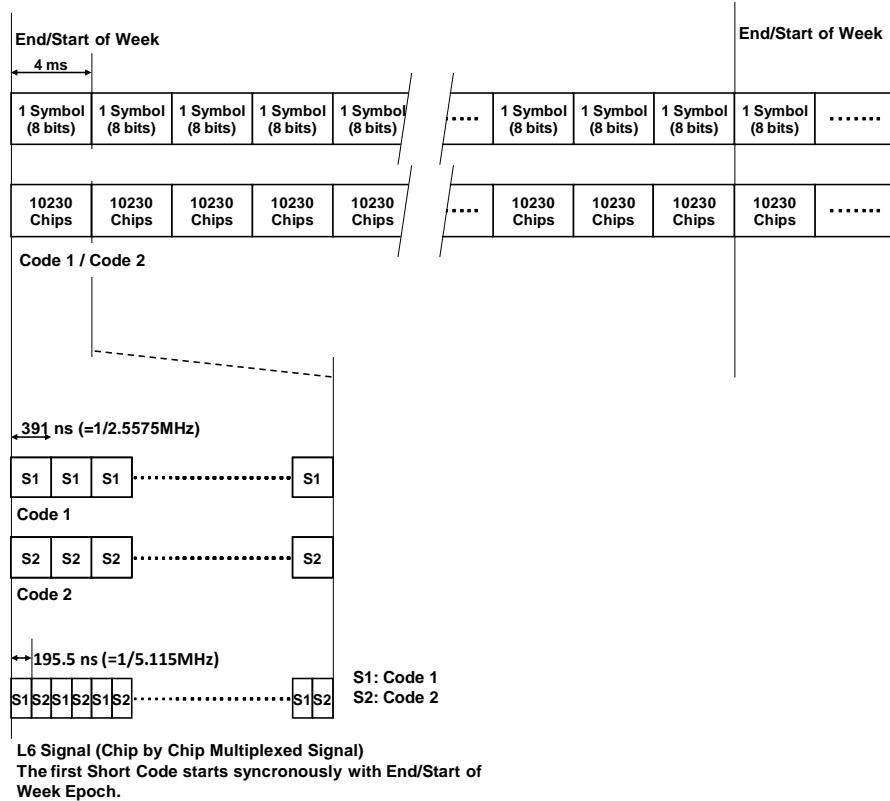
Figure 3.1.3-5 Signal timing (L62)

3.1.4. Correlation Loss

Correlation loss is defined as the difference between the theoretical demodulated (de-spread) power level and the output signal power level. The correlation loss values have the following levels.

Block I : 0.6 dB or less
Block II : 0.6 dB or less

3.1.5. Carrier Phase Noise

The spectrum density of the carrier phase noise for an un-modulated signal is of a level in which the tracking error of the carrier in a phase-locked loop (PLL) with a 10-Hz single-sided bandwidth is less than the following value:

Block I : 0.1 rad (RMS)
Block II : 0.1 rad (RMS)

3.1.6. Spurious Characteristics

Any spurious transmissions shall be of less than the following value of the power level of the unmodulated carrier wave.

Block I : -40 dB or less

Block II : -40 dB or less

3.1.7. Phase Relationships Between the Signals

N/A (L6 signal is BPSK modulation.)

3.1.8. Minimum Received Power Level

A ground-based isotropic antenna with a gain of 0 dBi for circularly polarized wave reception is provided and, when the signals are received from a satellite with an elevation angle of 10° or more, the received power must not be less than the value indicated in Table 3.1.8-1.

Table 3.1.8-1 Minimum received power level

Signal	Block I	Block II
L6	-155.7 dBW (Total power of Code 1 and Code 2)	-156.82 dBW (Total power of Code 1 and Code 2)

3.1.9. Polarization Characteristics

The L6 signal is right-hand circularly polarized.

Table 3.1.9-1 shows the axial ratio (power ratio of the long axis to the short axis) of the QZS circularly polarized waves, in a beam range of ± 10° from the boresight direction.

Table 3.1.9-1 Axial ratio (power ratio of long axis to short axis)

Signal	Block I	Block II
L6	No more than 2.0 dB	No more than 2.0 dB

3.1.10. Group Delay

3.1.10.1 PRN Code Phase Relationships Between Signals

The PRN code phase differences between the QZS signals at the antenna phase center shall not exceed the values listed in Table 3.1.10-1. The maximum allowable fluctuations in the phase differences are listed in Table 3.1.10-2.

Table 3.1.10-1 Differences in pseudo random noise (PRN) code phases between signals

Signal	Block I	Block II
L6-L1	35 ns	35 ns
L6-L2	15 ns	15 ns
L6-L5	20 ns	20 ns

Table 3.1.10-2 Fluctuation in phase difference

Block I	Block II
2 ns (3σ)	2 ns (3σ)

3.1.10.2 Phase Relationships within the Frequency Band

Not defined. Because the L6 signal consists of two codes (Code 1 and Code 2) that are time division multiplexed.

3.1.11. PRN Code Jitter

The jitter of the PRN code shall not exceed 2.0 ns for a value of 3σ.

Moreover, the mean value of the difference between the rising edge delay (or advance) and the falling edge shall not exceed 1.0 ns.

3.1.12. Code Carrier Coherency (Phase Relationship between PRN Code and Carrier Wave)

The fluctuations in the difference between the PRN code phase and the carrier wave phase at the antenna phase center for signals shall not exceed 1.2 ns.

3.1.13. Antenna Phase Center Characteristics

Not defined

3.1.14. Comparison of Block I And Block II RF Characteristics (Reference)

A comparison of the Block I and Block II RF characteristics is given in Table 3.1.14-1.

Table 3.1.14-1 Comparison table of Block I and Block II RF characteristics

No.	Item	QZSS Block I	QZSS Block II
1	Correlation loss	0.6 dB	0.6 dB
2	Carrier phase noise	0.1 rad(RMS)	0.1 rad(RMS)
3	Spurious characteristics	-40 dBc	-40 dBc
4	Phase relation	N/A	N/A
5	Minimum received power level	-155.7 dBW	-156.82 dBW
6	Polarization characteristics	2.0 dB	2.0 dB
7	Group delay (Absolute value of among the signals) *	L6-L1: 35 ns L6-L2: 15 ns L6-L5: 20 ns	L6-L1: 35 ns L6-L2: 15 ns L6-L5: 20 ns
8	Fluctuation of group delay between the frequency	2.0 ns (3σ)	2.0 ns (3σ)
9	Fluctuation of group delay in the identical frequency	N/A	N/A
10	Phase relationships within the frequency band	N/A	N/A
11	PRN code jitter	2.0 ns (3σ)	2.0 ns (3σ)
12	Coherency of code carrier	1.2 ns	1.2 ns
13	Antenna phase center special quality	N/A	N/A

＊Value at the transmitting antenna of the satellite.

When using the L1 signal timing to acquire the L6 signal, it is necessary to consider the propagation delay and the internal delay in the receiver design.

3.2. PRN Code

3.2.1. PRN Number Assignments

Table 3.2.1-1 lists the PRN numbers and satellites types.

Table 3.2.1-1 PRN numbers and satellite types

PRN (Code1)	PRN (Code2)	Satellite types	Remarks
193	203	QZO	Used in Block I (L61) Code1 and Code2 of Block I have the same number (193).
194	204	QZO	
195	205	QZO	
196	206	QZO	
197	207	QZO	
198	208	*	Undefined
199	209	GEO	
200	210	GEO	
201	211	GEO	

3.2.2. L6 Code Generation

Separate 20-bit stage code generators are used to generate the two code patterns (Code 1 and Code 2). The satellite numbers (PRN numbers) are identified by the default settings for each of these code generators.

For L61, as shown in Figure 3.2.2-1, the L6 signal code consists of a Kasami series Code 1 (2.5575 Mcps) with a chip length of 10,230 and a 4-ms period, and a Kasami series Code 2 (2.5575 Mcps) with a chip length of 1,048,575 and a 410-ms period.

For L62, as shown in Figure 3.2.2-2, the L62 signal code consists of a Kasami series Code 1 (2.5575 Mcps) and Code 2 (2.5575 Mcps). Both codes have a 10,230 chip length and a 4-ms period.

G(X) = X20 + X19 + X16 + X14 + 1

XOR

I
R
C
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

Initial Phase Register

Code 1:
2.5575 Mcps

2.5575 MHz

G(X) = X10 + X9 + X6 + X5 + X4 + X3 + 1

XOR

I
R
C
1 2 3 4 5 6 7 8 9 10

Initial Phase Register=all 1's

G(X) = X20 + X19 + X16 + X14 + 1

XOR

I
R
C
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

Initial Phase Register

Code 2:
2.5575 Mcps

Register Inputs
I: Input
R: Reset to initial conditions
C: Clock

10,230 count

1,048,575 count

Counter

OR

Week reset port

Week reset Command

Figure 3.2.2-1 Block diagram of code generation (L61)

G(X) = X20 + X19 + X16 + X14 + 1

XOR

2.5575 MHz

I
R
C

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |

**Code 1:
2.5575 Mcps**

Initial Phase Register

G(X) = X10 + X9 + X6 + X5 + X4 + X3 + 1

XOR

I
R
C

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

Initial Phase Register=all 1's

G(X) = X20 + X19 + X16 + X14 + 1

XOR

I
R
C

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |

**Code 2:
2.5575 Mcps**

Initial Phase Register

10,230 count

Counter

Week reset Command

**Register Inputs
I: Input
R: Reset to initial conditions
C: Clock**

Figure 3.2.2-2 Block diagram of code generation (L62)

Table 3.2.2-1 L6 code phase assignment (L61)

PRN No.	Code 1		Code 2	
	Initial Shift Register State (Octal)	End Shift Register State (Octal)	Initial Shift Register State (Octal)	End Shift Register State (Octal)
193	0255021	3766050	0000304	0000142 [*1] 3062067 [*2]

*1: End of the period (410 ms) *2: End of week

Table 3.2.2-2 L6 code phase assignment (L62)

PRN No.	Code 1		PRN No.	Code 2	
	Initial Shift Register State (Octal)	End Shift Register State (Octal)		Initial Shift Register State (Octal)	End Shift Register State (Octal)
193	0255021	3766050	203	1142153	0765516
194	0327455	1277740	204	1723711	3617751
195	0531421	0407113	205	3672765	0454615
196	0615350	0223234	206	0030404	2147760
197	0635477	1761450	207	0000546	0753651
198	*	*	208	*	*
199	1715254	2675565	209	3642512	1417417
200	1741247	1374150	210	0255043	3450571
201	2322713	1534774	211	2020075	1617410

* 198/208: It is possible to use non-standard code. Therefore, these values are undefined in this document.

The first digit in the octal notation represents the first two chips (i.e. The most significant "0" in the binary notation shall be ignored)

For example: In the case of '1741247' in octal notation, the first 20 chips are '01 111 100 001 010 100 111' in binary notation.

3.2.3. Non-Standard Code

In the event of a problem with the QZSS occurring upon testing, a non-standard code (NSC) is transmitted. This is done to protect users by ensuring that they do not use erroneous signals.

4. Message Format

4.1. L6 Message (Centimeter-Level Augmentation Service Message)

4.1.1. Message Structure

4.1.1.1   General

The L6 message signal structure is shown in Figure 4.1.1-1. Each message has a length of 2000 bits, consisting of a 49-bit header, a 1695-bit data section, and a 256-bit Reed-Solomon code. The transmission of each L6 message takes one second.

The header of the L6 message starts from bit 1 (MSB), followed by the data part (1695-bit), which is transmitted from bit 50. The Reed-Solomon Code is transmitted from bit 1745, after the data part. The data part for Code 1 (L6D) includes multiple RTCM STANDARD 10403.2 (applicable document (2)) compatible messages. The L6 message does not transmit the broadcast ephemeris included in each GNSS navigation message.
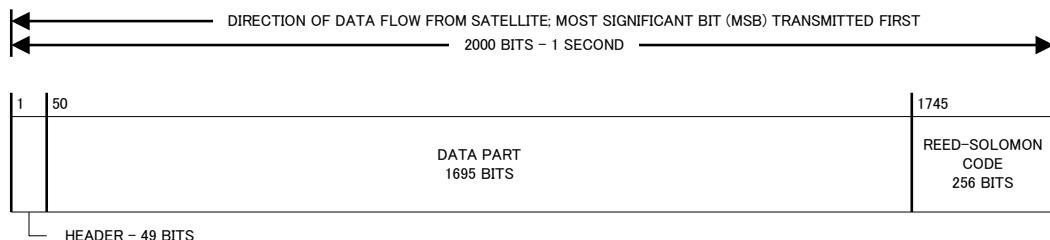
Figure 4.1.1-1 L6 Message Structure

4.1.1.2   Timing

(1) Transmission Pattern

Section 4.1.2.2.12 shows an example of the transmission pattern. The transmission pattern of the data part in the L6 message may differ between satellites. Therefore, the user algorithm cannot assume any specific transmission pattern. When QZS is located in the southern hemisphere, there is the possibility of transmitting information other than that for Japan.

(2) Transmission Timing

During normal operation, the L6 message is transmitted at the same timing from each satellite.

(3) Update Interval

Table 4.1.1-1 shows the nominal update interval for each message. Note that the user algorithm cannot rely on any specific transmission cycle because it may be changed in the future for reasons of performance improvement.

Table 4.1.1-1 Nominal Update Interval

Message Name	Message Type ID Sub Type ID *1	Nominal Update Interval [s]
Compact SSR Mask	MT4073,1	30
Compact SSR GNSS Orbit Correction	MT4073,2	30
Compact SSR GNSS Clock Correction	MT4073,3	5
Compact SSR GNSS Satellite Code Bias	MT4073,4	30
Compact SSR GNSS Satellite Phase Bias	MT4073,5	30
Compact SSR GNSS Satellite Code and Phase Bias	MT4073,6	30
Compact SSR GNSS URA	MT4073,7	30
Compact SSR STEC Correction	MT4073,8	30
Compact SSR Gridded Correction	MT4073,9	30
Compact SSR Service Information	MT4073,10	(N/A)
Compact SSR GNSS Combined Correction	MT4073,11	5 or 30
Null Message	(N/A)	(N/A)

(*1) Sub-type ID is compliant with Compact SSR (Message Type 4073) which is defined as a proprietary message in the applicable document (3) that is compatible with the applicable document (2) RTCM STANDARD 10403.2. Section 4.1.2.2 provides more information about the message format for each sub type.

(4) Nominal Validity Period

Each message has a nominal validity period based on each characteristic. Table 4.1.1-2 shows Nominal Validity Interval of each message. Origin of Validity Interval is exact second of QZSST that is sent in the header part of Message that contains the information (refer to the data field "GPS Epoch Time 1s" and "GNSS Hourly Epoch Time 1s"). The quality of data is not guaranteed if outdated data is used.

Table 4.1.1-2　Nominal Validity Period

Message Name	Message Type ID Sub Type ID	Nominal Validity Period [s]
Compact SSR Mask	MT4073,1	*1
Compact SSR GNSS Orbit Correction	MT4073,2	60
Compact SSR GNSS Clock Correction	MT4073,3	10
Compact SSR GNSS Satellite Code Bias	MT4073,4	60
Compact SSR GNSS Satellite Phase Bias	MT4073,5	60
Compact SSR GNSS Satellite Code and Phase Bias	MT4073,6	60
Compact SSR GNSS URA	MT4073,7	60
Compact SSR STEC Correction	MT4073,8	60
Compact SSR Gridded Correction	MT4073,9	60
Compact SSR Service Information	MT4073,10	(N/A)
Compact SSR GNSS Combined Correction	MT4073,11	10 or 60
Null Message	(N/A)	(N/A)

*1 Validity interval of Compact SSR Mask is described in 4.1.2.2.2 (6).

4.1.2. Message contents
4.1.2.1 Header Part

The header of the L6 message is shown in Figure 4.1.2-1. The header part has a length of 49-bit consisting of a 32-bit preamble, an 8-bit PRN, an 8-bit L6 message type ID and a 1-bit alert flag.   Table 4.1.2-1 defines the header parameters.
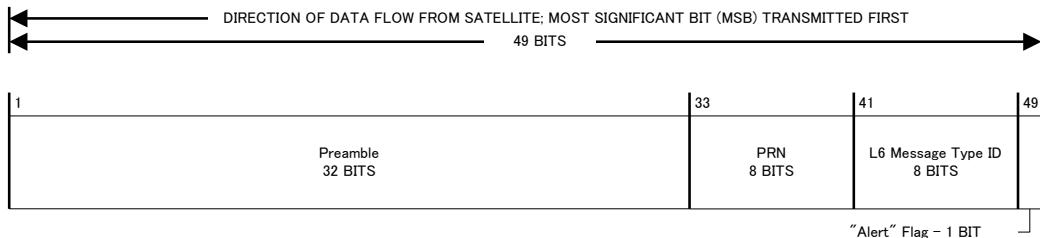
Figure 4.1.2-1 Header of L6 message

Table 4.1.2-1 Definitions of header parameters

DF Name	DF Range	BIT	LSB	DF Unit	Note
Preamble	-	32	-	-	
PRN	-	8	-	-	
L6 Message Type ID	-	8	-	-	
"Alert" Flag	-	1	-	-	

(1) Preamble

At the beginning of each message is a 32-bit preamble. The value of the preamble is "00011010110011111111110000011101"(B).

(2) PRN

Each message has an 8-bit PRN number immediately after the preamble. The PRN number is the PRN number of the satellite transmitting that message. For PRN No. = 193 - 211, then the satellite is QZSS.

(3) L6 Message Type ID

Each message has an 8-bit L6 message type ID immediately following the PRN. Table 4.1.2-2 lists the definitions of the L6 message type ID parameters.

The first 3-bit are the vendor ID for CLAS. The following 2-bit indicate the message generation facility, which will be either the Hitachi-Ota Master Control Station (MCS) or the Kobe MCS. The following 2-bit are reserved for future use. The last 1-bit is the indicator for the subframe header. If the value of this indicator is "1", the message is the start of a subframe. In the user algorithm, the data in the subsequent L6 messages cannot be mixed and the previous L6 frame data should be still used if the following conditions are satisfied in the current L6 frame.

(i) The Vender ID is different.
(ii) The Message Generation Facility ID is different.

Table 4.1.2-2 L6 message type ID

Bit Field	Data Name	Note
7-5	Vendor ID	"101"$_{(B)}$ for CLAS
4-3	Message Generation Facility ID	"00"$_{(B)}$, "01"$_{(B)}$: Hitachi-Ota "10"$_{(B)}$, "11"$_{(B)}$: Kobe
2-1	Reserved	
0	Subframe indicator	"1"$_{(B)}$: first data part of a subframe "0"$_{(B)}$: others

(4) Alert Flag

Each message has a 1-bit alert flag immediately following the L6 Message Type ID. The Alert Flag indicates the health status of CLAS. When the Alert flag is "1"$_{(B)}$, the service is not available.

4.1.2.2 Data Part

4.1.2.2.1 General

The nominal sequence of the CLAS message consists of 30 successive data parts of the L6 Message. Five successive data parts of the L6 message constitute a subframe. Six successive subframes of the L6 message constitute a frame. Sub Type ID 1 - 10 is transmitted in a given order. When the same message as that of Sub Type 1 - Sub Type 7 within one subframe is transmitted, users must use the latest message in the subframe. Figure 4.1.2-2 shows the structure of the L6 message, frame, and subframe.
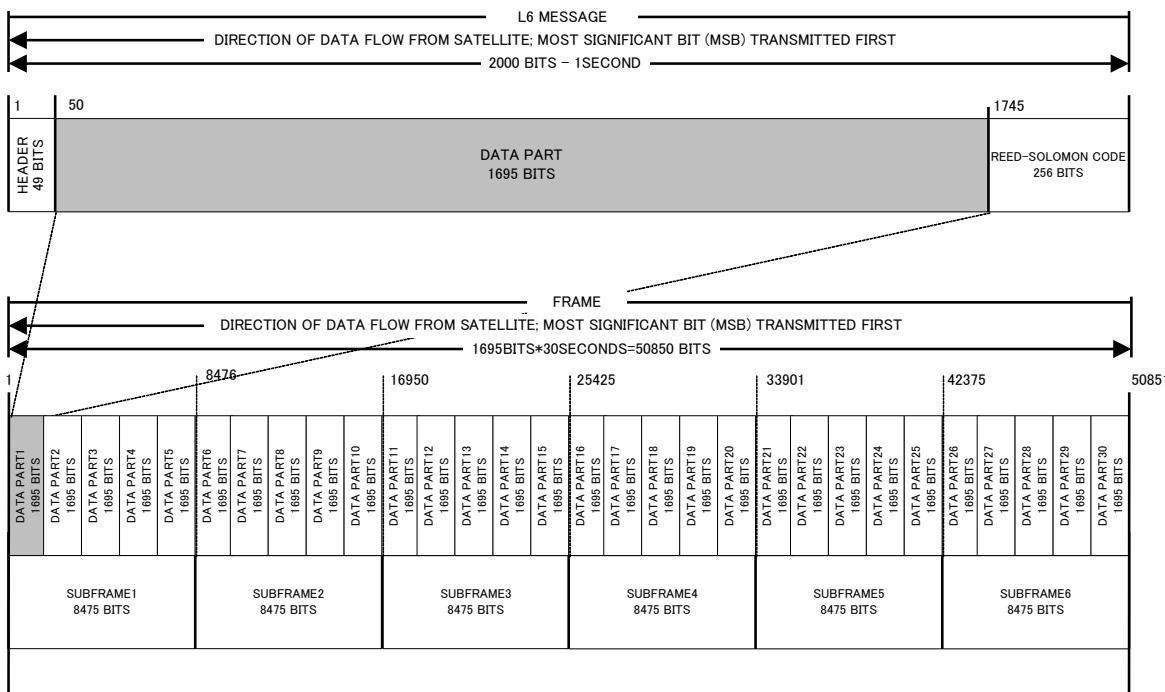
Figure 4.1.2-2 Structure of L6 message, frame, and subframe

The data part of the L6 message includes any sub type of multiple messages of MT 4073 "Compact SSR," as defined in the applicable document (3). The data in each message is given in state space representation (SSR) form, as standardized in the applicable document (2) RTCM STANDARD 10403.2. The correction in SSR form can be applied to precise point positioning - real-time kinematic (PPP-RTK). In the user algorithm, the SSR correction can be converted into a range correction in the observation space representation (OSR) and can be applied to the positioning calculation right after message acquisition if its user position is acquired by standalone positioning. The integer ambiguity of the carrier phase can be resolved by the single difference between satellites or the double difference between satellites and a virtual reference station.

Table 4.1.2-3 RTCM STANDARD 10403.2 Message Type 4073 Definition of Sub Type

Sub Type	Sub Type Name	No. of Bit*	Notes
1**	Compact SSR Mask	$49+(61+N_{cell})\times N_{sys}$	4.1.2.2.2
2	Compact SSR GNSS Orbit Correction	$37+(51\ or\ 49)\times N_{sat}$	4.1.2.2.3
3	Compact SSR GNSS Clock Correction	$37+15\times N_{sat}$	4.1.2.2.4
4	Compact SSR GNSS Satellite Code Bias	$37+11\times N_{code}\times N_{sat}$	4.1.2.2.5
5	Compact SSR GNSS Satellite Phase Bias	$37+17\times N_{phase}\times N_{sat}$	4.1.2.2.6
6***	Compact SSR GNSS Satellite Code and Phase Bias	$45+N_{sat}+$ $(11\ or\ 17\ or\ 28)\times N_{sig}\times M_{sat}$	4.1.2.2.7
7	Compact SSR GNSS URA	$37+6\times N_{sat}$	4.1.2.2.8
8	Compact SSR STEC Correction	$44+N_{sat}+(20\ or\ 44\ or\ 54)\times M_{sat}$	4.1.2.2.9
9	Compact SSR Gridded Correction	$57+N_{sat}+(17+(7\ or\ 16)\times M_{sat})\times N_{grid}$	4.1.2.2.10
10	Compact SSR Service Information	TBD	4.1.2.2.11
11	Compact SSR GNSS Combined Correction	$40+5+N_{sat}+(15\ or\ (+49\ or\ +51))\times M_{sat}$	4.1.2.2.12

* N_{cell} = No. of Cell Mask of each GNSS, N_{sat} = No. of satellite, N_{sig} = No. of signal, N_{sys} = No. of GNSS, N_{code} = No. of code bias, N_{phase} = No. of phase bias, M_{sat} = No. of satellite in local network, N_{grid}=No. of grid in local network

** The size of N_{cell} depends on each GNSS

*** In the case of "Network Bias Correction" equals to "0"$_{(B)}$, "No. of Bit" equals "$40+28*N_{sig}\times N_{sat}$".

4.1.2.2.2 Sub Type 1 – Compact SSR Mask Message

The sub type 1 message structure is shown in Figure 4.1.2-3. The message header and GNSS specific part are defined in Table 4.1.2-4 and Table 4.1.2-5, respectively.
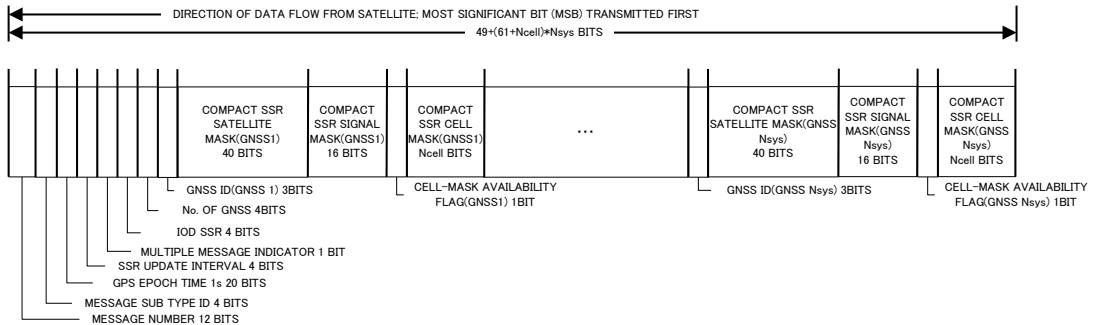
Figure 4.1.2-3 Compact SSR Mask Message structure

Table 4.1.2-4 Contents of message header, Compact SSR Mask Message

DF Name	DF Range	BIT	LSB	DF Unit	Note
Message Number	0-4095	12	-	-	4073
Message Sub Type ID	0-15	4	-	-	1
GPS Epoch Time 1s	0-604799	20	1	s	
SSR Update Interval	0-15	4	1	-	
Multiple Message Indicator	0-1	1	1	-	
IOD SSR	0-15	4	1	-	
No. of GNSS	0-15	4	1	-	

Table 4.1.2-5 Contents of GNSS-specific part of Compact SSR Mask Message

DF Name	DF Range	BIT	LSB	DF Unit	Note
GNSS ID 1	0-15	4	-	-	
Compact SSR Satellite mask 1	-	40	-	-	
Compact SSR Signal mask 1	-	16	-	-	
Cell-mask Availability Flag	0-1	1			
Compact SSR Cell mask 1	-	N_{cell}	-	-	
⟨					
GNSS ID N_{sys}	0-15	4	-	-	
Compact SSR Satellite mask N_{sys}	-	40	-	-	
Compact SSR Signal mask N_{sys}	-	16	-	-	
Cell-mask Availability Flag	0-1	1			
Compact SSR Cell mask N_{sys}	-	N_{cell}	-	-	

(1) Message Number

The message number is defined in "RTCM STANDARD 10403.2" (applicable document (2)). Until the standardization of compact SSR has been completed, 4073 is used as the proprietary message.

(2) Message Sub-Type ID

The message sub-type ID is defined in the compact SSR specification (applicable document (3)).

(3) GPS Epoch Time 1s

Seconds since the beginning of the GPS week. The data is defined in QZSST.

(4) SSR Update Interval

The SSR update intervals for all the SSR parameters start at time 00:00:00 of the QZSST time frame. The supported SSR update intervals are listed in Table 4.1.2-6.

Table 4.1.2-6 SSR update interval

SSR Update Interval	Update Interval
0	1 s
1	2 s
2	5 s
3	10 s
4	15 s
5	30 s
6	60 s
7	120 s
8	240 s
9	300 s
10	600 s
11	900 s
12	1800 s
13	3600 s
14	7200 s
15	10800 s

(5) Multiple Message Indicator

Indicator for transmitting message with the same message number, message sub-type ID, Compact Network ID, and epoch time. "0": last message of a sequence, "1": multiple message transmitted.

(6) IOD SSR

A change of issue of data SSR is used to indicate a change in the SSR generating configuration. The IOD SSR is counted up from $0_{(10)}$. When the compact SSR satellite mask, compact SSR signal mask, or compact SSR cell mask have been changed, the IOD SSR is counted up.

(7) No. of GNSS

Number of augmented GNSS.

(8) GNSS ID

Indicator for specifying the GNSS. Table 4.1.2-7 lists the reciprocal relationship between the GNSS ID and GNSS.

Table 4.1.2-7 GNSS ID

GNSS ID	GNSS
0	GPS
1	GLONASS
2	Galileo
3	Beidou
4	QZSS
5	SBAS
6-9	Reserved

(9) Compact SSR Satellite mask

The sequence of bits, which specifies those GNSS satellites for which data is augmented in this message. The most significant bit (MSB), or the first encoded bit corresponds to that GNSS satellite for which ID = 1, the second bit corresponds to a GNSS satellite for which ID = 2, etc. The least significant bit (LSB), or the last-encoded bit corresponds to a GNSS satellite with ID = 40. For QZSS, a satellite with ID = 0-9 is PRN193-202. Table 4.1.2-8 lists the reciprocal relationships between the compact SSR satellite mask and GNSS.

Table 4.1.2-8 Compact SSR satellite mask

Compact SSR Satellite Mask	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
GPS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
GLONASS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Galileo	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
QZSS	193	194	195	196	197	198	199	200	201	202	Reserved				

Compact SSR Satellite Mask	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
GPS	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
GLONASS	16	17	18	19	20	21	22	23	24	Reserved					
Galileo	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
QZSS	Reserved														

Compact SSR Satellite Mask	30	31	32	33	34	35	36	37	38	39
GPS	31	32	33	34	35	36	37	38	39	40
GLONASS	Reserved									
Galileo	31	32	33	34	35	36	37	Reserved		
QZSS	Reserved									

(10) Compact SSR Signal mask

The sequence of bits which defines the selected signals for correction messages defined for each GNSS, as listed in Table 4.1.2-9.

Table 4.1.2-9 Compact SSR signal mask

Compact SSR Signal mask	GPS	GLONASS	Galileo	Beidou	QZSS	SBAS
0	L1 C/A	G1 C/A	E1 B I/NAV OS/CS/SoL	B1 I	L1 C/A	L1 C/A
1	L1 P	G1 P	E1 C no data	B1 Q	L1 L1C(D)	L5 I
2	L1 Z-tracking	G2 C/A	E1 B+C	B1 I+Q	L1 L1C(P)	L5 Q
3	L1 L1C(D)	G2 P	E5a I F/NAV OS	B3 I	L1 L1C(D+P)	L5 I+Q
4	L1 L1C(P)	G1(D)	E5a Q no data	B3 Q	L2 L2C(M)	
5	L1 L1C(D+P)	G1(P)	E5a I+Q	B3 I+Q	L2 L2C(L)	
6	L2 L2C(M)	G1(D+P)	E5b I I/NAV OS/CS/SoL	B2 I	L2 L2C(M+L)	
7	L2 L2C(L)	G2(D)	E5b Q no data	B2 Q	L5 I	
8	L2 L2C(M+L)	G2(P)	E5b I+Q	B2 I+Q	L5 Q	
9	L2 P	G2(D+P)	E5 I		L5 I+Q	
10	L2 Z-tracking	G3 I	E5 Q			
11	L5 I	G3 Q	E5 I+Q			
12	L5 Q	G3 I+Q	Service specific 1			
13	L5 I+Q		Service specific 2			
14			Service specific 3			
15						

(11) Cell-mask Availability Flag

If the flag set to "1"$_{(B)}$, the cell-mask is included.

(12) Compact SSR Cell Mask

The sequence of bits, which specifies those signals for which data is available in this message for each satellite. Note that the cell mask is not included if the cell-mask availability flag is set to zero. In this case, all of the signals included in the signal mask are selected for all the selected satellites.

4.1.2.2.3 Sub Type 2 – Compact SSR GNSS Orbit Correction Message

The sub type 2 message structure is shown in Figure 4.1.2-4. The message header and satellite-specific part are defined in Table 4.1.2-10 and Table 4.1.2-11, respectively.
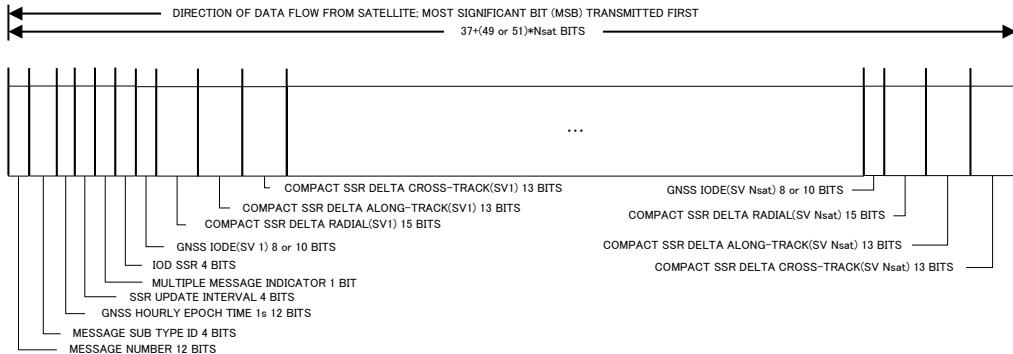
Figure 4.1.2-4 Compact SSR GNSS Orbit Correction Message structure

Table 4.1.2-10 Contents of message header, compact SSR GNSS Orbit Correction Message

DF Name	DF Range	BIT	LSB	DF Unit	Note
Message Number	0-4095	12	-	-	4073
Message Sub Type ID	0-15	4	-	-	2
GNSS Hourly Epoch Time 1s	0-3599	12	1	s	3600-4095 indicates data not available
SSR Update Interval	0-15	4	1	-	
Multiple Message Indicator	0-1	1	1	-	
IOD SSR	0-15	4	1	-	

Table 4.1.2-11 Contents of satellite-specific part of compact SSR GNSS Orbit Correction Message

DF Name	DF Range	BIT	LSB	DF Unit	Note
GNSS IODE(SV 1)	0-255 or 0-1023	8 or 10	1	-	
Compact SSR Delta Radial(SV 1)	±26.2128	15	0.0016	m	-26.2144 indicates data not available
Compact SSR Delta Along-Track(SV 1)	±26.208	13	0.0064	m	-26.2144 indicates data not available
Compact SSR Delta Cross-Track(SV 1)	±26.208	13	0.0064	m	-26.2144 indicates data not available
⟨					
GNSS IODE(SV Nsat)	0-255 or 0-1023	8 or 10	1	-	
Compact SSR Delta Radial (SV Nsat)	±26.2128	15	0.0016	m	-26.2144 indicates data not available
Compact SSR Delta Along-Track(SV Nsat)	±26.208	13	0.0064	m	-26.2144 indicates data not available
Compact SSR Delta Cross-Track(SV Nsat)	±26.208	13	0.0064	m	-26.2144 indicates data not available

(1) GNSS Hourly Epoch Time 1 s

　　　Hours, minutes, and seconds part of GPS epoch time.

(2) GNSS IODE

　　　IODE value of broadcast ephemeris used for calculation of range correction. Here, 10-bit are assigned for Galileo, and 8-bit are assigned for other GNSS.

(3) Compact SSR Delta Radial, Along-Track and Cross-Track

　　　Radial, along-track and cross-track orbit correction for broadcast ephemeris. In the user algorithm, the appropriate broadcast ephemeris provided by the navigation message defined in Table 4.1.2-12 should be used.

Table 4.1.2-12 Utilized Navigation Message

GNSS	Navigation Message
GPS	LNAV
GLONASS	GLONASS(CDMA)
Galileo	I/NAV
QZSS	LNAV

(4) IOD SSR

　　　A change of issue of data SSR is used to indicate a change in the information included in the compact SSR mask message.

4.1.2.2.4 Sub Type 3 – Compact SSR GNSS Clock Correction Message

The sub-type 3 message structure is shown in Figure 4.1.2-5. The message header and satellite-specific part are defined in Table 4.1.2-13 and Table 4.1.2-14, respectively.
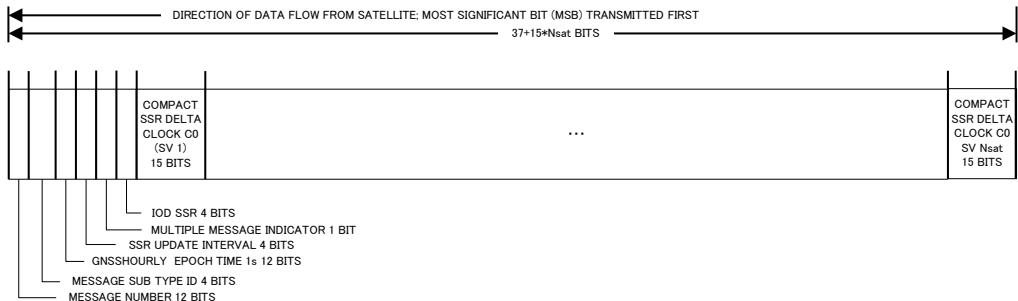

Figure 4.1.2-5 Compact SSR GNSS Clock Correction Message structure

Table 4.1.2-13 Contents of message header, compact SSR GNSS Clock Correction Message

DF Name	DF Range	BIT	LSB	DF Unit	Note
Message Number	0-4095	12		-	4073
Message Sub Type ID	0-15	4	-	-	3
GNSS Hourly Epoch Time 1s	0-3599	12	1	s	3600-4095 indicates data not available
SSR Update Interval	0-15	4	1	-	
Multiple Message Indicator	-	1	-	-	
IOD SSR	0-15	4	1	-	

Table 4.1.2-14 Contents of satellite-specific part of the compact SSR GNSS Clock Correction Message

DF Name	DF Range	BIT	LSB	DF Unit	Note
Compact SSR Delta Clock C0 (SV1)	±26.2128	15	0.0016	m	-26.2144 indicates data not available
⟨					
Compact SSR Delta Clock C0 (SV Nsat)	±26.2128	15	0.0016	m	-26.2144 indicates data not available

(1) Compact SSR Delta Clock

The bias term (C0) of clock correction for broadcast ephemeris. In the user algorithm, the appropriate broadcast ephemeris provided by the navigation message defined in Table 4.1.2-12 should be used.

4.1.2.2.5 Sub Type 4 – Compact SSR GNSS Satellite Code Bias Message

The sub type 4 message structure is shown in Figure 4.1.2-6. The message header and satellite-specific part are defined in Table 4.1.2-15 and Table 4.1.2-16, respectively.
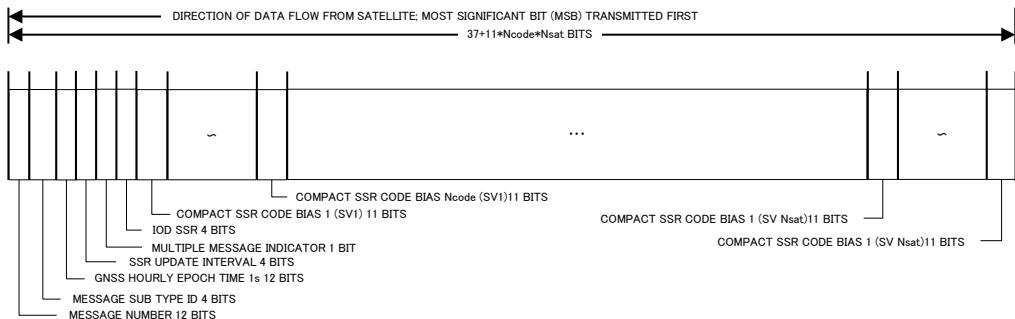

Figure 4.1.2-6 Compact SSR GNSS satellite code bias message structure

Table 4.1.2-15 Contents of message header, compact SSR GNSS satellite code bias message

DF Name	DF Range	BIT	LSB	DF Unit	Note
Message Number	0-4095	12	-	-	4073
Message Sub Type ID	0-15	4	-	-	4
GNSS Hourly Epoch Time 1s	0-3599	12	1	s	3600-4095 indicates data not available
SSR Update Interval	0-15	4	1	-	
Multiple Message Indicator	-	1	-	-	
IOD SSR	0-15	4	1	-	

Table 4.1.2-16 Contents of satellite-specific part of compact SSR GNSS satellite code bias message

DF Name	DF Range	BIT	LSB	DF Unit	Note
Compact SSR Code Bias 1 (SV 1)	±20.46	11	0.02	m	-20.48 indicates data not available
〈					
Compact SSR Code Bias N_{code} (SV 1)	±20.46	11	0.02	m	-20.48 indicates data not available
〈					
Compact SSR Code Bias 1 (SV N_{sat})	±20.46	11	0.02	m	-20.48 indicates data not available
〈					
Compact SSR Code Bias N_{code} (SV N_{sat})	±20.46	11	0.02	m	-20.48 indicates data not available

(1) Compact SSR Code Bias

This code bias is an absolute value. The code biases must be added to the pseudo range measurements of the corresponding code signal to get corrected pseudo ranges.

The compact SSR code bias for the satellite of each GNSS is transmitted in the order indicated in Sub Type 1: Compact SSR Mask. Only the signal indicated by the compact SSR cell mask is transmitted in this message.

4.1.2.2.6 Sub Type 5 – Compact SSR GNSS Satellite Phase Bias Message

The sub type 5 message structure is shown in Figure 4.1.2-7. The message header and satellite-specific part are defined in Table 4.1.2-17 and Table 4.1.2-18 respectively.
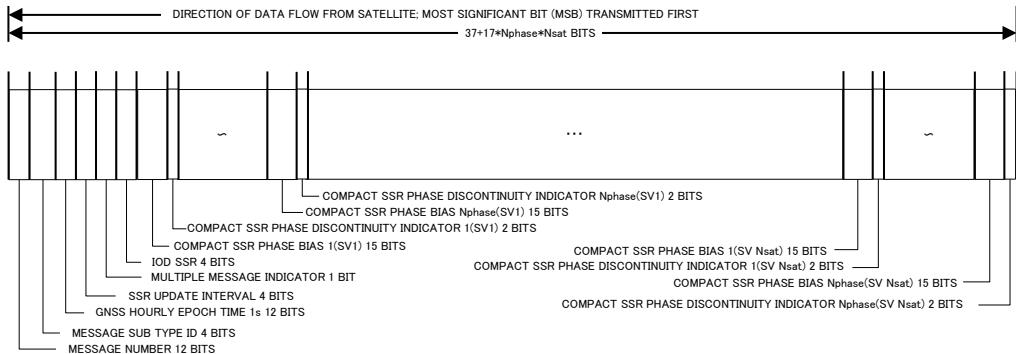

Figure 4.1.2-7 Compact SSR GNSS Satellite Phase Bias Message structure

Table 4.1.2-17 Contents of message header, Compact SSR Satellite Phase Bias Message

DF Name	DF Range	BIT	LSB	DF Unit	Note
Message Number	0-4095	12	-	-	4073
Message Sub Type ID	0-15	4	-	-	5
GNSS Hourly Epoch Time 1s	0-3599	12	1	s	3600-4095 indicates data not available
SSR Update Interval	0-15	4	1	-	
Multiple Message Indicator	-	1	-	-	
IOD SSR	0-15	4	1	-	

Table 4.1.2-18 Contents of satellite-specific part of Compact SSR GNSS Satellite Phase Bias Message

DF Name	DF Range	BIT	LSB	DF Unit	Note
Compact SSR Phase Bias1 (SV1)	±16.383	15	0.001	m	-16.384 indicates data not available
Compact SSR Phase Discontinuity Indicator1 (SV 1)	0-3	2	1	-	
⟨					
Compact SSR Phase Bias N_{phase}(SV 1)	±16.383	15	0.001	m	-16.384 indicates data not available
Compact SSR Phase Discontinuity IndicatorN_{phase} (SV 1)	0-3	2	1	-	
⟨					
Compact SSR Phase Bias 1 (SV N_{sat})	±16.383	15	0.001	m	-16.384 indicates data not available
Compact SSR Phase Discontinuity Indicator1 (SV N_{sat})	0-3	2	1	-	
⟨					
Compact SSR Phase Bias N_{phase}(SV N_{sat})	±16.383	15	0.001	m	-16.384 indicates data not available
Compact SSR Phase Discontinuity Indicator N_{phase}(SV N_{sat})	0-3	2	1	-	

(1) Compact SSR Phase Bias

SSR Phase bias for specified signal. The compact SSR phase bias for the satellite of each GNSS is transmitted in the order indicated by sub type 1: compact SSR mask. Only the signal indicated by compact SSR cell mask is transmitted with this message.

(2) Phase discontinuity indicator

The phase discontinuity indicator is counted up when the phase bias is discontinuous.

4.1.2.2.7 Sub Type 6 – Compact SSR GNSS Satellite Code and Phase Bias

The sub type 6 message structure is shown in Figure 4.1.2-8. The message header and satellite-specific part are defined in Table 4.1.2-19 and Table 4.1.2-20, respectively.
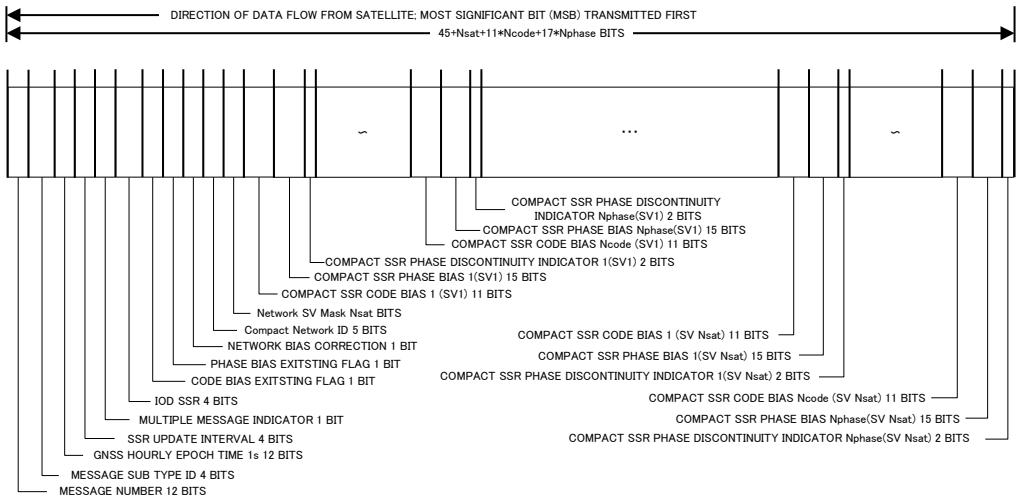

Figure 4.1.2-8 Compact SSR GNSS Satellite Code and Phase Bias Message structure

Table 4.1.2-19 Contents of message header, Compact SSR GNSS Satellite Code and
Phase Bias Message

DF Name	DF Range	BIT	LSB	DF Unit	Note
Message Number	0-4095	12	-	-	4073
Message Sub Type ID	0-15	4	-	-	6
GNSS Hourly Epoch Time 1s	0-3599	12	1	s	3600-4095 indicates data not available
SSR Update Interval	0-15	4	1	-	
Multiple Message Indicator	-	1	-	-	
IOD SSR	0-15	4	1	-	
Code Bias Existing Flag	-	1	-	-	
Phase Bias Existing Flag	-	1	-	-	
Network Bias Correction	-	1	-	-	
Compact Network ID	0-31	5	1	-	Included only if "Network Bias Correction" equals to "1" 0 - undefined
Network SV Mask	-	N_{sat}	1	-	Included only if "Network Bias Correction" equals to "1"

IS-QZSS-L6-001

Table 4.1.2-20 Contents of satellite-specific part of Compact SSR GNSS Satellite Code and Phase Bias Message

DF Name	DF Range	BIT	LSB	DF Unit	Note
Compact SSR Code Bias 1 (SV 1)	±20.46	11	0.02	m	-20.48 indicates data not available. Included only if "Code Bias Existing Flag" equals to "1"
Compact SSR Phase Bias1 (SV1)	±16.383	15	0.001	m	-16.384 indicates data not available. Included only if "Phase Bias Existing Flag" equals to "1"
Compact SSR Phase Discontinuity Indicator1 (SV 1)	0-3	2	1	-	Included only if "Phase Bias Existing Flag" equals to "1"
⟨					
Compact SSR Code Bias N_{code} (SV 1)	±20.46	11	0.02	m	-20.48 indicates data not available. Included only if "Code Bias Existing Flag" equals to "1"
Compact SSR Phase Bias N_{phase} (SV 1)	±16.383	15	0.001	m	-16.384 indicates data not available. Included only if "Phase Bias Existing Flag" equals to "1"
Compact SSR Phase Discontinuity IndicatorN_{phase} (SV 1)	0-3	2	1	-	Included only if "Phase Bias Existing Flag" equals to "1"
Compact SSR Code Bias 1 (SV 2)	±20.46	11	0.02	m	-20.48 indicates data not available. Included only if "Code Bias Existing Flag" equals to "1"
Compact SSR Phase Bias 1 (SV 2)	±16.383	15	0.001	m	-16.384 indicates data not available. Included only if "Phase Bias Existing Flag" equals to "1"
Compact SSR Phase Discontinuity Indicator1 (SV 2)	0-3	2	1	-	Included only if "Phase Bias Existing Flag" equals to "1"
⟨					
Compact SSR Code Bias N_{code} (SV N_{sat})	±20.46	11	0.02	m	-20.48 indicates data not available. Included only if "Code Bias Existing Flag" equals to "1"
Compact SSR Phase Bias N_{phase} (SV N_{sat})	±16.383	15	0.001	m	-16.384 indicates data not available. Included only if "Phase Bias Existing Flag" equals to "1"
Compact SSR Phase Discontinuity Indicator N_{phase} (SV N_{sat})	0-3	2	1	-	Included only if "Phase Bias Existing Flag" equals to "1"

(1) Code Bias Existing Flag

If the flag set to "1"(B), Code Bias is included.

(2) Phase Bias Existing Flag

If the flag set to "1"(B), Phase Bias is included.

(3) Network Bias Correction

If the flag set to "1"(B), correction for Phase or Code Bias in local network

Document subject to the disclaimer of liability

37

4.1.2.2.8 Sub Type 7 – Compact SSR URA Message

The Sub Type 7 Message structure is shown in Figure 4.1.2-9. The message header and satellite-specific part are defined in Table 4.1.2-21 and Table 4.1.2-22, respectively.
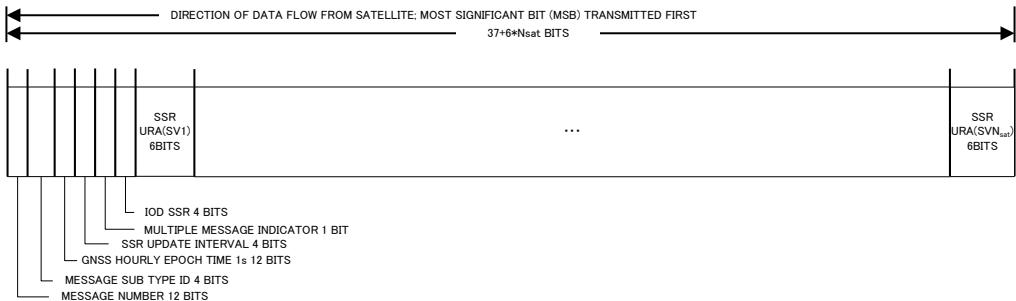

Figure 4.1.2-9 Compact SSR GNSS URA Message structure

Table 4.1.2-21 Contents of message header, compact SSR URA Message

DF Name	DF Range	BIT	LSB	DF Unit	Note
Message Number	0-4095	12	-	-	4073
Message Sub Type ID	0-15	4	-	-	7
GNSS Hourly Epoch Time 1s	0-3599	12	1	s	3600-4095 indicates data not available
SSR Update Interval	0-15	4	1	-	
Multiple Message Indicator	-	1	-	-	
IOD SSR	0-15	4	1	-	

Table 4.1.2-22 Contents of satellite-specific part of compact SSR GNSS URA message

DF Name	DF Range	BIT	LSB	DF Unit	Note
SSR URA（SV1）	bits 5-3：0-7 bits 2-0：0-7	6	-	-	
⟨					
SSR URA（SV Nsat）	bits 5-3：0-7 bits 2-0：0-7	6	-	-	

(1) SSR URA

SSR users range accuracy (URA) (1 sigma) for range correction computed from a complete signal in space specific SSR set as disseminated by the compact SSR messages. The URA is represented by a combination of URA_CLASS and URA_VALUE. The 3 MSBs define the URA_CLASS within a range of 0-7 while the 3 LSBs define the URA_VALUE within a range of 0-7. The URA is computed as described in 5.4.2.

4.1.2.2.9 Sub Type 8 – Compact SSR STEC Correction Message

The sub type 8 message structure is shown Figure 4.1.2-10. The message header and satellite-specific part are defined in Table 4.1.2-23 and Table 4.1.2-24, respectively.
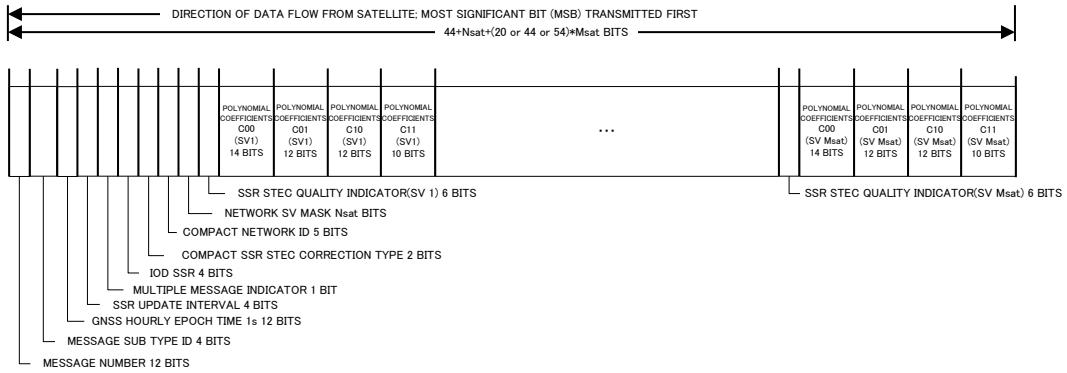

Figure 4.1.2-10 Compact SSR STEC Correction Message structure

Table 4.1.2-23 Contents of message header, Compact SSR STEC Correction Message

DF Name	DF Range	BIT	LSB	DF Unit	Note
Message Number	0-4095	12	-	-	4073
Message Sub Type ID	0-15	4	-	-	8
GNSS Hourly Epoch Time 1s	0-3599	12	1	s	3600-4095 indicates data not available
SSR Update Interval	0-15	4	1	-	
Multiple Message Indicator	-	1	-	-	
IOD SSR	0-15	4	1	-	
Compact SSR STEC Correction Type	0-3	2	1		
Compact Network ID	0-31	5	1	-	0 - undefined
Network SV mask	-	N_{sat}	1	-	

Table 4.1.2-24 Contents of satellite-specific part of Compact SSR STEC Correction Message

(i) STEC correction type = 0

DF Name	DF Range	BIT	LSB	DF Unit	Note
SSR STEC Quality Indicator(SV 1)	bits 5-3 : 0-7 bits 2-0 : 0-7	6	-	-	
Polynomial Coefficients C00(SV 1)	±409.55	14	0.05	TECU	-409.6 indicates data not available
⟨					
SSR STEC Quality Indicator(SV M_{sat})	bits 5-3 : 0-7 bits 2-0 : 0-7	6	-	-	
Polynomial Coefficients C00(SV M_{sat})	0-819.15	14	0.05	TECU	

(ii) STEC correction type = 1

DF Name	DF Range	BIT	LSB	DF Unit	Note
SSR STEC Quality Indicator(SV 1)	bits 5-3 : 0-7 bits 2-0 : 0-7	6	-	-	
Polynomial Coefficients C00 (SV 1)	±409.55	14	0.05	TECU	-409.6 indicates data not available
Polynomial Coefficients C01(SV 1)	±40.94	12	0.02	TECU/deg	-40.96 indicates data not available
Polynomial Coefficients C10(SV 1)	±40.94	12	0.02	TECU/deg	-40.96 indicates data not available
⟨					
SSR STEC Quality Indicator(SV M_{sat})	bits 5-3 : 0-7 bits 2-0 : 0-7	6	-	-	
Polynomial Coefficients C00(SV M_{sat})	±409.55	14	0.05	TECU	-409.6 indicates data not available
Polynomial Coefficients C01(SV M_{sat})	±40.94	12	0.02	TECU/deg	-40.96 indicates data not available
Polynomial Coefficients C10(SV M_{sat})	±40.94	12	0.02	TECU/deg	-40.96 indicates data not available

(iii) STEC correction type = 2

DF Name	DF Range	BIT	LSB	DF Unit	Note
SSR STEC Quality Indicator(SV 1)	bits 5-3 : 0-7 bits 2-0 : 0-7	6	-	-	
Polynomial Coefficients C00 (SV 1)	±409.55	14	0.05	TECU	-409.6 indicates data not available
Polynomial Coefficients C01(SV 1)	±40.94	12	0.02	TECU/deg	-40.96 indicates data not available
Polynomial Coefficients C10(SV 1)	±40.94	12	0.02	TECU/deg	-40.96 indicates data not available
Polynomial Coefficients C11(SV 1)	±10.22	10	0.02	$TECU/deg^2$	-10.24 indicates data not available
⟨					
SSR STEC Quality Indicator(SV M_{sat})	bits 5-3 : 0-7 bits 2-0 : 0-7	6	-	-	
Polynomial Coefficients C00(SV M_{sat})	±409.55	14	0.05	TECU	-409.6 indicates data not available
Polynomial Coefficients C01(SV M_{sat})	±40.94	12	0.02	TECU/deg	-40.96 indicates data not available
Polynomial Coefficients C10(SV M_{sat})	±40.94	12	0.02	TECU/deg	-40.96 indicates data not available
Polynomial Coefficients C11(SV M_{sat})	±10.22	10	0.02	$TECU/deg^2$	-10.24 indicates data not available

(1) Compact SSR STEC correction type
STEC correction type for 0-2 as listed in Table 4.1.2-24.

(2) Compact Network ID
Network ID to identify specific local correction messages.

(3) Network SV mask
Bit stream used to select specific satellite set.

(4) SSR STEC Quality Indicator
SSR STEC quality indicator. The definition is the same as that for DF389, whereas the dimension is TECU instead of m. The SSR STEC quality indicator is computed as described in 5.4.3.

(5) Polynomial Coefficients (C00, C01, C10, C11)
Coefficient C00 of polynomial used to define STEC in a specific local or regional network, as defined in Table 4.1.2-24. Table 4.1.2-25 defines C00, C01, C10, and C11. Where ϕ is the latitude of the user, λ is the longitude of the user, ϕ_0 is the latitude of the reference, and λ_0 is longitude of the reference.

Table 4.1.2-25 Definition of polynomial coefficients (C00, C01, C10, C11)

STEC Correction Type	STEC Network Correction
0	$\delta I_{ai} = C_{00}$
1	$\delta I_{ai} = C_{00} + C_{01}(\phi - \phi_0) + C_{10}(\lambda - \lambda_0)$
2	$\delta I_{ai} = C_{00} + C_{01}(\phi - \phi_0) + C_{10}(\lambda - \lambda_0) + C_{11}(\phi - \phi_0)(\lambda - \lambda_0)$
3	reserved

4.1.2.2.10 Sub Type 9 – Compact SSR Gridded Correction Message

The sub type 9 message structure is shown in Figure 4.1.2-11. The message header and grid-specific part are defined in Table 4.1.2-26 and Table 4.1.2-27, respectively.
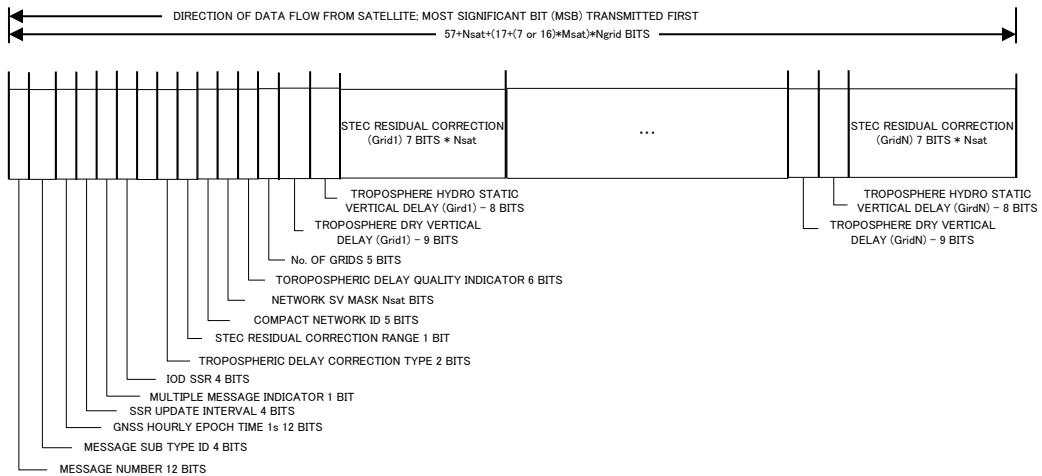
Figure 4.1.2-11 Compact SSR Gridded Correction Message structure

Table 4.1.2-26 Contents of message header, Compact SSR Gridded Correction Message

DF Name	DF Range	BIT	LSB	DF Unit	Note
Message Number	0-4095	12	-	-	4073
Message Sub Type ID	0-15	4	-	-	9
GNSS Hourly Epoch Time 1s	0-3599	12	1	s	3600-4095 indicates data not available
SSR Update Interval	0-15	4	1	-	
Multiple Message Indicator	-	1	-	-	
IOD SSR	0-15	4	1	-	
Tropospheric Delay Correction Type	0-3	2	1	-	
STEC Residual Correction Range	0-1	1	1	-	
Compact Network ID	0-31	5	1	-	0 - undefined
Network SV mask	-	N_{sat}	-	-	
Tropospheric Delay Quality Indicator	bits 5-3 : 0-7 bits 2-0 : 0-7	6	-	-	
No. of Grids	0-63	6	1	-	

Table 4.1.2-27 Contents of grid-specific part of compact SSR Gridded Correction Message

DF Name	DF Range	BIT	LSB	DF Unit	Note
Troposphere Hydro-Static Vertical Delay(Grid 1)	±1.02	9	0.004	m	-1.024 indicates data not available
Troposphere Wet Vertical Delay(Grid 1)	±0.508	8	0.004	m	-0.512 indicates data not available
STEC Residual Correction (Grid 1)(SV 1)	±2.52 or ±1310.68	7 or 16	0.04	TECU	-2.56 indicates data not available or -1310.72 indicates data not available
⌇					
STEC Residual Correction (Grid 1)(SV M_{sat})	±2.52 or ±1310.68	7 or 16	0.04	TECU	-2.56 indicates data not available or -1310.72 indicates data not available
⌇					
Troposphere Hydro Static Vertical Delay (Grid N)	±1.02	9	0.004	m	-1.024 indicates data not available
Troposphere Wet Vertical Delay (Grid N)	±0.508	8	0.004	m	-0.512 indicates data not available
STEC Residual Correction (Grid N)	±2.52 or ±1310.68	7 or 16	0.04	TECU	-2.56 indicates data not available or -1310.72 indicates data not available
⌇					
STEC Residual Correction (Grid N)(SV M_{sat})	±2.52 or ±1310.68	7 or 16	0.04	TECU	-2.56 indicates data not available or -1310.72 indicates data not available

(1) Tropospheric Delay Correction Type

It defines the nominal value of the hydrostatic and wet term and utilized mapping function for the calculation of tropospheric slant delay.

0: Tropospheric delay is not included.

1: Constant offset 2.3 is used for the hydrostatic term, 0.252 is used for the wet term and Neill mapping function is used.

2-3: Reserved.

(2) STEC Residual Correction Range

Bit 7 if it is set to 0, otherwise bit 16 is used for STEC residual correction.

Table 4.1.2-28 Diff mode (STEC residual correction range = 0)

DF Name	DF Range	BIT	LSB	DF Unit	Note
STEC Residual Correction	±2.52	7	0.04	TECU	-2.56 indicates data not available

Table 4.1.2-29 Standalone mode (STEC residual correction range = 1)

DF Name	DF Range	BIT	LSB	DF Unit	Note
STEC Residual Correction	±1310.68	16	0.04	TECU	-1310.72 indicates data not available

(3) Tropospheric Delay Quality Indicator

Quality indicator of tropospheric delay. Definition is the same as that for DF389. The tropospheric delay quality indicator is computed as described in 5.4.3.

(4) Troposphere Hydro-Static Vertical Delay

Variation in the hydro static troposphere vertical delay relative to the nominal value. The constant nominal value, 2.3 m, is applied if the tropospheric delay type is equal to 1. The other types are reserved.

(5) Tropospheric Wet Vertical Delay

Variation in the wet troposphere vertical delay relative to the nominal value. The constant nominal value, 0.252 m, is applied if the tropospheric delay type is equal to 1.

(6) STEC Residual Correction

If the STEC residual correction range is set to 0, the STEC residual correction is int7. Otherwise it is int16.

4.1.2.2.11 Sub Type 10 – CLAS Service Information

TBD

4.1.2.2.12 Sub Type 11 – Compact SSR GNSS Combined Correction

The sub type 11 message structure is shown in Figure 4.1.2-12. The message header and satellite-specific part are defined in Table 4.1.2-30 and Table 4.1.2-31, respectively.
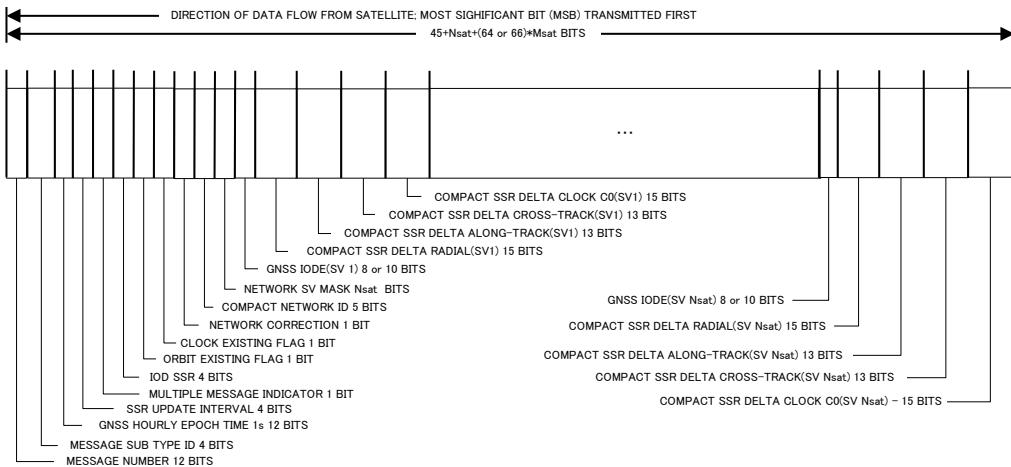
Figure 4.1.2-12 Compact SSR GNSS Combined Correction Message structure

Table 4.1.2-30 Contents of message header, Compact SSR GNSS Combined Correction Message

DF Name	DF Range	BIT	LSB	DF Unit	Note
Message Number	0-4095	12	-	-	4073
Message Sub Type ID	0-15	4	-	-	11
GNSS Hourly Epoch Time 1s	0-3599	12	1	s	3600-4095 indicates data not available
SSR Update Interval	0-15	4	1	-	
Multiple Message Indicator	-	1	-	-	
IOD SSR	0-15	4	1	-	
Orbit Existing Flag	-	1	-	-	
Clock Existing Flag	-	1	-	-	
Network Correction	-	1	-	-	
Compact Network ID	0-31	5	1	-	Included only if "Network Correction" equals to "1" 0 - undefined
Network SV Mask	-	N_{sat}	1	-	Included only if "Network Correction" equals to "1"

46

Table 4.1.2-31 Contents of satellite-specific part of Compact SSR GNSS Combined Correction Message

DF Name	DF Range	BIT	LSB	DF Unit	Note
GNSS IODE(SV 1)	0-255 or 0-1023	8 or 10	1	-	Included only if "Orbit Existing Flag" equals to "1"
Compact SSR Delta Radial(SV 1)	±26.2128	15	0.0016	m	Included only if "Orbit Existing Flag" equals to "1"' -26.2144 indicates data not available
Compact SSR Delta Along-Track(SV 1)	±26.208	13	0.0064	m	Included only if "Orbit Existing Flag" equals to "1" '-26.2144 indicates data not available
Compact SSR Delta Cross-Track(SV 1)	±26.208	13	0.0064	m	Included only if "Orbit Existing Flag" equals to "1" '-26.2144 indicates data not available
Compact SSR Delta Clock C0(SV1)	±26.2128	15	0.0016	m	Included only if "Clock Existing Flag" equals to "1" -26.2144 indicates data not available
）					
GNSS IODE(SV Msat)	0-255 or 0-1023	8 or 10	1	-	Included only if "Orbit Existing Flag" equals to "1"
Compact SSR Delta Radial (SV Msat)	±26.2128	15	0.0016	m	Included only if "Orbit Existing Flag" equals to "1" '-26.2144 indicates data not available
Compact SSR Delta Along-Track (SV Msat)	±26.208	13	0.0064	m	Included only if "Orbit Existing Flag" equals to "1" '-26.2144 indicates data not available
Compact SSR Delta Cross-Track (SV Msat)	±26.208	13	0.0064	m	Included only if "Orbit Existing Flag" equals to "1" '-26.2144 indicates data not available
Compact SSR Delta Clock C0 (SV Msat)	±26.2128	15	0.0016	m	Included only if "Clock Existing Flag" equals to "1" -26.2144 indicates data not available

(1) Orbit Existing Flag

If the flag set to "1"(B), "GNSS IODE", "Compact SSR Delta Radial", "Compact SSR Along-Track", and "Compact SSR Delta Cross-track" are included.

(2) Clock Existing Flag

If the flag set to "1"(B), "Compact SSR Delta Clock C0" is included.

(3) Network Correction

If the flag set to "1"(B), the state parameters "Compact SSR Delta Clock C0" or/and "GNSS IODE", "Compact SSR Delta Radial", "Compact SSR Along-Track", and "Compact SSR Delta Cross-track" in local network should be used in exchange of the state parameters included in Sub Type 2 or 3.

4.1.2.2.13 Sub Type Transmission Pattern

Each sub type is transmitted at a rate of one cycle within 30 seconds, according to the transmission schedule. Table 4.1.2-32 and Figure 4.1.2 show a nominal pattern. Note that the user algorithm should not assume any specific pattern.

Table 4.1.2-32 Nominal Transmission Pattern of Subtype

| Sec	Subframe Number	Sub Type	Compact Network ID
0-4	1	1,2,3,11,4,5,6,7,8,9	12,2
5-9	2	3,11,6,8,9	3,4,14
10-14	3	3,11,6,8,9	5,6,15,16
15-19	4	3,11,6,8,9	7,8,17,18
20-24	5	3,11,6,8,9	9,10,19
25-29	6	3,11,6,8,9	11,1
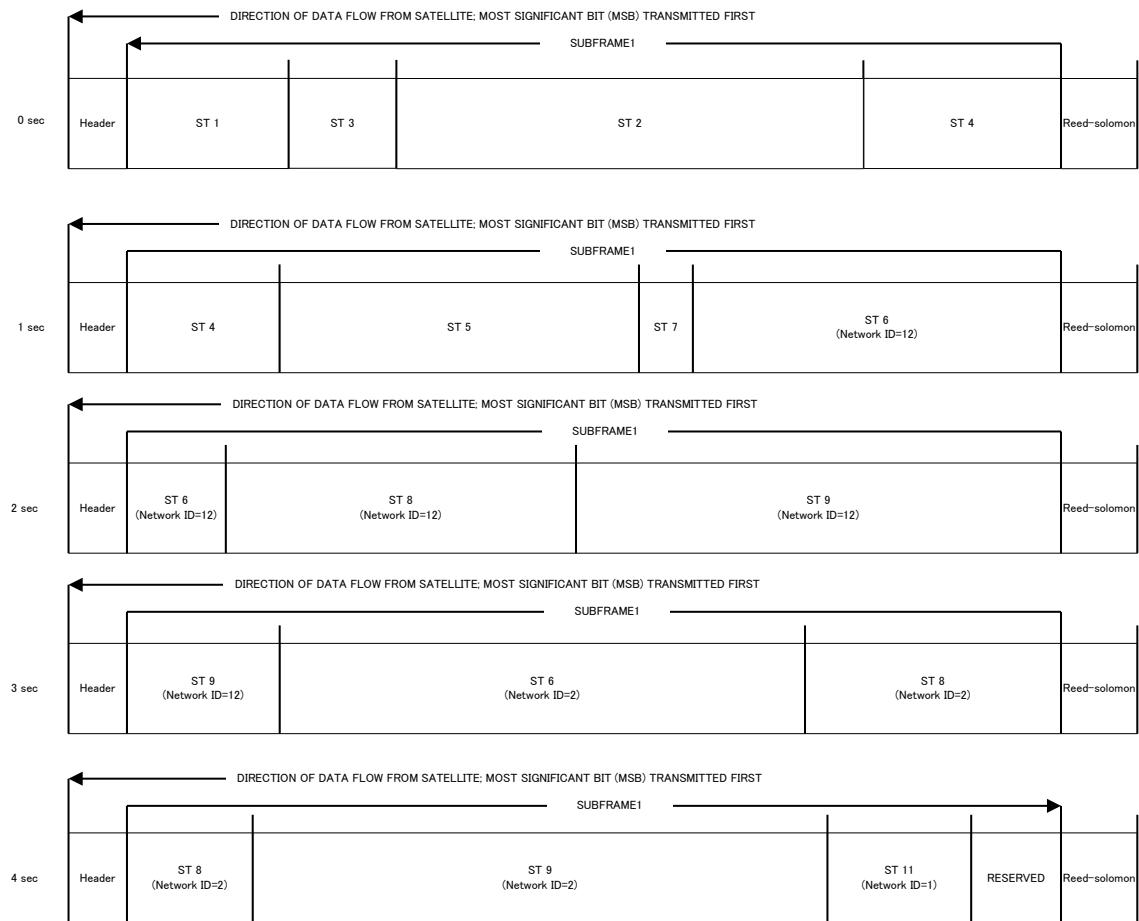
Figure 4.1.2-13 Subtype transmission pattern
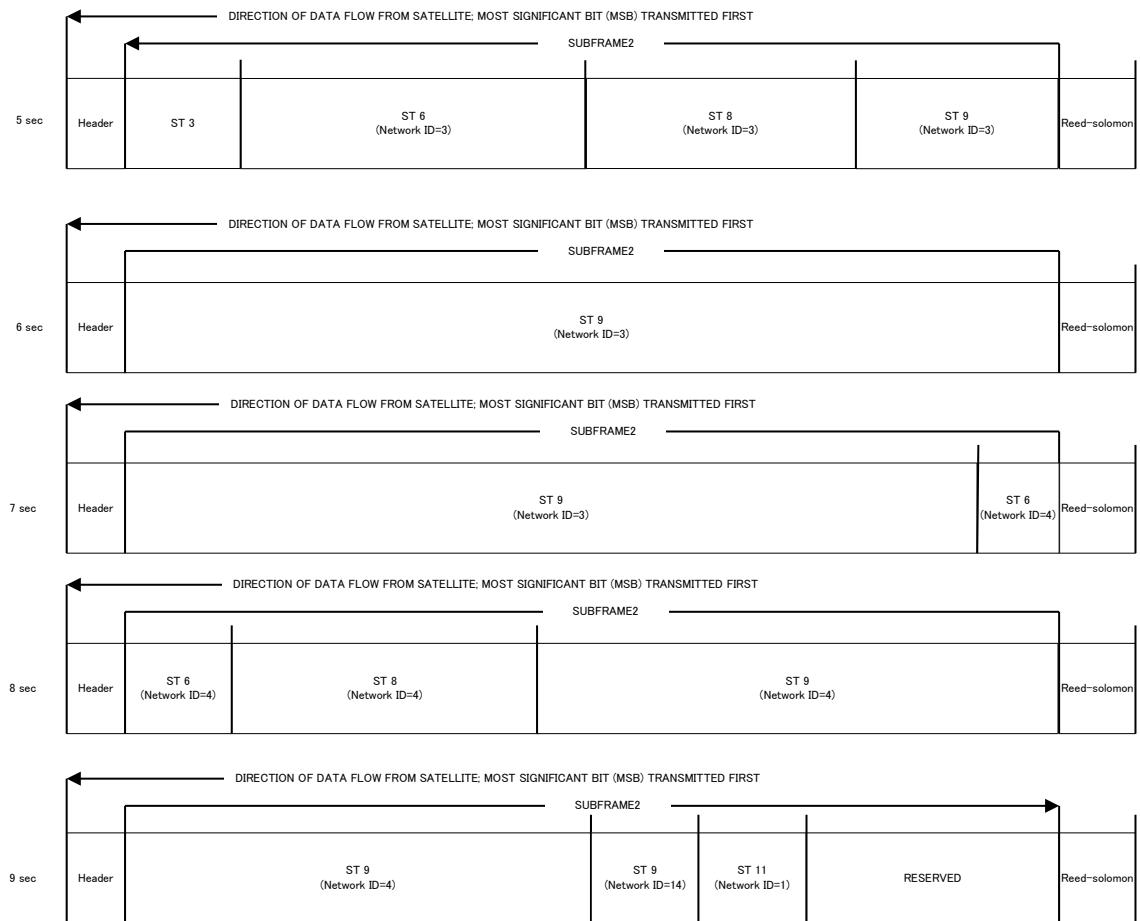
Figure 4.1.2-13 Subtype transmission pattern (continued)
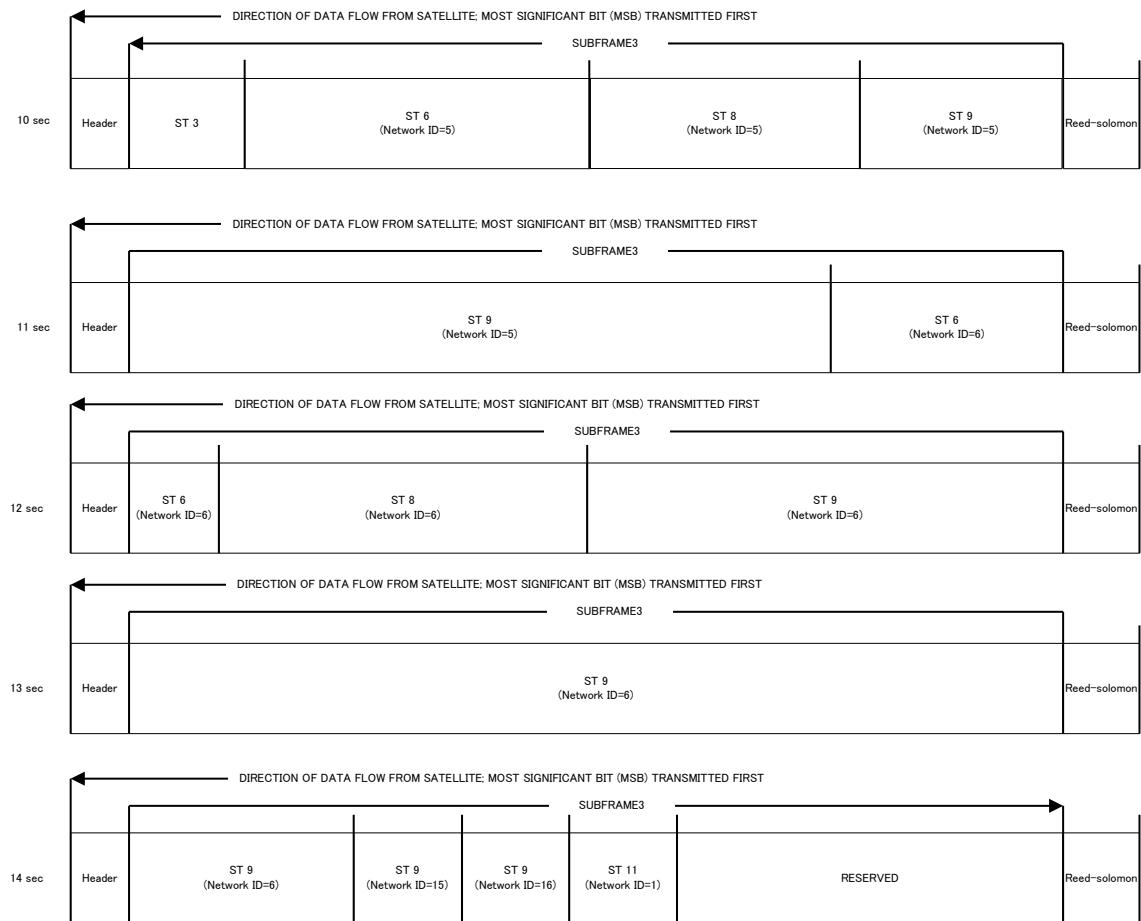
Figure 4.1.2-13 Subtype transmission pattern (continued)
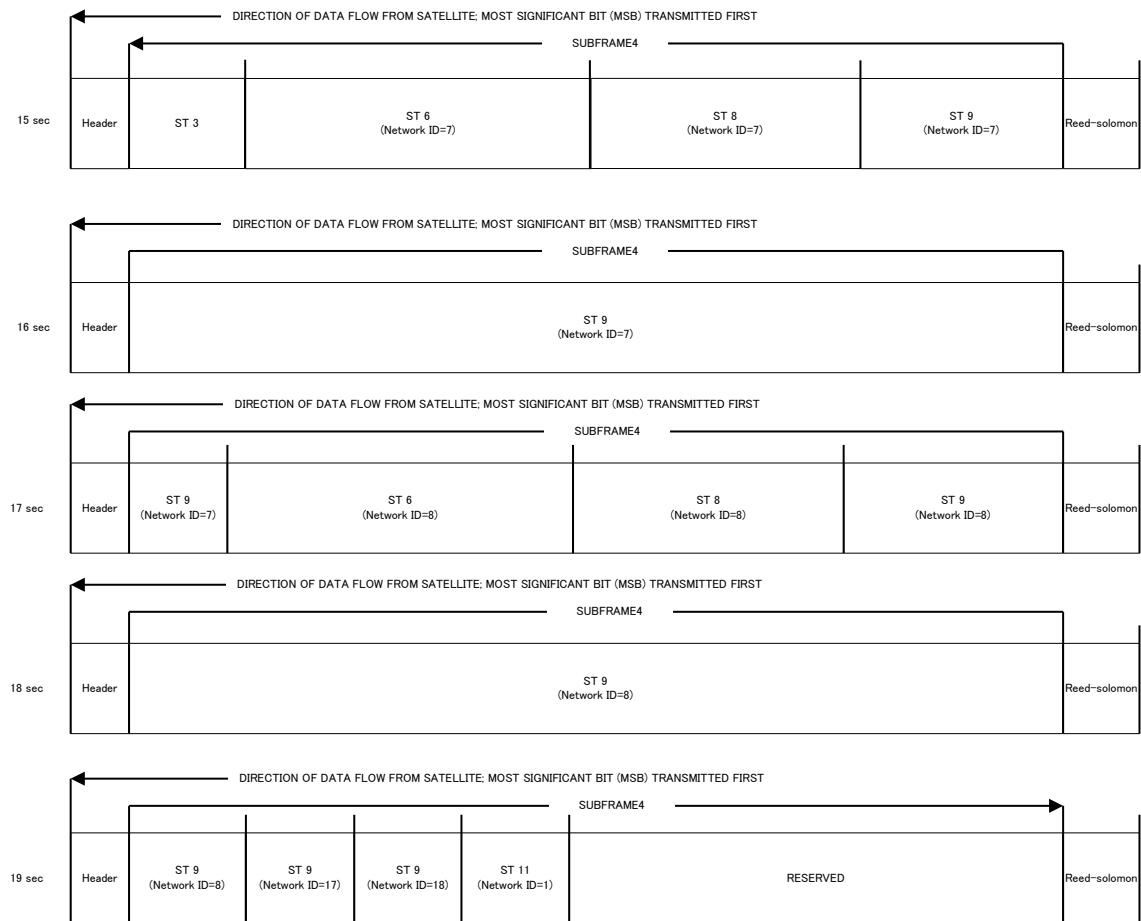
Figure 4.1.2-13 Subtype transmission pattern (continued)
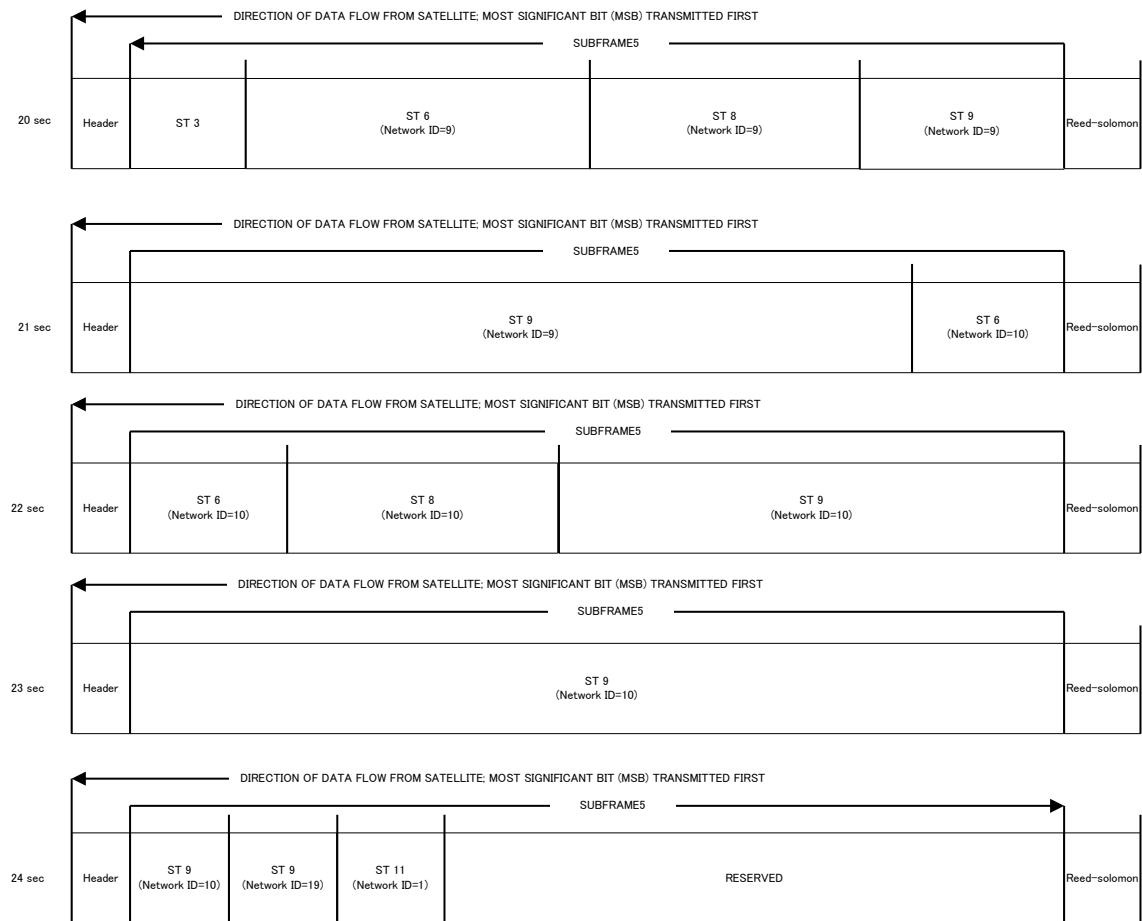
Figure 4.1.2-13 Subtype transmission pattern (continued)
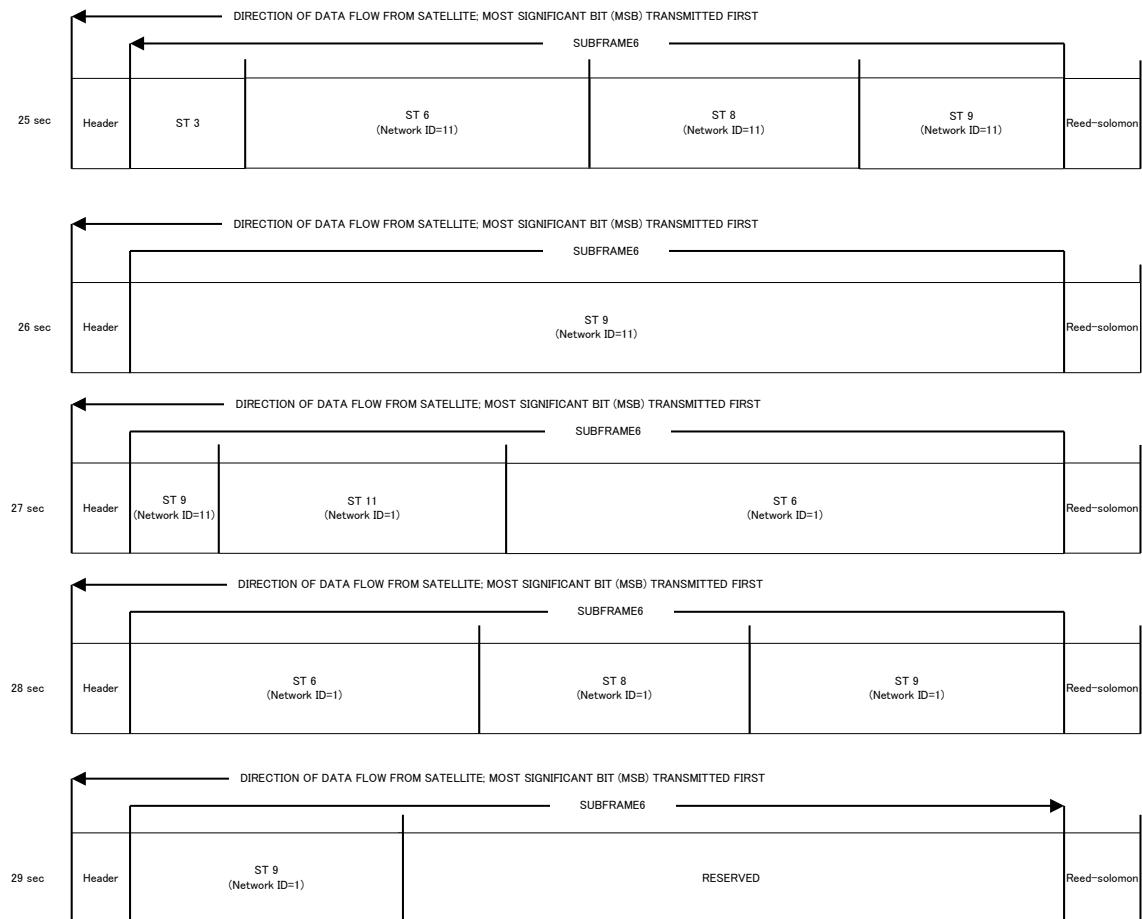
Figure 4.1.2-13 Subtype transmission pattern (continued)

4.1.2.3   Null Message

If there is no CLAS information to be transmitted, as determined by the satellite system side, a null message is sent. The nominal validity interval of each message after a null message is shown in Table 4.1.1‑2. User can use the message within the nominal validity interval.

The following events are envisaged in the situation when there is no CLAS information to be transmitted.

(1) The L6 positioning upload data from the ground system is not sent.
   When an abnormality occurs in the ground system and system uplink disconnection occurs, the null message is transmitted.

(2) Intended L6 positioning upload data is transmitted to the satellite system.
   When the L6 positioning upload data authentication becomes NG in the satellite system, the data is discarded and a null message is transmitted.

The preamble of the null message is a fixed value. PRN number is numbered (8-bit) with the PRN code to be used. Thus, the L6 message type ID is 0 and the Alert Flag is "1"$_{(B)}$. The first 7-bit of the data part (1695-bit) are "0101010"$_{(B)}$, and the other repeats the "10101010"$_{(B)}$.

4.1.3. FEC Encoded Algorithm

Reed-Solomon (255, 223) encoding is applied to the 1744-bit of the navigation message (preamble, PRN, message type ID, alert flag, and data section). Every 8-bit of the resulting bit-stream constitutes one symbol. (See Section 4.1.2.3.1 for details)

To add the 32-symbol (256-bit) Reed-Solomon code to the 218-symbol (1744-bit) navigation message, nine "0" symbols (72-bit) are inserted at the beginning of the 214-symbol (1712-bit) data bit string that does not include the 4-symbol (32-bit) preamble at the beginning of the header. The resulting 223-symbol (1784-bit) data bit string (with the 9 zero symbols inserted) is Reed-Solomon encoded (255,223) to generate a 32-symbol (256-bit) parity word. The 250 symbols (2000-bit) that comprise the 32-symbol parity words added to the original 218-symbol (1744-bit) data bit string (including the preamble) are then input to the CSK modulator (see Figure 4.1.3-1).
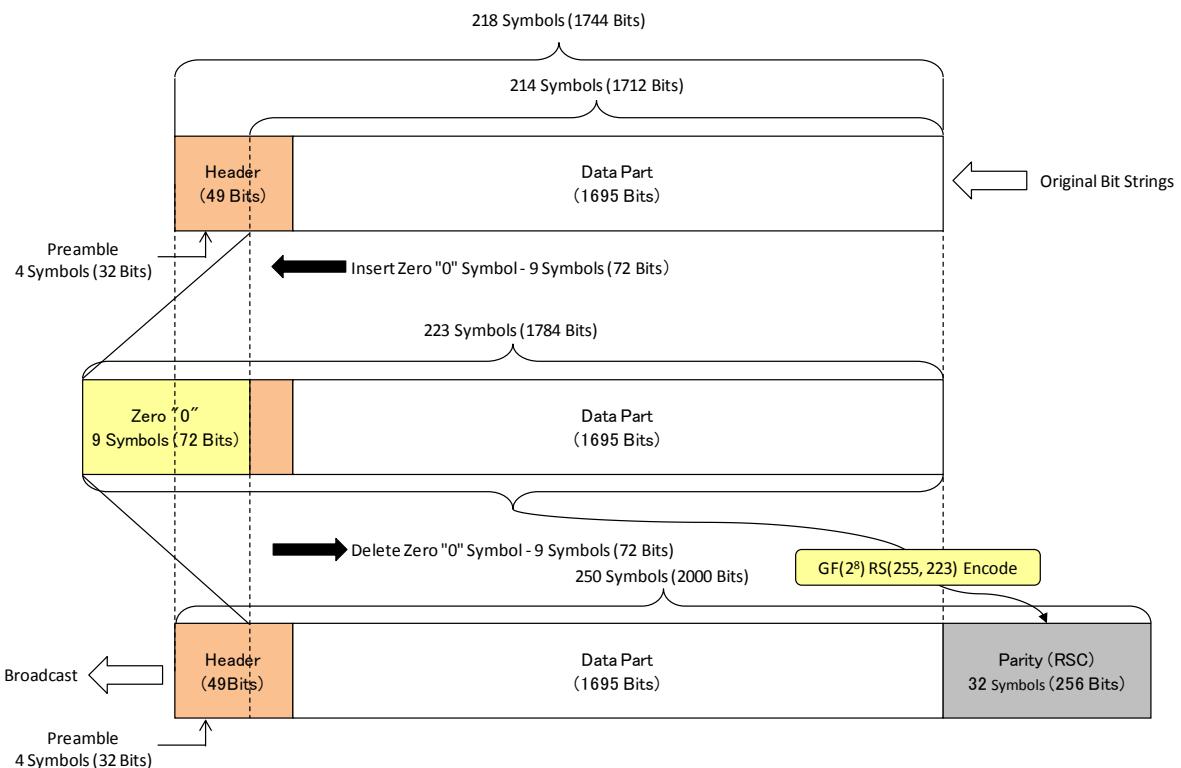
Figure 4.1.3-1 Compact SSR STEC correction message structure

4.1.3.1.1 Reed Solomon Coding/Decoding Algorithm for L6 Navigation Message
(1) Construct Galois Field GF(2^8)

We choose $F(x) = x^8 + x^7 + x^2 + x + 1$ as a primitive polynomial of degree 8 over $\mathbf{Z}_2$. (Note that, because this is the binary case, addition (+) is equivalent to exclusive-OR (XOR) and multiplication (x) is equivalent to the logical AND operation.) When α is a root of $F(x) = 0$, we have the following (note that $\alpha^8 = -\alpha^8$ over $\mathbf{Z}_2$):

$$\alpha^8 = -\alpha^8 = \alpha^7 + \alpha^2 + \alpha + 1 \qquad\qquad 4.1.3\text{-}1$$

From equation 4.1.3-1 any power of α can be represented by a linear combination of $\alpha^7, \alpha^6, \alpha^5, \alpha^4, \alpha^3, \alpha^2, \alpha^1, \alpha^0 (= 1)$ over $\mathbf{Z}_2$ (note that $\alpha^i + \alpha^i = 0$) as follows:

$$
\begin{aligned}
\alpha^8 &= \alpha^7 + \alpha^2 + \alpha + 1 \\
\alpha^9 &= \alpha^8 \times \alpha = \alpha^8 + \alpha^3 + \alpha^2 + \alpha \\
&= (\alpha^7 + \alpha^2 + \alpha + 1) + \alpha^3 + \alpha^2 + \alpha \\
&= \alpha^7 + \alpha^3 + 1 \\
\alpha^{10} &= \alpha^9 \times \alpha = \alpha^8 + \alpha^4 + \alpha \\
&= (\alpha^7 + \alpha^2 + \alpha + 1) + \alpha^4 + \alpha \\
&= \alpha^7 + \alpha^4 + \alpha^2 + 1 \\
&\vdots \\
\alpha^{254} &= \alpha^7 + \alpha^6 + \alpha + 1
\end{aligned}
\qquad 4.1.3\text{-}2
$$

Then, the order of α is 255, since:

$$
\begin{aligned}
\alpha^{255} &= \alpha^{254} \times \alpha = \alpha^8 + \alpha^7 + \alpha^2 + \alpha \\
&= (\alpha^7 + \alpha^2 + \alpha + 1) + \alpha^7 + \alpha^2 + \alpha \\
&= 1 + \alpha^0
\end{aligned}
\qquad 4.1.3\text{-}3
$$

From equations 4.1.3-3, the addition of two powers of α is as follows: When

$$\alpha^m = \mu_{m7}\alpha^7 + \mu_{m6}\alpha^6 + \cdots + \mu_{m1}\alpha^1 + \mu_{m0} \qquad 4.1.3\text{-}4$$
$$\alpha^n = \mu_{n7}\alpha^7 + \mu_{n6}\alpha^6 + \cdots + \mu_{n1}\alpha^1 + \mu_{n0} \qquad 4.1.3\text{-}5$$

the addition is given by:

$$
\begin{aligned}
\alpha^m + \alpha^n &= (\mu_{m7} + \mu_{n7})\alpha^7 + (\mu_{m6} + \mu_{n6})\alpha^6 + \\
&\quad \cdots (\mu_{m1} + \mu_{n1})\alpha^1 + (\mu_{m0} + \mu_{n0})\alpha^0 \\
&= \alpha^1
\end{aligned}
\qquad 4.1.3\text{-}6
$$

Each μ_{mi}, μ_{nj} coefficient is either a zero or a one, and $\mu_{mi} + \mu_{nj}$ is the logical "exclusive OR" of the two coefficients. As a result of the above operations, $\{0, 1(= \alpha^0), \alpha^1, \alpha^2, ..., \alpha^{254}\}$ makes a Galois Field GF(2^8).

(2) Change of Basis

From equations 4.1.3-2, one basis for $\{0, 1(= \alpha^0), \alpha^1, \alpha^2, ..., \alpha^{254}\}$ over $\mathbf{Z}_2$ is the set $\{\alpha^7, \alpha^6, \alpha^5, \alpha^4, \alpha^3, \alpha^2, \alpha^1, \alpha^0\}$.

When $l_0 = \alpha^{125}, l_1 = \alpha^{88}, l_2 = \alpha^{226}, l_3 = \alpha^{163}, l_4 = \alpha^{46}, l_5 = \alpha^{184}, l_6 = \alpha^{67}, l_7 = \alpha^{242}$, the set $\{l_0, l_1, l_2, l_3, l_4, l_5, l_6, l_7\}$ is another basis for $\{0, 1(= \alpha^0), \alpha^1, \alpha^2, ..., \alpha^{254}\}$ over $\mathbf{Z}_2$. When the nth power of α is represented by two linear combinations:

$$\begin{aligned}
\alpha^n &= u_7\alpha^7 + u_6\alpha^6 + u_5\alpha^5 + u_4\alpha^4 + u_3\alpha^3 \\
&\quad + u_2\alpha^2 + u_1\alpha^1 + u_0\alpha^0 \\
&= z_0 l_0 + z_1 l_1 + z_2 l_2 + z_3 l_3 + z_4 l_4 + z_5 l_5 + z_6 l_6 + z_7 l_7
\end{aligned} \qquad \text{4.1.3-7}$$

The relationship between $\mu_7, \mu_6, \mu_5, \mu_4, \mu_3, \mu_2, \mu_1, \mu_0$ and $z_0, z_1, z_2, z_3, z_4, z_5, z_6, z_7$ is given by the following two equations:

$$\left(z_0, z_1, z_2, z_3, z_4, z_5, z_6, z_7\right) = \begin{pmatrix} u_7 \\ u_6 \\ u_5 \\ u_4 \\ u_3 \\ u_2 \\ u_1 \\ u_0 \end{pmatrix}^t \begin{pmatrix} 1 & 0 & 0 & 0 & 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 0 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 0 & 1 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 & 0 & 1 & 0 \\ 1 & 0 & 0 & 1 & 1 & 0 & 0 & 1 \\ 1 & 0 & 1 & 0 & 1 & 1 & 1 & 1 \\ 0 & 1 & 1 & 1 & 1 & 0 & 1 & 1 \end{pmatrix} \qquad \text{4.1.3-8}$$

$$\left(u_7, u_6, u_5, u_4, u_3, u_2, u_1, u_0\right) = \begin{pmatrix} z_0 \\ z_1 \\ z_2 \\ z_3 \\ z_4 \\ z_5 \\ z_6 \\ z_7 \end{pmatrix}^t \begin{pmatrix} 1 & 1 & 0 & 0 & 0 & 1 & 0 & 1 \\ 0 & 1 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 1 & 0 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 1 & 1 & 0 & 0 & 1 \\ 1 & 0 & 1 & 0 & 1 & 1 & 0 & 0 \\ 1 & 1 & 0 & 0 & 1 & 1 & 0 & 0 \end{pmatrix} \qquad \text{4.1.3-9}$$

Each μ_i, z_j coefficient is either a zero or a one, and the addition of these matrix operations is simply "exclusive OR".

(3) Encoding

When the header and data parts of the L6 message are given, the Reed-Solomon encoding is performed as follows:

The target encoded length is 214 symbols (5 to 218) followed by the Preamble. Consider the bits in each symbol to be $z_0, z_1, z_2, z_3, z_4, z_5, z_6, z_7$ corresponding to the elements of $\{0,1(= \alpha^0), \alpha^1, \alpha^2, ..., \alpha^{254}\}$ (see Section (2)). When the binary string 5th, 6th, $\cdots$, 218th symbol is represented by $A_5, A_6, ..., A_{218}$ $(A_i \in \{0,1(= \alpha^0), \alpha^1, \alpha^2, ..., \alpha^{254}\})$ polynomial $I(x)$ over $\{0,1(= \alpha^0), \alpha^1, \alpha^2, ..., \alpha^{254}\}$ defined as follows:

$$I(x) = A_5 x^{213} + A_6 x^{212} + \cdots + A_{217} x + A_{218}$$

If the code generator polynomial over $\{0,1(= \alpha^0), \alpha^1, \alpha^2, ..., \alpha^{254}\}$ is defined as follows:

$$g(x) = \prod_{j=112}^{143} (x - \alpha^{11j}) \qquad \qquad 4.1.3\text{-}10$$

Then, $P(x)$ is the remainder after dividing $x^{32}I(x)$ by $g(x)$. Division is used for the operation of the Galois Field $\{0,1(= \alpha^0), \alpha^1, \alpha^2, ..., \alpha^{254}\}$ (see Section (1)).
$P(x)$ is written as follows:

$$P(x) = B_1 x^{31} + B_2 x^{30} + \cdots + B_{31} x + B_{32}$$
$$B_i \in \{0,1(= \alpha^0), \alpha^1, \alpha^2, ..., \alpha^{254}\} \qquad 4.1.3\text{-}11$$

When each B_i is represented by a linear combination of set $\{l_0, l_1, l_2, l_3, l_4, l_5, l_6, l_7\}$:

$$B_i = z_0 l_0 + z_1 l_1 + z_2 l_2 + z_3 l_3 + z_4 l_4 + z_5 l_5 + z_6 l_6 + z_7 l_7 \qquad 4.1.3\text{-}12$$

The 32-symbol Reed-Solomon Code is generated by thinking of $z_0, z_1, z_2, z_3, z_4, z_5, z_6, z_7$ as the bits of the symbol.

(4) Decoding

Similarly, in Section (3), the polynomial $S(x)$ is generated as follows from the 5th to 250th symbols of the received message.

$$S(x) = A'_5 x^{245} + A'_6 x^{244} + \cdots + A'_{249} x + A'_{250} \qquad \text{4.1.3-13}$$

Thus, by employing this R-S encoding/decoding, we can detect errors and correct those up until 16 symbol errors occur, by computing 32 polynomials $S(\alpha^{11j})$, $j = 112 \sim 143$. Provided there are no errors, $S(\alpha^{11j})$ is all zeroes.

4.1.4. Definition of GRID

Gridded Correction of Ionosphere and Troposphere information for subtype 9 is relative to the ellipsoid height 0 in the grid point. Table 4.1.4-1 shows the compact network ID and coordinates.

Network ID 12 and 14～19 are standalone. Sub type 9 is transmitted in ascending GRID No. These grid parameters are contained in the support file *clas_grid.def* file attached in this document as Appendix.

Table 4.1.4-1 Compact network ID and coordinates (1/6)

Compact Network ID	GRID No.	Latitude	Longitude
1	1	24.75	125.37
	2	24.83	125.17
	3	24.64	124.69
	4	24.54	124.30
	5	24.34	124.17
	6	24.06	123.80
	7	24.43	123.79
	8	24.45	122.94

Compact Network ID	GRID No.	Latitude	Longitude
2	1	26.42	126.87
	2	26.15	127.53
	3	26.69	127.53
	4	26.69	128.18
	5	27.23	128.18
	6	27.23	128.84
	7	27.77	128.51
	8	27.77	129.17
	9	28.30	129.17
	10	28.30	129.83
	11	25.83	131.23

Table 4.1.4-1 Compact network ID and coordinates (2/6)

Compact Network ID	GRID No.	Latitude	Longitude
3	1	33.16	129.50
	2	33.70	129.50
	3	34.23	129.50
	4	34.77	129.50
	5	34.23	129.01
	6	32.62	128.84
	7	33.16	128.84
	8	31.81	129.50
	9	31.00	130.49
	10	31.00	131.14
	11	30.46	130.49
	12	30.46	131.14
	13	31.54	130.16
	14	32.08	130.16
	15	32.62	130.16
	16	33.16	130.16
	17	33.70	130.16
	18	31.54	130.82
	19	32.08	130.82
	20	32.62	130.82
	21	33.16	130.82
	22	33.70	130.82
	23	31.54	131.47
	24	32.08	131.47
	25	32.62	131.47
	26	33.16	131.47
	27	33.70	131.47
	28	28.84	128.84
	29	28.84	129.50
	30	29.38	129.50
	31	29.92	129.50
	32	29.92	130.16

Compact Network ID	GRID No.	Latitude	Longitude
4	1	32.62	132.13
	2	33.16	132.13
	3	33.70	132.13
	4	32.62	132.79
	5	33.16	132.79
	6	33.70	132.79
	7	34.23	132.79
	8	33.16	133.45
	9	33.70	133.45
	10	34.23	133.45
	11	33.16	134.11
	12	33.70	134.11
	13	34.23	134.11
	14	33.70	134.76
	15	34.23	134.76

Document subject to the disclaimer of liability

Table 4.1.4-1 Compact network ID and coordinates (3/6)

Compact Network ID	GRID No.	Latitude	Longitude
5	1	34.23	130.82
	2	34.23	131.47
	3	34.77	131.47
	4	34.23	132.13
	5	34.77	132.13
	6	34.77	132.79
	7	35.31	132.79
	8	34.77	133.45
	9	35.31	133.45
	10	35.85	132.79
	11	35.85	133.45
	12	36.39	133.45
	13	34.77	134.11
	14	35.31	134.11
	15	35.85	134.11

Compact Network ID	GRID No.	Latitude	Longitude
6	1	34.77	134.76
	2	35.31	134.76
	3	35.85	134.76
	4	33.70	135.42
	5	34.23	135.42
	6	34.77	135.42
	7	35.31	135.42
	8	35.85	135.42
	9	33.70	136.08
	10	34.23	136.08
	11	34.77	136.08
	12	35.31	136.08
	13	35.85	136.08
	14	36.39	136.08
	15	34.23	136.74
	16	34.77	136.74
	17	35.31	136.74
	18	35.85	136.74
	19	36.39	136.74
	20	36.93	136.74
	21	37.47	136.74
	22	34.77	137.40
	23	35.31	137.40
	24	35.85	137.40
	25	36.39	137.40
	26	36.93	137.40
	27	37.47	137.40

Table 4.1.4-1 Compact network ID and coordinates (4/6)

Compact Network ID	GRID No.	Latitude	Longitude	Compact Network ID	GRID No.	Latitude	Longitude
7	1	34.77	138.05	8	1	36.93	138.05
	2	35.31	138.05		2	36.93	138.71
	3	35.85	138.05		3	37.47	138.71
	4	36.39	138.05		4	37.74	138.05
	5	34.77	138.71		5	38.28	138.05
	6	35.31	138.71		6	38.01	138.71
	7	35.85	138.71		7	36.93	139.37
	8	36.39	138.71		8	37.47	139.37
	9	34.23	139.04		9	38.01	139.37
	10	34.23	139.70		10	38.55	139.37
	11	34.77	139.37		11	36.93	140.03
	12	35.31	139.37		12	37.47	140.03
	13	35.85	139.37		13	38.01	140.03
	14	36.39	139.37		14	38.55	140.03
	15	34.77	140.03		15	36.93	140.69
	16	35.31	140.03		16	37.47	140.69
	17	35.85	140.03		17	38.01	140.69
	18	36.39	140.03		18	38.55	140.69
	19	35.31	140.69		19	37.47	141.34
	20	35.85	140.69		20	38.55	141.34
	21	36.39	140.69					
	22	33.11	139.79					

Table 4.1.4-1 Compact network ID and coordinates (5/6)

Compact Network ID	GRID No.	Latitude	Longitude
9	1	39.09	140.03
	2	39.62	140.03
	3	40.16	140.03
	4	40.70	140.03
	5	41.24	140.03
	6	39.09	140.69
	7	39.62	140.69
	8	40.16	140.69
	9	40.70	140.69
	10	41.24	140.69
	11	39.09	141.34
	12	39.62	141.34
	13	40.16	141.34
	14	40.70	141.34
	15	41.24	141.34
	16	39.09	142.00
	17	39.62	142.00
	18	40.16	142.00

Compact Network ID	GRID No.	Latitude	Longitude
10	1	42.32	139.37
	2	41.78	140.03
	3	42.32	140.03
	4	42.86	140.03
	5	41.78	140.69
	6	42.32	140.69
	7	42.86	140.69
	8	43.40	140.69
	9	41.78	141.34
	10	42.32	141.34
	11	42.86	141.34
	12	43.40	141.34
	13	43.94	141.34
	14	42.32	142.00
	15	42.86	142.00
	16	43.40	142.00
	17	43.94	142.00
	18	42.32	142.66
	19	42.86	142.66
	20	43.40	142.66
	21	41.78	143.32
	22	42.32	143.32
	23	42.86	143.32

Table 4.1.4-1 Compact network ID and coordinates (6/6)

Compact Network ID	GRID No.	Latitude	Longitude
11	1	45.28	141.34
	2	44.48	142.00
	3	45.01	142.00
	4	45.55	142.00
	5	43.94	142.66
	6	44.48	142.66
	7	45.01	142.66
	8	43.40	143.32
	9	43.94	143.32
	10	44.48	143.32
	11	42.86	143.98
	12	43.40	143.98
	13	43.94	143.98
	14	42.86	144.63
	15	43.40	144.63
	16	43.94	144.63
	17	43.40	145.29
	18	43.94	145.29
	19	44.37	145.29

Compact Network ID	GRID No.	Latitude	Longitude
12	1	27.07	142.20
	2	26.64	142.16

Compact Network ID	GRID No.	Latitude	Longitude
13	1	43.40	145.95
	2	43.94	145.95
	3	44.48	145.95
	4	43.94	146.61
	5	44.48	146.61
	6	45.01	146.61
	7	44.48	147.27
	8	45.01	147.27
	9	45.01	147.92
	10	45.55	147.92
	11	45.01	148.58
	12	45.55	148.58
	13	55.55	149.24

Compact Network ID	GRID No.	Latitude	Longitude
14	1	37.24	131.87
15	1	25.96	131.31
16	1	25.73	123.54
17	1	24.77	141.34
18	1	24.28	153.99
19	1	20.44	136.09

4.2. L6E Message (Centimeter-Level Augmentation Message for Experiments)

4.2.1. Message Structure

4.2.1.1 General

The experimental message for centimeter-level augmentation is broadcasted from L6E message signal of Block II satellites. On the test service of QZSS operated in 2017, the experimental message would also be broadcasted on L6 message of Block I satellite.

The L6E message signal structure is shown in Figure 4.2.1-1. Each message has a length of 2000-bit, consisting of a 49-bit header, a 1695-bit data section, and a 256-bit Reed-Solomon code. The transmission of each L6E message takes one second.

The header of the L6E message starts from bit 1 (MSB), followed by the data part (1695-bit), which is transmitted from bit 50. The Reed-Solomon Code is transmitted from bit 1745, after the data part. The data part for Code 2 (L6E) includes centimeter-level augmentation message for experiments. The contents of data part is defined by the contents provider for each experimental service.
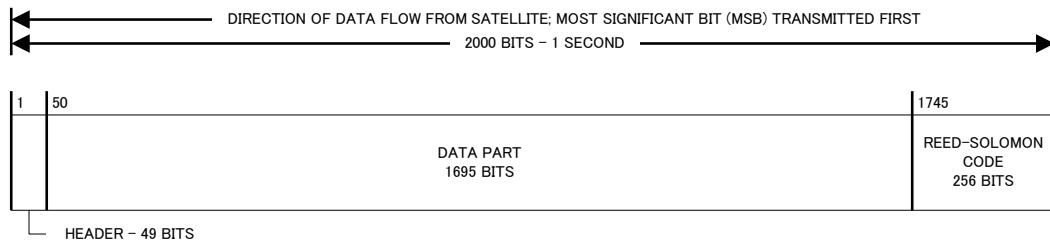
Figure 4.2.1-1 L6E Message Structure

4.2.1.2 Timing

(1) Transmission Pattern

The transmission pattern of the data part in the L6E message is defined for each experimental services, and it may differ between satellites. Therefore, the user algorithm cannot assume any specific transmission pattern.

(2) Transmission Timing

During normal operation, the L6E message is transmitted at the same timing from each satellite.

(3) Update Interval

The updated interval is defined for each experimental services.

For MADOCA, refer to Section 4.3 of the Reference Document (8).

(4) Nominal Validity Period

The nominal validity period is defined for each experimental services.

4.2.2. Message contents
4.2.2.1　Header Part

The header of the L6E message is shown in Figure 4.2.2-1. The header part has a length of 49-bit consisting of a 32-bit preamble, an 8-bit PRN, an 8-bit L6E message type ID and a 1-bit alert flag. Table 4.2.2-1 defines the header parameters.
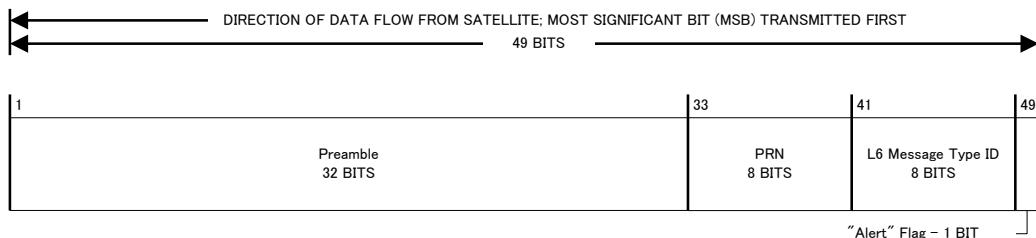
Figure 4.2.2-1 Header of L6E message

Table 4.2.2-1 Definitions of header parameters

DF Name	DF Range	BIT	LSB	DF Unit	Note
Preamble	-	32	-	-	
PRN	-	8	-	-	
L6E Message Type ID	-	8	-	-	
"Alert" Flag	-	1	-	-	

(1) Preamble

At the beginning of each message is a 32-bit preamble. The value of the preamble is "00011010110011111111110000011101"(B).

(2) PRN

Each message has an 8-bit PRN number immediately after the preamble. The PRN number is the PRN number of the satellite transmitting that message.

(3) L6E Message Type ID

Each message has an 8-bit L6E message type ID immediately following the PRN. Table 4.2.2-2 lists the definitions of the L6E message type ID parameters.

Table 4.2.2-2 L6E message type ID

Bit Field	Data Name	Note
7-5	Vendor ID	"001"$_{(B)}$: MADOCA Others$_{(B)}$: Reserved
4-3	Message Generation Facility ID	"00"$_{(B)}$, "01"$_{(B)}$: Hitachi-Ota "10"$_{(B)}$, "11"$_{(B)}$: Kobe
2-1	Reserved	
0	Subframe indicator	"1"$_{(B)}$: first data part of a subframe "0"$_{(B)}$: others

(4) Alert Flag

Each message has a 1-bit alert flag immediately following the L6E Message Type ID. The Alert Flag indicates the health status of the experimental service. When the Alert flag is "1"$_{(B)}$, the service is in experimental status.

4.2.2.2   Data Part

The data part is defined for each experimental services.

For MADOCA, refer to Section 5 of the reference document (8).

4.2.3. User Algorithms for experimental services

The user algorithms are defined for each experimental services, the description in Section 5 cannot be applied.

For MADOCA, refer to Section 4.5 of the reference document (8).

5. User Algorithms

5.1. Time System

The time system of QZSS is called QZSST and has the following characteristics.

(1) Definition

  (a) One-second length

    The length of one second is identical to International Atomic Time (TAI).

  (b) Integer second offset for TAI

    The integer second offset for TAI is the same as that for GPS and TAI is always 19 seconds ahead of QZSST.

  (c) Starting point of week number for QZSST

    The starting point of the week number for QZSST is identical to that for GPST (January 6, 1980).

(2) Time system of "Epoch Time" in compact SSR messages

    Data field "GNSS Epoch Time 1s" or "GNSS Hourly Epoch Time 1s" in each compact SSR message, transmitted from QZS, are represented in QZSST.

5.2. Geodetic Datum

The geodetic datum in CLAS is defined as follows.

5.2.1. Ellipsoid

GRS80

5.2.2. Coordinate

IGS05 (GEONET)

5.2.3. Relationship with Japanese Geodetic Datum 2011

Positioning results obtained by utilizing CLAS are in the IGS05(GEONET) coordinate system which are realized at the current epoch based on the daily coordinate values (F3 solution) published by the Geospatial Information Authority of Japan (GSI).

In the case of obtaining positioning results expressed in ITRF94 or ITRF2008, defined in the static datum "Japanese Geodetic Datum 2011 (JGD2011)", crustal movement transformations are necessary, which are used in ground-based RTK services or network RTK services in Japan (reference document (2), (3)).

5.3. Constants
5.3.1. Speed of Light
Expressed using a small letter "*c*". The value is c = 299792458 [m/s].

5.3.2. Circular Constant
Expressed using the Greek symbol " π ". The value is π = 3.1415926535898.

5.3.3. Angular Velocity of the Earth's Rotation
Expressed using the Greek symbol "$\dot{\Omega}_e$".
The value is $\dot{\Omega}_e = 7.2921151467 \times 10^{-5}$ [rad/s].

5.3.4. Earth's Gravitation Constant
Expressed using the Greek symbol " μ ". The value is $\mu = 3.986005 \times 10^{14} \, [\text{m}^3/\text{s}^2]$.

5.3.5. Semi-circle
Expressed using the circular constant " π ". 1[semi-circle] = π [rad]

5.4. Integrity
Integrity for CLAS is implemented with a flag-type-based method indicated in this section and a message-type-based method specified in the applicable document (2) and (3). Integrity information in CLAS consists of the Alert flag described in Section 5.4.1., the quality indicators in Compact SSR messages as defined in Sections 5.4.2. and 5.4.3., and the null message.

Integrity information can be commonly used in any application. Implementation of processing related to integrity information is not indispensable, but there are usage as follows.

The ranging error for satellite "i" can be estimated by the user receiver as follows:

$$\sigma_i = \sqrt{\left(\sigma_{i,user}\right)^2 + \left(\sigma_{i,sis}/10\right)^2 + \left(\frac{40.3 \times 10^{16}}{f^2}\sigma_{i,iono} \times 100\right) + \left(\left(\sigma_{i,trop}/10\right)/\sin E_i\right)^2}$$

Where, $\sigma_{i,user}$ is local error such as multipath in [cm], $\sigma_{i,sis}$ is SIS (Signal In Space) error such as orbit, clock and signal bias of satellite provided by the Compact SSR GNSS URA message in [mm], $\sigma_{i,iono}$ is ionospheric delay estimation error provided by the Compact SSR STEC Correction message in [TECU], $\sigma_{i,trop}$ is tropospheric delay estimation error provided by the Compact SSR Gridded Correction message in [mm]. E_i is the satellite elevation angle in [rad]. The first term $\sigma_{i,user}$ should be defined in the user receiver, the other term is provided by CLAS.

If the estimated ranging error exceeds the user defined threshold for each application, user receivers can, for example, (a) discard the Compact SSR message, (b) decrease the weight of the corresponding satellite observation in the positioning process, or (c) avoid fixing the corresponding satellite carrier phase ambiguities in the positioning process.

Document subject to the disclaimer of liability

5.4.1. Alert Flag

The 1-bit Alert flag that follows the message type ID in each message indicates the comprehensive health status for the satellite system, ground system, and external systems configured in CLAS.

When the Alert flag is set to "1"(B) , this indicates a situation in which CLAS should not be used. In this case, the L6 signal should be used at the user's own risk.

5.4.2. SSR URA

The SSR user range accuracy (URA) (1 sigma) indicates the quality indicator of SSR correction information for a signal in space (SIS). The user converts the 6-bit index information represented by a combination CLASS and VALUE included in the compact SSR GNSS URA message to a physical quantity using the following equation. The relationship between the SSR URA and index is presented in Table 5.4.2-1. A detailed definition of this message is given in Section 3.5.12.10 of the applicable document (2).

$$\text{SSR URA [mm]} \leq 3^{\text{CLASS}}(1 + \frac{\text{VALUE}}{4}) - 1 \text{ [mm]}$$

Table 5.4.2-1 Relationship between SSR URA or SSR troposphere quality indicator
and physical quantity

Class	Value	Index	SSR URA and SSR Troposphere Quality Indicator [mm]			
7	7	63	5466.50	<	SSR URA	
7	6	62	4919.75	<	SSR URA	≦ 5466.50
7	5	61	4373.00	<	SSR URA	≦ 4919.75
7	4	60	3826.25	<	SSR URA	≦ 4373.00
7	3	59	3279.50	<	SSR URA	≦ 3826.25
7	2	58	2732.75	<	SSR URA	≦ 3279.50
7	1	57	2186.00	<	SSR URA	≦ 2732.75
7	0	56	2003.75	<	SSR URA	≦ 2186.00
6	7	55	1821.50	<	SSR URA	≦ 2003.75
6	6	54	1639.25	<	SSR URA	≦ 1821.50
6	5	53	1457.00	<	SSR URA	≦ 1639.25
6	4	52	1274.75	<	SSR URA	≦ 1457.00
6	3	51	1092.50	<	SSR URA	≦ 1274.75
6	2	50	910.25	<	SSR URA	≦ 1092.50
6	1	49	728.00	<	SSR URA	≦ 910.25
6	0	48	667.25	<	SSR URA	≦ 728.00
5	7	47	606.50	<	SSR URA	≦ 667.25
5	6	46	545.75	<	SSR URA	≦ 606.50
5	5	45	485.00	<	SSR URA	≦ 545.75
5	4	44	424.25	<	SSR URA	≦ 485.00

(Table continues)

(Table continued)

Class	Value	Index	SSR URA and SSR Troposphere Quality Indicator [mm]				
5	3	43	363.50	<	SSR URA	≦	424.25
5	2	42	302.75	<	SSR URA	≦	363.50
5	1	41	242.00	<	SSR URA	≦	302.75
5	0	40	221.75	<	SSR URA	≦	242.00
4	7	39	201.50	<	SSR URA	≦	221.75
4	6	38	181.25	<	SSR URA	≦	201.50
4	5	37	161.00	<	SSR URA	≦	181.25
4	4	36	140.75	<	SSR URA	≦	161.00
4	3	35	120.50	<	SSR URA	≦	140.75
4	2	34	100.25	<	SSR URA	≦	120.50
4	1	33	80.00	<	SSR URA	≦	100.25
4	0	32	73.25	<	SSR URA	≦	80.00
3	7	31	66.50	<	SSR URA	≦	73.25
3	6	30	59.75	<	SSR URA	≦	66.50
3	5	29	53.00	<	SSR URA	≦	59.75
3	4	28	46.25	<	SSR URA	≦	53.00
3	3	27	39.50	<	SSR URA	≦	46.25
3	2	26	32.75	<	SSR URA	≦	39.50
3	1	25	26.00	<	SSR URA	≦	32.75
3	0	24	23.75	<	SSR URA	≦	26.00
2	7	23	21.50	<	SSR URA	≦	23.75
2	6	22	19.25	<	SSR URA	≦	21.50
2	5	21	17.00	<	SSR URA	≦	19.25
2	4	20	14.75	<	SSR URA	≦	17.00
2	3	19	12.50	<	SSR URA	≦	14.75
2	2	18	10.25	<	SSR URA	≦	12.50
2	1	17	8.00	<	SSR URA	≦	10.25
2	0	16	7.25	<	SSR URA	≦	8.00

(Table continues)

(Table continued)

Class	Value	Index	SSR URA and SSR Troposphere Quality Indicator [mm]				
1	7	15	6.50	<	SSR URA	≦	7.25
1	6	14	5.75	<	SSR URA	≦	6.50
1	5	13	5.00	<	SSR URA	≦	5.75
1	4	12	4.25	<	SSR URA	≦	5.00
1	3	11	3.50	<	SSR URA	≦	4.25
1	2	10	2.75	<	SSR URA	≦	3.50
1	1	9	2.00	<	SSR URA	≦	2.75
1	0	8	1.75	<	SSR URA	≦	2.00
0	7	7	1.50	<	SSR URA	≦	1.75
0	6	6	1.25	<	SSR URA	≦	1.50
0	5	5	1.00	<	SSR URA	≦	1.25
0	4	4	0.75	<	SSR URA	≦	1.00
0	3	3	0.50	<	SSR URA	≦	0.75
0	2	2	0.25	<	SSR URA	≦	0.50
0	1	1			SSR URA	≦	0.25
0	0	0	SSR URA undefined/unknown				

5.4.3. Atmosphere Correction Quality Indicator

The atmosphere correction quality indicator is composed of the SSR STEC quality indicator and SSR troposphere quality indicator. Table 5.4.3-1 describes the relationship between the SSR STEC quality indicator and the physical quantity. The relationship between the SSR troposphere quality indicator and index is the same as the SSR URA, as presented in Table 5.4.2-1.

Table 5.4.3-1　Relationship between SSR STEC quality indicator and physical quantity

Class	Value	Index	SSR STEC Quality Indicator [TECU]			
7	7	63	33.6664	<	Indicator	
7	6	62	30.2992	<	Indicator ≦	33.6664
7	5	61	26.9319	<	Indicator ≦	30.2992
7	4	60	23.5647	<	Indicator ≦	26.9319
7	3	59	20.1974	<	Indicator ≦	23.5647
7	2	58	16.8301	<	Indicator ≦	20.1974
7	1	57	13.4629	<	Indicator ≦	16.8301
7	0	56	12.3405	<	Indicator ≦	13.4629
6	7	55	11.2180	<	Indicator ≦	12.3405
6	6	54	10.0956	<	Indicator ≦	11.2180
6	5	53	8.9732	<	Indicator ≦	10.0956
6	4	52	7.8508	<	Indicator ≦	8.9732
6	3	51	6.7284	<	Indicator ≦	7.8508
6	2	50	5.6059	<	Indicator ≦	6.7284
6	1	49	4.4835	<	Indicator ≦	5.6059
6	0	48	4.1094	<	Indicator ≦	4.4835
5	7	47	3.7352	<	Indicator ≦	4.1094
5	6	46	3.3611	<	Indicator ≦	3.7352
5	5	45	2.9870	<	Indicator ≦	3.3611
5	4	44	2.6128	<	Indicator ≦	2.9870
5	3	43	2.2387	<	Indicator ≦	2.6128
5	2	42	1.8645	<	Indicator ≦	2.2387
5	1	41	1.4904	<	Indicator ≦	1.8645
5	0	40	1.3657	<	Indicator ≦	1.4904
4	7	39	1.2410	<	Indicator ≦	1.3657
4	6	38	1.1163	<	Indicator ≦	1.2410
4	5	37	0.9915	<	Indicator ≦	1.1163

(Table continues)

(Table continued)

Class	Value	Index	SSR STEC Quality Indicator [TECU]				
4	4	36	0.8668	<	Indicator	≦	0.9915
4	3	35	0.7421	<	Indicator	≦	0.8668
4	2	34	0.6174	<	Indicator	≦	0.7421
4	1	33	0.4927	<	Indicator	≦	0.6174
4	0	32	0.4511	<	Indicator	≦	0.4927
3	7	31	0.4096	<	Indicator	≦	0.4511
3	6	30	0.3680	<	Indicator	≦	0.4096
3	5	29	0.3264	<	Indicator	≦	0.3680
3	4	28	0.2848	<	Indicator	≦	0.3264
3	3	27	0.2433	<	Indicator	≦	0.2848
3	2	26	0.2017	<	Indicator	≦	0.2433
3	1	25	0.1601	<	Indicator	≦	0.2017
3	0	24	0.1463	<	Indicator	≦	0.1601
2	7	23	0.1324	<	Indicator	≦	0.1463
2	6	22	0.1186	<	Indicator	≦	0.1324
2	5	21	0.1047	<	Indicator	≦	0.1186
2	4	20	0.0908	<	Indicator	≦	0.1047
2	3	19	0.0770	<	Indicator	≦	0.0908
2	2	18	0.0631	<	Indicator	≦	0.0770
2	1	17	0.0493	<	Indicator	≦	0.0631
2	0	16	0.0447	<	Indicator	≦	0.0493
1	7	15	0.0400	<	Indicator	≦	0.0447
1	6	14	0.0354	<	Indicator	≦	0.0400
1	5	13	0.0308	<	Indicator	≦	0.0354
1	4	12	0.0262	<	Indicator	≦	0.0308
1	3	11	0.0216	<	Indicator	≦	0.0262
1	2	10	0.0169	<	Indicator	≦	0.0216
1	1	9	0.0123	<	Indicator	≦	0.0169
1	0	8	0.0108	<	Indicator	≦	0.0123
0	7	7	0.0092	<	Indicator	≦	0.0108
0	6	6	0.0077	<	Indicator	≦	0.0092
0	5	5	0.0062	<	Indicator	≦	0.0077
0	4	4	0.0046	<	Indicator	≦	0.0062

(Table continues)

(Table continued)

Class	Value	Index	SSR STEC Quality Indicator [TECU]				
0	3	3	0.0031	<	Indicator	≦	0.0046
0	2	2	0.0015	<	Indicator	≦	0.0031
0	1	1			Indicator	≦	0.0015
0	0	0	Indicator undefined/unknown				

5.4.4. Null Message

The null message indicates those situations in which CLAS should not be used.

5.5. Calculation Algorithms for Compact SSR

This section shows the compact SSR calculation algorithms, which are also defined in the applicable document (3). Also the observation space representation (OSR) calculation algorithm from the Compact SSR is shown in the section 5.5.6.

5.5.1. Calculation of GNSS Clock Correction

5.5.1.1 Parameter

Table 5.5.1-1 and Table 5.5.1-2 show the parameters defined in the Compact SSR GNSS Clock Correction message and Compact SSR GNSS Combined message. Table 5.5.1-3 lists the parameter required for the calculations.

The algorithms are same for GPS, QZSS (Block IIQ and Block IIG), Galileo, and GLONASS (CDMA).

Table 5.5.1-1 Compact SSR GNSS Clock Correction message parameter

Parameter	Definition	Unit
C_0	Compact SSR Delta Clock	m

Table 5.5.1-2 Compact SSR GNSS Combined message parameter

Parameter	Definition	Unit
$C_{0,k}$	Compact SSR Delta Clock for a specific network k	m

Table 5.5.1-3 Other parameter

Parameter	Definition	Unit
c	Speed of Light (Section 5.3.1.)	m/s

5.5.1.2 Algorithm

If "Network correction" and "Clock Existing Flag" in the sub type 11 message is equals to "1", the sub type 11 message includes "Compact SSR Delta Clock" in a specific network. The network is identified by "Network ID". The clock in the network k for satellite *PRN* is respectively defined by,

if   "Network correction" == 1 and "Clock Existing Flag"==1 in a specific network

$$C'_{0,k} = C_{0,k}$$

else

$$C'_{0,k} = C_0$$

end

Satellite clock correction δC establishes the following relationship between the parameters of the compact SSR GNSS clock correction.

$$\delta C = C'_{0,k}$$

Where the relationship between the SV clock $t_{broadcast}$ which is derived from the SV clock parameter of the navigation message and satellite clock, derived from the compact SSR GNSS clock correction and SV clock $t_{satellite}$ after correction are as follows:

$$t_{satellite} = t_{broadcast} - \frac{\delta C}{C}$$

5.5.2. Calculation of GNSS Orbit Correction

5.5.2.1　Parameters

Table 5.5.2-1 and Table 5.5.2-2 list the parameters defined in the Compact SSR GNSS Orbit Correction message and Compact SSR GNSS Combined message. Table 5.5.2-3 lists the other parameters required for the calculations.

The algorithms are same for GPS, QZSS (Block IIQ and Block IIG), Galileo, and GLONASS (CDMA).

Table 5.5.2-1 Compact SSR GNSS Orbit Correction message parameters

Parameter	Definition	Unit
δO_{radial}	Compact SSR Delta Radial	m
δO_{along}	Compact SSR Delta Along Track	m
δO_{cross}	Compact SSR Delta Cross Track	m

Table 5.5.2-2 Compact SSR GNSS Combined message parameters

Parameter	Definition	Unit
$\delta O_{radial,k}$	Compact SSR Delta Radial for a specific network k	m
$\delta O_{along,k}$	Compact SSR Delta Along Track for a specific network k	m
$\delta O_{cross,k}$	Compact SSR Delta Cross Track for a specific network k	m

Table 5.5.2-3 Other parameters

Parameter	Definition	Unit
$\delta \mathbf{X}$	Satellite Orbit Correction	m
$\mathbf{e}_{radial}$	Delta Radial Unit Vector	-
$\mathbf{e}_{along}$	Delta Along Track Unit Vector	-
$\mathbf{e}_{cross}$	Delta Cross Track Unit Vector	-
$\mathbf{r}$	Satellite Position calculated from broadcast ephemeris	m
$\dot{\mathbf{r}}$	Satellite Speed calculated from broadcast ephemeris	m/s

5.5.2.2 Algorithm

If "Network correction" and "Orbit Existing Flag" in the sub type 11 message is equals to "1", the sub type 11 message includes "Compact SSR Delta Radial/Along-Track/Cross-Track" in a specific network. The network is identified by "Network ID". The orbit in the network k for satellite *PRN* is respectively defined by,

if   "Network correction" == 1 and "Orbit Existing Flag"==1 in a specific network
$$\delta O'_{radial,k} = \delta O_{radial,k}$$
$$\delta O'_{along,k} = \delta O_{along,k}$$
$$\delta O'_{cross,k} = \delta O_{cross,k}$$

else

$$\delta O'_{radial,k} = \delta O_{radial}$$
$$\delta O'_{along,k} = \delta O_{along}$$
$$\delta O'_{cross,k} = \delta O_{cross}$$

end

Satellite orbit correction $\delta \mathbf{X}$ at time t is calculated as follows:

$$\delta \mathbf{X} = [\boldsymbol{e_{radial}} \quad \boldsymbol{e_{along}} \quad \boldsymbol{e_{cross}}]\begin{bmatrix} \delta O'_{radial,k} \\ \delta O'_{along,k} \\ \delta O'_{cross,k} \end{bmatrix}$$

where

$$\boldsymbol{e_{along}} = \frac{\dot{r}(t)}{|\dot{r}(t)|}, \boldsymbol{e_{cross}} = \frac{\mathbf{r}(t) \times \dot{\mathbf{r}}(t)}{|\mathbf{r}(t) \times \dot{\mathbf{r}}(t)|}, \boldsymbol{e_{radial}} = \boldsymbol{e_{along}}(t) \times \boldsymbol{e_{cross}}(t)$$

The relationship among the satellite position $\boldsymbol{r}$ derived from the broadcast ephemeris, the satellite orbit correction $\delta \mathbf{X}$ derived from the compact SSR GNSS orbit correction message, and the corrected satellite position $\mathbf{X}_{orbit}$ are as follows:

$$\mathbf{X}_{orbit} = \boldsymbol{r} - \delta \mathbf{X}$$

Note that the satellite broadcast velocity vector $\dot{\mathbf{r}}$ for the GEO satellite (QZS-3) can be null, which gives no satellite orbit corrections using the above equations. The velocity vector for QZS-3 is therefore defined in a non-rotating system parallel to the IGS05 at QZSST epoch time as follows:

$$\dot{r} = \dot{r}_{broadcast} + \begin{bmatrix} -\dot{\Omega}_e Y_{broadcast} \\ \dot{\Omega}_e X_{broadcast} \\ 0 \end{bmatrix}$$

where the value of the angular velocity of the Earth's rotation $\dot{\Omega}_e$ is defined in the section 5.3.3.

Document subject to the disclaimer of liability

5.5.3. Calculation of GNSS Code/Phase Bias

5.5.3.1　Parameter

Table 5.5.3-1 and Table 5.5.3-2 shows the parameter defined in the sub type 4 (compact SSR GNSS Satellite Code Bias) message and sub type 5 (compact SSR GNSS Satellite Phase Bias) message and the sub type 6 (Compact SSR GNSS Satellite Code and Phase Bias) message.

The algorithms are same for GPS, QZSS (Block IIQ and Block IIG), Galileo, and GLONASS (CDMA).

Table 5.5.3-1 Compact SSR GNSS Satellite Code Bias message parameter
and Phase Bias message parameter

Parameter	Definition	Unit
$BIAS^{PRN}_{phase\ or\ code}$	Compact SSR Code Bias (sub type 4) or Compact SSR Phase Bias (sub type 5)	m

Table 5.5.3-2　Compact SSR GNSS Satellite Code and Phase Bias message parameter

Parameter	Definition	Unit
$\delta BIAS^{PRN}_{k,phase\ or\ code}$	Compact SSR Code Bias(sub type 6) or Compact SSR Phase Bias(sub type 6)	m
$\boldsymbol{los}^{PRN}_{user}$	Line-of-sight vector from user's rough position to the satellite in earth center earth fixed coordinates	-

5.5.3.2　Algorithm

If "Network Bias correction" in the sub type 6 message is equals to "1", the sub type 6 message includes bias phase and/or code bias correction in a specific network. The network is identified by "Network ID". The code or phase bias in the network k for satellite *PRN* is respectively defined by,

$$NET\_BIAS^{PRN}_{k,phase\ or\ code} = BIAS^{PRN}_{phase\ or\ code} + \delta BIAS^{PRN}_{k,phase\ or\ code}$$

Note that update timing of $\delta BIAS^{PRN}_{k,phase}$ included in sub type 6 is different from the Compact SSR orbit correction message (sub type 2) in CLAS. This may cause discontinuity in corrected measurement when latest orbit correction message is applied while previous $\delta BIAS^{PRN}_{k,phase}$ is still used. The discontinuity can be compensated by subtracting difference of sum of clock and orbit correction between before (i-1th) and after (ith) the update of the orbit correction as follows:

$$\delta BIAS_{k.phase}^{PRN}{}' = \delta BIAS_{k,phase}^{PRN}$$
$$-[\,\{-\delta C_i^{PRN} - \delta \boldsymbol{X}_i^{PRN} \cdot \boldsymbol{los}_{user}^{PRN}(t)\}$$
$$-\{-\delta C_{i-1}^{PRN} - \delta \boldsymbol{X}_{i-1}^{PRN} \cdot \boldsymbol{los}_{user}^{PRN}(t-1)\}]$$

where t is the update epoch of the latest Compact SSR GNSS orbit correction message.

5.5.4. Calculation of Ionosphere Slant Delay Correction

5.5.4.1 Parameters

Table 5.5.4-1 lists the parameters defined in the compact SSR STEC network correction and compact SSR gridded correction.

Table 5.5.4-2 lists the parameters required for the calculations.

The algorithms are same for GPS, QZSS (Block IIQ and Block IIG), Galileo, and GLONASS (CDMA).

Table 5.5.4-1　Compact SSR STEC network correction and compact SSR gridded correction message parameters

Parameter	Definition	Unit
Polynomial Coefficients C_{00}, C_{01}, C_{10}, C_{11}	SSR ionosphere slant delay correction : Polynomial Coefficients	TECU
STEC Residual Correction $\delta STEC$	SSR ionosphere slant delay correction : Grid-specific parameter	TECU

Table 5.5.4-2　Other parameters

Parameter	Definition	Unit
f	Frequency	Hz

5.5.4.2 Algorithm

The ionosphere slant delay (STEC) consists of the polynomial part of the compact SSR STEC network correction message and the residual part from the compact SSR gridded correction message.

At first, 4 or 3 reference grids with valid STEC values from the compact SSR gridded correction message surrounding the user's rough position obtained from the likes of single-point positioning are selected.

Then, the ionosphere slant delay I_k^{PRN} at each reference grid k and time t for the pseudo-range of satellite PRN is calculated as follows:

$$I_{k,pseudorange}^{PRN}(t) = \frac{40.31 * 10^{16}}{f^2} \times STEC_k^{PRN}(t)$$

where,

$STEC_k^{PRN}(t)$ is calculated in accordance with the "STEC Correction Type" included in the compact SSR STEC correction message, as follows:

STEC Correction Type = 0:

$$STEC_k^{PRN}(t) = C_{00}^{PRN}(t) + \delta STEC_k^{PRN}(t)$$

STEC Correction Type = 1:

$$STEC_k^{PRN}(t) = C_{00}^{PRN}(t) + C_{01}^{PRN}(\varphi - \varphi_0)(t) + C_{10}^{PRN}(\lambda - \lambda_0)(t)$$
$$+ \delta STEC_k^{PRN}(t)$$

STEC Correction Type = 2:

$$STEC_k^{PRN}(t) = C_{00}^{PRN}(t) + C_{01}^{PRN}(\varphi - \varphi_0)(t) + C_{10}^{PRN}(\lambda - \lambda_0)(t)$$
$$+ C_{11}^{PRN}(\varphi - \varphi_0)(\lambda - \lambda_0)(t) + \delta STEC_k^{PRN}(t)$$

with

$\varphi, \quad \lambda \quad$: Grid coordinate (Latitude, Longitude)

$\varphi_0, \quad \lambda_0$: Grid coordinate of the smallest Grid ID within each network (Latitude, Longitude) for which the coordinates are as defined in Section 4.1.4

Note: If STEC Network Correction is not defined at a specific network, it should be defined as zero.

Last, the ionosphere slant delay for the satellite PRN at the user position $I_{user}^{PRN}(t)$ is computed by interpolating or extrapolating $I_k^{PRN}(t)$ on reference grids. An example interpolation method is the bi-linear method defined in the data filed DF212 of the applicable document (2). The following equation is to be utilized for interpolation with four nearest grids. The weighting coefficient W_k for each grid is computed depending on the distance between user's rough position and the grid position.

$$I_{user,}^{PRN}(t) = \sum_{k=1}^{4} W_k I_k^{PRN}(t)$$

For interpolation or extrapolation with three grids, a similar algorithm is used. The weighting coefficient w_k for each grid is computed depending on the distance between user's rough position and the grid position.

$$I_{user,}^{PRN}(t) = \sum_{k=1}^{3} w_k I_k^{PRN}(t)$$

Note: For carrier-phase range correction, the opposite sign should be applied.

$$I_{k,carrier\ phase}^{PRN}(t) = -\frac{40.31 * 10^{16}}{f^2} \times STEC_k^{PRN}(t)$$

5.5.5. Calculation of Troposphere Delay Correction

5.5.5.1 Parameters

Table 5.5.5-1 lists the parameters defined in the compact SSR gridded correction message. Table 5.5.5-2 lists the parameters required for calculations and recalculations.

The algorithms are same for GPS, QZSS (Block IIQ and Block IIG), Galileo, and GLONASS (CDMA).

Table 5.5.5-1 Compact SSR Gridded Correction Message Parameters

Parameter	Definition	Unit
$\Delta T_{k,hs}$	Troposphere Hydrostatic Vertical Delay Variation at GRID k	m
$\Delta T_{k,wet}$	Troposphere Wet Vertical Delay Variation at GRID k	m

Table 5.5.5-2 Parameters

Parameter	Definition	Unit
M_{hs}^{PRN}	Mapping Function (Hydrostatic)	-
M_{wet}^{PRN}	Mapping Function (Wet)	-
δ_{hs0}	Troposphere Vertical Delay Hydrostatic Variation value(= 2.3)	m
δ_{wet0}	Troposphere Vertical Delay Wet Variation value (=0.252)	m
el	Elevation	deg

5.5.5.2 Algorithm

At first, 4 or 3 reference grids with a valid troposphere vertical delay surrounding the user's rough position are selected. The rough position is obtained from the likes of single-point positioning.

The hydrostatic vertical delay $T_{k,hs}(t)$ and wet vertical delay $T_{k,wet}(t)$ at time t at a selected GRID k are computed by using the troposphere hydrostatic vertical delay variation $\Delta T_{k,hs}(t)$ and wet vertical delay variation $\Delta T_{k,wet}(t)$ in the compact SSR gridded correction message.

$$T_{k,hs}(t) = \Delta T_{k,hs}(t) + \delta_{hs0}$$
$$T_{k,wet}(t) = \Delta T_{k,wet}(t) + \delta_{wet0}$$

$T_{user,hs}(t)$ and $T_{user,wet}(t)$ are computed by interpolating or extrapolating the data on the reference grid. An example interpolation or extrapolation method is the bi-linear method defined in the

data filed DF212 of the applicable document (2). The following equation is to be utilized for interpolation with four nearest grids. The weighting coefficient W_k for each grid is computed depending on the distance between user's rough position and the grid position.

$$T_{user,hs}(t) = \sum_{k=1}^{4} W_k T_{k,hs}(t)$$

$$T_{user,wet}(t) = \sum_{k=1}^{4} W_k T_{k,wet}(t)$$

For interpolation or extrapolation with three grids, a similar algorithm is used. The weighting coefficient w_k for each grid is computed depending on the distance between user's rough position and the grid position.

$$T_{user,hs}(t) = \sum_{k=1}^{3} w_k T_{k,hs}(t)$$

$$T_{user,wet}(t) = \sum_{k=1}^{3} w_k T_{k,wet}(t)$$

Last, the troposphere slant delay $T_{user}^{PRN}(t)$ is computed by using Niell mapping function $M_{user,hs}^{PRN}(el, t)$ and $M_{user,wet}^{PRN}(el, t)$ at the user's rough position as described in the reference document (4).

$$T_{user}^{PRN}(t) = T_{user,hs}(t) \cdot M_{user,hs}^{PRN}(el, t) + T_{user,wet}(t) \cdot M_{user,wet}^{PRN}(el, t)$$

5.5.6. (Reference) User dependent errors

The estimated compact SSR parameters of CLAS are free of reference station site displacements, phase wind up effect, receiver antenna PCV, inter system bias, quarter cycle shifts and etc. Users have to apply corresponding user dependent corrections when using compact SSR parameters in the positioning calculation process.

The following correction models have to be considered to meet the CLAS positioning accuracy described in the Section 6.3 of the applicable document (1).

- solid earth tides
- ocean loading
- pole tide
- phase wind up
- receiver antenna phase center offset and variation (PCO, PCV)
- receiver inter system bias (ISB)
- receiver quarter cycle carrier phase shifts
  (if provided carrier phase bias for different signals on the same frequency)

References for user site displacements such as solid earth tide, ocean loading and pole tide are the IERS Conventions (6) Section 7. References for phase wind-up correction is the reference document (5). Reference for the method of user receiver inter system bias estimation and its compensation at user receivers are Section 5-2 of the reference document (9).

Note that in the phase wind up computation, a satellite yaw angle[1] used for the computation is always zero. It is not necessary to use a satellite attitude model.

---

[1] The satellite yaw angle is defined as the rotation angle around the satellites radial axis and represents the angle between the satellites along-track vector and satellites X-axis in the satellites along-track, across-track plane counter positive clockwise.

5.5.7. (Reference) Calculation of Observation Space Representation
5.5.7.1　Parameters

Table 5.5.7-1 lists the parameters defined between in the Section 5.5.1 and in the Section 5.5.6, which are used for calculation of the carrier phase correction (CPC) and the pseudo range correction (PRC) from the compact SSR messages as examples of observation space representation (OSR). The carrier phase correction and the pseudo range correction are similar data defined in the message type 20 and 21 of RTCM 10402.3 Recommended Standards for Differential GNSS Service version 2.3.

Table 5.5.7-1　Parameters

Parameter	Definition	Unit
δC^{PRN}	Satellite clock correction	m
$\delta \mathbf{X}^{PRN}$	Satellite orbit correction	m
$\boldsymbol{los}_{user}^{PRN}$	Line-of-sight vector from user's rough position to the satellite in earth center earth fixed coordinates	-
$NET\_BIAS_{k,phase\ or\ code}^{PRN}$	Satellite phase bias or code bias correction for the specific network k where the user's rough position is located	m
I_{user}^{PRN}	Ionosphere slant delay at the user's rough position	m
T_{user}^{PRN}	Troposphere slant delay at the user's rough position	m

5.5.7.2　Algorithm

Carrier phase correction CPC or pseudo range correction PRC at user's rough position at time t for satellite PRN is defined by,

$$CPC_{user}^{PRN}(t) = -\delta C^{PRN}(t) - \delta \mathbf{X}^{PRN} \cdot \boldsymbol{los}_{user}^{PRN}(t) + NET\_BIAS_{k,phase}^{PRN}(t) - I_{user}^{PRN}(t) + T_{user}^{PRN}(t)$$
$$PRC_{user}^{PRN}(t) = -\delta C^{PRN}(t) - \delta \mathbf{X}^{PRN} \cdot \boldsymbol{los}_{user}^{PRN}(t) + NET\_BIAS_{k,code}^{PRN}(t) + I_{user}^{PRN}(t) + T_{user}^{PRN}(t)$$

Here, if the satellite clock correction δC and the orbit correction δX have already applied to the broadcast ephemeris shown in the section 5.5.1 and 5.5.2, the above related term ($\delta C^{PRN}(t)$ and $\delta \mathbf{X}^{PRN} \cdot \boldsymbol{los}_{user}^{PRN}(t)$) are excluded from the formula.

And note that the user receiver side specific compensations such as user site displacements, phase wind up, user receiver antenna phase center offset (PCO), user receiver phase center variation (PCV), quarter cycle carrier phase shifts and user receiver inter system bias (ISB) which are described in the section 5.5.6, are excluded from this OSR calculation formula. Users have to apply these compensations to the GNSS observation data (both carrier phase and pseudo range) in the process of generating single or double difference observations between satellites required for the positioning calculation process.