International Civil Aviation Organization

**WORKING PAPER**

# NAVIGATION SYSTEMS PANEL (NSP)

**DFMC SBAS SARPs Sub Group (DS2)**

**15 November 2018**

DFMC SBAS SARPs - PART B VERSION 2.0

**SUMMARY**

This paper contains proposed SARPs amendments to introduce DFMC SBAS within Appendix B sections 3.5 and 3.7.
Part B version 2.0 with Part A version 2.2 constitute the technical baseline endorsed during NSP/5.

## 1. INTRODUCTION

1.1 This paper contains proposed draft SARPs amendments to introduce the DFMC SBAS system within Appendix B.

1.2 This version was developed and endorsed during NSP/5 on 15 November 2018.

## 2. PROPOSED AMENDMENTS

The text of the amendment is arranged to show deleted text with a line through it and new text highlighted with grey shading, as shown below:

| | |
|---|---|
| ~~Text to be deleted is shown with a line through it.~~ | text to be deleted |
| New text to be inserted is highlighted with grey shading. | new text to be inserted |
| ~~Text to be deleted is shown with a line through it~~ followed by the replacement text which is highlighted with grey shading. | new text to replace existing text |
| Yellow shading text as material to be updated | material to be developed by DS2. |

(82 pages)

### *3.5 Satellite-based augmentation system (SBAS)*

#### 3.5.1 GENERAL

*Note.— Parameters in this section are defined in WGS-84.*

3.5.1.1 *SBAS service provider identifiers.* The SBAS service provider identifiers shall be as shown in Table B-27.

**Table B-27. SBAS service provider identifiers**

| Identifier | SBAS Service provider |
|---|---|
| 0 | WAAS |
| 1 | EGNOS |
| 2 | MSAS |
| 3 | GAGAN |
| 4 | SDCM |
| 5 | BDSBAS |
| 6 | KASS |
| 7 | A-SBAS |
| 8 | AUSBAS |
| 9 to13 | Spare |
| 14 to15 | Reserved |
| 16 to 31 | Spare for additional SBAS L5 provider only |

*Note 1.— A service provider ID of 14 is used for GBAS and is not applicable to SBAS.*
*Note 2.— Service Provider IDs of 16-31 cannot be coded in the SBAS L1 message.*

#### 3.5.2 L1 RF CHARACTERISTICS

3.5.2.1 *Carrier frequency stability*. The short-term stability of the carrier frequency (square root of the Allan Variance) at the output of the satellite transmit antenna shall be better than $5 \times 10^{-11}$over 1 to 10 seconds.

3.5.2.2 *Carrier phase noise.* The phase noise spectral density of the unmodulated carrier shall be such that a phase locked loop of 10 Hz one-sided noise bandwidth is able to track the carrier to an accuracy of 0.1 radian (1 sigma)

3.5.2.3 *Spurious emissions***.** Spurious emissions shall be at least 40 dB below the unmodulated carrier power over all frequencies.

3.5.2.4 *Code/carrier frequency coherence.* The short-term (less than 10 seconds) fractional frequency difference between the code phase rate and the carrier frequency shall be less than $5 \times 10^{-11}$ (standard deviation). Over the long term (less than 100 seconds), the difference between the change in the broadcast code phase, converted to carrier cycles by multiplying the number of code chips by 1 540, and the change in the broadcast carrier phase, in cycles, shall be within one carrier cycle (standard deviation).

*Note.— This applies to the output of the satellite transmit antenna and does not include code/carrier divergence due to ionospheric refraction in the downlink propagation path.*

3.5.2.5 *Correlation loss.* The loss in the recovered signal power due to imperfections in the signal modulation and waveform distortion shall not exceed 1 dB.

*Note.— The loss in signal power is the difference between the broadcast power in a 2.046 MHz bandwidth and the signal power recovered by a noise-free, loss-free receiver with 1-chip correlator spacing and a 2.046 MHz bandwidth.*

3.5.2.6 *Maximum code phase deviation.* The maximum uncorrected code phase of the L1 broadcast signal shall not deviate from the equivalent SBAS network time (SNT) for L1 SBAS by more than $\pm 2^{-20}$ seconds.

3.5.2.7 *Code/data coherence.* Each 2-millisecond symbol shall be synchronous with every other code epoch.

3.5.2.8 *Message synchronization.* The leading edge of the first symbol that depends on the first bit of the current message shall be broadcast from the SBAS satellite synchronous with a 1-second epoch of SNT for L1 SBAS.

3.5.2.9 *Convolutional encoding*. A 250-bit-per-second data stream shall be encoded at a rate of 2 symbols per bit using a convolutional code with a constraint length of 7 to yield 500 symbols per second. The convolutional encoder logic arrangement shall be as illustrated in Figure B-11 with the G3 output selected for the first half of each 4-millisecond data bit period.

3.5.2.10 *Pseudo-random noise (PRN) codes.* Each PRN code shall be a 1 023-bit Gold code which is itself the Modulo-2 addition of two 1 023-bit linear patterns, G1 and G2i. The G2i sequence shall be formed by delaying the G2 sequence by the associated integer number of chips as illustrated in Table B-23. Each of the G1 and G2 sequences shall be defined as the output of stage 10 of a 10-stage shift register, where the input to the shift register is the Modulo-2 addition of the following stages of the shift register:

a) G1: stages 3 and 10; and

b) G2: stages 2, 3, 6, 8, 9 and 10.

The initial state for the G1 and G2 shift registers shall be “1111111111”.

Table B-23. SBAS L1 PRN codes

| ~~PRN code number~~ | ~~G2 delay (chips)~~ | ~~First 10 SBAS chips (Leftmost bit represents first transmitted chip, binary)~~ |
|---|---|---|
| ~~120~~ | ~~145~~ | ~~110111001~~ |
| ~~121~~ | ~~175~~ | ~~101011110~~ |
| ~~122~~ | ~~52~~ | ~~1101001000~~ |
| ~~123~~ | ~~21~~ | ~~1101100101~~ |
| ~~124~~ | ~~237~~ | ~~1110000~~ |
| ~~125~~ | ~~235~~ | ~~111000001~~ |
| ~~126~~ | ~~886~~ | ~~1011~~ |
| ~~127~~ | ~~657~~ | ~~1000110000~~ |
| ~~128~~ | ~~634~~ | ~~10100101~~ |
| ~~129~~ | ~~762~~ | ~~101010111~~ |
| ~~130~~ | ~~355~~ | ~~1100011110~~ |
| ~~131~~ | ~~1 012~~ | ~~1010010110~~ |
| ~~132~~ | ~~176~~ | ~~1010101111~~ |
| ~~133~~ | ~~603~~ | ~~100110~~ |
| ~~134~~ | ~~130~~ | ~~1000111001~~ |
| ~~135~~ | ~~359~~ | ~~101110001~~ |
| ~~136~~ | ~~595~~ | ~~1000011111~~ |
| ~~137~~ | ~~68~~ | ~~111111000~~ |

| ~~PRN code number~~ | ~~G2 delay (chips)~~ | ~~First 10 SBAS chips (Leftmost bit represents first transmitted chip, binary)~~ |
|---|---|---|
| ~~138~~ | ~~386~~ | ~~1011010111~~ |

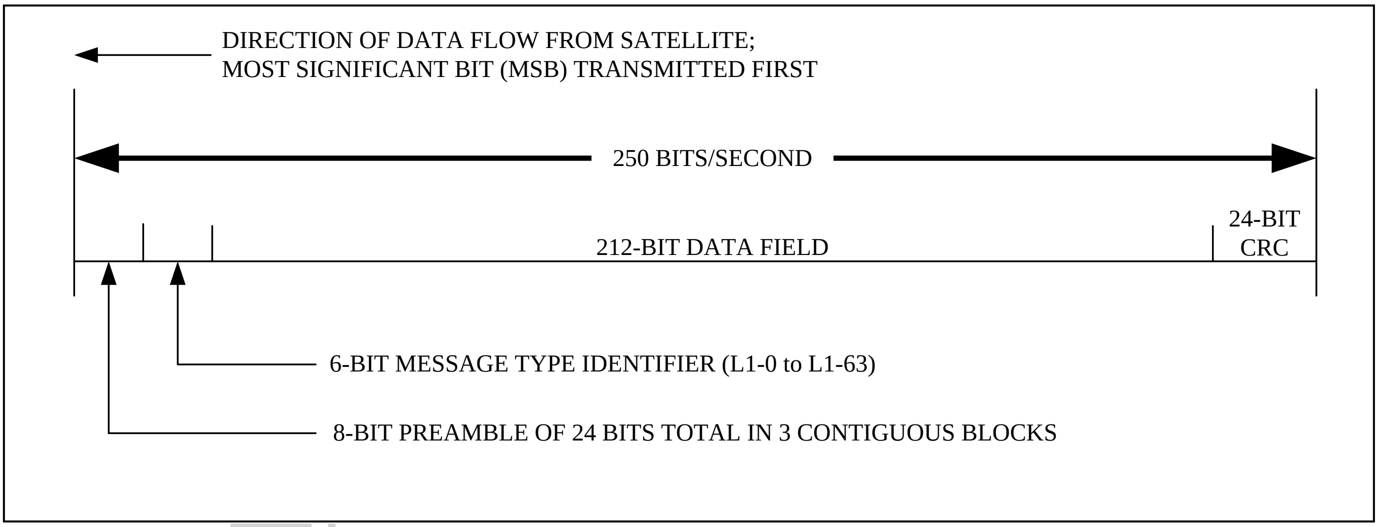
| PRN code number | G2 delay (chips) | First 10 SBAS chips (Leftmost bit represents first transmitted chip, binary) |
|---|---|---|
| 120 | 145 | 0110111001 |
| 121 | 175 | 0101011110 |
| 122 | 52 | 1101001000 |
| 123 | 21 | 1101100101 |
| 124 | 237 | 0001110000 |
| 125 | 235 | 0111000001 |
| 126 | 886 | 0000001011 |
| 127 | 657 | 1000110000 |
| 128 | 634 | 0010100101 |
| 129 | 762 | 0101010111 |
| 130 | 355 | 1100011110 |
| 131 | 1 012 | 1010010110 |
| 132 | 176 | 1010101111 |
| 133 | 603 | 0000100110 |
| 134 | 130 | 1000111001 |
| 135 | 359 | 0101110001 |
| 136 | 595 | 1000011111 |
| 137 | 68 | 0111111000 |
| 138 | 386 | 1011010111 |
| 139 | 797 | 1100111010 |
| 140 | 456 | 0001010100 |
| 141 | 499 | 0011110110 |
| 142 | 883 | 0001011011 |
| 143 | 307 | 0010110101 |
| 144 | 127 | 0111001111 |
| 145 | 211 | 0010001111 |
| 146 | 121 | 1111100010 |
| 147 | 118 | 1100010010 |
| 148 | 163 | 1100100010 |
| 149 | 628 | 0101010011 |
| 150 | 853 | 0111011110 |
| 151 | 484 | 1110011101 |
| 152 | 289 | 0001011110 |
| 153 | 811 | 0010111011 |
| 154 | 202 | 1000010110 |
| 155 | 1021 | 0000000011 |
| 156 | 463 | 1110111000 |
| 157 | 568 | 0110010100 |
| 158 | 904 | 0010011101 |

### 3.5.3 L1 DATA STRUCTURE

*Note.- Messages broadcast on L1 are independent of those broadcast on L5. Information broadcast on L1 SBAS is used only for single-frequency navigation solutions using GPS L1 C/A and GLONASS L1OF (FDMA signal).*

3.5.3.1 *Format summary.* All messages shall consist of a message type identifier, a preamble, a data field and a cyclic redundancy check as illustrated in Figure B-12

**Figure B-12. L1 Data block format**




3.5.3.2 *Preamble.* For L1 ~~T~~the preamble shall consist of the sequence of bits “01010011 10011010 11000110”, distributed over three successive blocks. The start of every other 24-bit preamble shall be synchronous with a 6-second GPS subframe epoch.

3.5.3.3 *Message type identifier.* The L1 message type identifier shall be a 6-bit value identifying the message type (Types 0 to 63) as defined in Table B-24. The message type identifier shall be transmitted MSB first.

3.5.3.4 *Data field.* The L1 data field shall be 212 bits as defined in 3.5.6. Each data field parameter shall be transmitted MSB first.

3.5.3.5 *Cyclic redundancy check (CRC).* The SBAS message CRC code on L1 shall be calculated in accordance with 3.9.

3.5.3.5.1 The length of the CRC code shall be k = 24 bits.

3.5.3.5.2 The CRC generator polynomial shall be:

$$G(x) = x^{24} + x^{23} + x^{18} + x^{17} + x^{14} + x^{11} + x^{10} + x^{7} + x^{6} + x^{5} + x^{4} + x^{3} + x + 1$$

3.5.3.5.3 The CRC information field, M(x), shall be:

$$M(x) = \sum_{i=1}^{226} m_i x^{226-i} = m_1 x^{225} + m_2 x^{224} + \cdots + m_{226} x^0$$

3.5.3.5.4 M(x) shall be formed from the 8-bit SBAS message preamble, 6-bit message type identifier, and 212-bit data field. Bits shall be arranged in the order transmitted from the SBAS satellite, such that $m_1$ corresponds to the first transmitted bit of the preamble, and $m_{226}$ corresponds to bit 212 of the data field.

3.5.3.5.5 The CRC code r-bits shall be ordered such that $r_1$ is the first bit transmitted and $r_{24}$ is the last bit transmitted.

**Table B-24. L1 Broadcast message types**

| L1 Message type | Contents |
|---|---|
| 0 | "Do Not Use" (SBAS test mode) – Content applies to L1 signal only |
| 1 | PRN mask |
| 2 to 5 | Fast corrections |
| 6 | Integrity information |
| 7 | Fast correction degradation factor |
| 8 | Spare |
| 9 | GEO ranging function parameters |
| 10 | Degradation parameters |
| 11 | Spare |
| 12 | SBAS network time/UTC offset parameters |
| 13 to 16 | Spare |
| 17 | GEO satellite almanacs |
| 18 | Ionospheric grid point masks |
| 19 to 23 | Spare |
| 24 | Mixed fast/long-term satellite error corrections |
| 25 | Long-term satellite error corrections |
| 26 | Ionospheric delay corrections |
| 27 | SBAS service message |
| 28 | Clock-ephemeris covariance matrix |
| 29 to 61 | Spare |
| 62 | Reserved– Content applies to L1 signal only |
| 63 | Null message – Content applies to L1 signal only |

*Note.— The message Types (decimal) for the L5 broadcast messages are different than the ones on the SBAS L1 broadcast messages, except for message types 0, 62 and 63 messages. Types 0, 62 and 63 message apply respectively for the frequency band on which they are broadcast.*

### 3.5.4 L1 DATA CONTENT

3.5.4.1 *PRN mask parameters.* PRN mask parameters shall be as follows:

*PRN code number: a number that uniquely identifies the satellite PRN code and related assignments as shown in Table B-25.*

*PRN mask:* 210 PRN mask values that correspond to satellite PRN code numbers. The mask shall set up to 51 of the 210 PRN mask values.

*Note.— The first transmitted bit of the PRN mask corresponds to PRN code number 1.*

**Table B-25. PRN code number assignments**

| PRN code number | Assignment |
|---|---|
| 1 – 37 | GPS |
| 38 – 61 | GLONASS slot number plus 37 |
| 62 – 119 | Spare |
| 120 – 158 | SBAS |
| 159 – 210 | Spare |

*PRN mask value:* a bit in the PRN mask indicating whether data are provided for the associated satellite PRN code number (1 to 210).

Coding: 0 = data not provided
1 = data provided

*PRN mask number:* the sequence number (1 to 51) of the mask values set in the PRN mask.

*Note.— The PRN mask number is "1" for the lowest satellite PRN number for which the PRN mask value is "1".*

*Issue of data* — PRN (IODP): an indicator that associates the correction data with a PRN mask.

*Note.— Parameters are broadcast in the following messages:*

*a) PRN mask (consisting of 210 PRN mask values) in Type 1 message;*

*b) PRN mask number in Type 24, 25 and 28 messages;*

*c) PRN code number in Type 17 message; and*

*d) IODP in Type 1 to 5, 7, 24, 25 and 28 messages.*

3.5.4.2 *Geostationary orbit (GEO) ranging function parameters.* GEO ranging function parameters shall be as follows:

$t_{0,GEO}$*: the reference time for the GEO ranging function data, expressed as the time after midnight of the current day.*

$[X_G \quad Y_G \quad Z_G]$: *the position of the GEO at time* $t_{0,GEO}$.

$[\dot{X}_G \quad \dot{Y}_G \quad \dot{Z}_G]$: *the velocity of the GEO at time* $t_{0,GEO}$

$[\ddot{X}_G \quad \ddot{Y}_G \quad \ddot{Z}_G]$: *the acceleration of the GEO at time $t_{0,GEO}$.*

$a_{Gf0}$: the time offset of the GEO clock with respect to SNT for L1 SBAS, defined at $t_{0,GEO}$.

$a_{Gf1}$: the drift rate of the GEO clock with respect to SNT for L1 SBAS.

*User range accuracy (URA):* an indicator of the root-mean-square ranging error, excluding atmospheric effects, as described in Table B-26.

*Note.— All parameters are broadcast in Type 9 message.*

**Table B-26. User range accuracy**

| URA | Accuracy (rms) |
|---|---|
| 0 | 2 m |
| 1 | 2.8 m |
| 2 | 4 m |
| 3 | 5.7 m |
| 4 | 8 m |
| 5 | 11.3 m |
| 6 | 16 m |
| 7 | 32 m |
| 8 | 64 m |
| 9 | 128 m |
| 10 | 256 m |
| 11 | 512 m |
| 12 | 1 024 m |
| 13 | 2 048 m |
| 14 | 4 096 m |
| 15 | “Do Not Use” |

*Note.— URA values 0 to 14 are not used in the protocols for data application (3.5.5). Airborne receivers will not use the GEO ranging function if URA indicates “Do Not Use” (3.5.8.3).*

3.5.4.3 *GEO almanac parameters.* GEO almanac parameters shall be as follows.

*PRN code number:* see 3.5.4.1

*Health and status:* an indication of the functions provided by the SBAS. The service provider identifiers are shown in Table B-27 in section 3.5.1.

| | | | | |
|---|---|---|---|---|
| Coding: Bit 0 (LSB) | Ranging | On (0) | Off (1) |
| Bit 1 | Precision corrections | On (0) | Off (1) |
| Bit 2 | Satellite status and basic corrections | On (0) | Off (1) |
| Bits 3 | Spare | | |
| Bits 4 to 7 | Service provider identifier | | |

~~*Note.— A service provider ID of 14 is used for GBAS and is not applicable to SBAS.*~~

$[X_{G,A} Y_{G,A} Z_{G,A}]$*:* the position of the GEO at time $t_{almanac}$.

$[\dot{X}_{G,A} \dot{Y}_{G,A} \dot{Z}_{G,A}]$*:* the velocity of the GEO at time $t_{almanac}$.

$t_{almanac}$*:* the reference time for the GEO almanac data, expressed as the time after midnight of the current day.

*Note.— All parameters are broadcast in Type 17 message.*

3.5.4.4 *Satellite correction broadcast parameters*

3.5.4.4.1 Long-term correction parameters shall be as follows:

*Issue of data ($IOD_i$):* an indicator that associates the long-term corrections for the $i^{th}$ satellite with the ephemeris data broadcast by that satellite.

*Note 1.— For GPS, the $IOD_i$ matches the IODE and 8 LSBs of the IODC (3.1.1.3.1.4 and 3.1.1.3.2.2).*

*Note 2.— For GLONASS, the $IOD_i$ indicates a period of time that GLONASS data are to be used with SBAS data. It consists of two fields as shown in Table B-28.*

$\delta x_i$*:* for satellite i, the ephemeris correction for the x axis.

$\delta y_i$*:* for satellite i, the ephemeris correction for the y axis.

$\delta z_i$*:* for satellite i, the ephemeris correction for the z axis.

$\delta a_{i,f0}$*:* for satellite i, the ephemeris time correction.

$\delta \dot{x}_i$*:* for satellite i, ephemeris velocity correction for x axis.

$\delta \dot{y}_i$*:* for satellite i, ephemeris velocity correction for y axis.

$\delta \dot{z}_i$*:* for satellite i, ephemeris velocity correction for z axis.

$\delta a_{i,f1}$*:* for satellite i, rate of change of the ephemeris time correction.

$t_{i,LT}$*:* the time of applicability of the parameters $\delta x_i$, $\delta y_i$, $\delta z_i$, $\delta a_{i,f0}$, $\delta \dot{x}_i$, $\delta \dot{y}_i$, $\delta \dot{z}_i$ and $\delta a_{i,f1}$, expressed in seconds after midnight of the current day.

*Velocity code:* an indicator of the message format broadcast (Table B-48 and Table B-49).

Coding: 0 = $\delta \dot{x}_i$, $\delta \dot{y}_i$, $\delta \dot{z}_i$ and $\delta a_{i,f1}$ are not broadcast.
1 = $\delta \dot{x}_i$, $\delta \dot{y}_i$, $\delta \dot{z}_i$ and $\delta a_{i,f1}$ are broadcast.

*Note.— All parameters are broadcast in Type 24 and 25 messages.*

~~**Table B-27. SBAS service provider identifiers**~~

| ~~Identifier~~ | ~~Service provider~~ |
|---|---|
| ~~0~~ | ~~WAAS~~ |
| ~~1~~ | ~~EGNOS~~ |
| ~~2~~ | ~~MSAS~~ |
| ~~3~~ | ~~GAGAN~~ |
| ~~4~~ | ~~SDCM~~ |
| ~~5 to 13~~ | ~~Spare~~ |
| ~~14, 15~~ | ~~Reserved~~ |

~~*Note.— A service provider ID of 14 is used for GBAS and is not applicable to SBAS.*~~

**Table B-28. $IOD_i$ for GLONASS satellites**

| MSB | LSB |
|---|---|
| Validity interval (5 bits) | Latency time (3 bits) |

3.5.4.4.2 Fast correction parameters shall be as follows:

*Fast correction ($FC_i$):* for satellite *i*, the pseudo-range correction for rapidly varying errors, other than tropospheric or ionospheric errors, to be added to the pseudo-range after application of the long-term correction.

*Note.— The user receiver applies separate tropospheric corrections (3.5.8.4.2 and 3.5.8.4.3).*

*Fast correction type identifier:* an indicator (0, 1, 2, 3) of whether the Type 24 message contains the fast correction and integrity data associated with the PRN mask numbers from Type 2, Type 3, Type 4 or Type 5 messages, respectively.

*Issue of data-fast correction ($IODF_j$):* an indicator that associates $UDREI_i$s with fast corrections. The index *j* shall denote the message type (j = 2 to 5) to which $IODF_j$ applies (the fast correction type identifier +2).

*Note.— The fast correction type identifier is broadcast in Type 24 messages. The $FC_i$ are broadcast in Type 2 to 5, and Type 24 messages. The $IODF_j$ are broadcast in Type 2 to 6, and Type 24 messages.*

3.5.4.5 *Fast and long-term correction integrity parameters. Fast and long-term correction integrity parameters shall be as follows:*

*$UDREI_i$:* an indicator that defines the $\sigma^2_{i,UDRE}$ for satellite *i* as described in Table B-29.

*Model variance of residual clock and ephemeris errors ($\sigma^2_{i,UDRE}$):* the variance of a normal distribution associated with the user differential range errors for satellite *i* after application of fast and long-term corrections, excluding atmospheric effects and used in horizontal protection level/vertical protection level computations (3.5.5.6).

*Note.— All parameters are broadcast in Type 2 to 6, and Type 24 messages.*

3.5.4.6 *Ionospheric correction parameters.* Ionospheric correction parameters shall be as follows:

*IGP mask:* a set of 11 ionospheric grid point (IGP) band masks defined in Table B-30.

*IGP band mask:* a set of IGP mask values which correspond to all IGP locations in one of the 11 IGP bands defined in Table B-30.

**Table B-29. Evaluation of $UDREI_i$**

| $UDREI_i$ | $\sigma^2_{i,UDRE}$ |
|---|---|
| 0 | 0.0520 $m^2$ |
| 1 | 0.0924 $m^2$ |
| 2 | 0.1444 $m^2$ |
| 3 | 0.2830 $m^2$ |
| 4 | 0.4678 $m^2$ |
| 5 | 0.8315 $m^2$ |
| 6 | 1.2992 $m^2$ |
| 7 | 1.8709 $m^2$ |
| 8 | 2.5465 $m^2$ |
| 9 | 3.3260 $m^2$ |
| 10 | 5.1968 $m^2$ |
| 11 | 20.7870 $m^2$ |
| 12 | 230.9661 $m^2$ |
| 13 | 2 078.695 $m^2$ |
| 14 | "Not Monitored" |
| 15 | "Do Not Use" |

*IGP mask value:* a bit indicating whether data are provided within that IGP band for the associated IGP.

Coding: 0 = data are not provided
1 = data are provided

*Number of IGP bands:* the number of IGP band masks being broadcast.

*IGP band identifier:* the number identifying the ionospheric band as defined in Table B-30.

*IGP block identifier:* the identifier of the IGP block. The IGP blocks are defined by dividing into groups of 15 IGPs the sequence of IGPs within an IGP band mask which have IGP mask values of "1". The IGP blocks are numbered in an order of IGP mask value transmission, starting with "0".

*Validity interval (V):* the time interval for which the GLONASS ephemeris data are applicable (coded with an offset of 30 s) as described in Table B-31.

*Latency time (L):* the time interval between the time the last GLONASS ephemeris has been received by the ground segment and the time of transmission of the first bit of the long-term correction message at the GEO($t_{ltc}$) as described in Table B-32.

*$IODI_k$:* an indication of when the $k^{th}$ IGP band mask changes.

*IGP vertical delay estimate broadcast on L1:* an estimate of the delay induced for a signal at 1 575.42 MHz if it traversed the ionosphere vertically at the IGP.

Coding: The bit pattern "111111111" indicates "Do Not Use".

*$GIVEI_i$:* an indicator that defines the $\sigma^2_{i,GIVE}$ as described in Table B-33.

*Model variance of residual ionospheric errors ($\sigma^2_{i,GIVE}$):* the variance of a normal distribution associated with the residual ionospheric vertical error at the IGP for an L1 signal.

*Note.— All parameters are broadcast in Type 18 and Type 26 messages.*

**Table B-30. IGP locations and band numbers**

| IGP location | | Transmission order in IGP band mask |
|---|---|---|
| Band 0 | | |
| 180 W | 75S, 65S, 55S, 50S, 45S, ..., 45N, 50N, 55N, 65N, 75N, 85N | 1 – 28 |
| 175 W | 55S, 50S, 45S, ..., 45N, 50N, 55N | 29 – 51 |
| 170 W | 75S, 65S, 55S, 50S, 45S, ..., 45N, 50N, 55N, 65N, 75N | 52 – 78 |
| 165 W | 55S, 50S, 45S, ..., 45N, 50N, 55N | 79 – 101 |
| 160 W | 75S, 65S, 55S, 50S, 45S, ..., 45N, 50N, 55N, 65N, 75N | 102 – 128 |
| 155 W | 55S, 50S, 45S, ..., 45N, 50N, 55N | 129 – 151 |
| 150 W | 75S, 65S, 55S, 50S, 45S, ..., 45N, 50N, 55N, 65N, 75N | 152 – 178 |
| 145 W | 55S, 50S, 45S, ..., 45N, 50N, 55N | 179 – 201 |
| Band 1 | | |
| 140 W | 85S, 75S, 65S, 55S, 50S, 45S, ..., 45N, 50N, 55N, 65N, 75N | 1 – 28 |
| 135 W | 55S, 50S, 45S, ..., 45N, 50N, 55N | 29 – 51 |
| 130 W | 75S, 65S, 55S, 50S, 45S, ..., 45N, 50N, 55N, 65N, 75N | 52 – 78 |
| 125 W | 55S, 50S, 45S, ..., 45N, 50N, 55N | 79 – 101 |
| 120 W | 75S, 65S, 55S, 50S, 45S, ..., 45N, 50N, 55N, 65N, 75N | 102 – 128 |
| 115 W | 55S, 50S, 45S, ..., 45N, 50N, 55N | 129 – 151 |
| 110 W | 75S, 65S, 55S, 50S, 45S, ..., 45N, 50N, 55N, 65N, 75N | 152 – 178 |
| 105 W | 55S, 50S, 45S, ..., 45N, 50N, 55N | 179 – 201 |
| Band 2 | | |
| 100 W | 75S, 65S, 55S, 50S, 45S, ..., 45N, 50N, 55N, 65N, 75N | 1 – 27 |
| 95 W | 55S, 50S, 45S, ..., 45N, 50N, 55N | 28 – 50 |
| 90 W | 75S, 65S, 55S, 50S, 45S, ..., 45N, 50N, 55N, 65N, 75N, 85N | 51 – 78 |
| 85 W | 55S, 50S, 45S, ..., 45N, 50N, 55N | 79 – 101 |
| 80 W | 75S, 65S, 55S, 50S, 45S, ..., 45N, 50N, 55N, 65N, 75N | 102 – 128 |
| 75 W | 55S, 50S, 45S, ..., 45N, 50N, 55N | 129 – 151 |
| 70 W | 75S, 65S, 55S, 50S, 45S, ..., 45N, 50N, 55N, 65N, 75N | 152 – 178 |
| 65 W | 55S, 50S, 45S, ..., 45N, 50N, 55N | 179 – 201 |
| Band 3 | | |
| 60 W | 75S, 65S, 55S, 50S, 45S, ..., 45N, 50N, 55N, 65N, 75N | 1 – 27 |
| 55 W | 55S, 50S, 45S, ..., 45N, 50N, 55N | 28 – 50 |
| 50 W | 85S, 75S, 65S, 55S, 50S, 45S, ..., 45N, 50N, 55N, 65N, 75N | 51 – 78 |
| 45 W | 55S, 50S, 45S, ..., 45N, 50N, 55N | 79 – 101 |
| 40 W | 75S, 65S, 55S, 50S, 45S, ..., 45N, 50N, 55N, 65N, 75N | 102 – 128 |
| 35 W | 55S, 50S, 45S, ..., 45N, 50N, 55N | 129 – 151 |
| 30 W | 75S, 65S, 55S, 50S, 45S, ..., 45N, 50N, 55N, 65N, 75N | 152 – 178 |
| 25 W | 55S, 50S, 45S, ..., 45N, 50N, 55N | 179 – 201 |
| Band 4 | | |
| 20 W | 75S, 65S, 55S, 50S, 45S, ..., 45N, 50N, 55N, 65N, 75N | 1 – 27 |
| 15 W | 55S, 50S, 45S, ..., 45N, 50N, 55N | 28 – 50 |
| 10 W | 75S, 65S, 55S, 50S, 45S, ..., 45N, 50N, 55N, 65N, 75N | 51 – 77 |
| 5 W | 55S, 50S, 45S, ..., 45N, 50N, 55N | 78 – 100 |

| IGP location | | Transmission order in IGP band mask |
|---|---|---|
| 0 | 75S, 65S, 55S, 50S, 45S, ..., 45N, 50N, 55N, 65N, 75N, 85N | 101 – 128 |
| 5 E | 55S, 50S, 45S, ..., 45N, 50N, 55N | 129 – 151 |
| 10 E | 75S, 65S, 55S, 50S, 45S, ..., 45N, 50N, 55N, 65N, 75N | 152 – 178 |
| 15 E | 55S, 50S, 45S, ..., 45N, 50N, 55N | 179 – 201 |
| Band 5 | | |
| 20 E | 75S, 65S, 55S, 50S, 45S, ..., 45N, 50N, 55N, 65N, 75N | 1 – 27 |
| 25 E | 55S, 50S, 45S, ..., 45N, 50N, 55N | 28 – 50 |
| 30 E | 75S, 65S, 55S, 50S, 45S, ..., 45N, 50N, 55N, 65N, 75N | 51 – 77 |
| 35 E | 55S, 50S, 45S, ..., 45N, 50N, 55N | 78 – 100 |
| 40 E | 85S, 75S, 65S, 55S, 50S, 45S, ..., 45N, 50N, 55N, 65N, 75N | 101 – 128 |
| 45 E | 55S, 50S, 45S, ..., 45N, 50N, 55N | 129 – 151 |
| 50 E | 75S, 65S, 55S, 50S, 45S, ..., 45N, 50N, 55N, 65N, 75N | 152 – 178 |
| 55 E | 55S, 50S, 45S, ..., 45N, 50N, 55N | 179 – 201 |
| Band 6 | | |
| 60 E | 75S, 65S, 55S, 50S, 45S, ..., 45N, 50N, 55N, 65N, 75N | 1 – 27 |
| 65 E | 55S, 50S, 45S, ..., 45N, 50N, 55N | 28 – 50 |
| 70 E | 75S, 65S, 55S, 50S, 45S, ..., 45N, 50N, 55N, 65N, 75N | 51 – 77 |
| 75 E | 55S, 50S, 45S, ..., 45N, 50N, 55N | 78 – 100 |
| 80 E | 75S, 65S, 55S, 50S, 45S, ..., 45N, 50N, 55N, 65N, 75N | 101 – 127 |
| 85 E | 55S, 50S, 45S, ..., 45N, 50N, 55N | 128 – 150 |
| 90 E | 75S, 65S, 55S, 50S, 45S, ..., 45N, 50N, 55N, 65N, 75N, 85N | 151 – 178 |
| 95 E | 55S, 50S, 45S, ..., 45N, 50N, 55N | 179 – 201 |
| Band 7 | | |
| 100 E | 75S, 65S, 55S, 50S, 45S, ..., 45N, 50N, 55N, 65N, 75N | 1 – 27 |
| 105 E | 55S, 50S, 45S, ..., 45N, 50N, 55N | 28 – 50 |
| 110 E | 75S, 65S, 55S, 50S, 45S, ..., 45N, 50N, 55N, 65N, 75N | 51 – 77 |
| 115 E | 55S, 50S, 45S, ..., 45N, 50N, 55N | 78 – 100 |
| 120 E | 75S, 65S, 55S, 50S, 45S, ..., 45N, 50N, 55N, 65N, 75N | 101 – 127 |
| 125 E | 55S, 50S, 45S, ..., 45N, 50N, 55N | 128 – 150 |
| 130 E | 85S, 75S, 65S, 55S, 50S, 45S, ..., 45N, 50N, 55N, 65N, 75N | 151 – 178 |
| 135 E | 55S, 50S, 45S, ..., 45N, 50N, 55N | 179 – 201 |
| Band 8 | | |
| 140 E | 75S, 65S, 55S, 50S, 45S, ..., 45N, 50N, 55N, 65N, 75N | 1 – 27 |
| 145 E | 55S, 50S, 45S, ..., 45N, 50N, 55N | 28 – 50 |
| 150 E | 75S, 65S, 55S, 50S, 45S, ..., 45N, 50N, 55N, 65N, 75N | 51 – 77 |
| 155 E | 55S, 50S, 45S, ..., 45N, 50N, 55N | 78 – 100 |
| 160 E | 75S, 65S, 55S, 50S, 45S, ..., 45N, 50N, 55N, 65N, 75N | 101 – 127 |
| 165 E | 55S, 50S, 45S, ..., 45N, 50N, 55N | 128 – 150 |
| 170 E | 75S, 65S, 55S, 50S, 45S, ..., 45N, 50N, 55N, 65N, 75N | 151 – 177 |
| 175 E | 55S, 50S, 45S, ..., 45N, 50N, 55N | 178 – 200 |
| Band 9 | | |

| IGP location | | Transmission order in IGP band mask |
|---|---|---|
| 60 N | 180W, 175W, 170W, …, 165E, 170E, 175E | 1 – 72 |
| 65 N | 180W, 170W, 160W, …, 150E, 160E, 170E | 73 – 108 |
| 70 N | 180W, 170W, 160W, …, 150E, 160E, 170E | 109 – 144 |
| 75 N | 180W, 170W, 160W, …, 150E, 160E, 170E | 145 – 180 |
| 85 N | 180W, 150W, 120W, …, 90E, 120E, 150E | 181 – 192 |
| Band 10 | | |
| 60 S | 180W, 175W, 170W, …, 165E, 170E, 175E | 1 – 72 |
| 65 S | 180W, 170W, 160W, …, 150E, 160E, 170E | 73 – 108 |
| 70 S | 180W, 170W, 160W, …, 150E, 160E, 170E | 109 – 144 |
| 75 S | 180W, 170W, 160W, …, 150E, 160E, 170E | 145 – 180 |
| 85 S | 170W, 140W, 110W, …, 100E, 130E, 160E | 181 – 192 |

**Table B-31. Validity interval**

| Data | Bits used | Range of values | Resolution |
|---|---|---|---|
| Validity interval (V) | 5 | 30 s to 960 s | 30 s |

**Table B-32. Latency time**

| Data | Bits used | Range of values | Resolution |
|---|---|---|---|
| Latency time (L) | 3 | 0 s to 120 s | 30 s |

**Table B-33. Evaluation of $GIVEI_i$**

| $GIVEI_i$ | $\sigma^2_{i,GIVE}$ |
|---|---|
| 0 | 0.0084 $m^2$ |
| 1 | 0.0333 $m^2$ |
| 2 | 0.0749 $m^2$ |
| 3 | 0.1331 $m^2$ |
| 4 | 0.2079 $m^2$ |
| 5 | 0.2994 $m^2$ |
| 6 | 0.4075 $m^2$ |
| 7 | 0.5322 $m^2$ |
| 8 | 0.6735 $m^2$ |
| 9 | 0.8315 $m^2$ |
| 10 | 1.1974 $m^2$ |
| 11 | 1.8709 $m^2$ |
| 12 | 3.3260 $m^2$ |
| 13 | 20.787 $m^2$ |
| 14 | 187.0826 $m^2$ |
| 15 | “Not Monitored” |

3.5.4.7 *Degradation parameters.* Degradation parameters, whenever used, shall be as follows:

*Fast correction degradation factor indicator ($ai_i$):* an indicator of the fast correction degradation factor ($a_i$) for the $i^{th}$ satellite as described in Table B-34.

*Note.— The $ai_i$ is also used to define the time-out interval for fast corrections, as described in 3.5.8.1.1.*

*System latency time ($t_{lat}$):* the time interval between the origin of the fast correction degradation and the user differential range estimate indicator (UDREI) reference time.

$B_{rrc}$: a parameter that bounds the noise and round-off errors when computing the range rate correction degradation as in 3.5.5.6.2.2.

$C_{ltc\_lsb}$: the maximum round-off error due to the resolution of the orbit and clock information.

$C_{ltc\_v1}$: the velocity error bound on the maximum range rate difference of missed messages due to clock and orbit rate differences.

$I_{ltc\_v1}$: the update interval for long-term corrections if velocity code = 1 (3.5.4.4.1).

$C_{ltc\_v0}$: a parameter that bounds the difference between two consecutive long-term corrections for satellites with a velocity code = 0.

$I_{ltc\_v0}$: the minimum update interval for long-term messages if velocity code = 0 (3.5.4.4.1).

$C_{GEO\_lsb}$: the maximum round-off error due to the resolution of the orbit and clock information.

$C_{GEO\_v}$: the velocity error bound on the maximum range rate difference of missed messages due to clock and orbit rate differences.

$I_{GEO}$: the update interval for GEO ranging function messages.

**Table B-34. Fast correction degradation factor**

| Fast correction degradation factor indicator ($ai_i$) | Fast correction degradation factor ($a_i$) |
|---|---|
| 0 | 0.0 mm/s$^2$ |
| 1 | 0.05 mm/s$^2$ |
| 2 | 0.09 mm/s$^2$ |
| 3 | 0.12 mm/s$^2$ |
| 4 | 0.15 mm/s$^2$ |
| 5 | 0.20 mm/s$^2$ |
| 6 | 0.30 mm/s$^2$ |
| 7 | 0.45 mm/s$^2$ |
| 8 | 0.60 mm/s$^2$ |
| 9 | 0.90 mm/s$^2$ |
| 10 | 1.50 mm/s$^2$ |
| 11 | 2.10 mm/s$^2$ |
| 12 | 2.70 mm/s$^2$ |
| 13 | 3.30 mm/s$^2$ |
| 14 | 4.60 mm/s$^2$ |
| 15 | 5.80 mm/s$^2$ |

$C_{er}$*:* the bound on the residual error associated with using data beyond the precision approach/approach with vertical guidance time-out.

$C_{iono\_step}$*:* the bound on the difference between successive ionospheric grid delay values.

$I_{iono}$*:* the minimum update interval for ionospheric correction messages.

$C_{iono\ ramp}$*:* the rate of change of the ionospheric corrections.

$RSS_{UDRE}$*:* the root-sum-square flag for fast and long-term correction residuals.

Coding: 0 = correction residuals are linearly summed
1 = correction residuals are root-sum-squared

$RSS_{iono}$*:* the root-sum-square flag for ionospheric residuals.

Coding: 0 = correction residuals are linearly summed
1 = correction residuals are root-sum-squared

$C_{covariance}$*:* the term which is used to compensate for quantization effects when using the Type 28 message.

*Note 1.— The parameters $a_i$ and $t_{lat}$ are broadcast in Type 7 message. All other parameters are broadcast in Type 10 message.*

*Note 2.— If message Type 28 is not broadcast, $C_{covariance}$ is not applicable.*

3.5.4.8 *Time parameters.* Time parameters, whenever used, shall be as follows:

*UTC standard identifier:* an indication of the UTC reference source as defined in Table B-35.

*GPS time-of-week count:* the number of seconds that have passed since the transition from the previous GPS week (similar to the GPS parameter in 3.1.1.2.6.1 but with a 1-second resolution).

**Table B-35. UTC standard identifier**

| UTC standard identifier | UTC standard |
|---|---|
| 0 | UTC as operated by the National Institute of Information and Communications Technology, Tokyo, Japan |
| 1 | UTC as operated by the U.S. National Institute of Standards and Technology |
| 2 | UTC as operated by the U.S. Naval Observatory |
| 3 | UTC as operated by the International Bureau of Weights and Measures |
| 4 | Reserved for UTC as operated by a European laboratory |
| 5 | UTC as operated by the National Time Service Center, Chinese Academy of Sciences |
| ~~5 to~~ 6 | Spare |
| 7 | UTC not provided |

*GPS week number (week count):* see 3.1.1.2.6.2.

*GLONASS indicator:* a flag indicating if GLONASS time parameters are provided.

Coding: 0 = GLONASS time parameters are not provided
1 = GLONASS time parameters are provided

*GLONASS time offset L1 ($\delta a_{i,GLONASS}$):* A parameter broadcast on L1 that represents the stable part of the offset between the L1 GLONASS time and the L1 SBAS network time.

*Note.— If SBAS L1 does not support GLONASS, $\delta a_{i,GLONASS}$ is not applicable.*

*UTC parameters:* $A_{1SNT}$, $A_{0SNT}$, $t_{0t}$, $WN_t$, $\Delta t_{LS}$, $WN_{LSF}$, DN and $\Delta t_{LSF}$ are as described in 3.1.1.3.3.6, with the exception that the SBAS parameters relate SNT to UTC time, rather than GPS time.

*Note.— All parameters are broadcast in Type 12 message.*

3.5.4.9 *Service region parameters.* Service region parameters shall be as follows:

*Issue of data, service (IODS):* an indication of a change of the service provided in the region.

*Number of service messages:* the number of different Type 27 SBAS service messages being broadcast. (Value is coded with an offset of 1.)

*Service message number:* a sequential number identifying the message within the currently broadcast set of Type 27 messages (from 1 to number of service messages, coded with an offset of 1).

*Number of regions:* the number of service regions for which coordinates are broadcast in the message.

*Priority code:* an indication of a message precedence if two messages define overlapping regions. The message with a higher value of priority code takes precedence. If priority codes are equal, the message with the lower δUDRE takes precedence.

*δUDRE indicator-inside:* an indication of regional UDRE degradation factor (δUDRE) applicable at locations inside any region defined in the message, in accordance with Table B-36.

*δUDRE indicator-outside:* an indication of regional UDRE degradation factor (δUDRE) applicable at locations outside all regions defined in all current Type 27 messages, in accordance with Table B-36.

*Coordinate latitude:* the latitude of one corner of a region.

*Coordinate longitude:* the longitude of one corner of a region.

*Region shape:* an indication of whether a region is a triangle or quadrangle.

Coding: 0 = triangle
1 = quadrangle

*Note 1.— Coordinate 3 has Coordinate 1 latitude and Coordinate 2 longitude. If region is a quadrangle, Coordinate 4 has Coordinate 2 latitude and Coordinate 1 longitude. Region boundary is formed by joining coordinates in the sequence 1-2-3-1 (triangle) or 1-3-2-4-1 (quadrangle). Boundary segments have either constant latitude, constant longitude, or constant slope in degrees of latitude per degree of longitude. The change in latitude or longitude along any boundary segment between two coordinates is less than ±180 degrees.*

*Note 2.— All parameters are broadcast in Type 27 message.*

**Table B-36. δUDRE indicator evaluation**

| δUDRE indicator | δUDRE |
|---|---|
| 0 | 1 |
| 1 | 1.1 |
| 2 | 1.25 |
| 3 | 1.5 |
| 4 | 2 |
| 5 | 3 |
| 6 | 4 |
| 7 | 5 |
| 8 | 6 |
| 9 | 8 |
| 10 | 10 |
| 11 | 20 |
| 12 | 30 |
| 13 | 40 |
| 14 | 50 |
| 15 | 100 |

3.5.4.10 *Clock-ephemeris covariance matrix parameters.* Clock-ephemeris covariance matrix parameters shall be as follows:

*PRN mask number:* see 3.5.4.1

*Scale exponent:* A term to compute the scale factor used to code the Cholesky factorization elements.

*Cholesky factorization elements ($E_{i,j}$):* Elements of an upper triangle matrix which compresses the information in the clock and ephemeris covariance matrix. These elements are used to compute the user differential range estimate (UDRE) degradation factor (δUDRE) as a function of user position.

### 3.5.5 Definitions of protocols for L1 data application

*Note.— This section provides definitions of parameters used by the non-aircraft or aircraft elements that are not transmitted. These parameters, necessary to ensure interoperability of SBAS, are used to determine the navigation solution and its integrity (protection levels).*

#### 3.5.5.1 *GEO POSITION AND CLOCK*

3.5.5.1.1 *GEO position estimate*. The estimated position of a GEO at any time $t_k$ is:

•

•

•

•

### 3.5.6 L1 Message tables

Each SBAS message shall be coded in accordance with the corresponding message format defined in Tables B-37 through B-53. All signed parameters in these tables shall be represented in two's complement, with the sign bit occupying the MSB.

*Note.— The range for the signed parameters is smaller than indicated, as the maximum positive value is constrained to be one value less (the indicated value minus the resolution).*

**Table B-37. Type 0 "Do Not Use" message broadcast on L1**

| Data content | Bits used | Range of values | Resolution |
|---|---|---|---|
| Spare | 212 | — | — |

**Table B-38. Type 1 PRN mask message**

| Data content | Bits used | Range of values | Resolution |
|---|---|---|---|
| For each of 210 PRN code numbers | | | |
| Mask value | 1 | 0 or 1 | 1 |
| IODP | 2 | 0 to 3 | 1 |

*Note.— All parameters are defined in 3.5.4.1.*

**Table B-39. Types 2 to 5 fast correction message**

| Data content | Bits used | Range of values | Resolution |
|---|---|---|---|
| $IODF_j$ | 2 | 0 to 3 | 1 |
| IODP | 2 | 0 to 3 | 1 |
| For 13 slots | | | |
| Fast correction ($FC_i$) | 12 | ±256.000 m | 0.125 m |

| | | | |
|---|---|---|---|
| For 13 slots | | | |
| $UDREI_i$ | 4 | (see Table B-29) | (see Table B-29) |

*Notes.—*
*1. The parameters $IODF_j$ and $FC_i$ are defined in 3.5.4.4.2.*
*2. The parameter IODP is defined in 3.5.4.1.*
*3. The parameter $UDREI_i$ is defined in 3.5.4.5.*

**Table B-40. Type 6 integrity message**

| Data content | Bits used | Range of values | Resolution |
|---|---|---|---|
| $IODF_2$ | 2 | 0 to 3 | 1 |
| $IODF_3$ | 2 | 0 to 3 | 1 |
| $IODF_4$ | 2 | 0 to 3 | 1 |
| $IODF_5$ | 2 | 0 to 3 | 1 |
| For 51 satellites (ordered by PRN mask number) | | | |
| $UDREI_i$ | 4 | (see Table B-29) | (see Table B-29) |

*Notes.—*
*1. The parameters $IODF_j$ are defined in 3.5.4.4.2.*
*2. The parameter $UDREI_i$ is defined in 3.5.4.5.*

**Table B-41. Type 7 fast correction degradation factor message**

| Data content | Bits used | Range of values | Resolution |
|---|---|---|---|
| System latency ($t_{lat}$) | 4 | 0 to 15 s | 1 s |
| IODP | 2 | 0 to 3 | 1 |
| Spare | 2 | — | — |
| For 51 satellites (ordered by PRN mask number) | | | |
| Degradation factor indicator ($ai_i$) | 4 | (see Table B-34) | (see Table B-34) |

*Notes.—*
*1. The parameters $t_{lat}$ and $ai_i$ are defined in 3.5.4.7.*
*2. The parameter IODP is defined in 3.5.4.1.*

**Table B-42. Type 9 ranging function message**

| Data content | Bits used | Range of values | Resolution |
|---|---|---|---|
| Reserved | 8 | — | — |
| $t_{0,GEO}$ | 13 | 0 to 86 384 s | 16 s |
| URA | 4 | (see Table B-26) | (see Table B-26) |
| $X_G$ | 30 | ±42 949 673 m | 0.08 m |
| $Y_G$ | 30 | ±42 949 673 m | 0.08 m |
| $Z_G$ | 25 | ±6 710 886.4 m | 0.4 m |
| $\dot{X}_G$ | 17 | ±40.96 m/s | 0.000625 m/s |
| $\dot{Y}_G$ | 17 | ±40.96 m/s | 0.000625 m/s |
| $\dot{Z}_G$ | 18 | ±524.288 m/s | 0.004 m/s |
| $\ddot{X}_G$ | 10 | ±0.0064 $m/s^2$ | 0.0000125 $m/s^2$ |
| $\ddot{Y}_G$ | 10 | ±0.0064 $m/s^2$ | 0.0000125 $m/s^2$ |
| $\ddot{Z}_G$ | 10 | ±0.032 $m/s^2$ | 0.0000625 $m/s^2$ |
| $a_{Gf0}$ | 12 | $\pm 0.9537 \times 10^{-6}$ s | $2^{-31}$ s |
| $a_{Gf1}$ | 8 | $\pm 1.1642 \times 10^{-10}$ s/s | $2^{-40}$ s/s |

| Data content | Bits used | Range of values | Resolution |
|---|---|---|---|

*Note.— All parameters are defined in 3.5.4.2.*

**Table B-43. Type 10 degradation parameter message**

| Data content | Bits used | Range of values | Resolution |
|---|---|---|---|
| $B_{rrc}$ | 10 | 0 to 2.046 m | 0.002 m |
| $C_{ltc\ lsb}$ | 10 | 0 to 2.046 m | 0.002 m |
| $C_{ltc\ v1}$ | 10 | 0 to 0.05115 m/s | 0.00005 m/s |
| $I_{ltc\ v1}$ | 9 | 0 to 511 s | 1 s |
| $C_{ltc\ v0}$ | 10 | 0 to 2.046 m | 0.002 m |
| $I_{ltc\ v0}$ | 9 | 0 to 511 s | 1 s |
| $C_{geo\ lsb}$ | 10 | 0 to 0.5115 m | 0.0005 m |
| $C_{geo\ v}$ | 10 | 0 to 0.05115 m/s | 0.00005 m/s |
| $I_{geo}$ | 9 | 0 to 511 s | 1 s |
| $C_{er}$ | 6 | 0 to 31.5 m | 0.5 m |
| $C_{iono\ step}$ | 10 | 0 to 1.023 m | 0.001 m |
| $I_{iono}$ | 9 | 0 to 511 s | 1 s |
| $C_{iono\ ramp}$ | 10 | 0 to 0.005115 m/s | 0.000005 m/s |
| $RSS_{UDRE}$ | 1 | 0 or 1 | 1 |
| $RSS_{iono}$ | 1 | 0 or 1 | 1 |
| $C_{covariance}$ | 7 | 0 to 12.7 | 0.1 |
| Spare | 81 | — | — |

*Note.— All parameters are defined in 3.5.4.7.*

**Table B-44. Type 12 SBAS network time/UTC message**

| Data content | Bits used | Range of values | Resolution |
|---|---|---|---|
| $A_{1SNT}$ | 24 | $\pm 7.45 \times 10^{-9}$ s/s | $2^{-50}$ s/s |
| $A_{0SNT}$ | 32 | ±1 s | $2^{-30}$ s |
| $t_{0t}$ | 8 | 0 to 602 112 s | 4 096 s |
| $WN_t$ | 8 | 0 to 255 weeks | 1 week |
| $\Delta t_{LS}$ | 8 | ±128 s | 1 s |
| $WN_{LSF}$ | 8 | 0 to 255 weeks | 1 week |
| DN | 8 | 1 to 7 days | 1 day |
| $\Delta t_{LSF}$ | 8 | ±128 s | 1 s |
| UTC standard identifier | 3 | (see Table B-35) | (see Table B-35) |
| GPS time-of-week (TOW) | 20 | 0 to 604 799 s | 1 s |
| GPS week number (WN) | 10 | 0 to 1 023 weeks | 1 week |
| GLONASS indicator | 1 | 0 or 1 | 1 |
| $\delta a_{i,\ GLONASS}$ (Note 2) | 24 | $\pm 2.0 \cdot 10^{-8}$ s | $2.0 \cdot 10^{-31}$ s |
| Spare | 50 | — | — |

*Notes.—*
1. *All parameters are defined in 3.5.4.8.*
2. *Applies only if SBAS sends GLONASS timing information in message Type 12 (see 3.5.7.4.4, Timing data).*

**Table B-45. Type 17 GEO almanac message**

| Data content | Bits used | Range of values | Resolution |
|---|---|---|---|
| For each of 3 satellites | | | |
| Reserved | 2 | 0 | — |
| PRN code number | 8 | 0 to 210 | 1 |
| Health and status | 8 | — | — |
| $X_{G,A}$ | 15 | ±42 598 400 m | 2 600 m |
| $Y_{G,A}$ | 15 | ±42 598 400 m | 2 600 m |
| $Z_{G,A}$ | 9 | ±6 656 000 m | 26 000 m |
| $\dot{X}_{G,A}$ | 3 | ±40 m/s | 10 m/s |
| $\dot{Y}_{G,A}$ | 3 | ±40 m/s | 10 m/s |
| $\dot{Z}_{G,A}$ | 4 | ±480 m/s | 60 m/s |
| $t_{almanac}$ (applies to all three satellites) | 11 | 0 to 86 336 s | 64 s |

*Note.— All parameters are defined in 3.5.4.3.*

**Table B-46. Type 18 IGP mask message**

| Data content | Bits used | Range of values | Resolution |
|---|---|---|---|
| Number of IGP bands | 4 | 0 to 11 | 1 |
| IGP band identifier | 4 | 0 to 10 | 1 |
| Issue of data — ionosphere ($IODI_k$) | 2 | 0 to 3 | 1 |
| For 201 IGPs | | | |
| IGP mask value | 1 | 0 or 1 | 1 |
| Spare | 1 | — | — |

*Note.— 1 All parameters are defined in 3.5.4.6.*

**Table B-47. Type 24 mixed fast/long-term satellite error correction message**

| Data content | Bits used | Range of values | Resolution |
|---|---|---|---|
| For 6 slots | | | |
| Fast correction ($FC_i$) | 12 | ±256.000 m | 0.125 m |
| For 6 slots | | | |
| $UDREI_i$ | 4 | (see Table B-31) | (see Table B-31) |
| IODP | 2 | 0 to 3 | 1 |
| Fast correction type identifier | 2 | 0 to 3 | 1 |
| $IODF_j$ | 2 | 0 to 3 | 1 |
| Spare | 4 | — | — |
| Type 25 half-message | 106 | — | — |

*Notes.—*

1. *The parameters fast correction type identifier, $IODF_j$, and $FC_i$ are defined in 3.5.4.4.2.*
2. *The parameter IODP is defined in 3.5.4.1.*
3. *The parameter $UDREI_i$ is defined in 3.5.4.5.*
4. *The long-term satellite error correction message is divided into two half-messages. The half message for a velocity code = 0 is defined in Table B-48 The half message for a velocity code = 1 is defined in Table B-49.*

**Table B-48. Type 25 long-term satellite error correction half message (VELOCITY CODE = 0)**

| Data content | Bits used | Range of values | Resolution |
|---|---|---|---|
| Velocity Code = 0 | 1 | 0 | 1 |
| For 2 Satellites | | | |
| PRN mask number | 6 | 0 to 51 | 1 |
| Issue of data ($IOD_i$) | 8 | 0 to 255 | 1 |
| $\delta x_i$ | 9 | ±32 m | 0.125 m |
| $\delta y_i$ | 9 | ±32 m | 0.125 m |
| $\delta z_i$ | 9 | ±32 m | 0.125 m |
| $\delta a_{i,f0}$ | 10 | $\pm 2^{-22}$ s | $2^{-31}$ s |
| IODP | 2 | 0 to 3 | 1 |
| Spare | 1 | — | — |

*Notes.—*

*1. The parameters PRN mask number and IODP are defined in 3.5.4.1.*

*2. All other parameters are defined in 3.5.4.4.1.*

**Table B-49. Type 25 long-term satellite error correction half message (VELOCITY CODE = 1)**

| Data content | Bits used | Range of values | Resolution |
|---|---|---|---|
| For 1 Satellite | | | |
| Velocity Code = 1 | 1 | 1 | 1 |
| PRN mask number | 6 | 0 to 51 | 1 |
| Issue of data ($IOD_i$) | 8 | 0 to 255 | 1 |
| $\delta x_i$ | 11 | ±128 m | 0.125 m |
| $\delta y_i$ | 11 | ±128 m | 0.125 m |
| $\delta z_i$ | 11 | ±128 m | 0.125 m |
| $\delta a_{i,f0}$ | 11 | $\pm 2^{-21}$ s | $2^{-31}$ s |
| $\delta \dot{x}_i$ | 8 | ±0.0625 m/s | $2^{-11}$ m/s |
| $\delta \dot{y}_i$ | 8 | ±0.0625 m/s | $2^{-11}$ m/s |
| $\delta \dot{z}_i$ | 8 | ±0.0625 m/s | $2^{-11}$ m/s |
| $\delta a_{i,f1}$ | 8 | $\pm 2^{-32}$ s/s | $2^{-39}$ s/s |
| Time-of-applicability ($t_{i,LT}$) | 13 | 0 to 86 384 s | 16 s |
| IODP | 2 | 0 to 3 | 1 |

*Notes.—*
*1. The parameters PRN mask number and IODP are defined in 3.5.4.1.*
*2. All other parameters are defined in 3.5.4.4.1.*

**Table B-50. Type 26 Ionospheric delay message**

| Data content | Bits used | Range of values | Resolution |
|---|---|---|---|
| IGP band identifier | 4 | 0 to 10 | 1 |
| IGP block identifier | 4 | 0 to 13 | 1 |
| For each of 15 grid points | | | |
| IGP vertical delay estimate | 9 | 0 to 63.875 m | 0.125 m |
| Grid ionospheric vertical error indicator ($GIVEI_i$) | 4 | (see Table B-33) | (see Table B-33) |
| $IODI_k$ | 2 | 0 to 3 | 1 |
| Spare | 7 | — | — |

*Note.— All parameters are defined in 3.5.4.6.*

**Table B-51. Type 27 SBAS service message**

| Data content | Bits used | Range of values | Resolution |
|---|---|---|---|
| Issue of data, service (IODS) | 3 | 0 to 7 | 1 |
| Number of service messages | 3 | 1 to 8 | 1 |
| Service message number | 3 | 1 to 8 | 1 |
| Number of regions | 3 | 0 to 5 | 1 |
| Priority code | 2 | 0 to 3 | 1 |
| δUDRE indicator-inside | 4 | 0 to 15 | 1 |
| δUDRE indicator-outside | 4 | 0 to 15 | 1 |
| For each of 5 regions | | | |
| Coordinate 1 latitude | 8 | ±90° | 1° |
| Coordinate 1 longitude | 9 | ±180° | 1° |
| Coordinate 2 latitude | 8 | ±90° | 1° |
| Coordinate 2 longitude | 9 | ±180° | 1° |
| Region shape | 1 | — | — |
| Spare | 15 | — | — |

*Note.— All parameters are defined in 3.5.4.9.*

**Table B-52. Type 63 null message**

| Data content | Bits used | Range of values | Resolution |
|---|---|---|---|
| Spare | 212 | — | — |

**Table B-53. Type 28 clock-ephemeris covariance matrix**

| Data content | Bits used | Range of values | Resolution |
|---|---|---|---|
| IODP | 2 | 0 to 3 | 1 |
| For two satellites | | | |
| PRN mask number | 6 | 0 to 51 | 1 |
| Scale exponent | 3 | 0 to 7 | 1 |
| $E_{1,1}$ | 9 | 0 to 511 | 1 |
| $E_{2,2}$ | 9 | 0 to 511 | 1 |
| $E_{3,3}$ | 9 | 0 to 511 | 1 |
| $E_{4,4}$ | 9 | 0 to 511 | 1 |
| $E_{1,2}$ | 10 | ±512 | 1 |
| $E_{1,3}$ | 10 | ±512 | 1 |
| $E_{1,4}$ | 10 | ±512 | 1 |
| $E_{2,3}$ | 10 | ±512 | 1 |
| $E_{2,4}$ | 10 | ±512 | 1 |
| $E_{3,4}$ | 10 | ±512 | 1 |

*Notes.—*
*1. The parameters PRN mask number and IODP are defined in 3.5.4.1.*
*2. All other parameters are defined in 3.5.4.10.*

### 3.5.7 L1 Non-aircraft elements

*Note 1.— Depending on the level of service offered by a particular SBAS, different functions can be implemented as described in Chapter 3, 3.7.3.4.2.*

*Note 2.— The parameters that are referred to in this section are defined in 3.5.4.*

#### 3.5.7.1 *GENERAL*

**3.5.7.1.1** *Required data and broadcast intervals*. SBAS shall broadcast the data required for the supported functions as shown in Table B-54. If the SBAS broadcasts data that are not required for a particular function, the requirements for that data supporting other functions shall apply. The maximum interval between broadcasts for all data of each data type provided shall be as defined in Table B-54.

**3.5.7.1.2** *SBAS radio frequency monitoring*. The SBAS shall monitor the SBAS satellite parameters shown in Table B-55 and take the indicated action.

*Note.— SBAS may broadcast null messages (Type 63 messages) in each time slot for which no other data are broadcast.*

**3.5.7.1.3** *"Do Not Use"*. SBAS shall broadcast a "Do Not Use" message (Type 0 message) when necessary to inform users not to use the SBAS satellite ranging function and its broadcast data.

**3.5.7.1.4** The Doppler shift in the GEO satellite signal seen at any fixed location within the GEO footprint for any GEO shall not exceed ±450 Hz.

*Note.— This maximum Doppler shift corresponds approximately to the maximum GEO satellite orbit inclination that can be supported by the coding ranges for Type 9 and Type 17 messages.*

**3.5.7.1.5** *Geostationary orbit (GEO) ranging function parameters.* Each SBAS satellite shall broadcast geostationary orbit (GEO) ranging function parameters (defined in 3.5.4.2).

*Note.— It is necessary to broadcast geostationary orbit ranging function parameters even when a ranging function is not provided, so that airborne receivers may implement a positive identification of the broadcasting SBAS satellite. When ranging is not provided, the accuracy of the Type 17 data (and Type 9 data) only needs to support the acquisition of the satellite.*

3.5.7.1.5.1 The error in the Doppler shift of a GEO satellite derived from any Type 9 message that has not timed out, with respect to the true GEO Doppler shift seen at any fixed location within the GEO footprint, shall not exceed ±210 Hz.

**3.5.7.1.6** *Almanac data*. Each SBAS satellite shall broadcast almanac data (defined in 3.5.4.3) for all SBAS satellites of the same service provider.

3.5.7.1.6.1 The error in the estimated position of the satellite derived from any Type 17 message broadcast within the previous 15 minutes, with respect to the true satellite position, shall not exceed 3 000 km.

3.5.7.1.6.2 The separation distance between the estimated position of the satellite derived from any Type 17 message broadcast within the previous 15 minutes and the position of the satellite derived from the GEO ranging parameters in any Type 9 message that has not timed out shall not exceed 200 km.

3.5.7.1.6.3 The error in the Doppler shift of a GEO satellite derived from any Type 17 message broadcast within the previous 15 minutes, with respect to the true GEO Doppler shift seen at any fixed location within the GEO footprint, shall not exceed ±210 Hz.

3.5.7.1.6.4 SBAS shall not broadcast almanac data for any SBAS satellite from a different service provider for which the position estimated from the almanac data broadcast within the previous 15 minutes would be within 200 km of the position of any of its own GEOs as derived from the GEO ranging parameters from any Type 9 message that has not timed out.

3.5.7.1.6.5 Where the estimated position of a GEO satellite providing a ranging function, derived from the Type 17 message broadcast within the previous 15 minutes, is within 200 km of the position of another GEO satellite of the same service provider, derived from a Type 9 message for this GEO that has not timed out, the GEO UDRE value shall be set sufficiently large to account for the possibility that a user could misidentify the PRN of the GEO providing the ranging function.

3.5.7.1.6.6 The health and status parameter shall indicate the satellite status and the service provider identifier, as defined in 3.5.4.3.

3.5.7.1.6.7 Unused almanac slots in Type 17 messages shall be coded with a PRN code number of “0”.

3.5.7.1.6.8 The service provider shall ensure the correctness of the service provider ID broadcast in any almanac.

3.5.7.2 *Ranging function*. If an SBAS provides a ranging function, it shall comply with the requirements contained in this section in addition to the requirements of 3.5.7.1.

**3.5.7.2.1** *Performance requirements*

*Note.— See Chapter 3, 3.7.3.4~~.2.1~~.3.*

**3.5.7.2.2** *Ranging function data*. SBAS shall broadcast ranging function data such that the SBAS satellite position error projected on the line-of-sight to any user in the satellite footprint is less than 256 metres. Each SBAS satellite shall broadcast a URA representing an estimate of the standard deviation of the ranging errors referenced to SNT for L1 SBAS.

3.5.7.3 *GNSS satellite status function*. If an SBAS provides a satellite status function, it shall also comply with the requirements contained in this section.

*Note.— An SBAS may be able to provide integrity on some GPS satellites that are designated either marginal or unhealthy.*

**3.5.7.3.1** *Performance of satellite status functions*. Given any valid combination of active data, the probability of a horizontal error exceeding the $HPL_{SBAS}$ (as defined in 3.5.5.6) for longer than 8 consecutive seconds shall be less than $10^{-7}$ in any hour, assuming a user with zero latency.

*Note.— Active data is defined to be data that have not timed out per 3.5.8.1.2. This requirement includes core satellite constellation(s) and SBAS failures.*

**3.5.7.3.2** *PRN mask and Issue of data — PRN (IODP)*. SBAS shall broadcast a PRN mask and IODP (Type 1 message). The PRN mask values shall indicate whether or not data are being provided for each GNSS satellite. The IODP shall change when there is a change in the PRN mask. The change of IODP in Type 1 messages shall occur before the IODP changes in any other message. The IODP in Type 2 to 5, 7, 24, 25 and 28 messages shall equal the IODP broadcast in the PRN mask message (Type 1 message) used to designate the satellites for which data are provided in that message.

**Table B-54. Data broadcast intervals and supported functions**

| Data type | Maximum broadcast interval | Ranging | GNSS satellite status | Basic differential correction | Precise differential correction | Associated message types |
|---|---|---|---|---|---|---|
| Clock-Ephemeris covariance matrix | 120 s | | | | | 28 |
| SBAS in test mode | 6 s | | | | | 0 |
| PRN mask | 120 s | | R | R | R | 1 |
| UDREI | 6 s | | R* | R | R | 2 to 6, 24 |
| Fast corrections | $I_{fc}/2$ (see *Note 4*) | | R* | R | R | 2 to 5, 24 |
| Long-term corrections | 120 s | | R* | R | R | 24, 25 |
| GEO ranging function data | 120 s | R | R | R | R | 9 |
| Fast correction degradation | 120 s | | R* | R | R | 7 |
| Degradation parameters | 120 s | | | | R | 10 |
| Ionospheric grid mask | 300 s | | | | R | 18 |
| Ionospheric corrections, GIVEI | 300 s | | | | R | 26 |
| Timing data | 300 s | R (see *Note 3*) | R (see *Note 3*) | R (see *Note 3*) | R (see *Note 3*) | 12 |
| Almanac data | 300 s | R | R | R | R | 17 |
| Service level | 300 s | | | | | 27 |

*Notes.—*
*1. "R" indicates that the data must be broadcast to support the function.*
*2. "R*" indicates special coding as described in 3.5.7.3.3.*
*3. Type 12 messages are only required if data are provided for GLONASS satellites.*
*4. $I_{fc}$ refers to the PA/APV time-out interval for fast corrections, as defined in Table B-57.*

**Table B-55. SBAS L1 radio frequency monitoring**

| Parameter | Reference | Alarm limit | Required action |
|---|---|---|---|
| Signal power level | Chapter 3, 3.7.3.4.45.3 | minimum specified power<br>maximum specified power<br>*(Note 2)* | Cease ranging function (*Note 1*).<br>Cease broadcast. |
| Modulation | Chapter 3, 3.7.3.4.45.5 | monitor for waveform distortion | Cease L1 ranging function (*Note 1*). |
| SNT-to-GPS time | Chapter 3, 3.7.3.4.57 | N/A<br>(*Note 3*) | Cease L1 ranging function unless $\sigma_{UDRE}$ reflects error. |
| Carrier frequency stability | 3.5.2.1 | N/A<br>(*Note 3*) | Cease L1 ranging function unless $\sigma_{UDRE}$ reflects error. |
| Code/frequency coherence | 3.5.2.4 | N/A<br>(*Note 3*) | Cease L1 ranging function unless $\sigma_{UDRE}$ reflects error. |
| Maximum code phase deviation | 3.5.2.6 | N/A<br>(*Notes 2* and *3*) | Cease L1 ranging function unless $\sigma_{UDRE}$ reflects error. |
| Convolutional encoding | 3.5.2.9 | all transmit messages are erroneous | Cease broadcast. |

*Notes.—*
1. *Ceasing the ranging function is accomplished by broadcasting a URA and $\sigma^2_{UDRE}$ of "Do Not Use" for that SBAS satellite.*
2. *These parameters can be monitored by their impact on the received signal quality ($C/N_0$ impact), since that is the impact on the user.*
3. *Alarm limits are not specified because the induced error is acceptable, provided it is represented in the $\sigma^2_{UDRE}$ and URA parameters. If the error cannot be represented, the ranging function must cease.*

3.5.7.3.2.1 **Recommendation.—** *When the PRN mask is changed, SBAS should repeat the Type 1 message several times before referencing it in other messages to ensure that users receive the new mask.*

**3.5.7.3.3** *Integrity data*. If SBAS does not provide the basic differential correction function, it shall transmit fast corrections, long-term corrections and fast correction degradation parameters coded to zero for all visible satellites indicated in the PRN mask.

3.5.7.3.3.1 If SBAS does not provide the basic differential correction function, SBAS shall indicate that the satellite is unhealthy ("Do Not Use") if the pseudo-range error exceeds 150 metres.

3.5.7.3.3.2 If SBAS does not provide the basic differential correction function, SBAS shall indicate that the satellite is "Not Monitored" if the pseudo-range error cannot be determined.

3.5.7.3.3.3 If SBAS does not provide the basic differential correction function, SBAS shall transmit a $UDREI_i$ of 13 if the satellite is not "Do Not Use" or "Not Monitored".

3.5.7.3.3.4 The $IODF_j$ parameter in Type 2 to 5, 6 or 24 messages shall be equal to 3.

3.5.7.4 *Basic differential correction function*. If an SBAS provides a basic differential correction function, it shall comply with the requirements contained in this section in addition to the GNSS satellite status function requirements defined in 3.5.7.3.

**3.5.7.4.1** *Performance of basic differential correction function*. Given any valid combination of active data, the probability of a horizontal error exceeding the $HPL_{SBAS}$ (as defined in 3.5.5.6) for longer than 8 consecutive seconds shall be less than $10^{-7}$ in any hour, assuming a user with zero latency.

*Note.— Active data is defined to be data that has not timed out per 3.5.8.1.2. This requirement includes core satellite constellation(s) and SBAS failures.*

**3.5.7.4.2** *Long-term corrections*. Except for SBAS satellites from the same service provider, SBAS shall determine and broadcast long-term corrections for each visible GNSS satellite (see *Note*) indicated in the PRN mask (PRN mask value equal to “1”). The long-term corrections shall be such that the core satellite constellation(s) satellite position error projected on the line-of-sight to any user in the satellite footprint after application of these long-term corrections is less than 256 metres. For each GLONASS satellite, SBAS shall translate satellite coordinates into WGS-84 as defined in 3.~~5~~2.5.2 prior to determining the long-term corrections. For each GPS satellite, the broadcast IOD shall match both the GPS IODE and 8 LSBs of IODC associated with the clock and ephemeris data used to compute the corrections (3.1.1.3.1.4 and 3.1.1.3.2.2). Upon transmission of a new ephemeris by a GPS satellite, SBAS shall continue to use the old ephemeris to determine the fast and long-term error corrections for at least 2 minutes and not more than 4 minutes. For each GLONASS satellite, SBAS shall compute and broadcast an IOD that consists of a latency and a validity interval as defined in 3.5.4.4.1.

*Note.— The criteria for satellite visibility include the locations of reference stations and the achieved mask angle at those locations.*

3.5.7.4.2.1 Recommendation**.—** *To ensure accurate range rate corrections, SBAS should minimize discontinuities in the satellite ephemerides after application of long-term corrections.*

**3.5.7.4.3** *Fast corrections.* SBAS shall determine fast corrections for each visible GNSS satellite indicated in the PRN mask (PRN mask value equal to “1”). Unless the IODF = 3, each time any fast correction data in Type j (j = 2, 3, 4 or 5) message changes, the $IODF_j$ shall sequence “0, 1, 2, 0, ...”.

*Note.— If there is an alarm condition, the $IODF_j$ may equal 3 (see 3.5.7.4.5).*

**3.5.7.4.4** *Timing data*. If data are provided for GLONASS, SBAS shall broadcast the timing message (Type 12 message) including GLONASS time offset as defined in Table B-44.

**3.5.7.4.5** *Integrity data*. For each satellite for which corrections are provided, SBAS shall broadcast integrity data (UDREIi and, optionally, Type 27 or 28 message data to calculate δUDRE) such that the integrity requirement in 3.5.7.4.1 is met. If the fast corrections or long-term corrections exceed their coding range, SBAS shall indicate that the satellite is unhealthy (“Do Not Use”). If $\sigma^2_{i,UDRE}$ cannot be determined, SBAS shall indicate that the satellite is “Not Monitored”.

If Type 6 message is used to broadcast $\sigma^2_{i,UDRE}$, then:

a) the $IODF_j$ shall match the $IODF_j$ for the fast corrections received in Type j message to which the $\sigma^2_{i,UDRE}$ apply; or

b) the $IODF_j$ shall equal 3 if the $\sigma^2_{i,UDRE}$ apply to all valid fast corrections received in Type j message which have not timed out.

**3.5.7.4.6** *Degradation data*. SBAS shall broadcast degradation parameters (Type 7 message) to indicate the applicable time out interval for fast corrections and ensure that the integrity requirement in 3.5.7.4.1 is met.

3.5.7.5 *Precise differential correction function*. If SBAS provides a precise differential correction function, it shall comply with the requirements contained in this section in addition to the basic differential correction function requirements in 3.5.7.4.

**3.5.7.5.1** *Performance of precise differential correction function*. Given any valid combination of active data, the probability of an out-of-tolerance condition for longer than the relevant time-to-alert shall be less than $2 \times 10^{-7}$ during any approach, assuming a user with zero latency. The time-to-alert shall be 5.2 seconds for an SBAS that supports precision approach operations, and 8 seconds for an SBAS that supports APV or NPA operations. An out-of-tolerance condition shall be defined as a horizontal error exceeding the $HPL_{SBAS}$ or a vertical error exceeding the $VPL_{SBAS}$ (as defined in 3.5.5.6). When an out-of-tolerance condition is detected, the resulting alert message (broadcast in a Type 2 to 5 and 6, 24, 26 or 27 messages) shall be repeated three times after the initial notification of the alert condition for a total of four times in 4 seconds.

*Note 1.— Active data is defined to be data that has not timed out per 3.5.8.1.2. This requirement includes core satellite constellation(s) and SBAS failures.*

*Note 2.— Subsequent messages can be transmitted at the normal update rate.*

**3.5.7.5.2** *Ionospheric grid point (IGP) mask*. SBAS shall broadcast an IGP mask and $IODI_k$ (up to 11 Type 18 messages, corresponding to the 11 IGP bands). The IGP mask values shall indicate whether or not data are being provided for each IGP. If IGP Band 9 is used, then the IGP mask values for IGPs north of 55°N in Bands 0 through 8 shall be set to "0". If IGP Band 10 is used, then the IGP mask values for IGPs south of 55°S in Bands 0 through 8 shall be set to "0". The $IODI_k$ shall change when there is a change of IGP mask values in the $k^{th}$ band. The new IGP mask shall be broadcast in a Type 18 message before it is referenced in a related Type 26 message. The $IODI_k$ in Type 26 message shall equal the $IODI_k$ broadcast in the IGP mask message (Type 18 message) used to designate the IGPs for which data are provided in that message.

3.5.7.5.2.1 Recommendation.— *When the IGP mask is changed, SBAS should repeat the Type 18 message several times before referencing it in a Type 26 message to ensure that users receive the new mask. The same* $IODI_k$ *should be used for all bands.*

**3.5.7.5.3** *Ionospheric corrections*. SBAS shall broadcast ionospheric corrections for the IGPs designated in the IGP mask (IGP mask values equal to "1").

**3.5.7.5.4** *Ionospheric integrity data*. For each IGP for which corrections are provided, SBAS shall broadcast GIVEI data such that the integrity requirement in 3.5.7.5.1 is met. If the ionospheric correction or $\sigma^2_{i,GIVE}$ exceed their coding range, SBAS shall indicate the status "Do Not Use" (designated in the correction data, 3.5.4.6) for the IGP. If $\sigma^2_{i,GIVE}$ cannot be determined, SBAS shall indicate that the IGP is "Not Monitored" (designated in the GIVEI coding).

**3.5.7.5.5** *Degradation data*. SBAS shall broadcast degradation parameters (Type 10 message) such that the integrity requirement in 3.5.7.5.1 is met.

3.5.7.6 *OPTIONAL FUNCTIONS*

**3.5.7.6.1** *Timing data*. If UTC time parameters are broadcast, they shall be as defined in 3.5.4.8 (Type 12 message).

**3.5.7.6.2** *Service indication*. If service indication data are broadcast, they shall be as defined in 3.5.4.9 (Type 27 message) and Type 28 messages shall not be broadcast. The IODS in all Type 27 messages shall increment when there is a change in any Type 27 message data.

**3.5.7.6.3** *Clock-ephemeris covariance matrix*. If clock-ephemeris covariance matrix data are broadcast, they shall be broadcast for all monitored satellites as defined in 3.5.4.10 (Type 28 message) and Type 27 messages shall not be broadcast.

3.5.7.7 *MONITORING*

**3.5.7.7.1** *SBAS radio frequency monitoring.* The SBAS shall monitor the SBAS satellite parameters shown in Table B-55 and take the indicated action.

*Note.— In addition to the radio frequency monitoring requirements in this section, it will be necessary to make special provisions to monitor pseudo-range acceleration specified in Chapter 3, 3.7.3.4.~~2.1~~3.5, and carrier phase noise specified in 3.5.2.2 and correlation loss in 3.5.2.5, unless analysis and testing shows that these parameters cannot exceed the stated limits.*

**3.5.7.7.2** *Data monitoring.* SBAS shall monitor the satellite signals to detect conditions that will result in improper operation of differential processing for airborne receivers with the tracking performance defined in Attachment D, 8.11.

3.5.7.7.2.1 The ground subsystem shall use the strongest correlation peak in all receivers used to generate the pseudo-range corrections.

3.5.7.7.2.2 The ground subsystem shall also detect conditions that cause more than one zero crossing for airborne receivers that use the Early-Late discriminator function as defined in Attachment D, 8.11.

3.5.7.7.2.3 The monitor action shall be to set UDRE to “Do Not Use” for the satellite.

3.5.7.7.2.4 SBAS shall monitor all active data that can be used by any user within the service area.

3.5.7.7.2.5 SBAS shall raise an alarm within 5.2 seconds if any combination of active data and GNSS signals-in-space results in an out-of-tolerance condition for precision approach (3.5.7.5.1).

3.5.7.7.2.6 SBAS shall raise an alarm within 8 seconds if any combination of active data and GNSS signals-in-space results in an out-of-tolerance condition for en-route through APV I (3.5.7.4.1).

*Note.— The monitoring applies to all failure conditions, including failures in core satellite constellation(s) or SBAS satellites. This monitoring assumes that the aircraft element complies with the requirements of RTCA/DO-229D with Change 1, except as superseded by 3.5.8 and Attachment D, 8.11.*

3.5.7.8 *Robustness to core satellite constellation(s) failures*. Upon occurrence of a core satellite constellation(s) satellite anomaly, SBAS shall continue to operate normally using the available healthy satellite signals that can be tracked

3.5.8 L1 Aircraft Elements

…

3.5.9 L5 RF CHARACTERISTICS

3.5.9.1 *Carrier frequency stability*. The short-term stability of the L5 carrier frequency (square root of the Allan variance) at the output of the satellite transmit antenna shall be better than $6.7 \times 10^{-11}$ over 1 to 10 seconds.

3.5.9.2 *Carrier phase noise*. The phase noise spectral density of the unmodulated carrier shall be such that a phase locked loop of 10 Hz one-sided noise bandwidth is able to track the carrier to an accuracy of 0.1 radian (1 sigma).

3.5.9.3 *Spurious emissions*. Spurious emissions shall be at least 40 dB below the unmodulated carrier power over all frequencies.

3.5.9.4 *Code/carrier frequency coherence.*

3.5.9.4.1 For L5, the code minus carrier rate shall be less than 0.5 metres/second TBC.

3.5.9.4.2 For DFMC SBAS ranging satellites:

3.5.9.4.2.1 For an SBAS GEO ranging satellite, the L5 short-term root mean squared error over 3600 seconds due to a 10-second carrier smoothing of the code based pseudorange shall be less than 0.200 metres, and the L5 long-term root mean squared error over 86400 seconds due to a 100-second carrier smoothing of the code based pseudorange shall be less than 0.255 metres.

3.5.9.4.2.2 *L1 and L5 short term fractional code/carrier frequency coherence*. For L1 and L5 signals broadcast by an SBAS GEO ranging satellite, the short-term root mean squared error over 3600 seconds due to a 10-second carrier smoothing of the L1/L5 ionosphere free pseudorange combination shall be less than 0.200 metres.

3.5.9.4.2.3 *L1 and L5 long term fractional code/carrier frequency coherence*. For L1 and L5 signals broadcast by an SBAS GEO ranging satellite, the long-term root mean squared error over 86400 seconds due to a 100 seconds differential carrier smoothing of the L1/L5 ionosphere free pseudorange combination shall be less than 0.255 metres.

3.5.9.5 *Correlation loss.* The loss in the recovered signal power due to imperfections in the signal modulation and waveform distortion shall not exceed 1 dB.

*Note.— The correlation loss is defined as the ratio of output powers from a perfect correlator for two cases:*

*a) the actual received L5 SBAS signal correlated against a perfect unfiltered pseudo-random noise reference; and*

*b) a perfect unfiltered pseudo-random noise signal normalised to the same total power as the SBAS signal in case (a), correlated against a perfect unfiltered pseudo-random noise reference.*

3.5.9.6 *Maximum Code Phase Deviation.* The L5 broadcast signal shall not deviate from the equivalent SBAS Network Time (SNT) for DFMC SBAS by more than $\pm 2^{-10}$ seconds.

3.5.9.7 *Code/data coherence.* Each 2-millisecond symbol shall be synchronous with every other code epoch.

3.5.9.8 *Message synchronization.* The leading edge of the first symbol that depends on the first bit of the current message shall be broadcast from the SBAS satellite synchronous with a 1-second epoch of SNT for DFMC SBAS.

*Note.— The SNT time reference is provided by Type 37 message as described in section 3.5.11.5.*

3.5.9.9 *Convolutional and bi-binary encoding.*

3.5.9.9.1 *Convolution encoding.* A 250-bit-per-second data stream shall be encoded at a rate of 2 symbols per bit using a convolutional code with a constraint length of 7 to yield 500 symbols per second. The convolutional encoder logic arrangement shall be as illustrated in Figure B-11 with the G3 output selected for the first half of each 4-millisecond data bit period.

3.5.9.9.2 *Bi-binary encoding.* In addition to the convolution coding detailed in paragraph 3.5.9.9.1, the L5, 500 symbol per second data stream shall be bi-binary encoded with a code synchronised with the code epoch period.

3.5.9.10 *Pseudo-random noise (PRN) codes for L5.* Each PRN code shall be a 10 230-bit code as described in IS-GPS-705D, dated 24th September 2013.

The initial state for the XA shift register shall be "1111111111111", and the initial state for the $XB_i$ register shall be as illustrated in Table B-89.

Table B-89. SBAS L5 PRN codes

| PRN code number | Initial XB Code State (I channel) (Note 1) | XB Code Advance (chips) (I channel) (Note 2) |
|---|---|---|
| 120 | 1101001100010 | 2797 |
| 121 | 1100011001100 | 934 |
| 122 | 1000011000101 | 3023 |
| 123 | 1111011011011 | 3632 |
| 124 | 0000001100100 | 1330 |
| 125 | 1101110000101 | 4909 |
| 126 | 1100001000010 | 4867 |
| 127 | 0001101001101 | 1183 |
| 128 | 1010100101011 | 3990 |
| 129 | 1111011110100 | 6217 |
| 130 | 1111111101100 | 1224 |
| 131 | 0000010000111 | 1733 |
| 132 | 1111110000010 | 2319 |
| 133 | 0011100111011 | 3928 |
| 134 | 1101100010101 | 2380 |
| 135 | 0101011111011 | 841 |
| 136 | 0001100011011 | 5049 |
| 137 | 0001101110111 | 7027 |
| 138 | 1110011110000 | 1197 |
| 139 | 0111100011111 | 7208 |
| 140 | 0011101110000 | 8000 |
| 141 | 1111001001000 | 152 |
| 142 | 0001101110010 | 6762 |
| 143 | 0101100111100 | 3745 |
| 144 | 0010010111101 | 4723 |
| 145 | 1101110110011 | 5502 |
| 146 | 0011110011111 | 4796 |
| 147 | 1001010101111 | 123 |

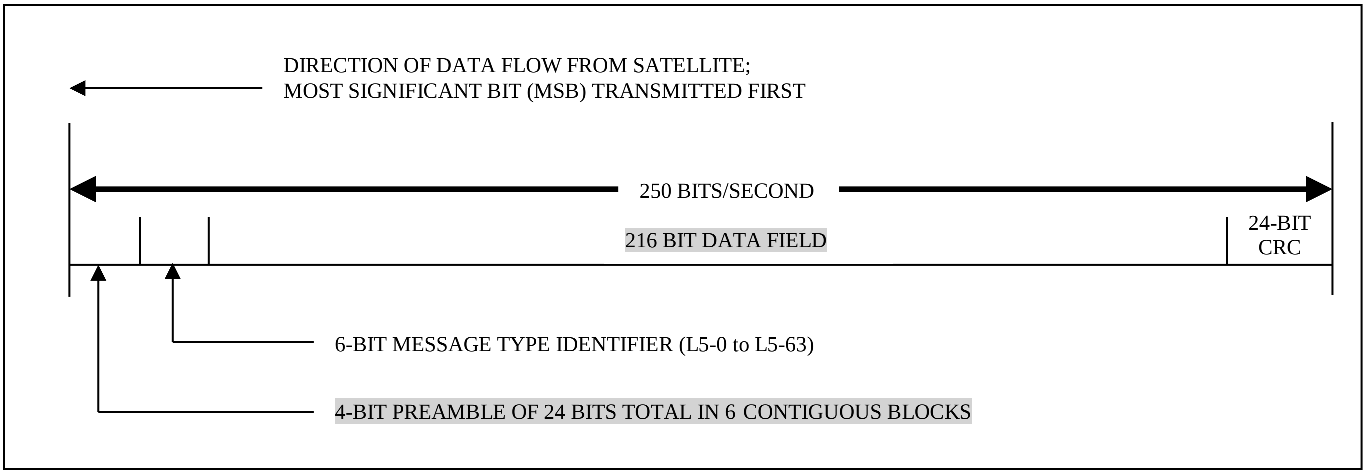
| PRN code number | Initial XB Code State (I channel) (Note 1) | XB Code Advance (chips) (I channel) (Note 2) |
|---|---|---|
| 148 | 0111111101111 | 8142 |
| 149 | 0000100100001 | 5091 |
| 150 | 1110001101011 | 7875 |
| 151 | 1111010010001 | 330 |
| 152 | 1011010111101 | 5272 |
| 153 | 0001101110000 | 4912 |
| 154 | 0000010111100 | 374 |
| 155 | 0100101111100 | 2045 |
| 156 | 1110110111010 | 6616 |
| 157 | 1101110101011 | 6321 |
| 158 | 1101000110001 | 7605 |

### 3.5.10 L5 DATA STRUCTURE

*Note.— Messages broadcast on L5 are independent of those broadcast on L1. Information broadcast on L5 SBAS is used only for dual-frequency navigation solutions using dual-frequency measurements from core constellations.*

3.5.10.1 *Format summary.* All messages shall consist of a preamble, a message type identifier, a data field and a cyclic redundancy check as illustrated in Figure B-20.

Figure B-20. L5 Data block format




3.5.10.2 *Preamble.* For L5, the preamble shall consist of the sequence of bits "0101 1100 0110 1001 0011 1010", distributed over six successive blocks.

3.5.10.3 *Message type identifier.* The L5 message type identifier shall be a 6-bit value identifying the message type as defined in Table B-90. The message type identifier shall be transmitted MSB first.

Table B-90. L5 Broadcast message types

| L5 Message type | Contents |
|---|---|
| 0 | "Do Not Use" – Content applies to L5 signal only |
| 1-30 | Spare |
| 31 | SBAS Satellite Mask |
| 32 | Satellite Clock Ephemeris corrections and covariance matrix |

| L5 Message type | Contents |
|---|---|
| 33 | Spare |
| 34, 35, 36 | Integrity Information (DFREI and DFRECI) |
| 37 | Degradation parameters and DFREI scale table |
| 38 | Spare |
| 39 | SBAS satellite clock, ephemeris and covariance matrix - 1 |
| 40 | SBAS satellite clock, ephemeris and covariance matrix - 2 |
| 41 | Spare |
| 42 | GNSS time offset |
| 43-46 | Spare |
| 47 | SBAS satellites almanacs |
| 48-61 | Spare |
| 62 | Reserved – Content applies to L5 signal only |
| 63 | Null message – Content applies to L5 signal only |

*Note.— L1 messages are intended for use with L1 SBAS service and L5 messages are intended for use with DFMC SBAS service. The messages on each frequency should be treated independently. Type 0, 62 and 63 messages apply respectively for the frequency band on which they are broadcast.*

3.5.10.4 *Data field.* The L5 data field shall be 216 bits as defined in 3.5.13. Each data field parameter shall be transmitted MSB first.

3.5.10.5 *Cyclic redundancy check (CRC).* The SBAS message CRC code on L5 shall be calculated in accordance with 3.9.

3.5.10.5.1 The length of the CRC code shall be k = 24 bits.

3.5.10.5.2 The CRC generator polynomial shall be:

$$G(x) = x^{24} + x^{23} + x^{18} + x^{17} + x^{14} + x^{11} + x^{10} + x^{7} + x^{6} + x^{5} + x^{4} + x^{3} + x + 1$$

3.5.10.5.3 The CRC information field, M(x), shall be:

$$M(x) = \sum_{i=1}^{226} m_i x^{226-i} = m_1 x^{225} + m_2 x^{224} + \ldots + m_{226} x^0$$

3.5.10.5.4 M(x) shall be formed from the 4-bit SBAS message preamble, 6-bit message type identifier, and 216-bit data field. Bits shall be arranged in the order transmitted from the SBAS satellite, such that $m_1$ corresponds to the first transmitted bit of the preamble, and $m_{226}$ corresponds to bit 216 of the data field.

3.5.10.5.5 The CRC code r-bits shall be ordered such that $r_1$ is the first bit transmitted and $r_{24}$ is the last bit transmitted.

## 3.5.11 DFMC SBAS DATA CONTENT

3.5.11.1 *Satellite mask parameters.* The satellite mask parameters shall be as follows:

*SBAS satellite mask:* The satellite mask is a set of 214 bits such that each bit represents one specific satellite as shown in Table B-91 and the value of that bit indicates whether augmentation is, or is not, provided for that satellite. The satellite mask can set up to 92 satellites from the 214 possible satellites available for augmentation. It is broadcast in Type 31 message.

*Satellite slot number:* a unique number representing a specific slot in the SBAS satellite mask (slots numbers range from 1 to 214) assigned to a specific satellite for which augmentation can be provided.

*Note 1.— The first transmitted bit of the satellite mask corresponds to GPS PRN code number 1.*
*Note 2.— Type 32 messages, Clock-Ephemeris corrections and covariance matrix message, is also broadcasting this parameter to identify the satellite to which the corrections apply.*

Table B-91. Satellite slot number assignments

| *Satellite slot number* | Assignment Logic |
|---|---|
| 1 – 32 | GPS PRN |
| 33 – 37 | Reserved (GPS) |
| 38 – 69 | GLONASS ID number plus 37 |
| 70 – 74 | Reserved (GLONASS) |
| 75 – 110 | Galileo space vehicle identifier plus 74 |
| 111 | Reserved (Galileo) |
| 112 – 119 | Spare |
| 120 – 158 | GEO SBAS PRN |
| 159 – 195 | BDS ranging code number plus 158 |
| 196 – 207 | Reserved |
| 208 – 214 | Spare |

*Note 3. — An SBAS may augment different sets of satellites for the provision of L1 SBAS service and for the provision of DFMC SBAS service.*
*Note 4. — Reserved means that the slot number has not yet been assigned but is planned for assignment to a specific satellite constellation.*

*SBAS augmented satellite signals*: The SBAS L5 standards allow the augmentation of the ionosphere-free combination of the following signal per core constellation:

- For GPS: The GPS L1 C/A signal (as described in chapter 3 section 3.7.3.1.7 and section 3.1.1) and the GPS L5-Q signal (as described in TBD). The LNAV data on GPS L1C/A is used in DFMC SBAS mode position solution.
- For GLONASS: GLONASS L1 OC signal (as described in TBD) and GLONASS L3 OC signal (as described in TBD). The data on GLONASS L1 OC is used in DFMC SBAS mode position solution.
- For Galileo: The Galileo E1-C signal (as described in TBD) and the Galileo E5a-Q signal (as described in TBD). The FNAV data on Galileo E5a-I is used in DFMC SBAS mode position solution.
- For BDS: The BDS B1C signal (as described in TBD) and the BDS B2a signal (as described in TBD). The B-CNAV2 data on BDS B2a is used in SBAS L5 position solution.
- For SBAS: The SBAS L1 ranging signal (as described in section 3.5.2) and SBAS L5 ranging signal (as described in section 3.5.9). The data broadcast on SBAS L5 is used in DFMC SBAS mode position solution.

*Satellite slot value:* Binary indication per satellite slot to indicate whether correction and integrity data are provided for the satellite.

Coding: 0 = data not provided

1 = data provided

*Augmented slot index:* number in the sequence of the satellite slot values set to "1" (1 up to 92) in the SBAS satellite mask.

*Note 5.— The augmented slot index is "1" for the lowest satellite slot number for which the Satellite Slot value is "1".*

*Issue of data Mask*— IODM : an indicator provided in Type 31, 34, 35 and 36 messages that links the integrity data provided in Type 34, 35 and 36 messages with the augmented slot indexes in the Type 31 message with the same IODM.

3.5.11.2 *Satellite Clock-Ephemeris Corrections and Covariance Matrix parameters.* The Clock Ephemeris Corrections and Covariance Matrix function parameters shall be as follows:

*Satellite slot number:* See section 3.5.11.1.

*Issue of Data Navigation (IODN):* is a 10-bits indicator broadcast in MT 32 that associates the clock and ephemeris corrections of a satellite with the ephemeris data broadcast by that satellite. The IODN for a given satellite matches with the following information (IODs) broadcast by the same satellite:

- For GPS: IODC parameter ( 3.1.1.3.1.4) in the L1 LNAV message
- For GLONASS: $t_b$ parameter (TBD) in strings Type 10, 31, 32 of L1OC navigation message
- For Galileo: IODnav parameter (TBD) in the F/NAV message
- For BDS: IODC parameter (TBD) in the B-CNAV2 message
- For SBAS: IODG parameter (TBD) in the Type 39/40 messages

*Orbit and Clock Parameters Corrections:* The orbit parameters shall be defined as follows:

a) $\delta x_{(ECEF)}$: the ephemeris correction for the x axis in WGS84 ECEF coordinates
b) $\delta y_{(ECEF)}$: the ephemeris correction for the y axis in WGS84 ECEF coordinates
c) $\delta z_{(ECEF)}$: the ephemeris correction for the z axis in WGS84 ECEF coordinates
d) $\delta B_{(ECEF)}$: the clock offset error correction expressed in metres.
e) $\delta \dot{x}_{(ECEF)}$: ephemeris velocity correction for the x axis in WGS84 ECEF coordinates
f) $\delta \dot{y}_{(ECEF)}$: ephemeris velocity correction for the y axis in WGS84 ECEF coordinates
g) $\delta \dot{z}_{(ECEF)}$: ephemeris velocity correction for the z axis in WGS84 ECEF coordinates
h) $\delta \dot{B}_{(ECEF)}$: the clock drift error correction expressed in metres per second.
i) $t_D$: the time of applicability of the parameters $\delta x$, $\delta y$, $\delta z$, $\delta B$, $\delta \dot{x}$, $\delta \dot{y}$, $\delta \dot{z}$ and $\delta \dot{B}$ expressed in seconds after midnight of the current day.

*Scale exponent:* A term to compute the scale factor used to code the Cholesky factorization elements.

*Cholesky factorization elements (Ei,j):* Elements of an upper triangle matrix which compresses the information in the clock and ephemeris covariance matrix. These elements are used to compute the delta dual frequency range error indicator ($\delta_{DFREI}$) as a function of user position.

*DFREI*: *Dual Frequency Range Error Indicator* (DFREI) is a 4 bit indicator of the dual frequency range error (DFRE) value, with range from 0 to 15, with value 15 corresponding to "Do Not Use for SBAS". For other values (from 0 to 14), the DFREI table defining the correspondence between the DFRE Indicator (DFREI) values and the standard deviation ($\sigma_{DFRE}$, in metres) is described in section 3.5.11.4).

*Note 1.—The broadcast standard deviation values (within the allowed ranges as defined in 3.5.11.4) are SBAS dependent.*

$\delta R_{CORR}$: is the 1st order degradation parameter multiplier.

*Note 2.— All parameters are broadcast in the Type 32 message.*

3.5.11.3 *Integrity message parameters.* The integrity message parameters shall consist of:

*Dual Frequency Range Error Change Indicator (DFRECI).* The Dual Frequency Range Error Change Indicator (DFRECI) is a 2 bit indicator that denotes the integrity status of a specific satellite identified by its augmented slot index (see 3.5.11.1). The definitions of the DFRECI indicators are provided in Table B–92 as follows:

Table B–92: DFRECI Indicator

| $DFRECI_i$ | **State** |
|---|---|
| 0 (“00”) | Unchanged DFREI |
| 1 (“01”) | Changed DFREI. |
| 2 (“10”) | Active DFREI value increased by a value of one. |
| 3 (“11”) | Do not use this satellite in SBAS mode. |
| | |

*Note 1.—For a given satellite, the DFRECI indication “00”, and “10” always refers to the last valid DFREI received (active DFREI) for that satellite. An active DFREI could be any broadcast DFREI that has not yet timed out. DFRECI “10” indications are not cumulative.*

*Issue of data Mask— IODM:* See section 3.5.11.1.

*Dual Frequency Range Error Indicator (DFREI).* See section 3.5.11.2.

*Note 2.— Parameters are broadcast using one or more the following message types:*

*a) Type 34 message providing DFRECI for all augmented satellites, DRFEI for up to 7 augmented satellites and IODM*

*b) Type 35 and 36 messages broadcasting IODM and DFREIs for a maximum set of 53 and 39 augmented satellites respectively.*

3.5.11.4 *Degradation parameters and DFREI scale table parameters.* The old but active data (OBAD) parameters and DFREI scale table parameters shall consist of:

*Common OBAD parameters:* a set of parameters common to all augmented satellites where:

a) $(I_{VALID})_{32}$ is the Type 32 message validity interval,
b) $(I_{VALID})_{39/40}$ is the Types 39 and 40 messages validity interval,
c) $C_{ER}$ is the step degradation parameter for en-route through Non Precision Approach applications, and
d) $C_{COVARIANCE}$ is the clock-ephemeris covariance degradation parameter.

*Specific OBAD parameter:* a set of parameters linked to a given core constellation used to account for the degradation of corrections that are old but still valid where:

a) $I_{CORR}$ is the time interval for application of $C_{CORR}$,
b) $C_{CORR}$ is the step degradation parameter for precision approach applications, and
c) $R_{CORR}$ is the 1st order degradation parameter

*Time Reference Identifier* specifies the GNSS constellation on which the SBAS Network Time for DFMC SBAS is aligned, where

a) ‘0’ is GPS,
b) ‘1’ is GLONASS,
c) ‘2’ is Galileo,
d) ‘3’ is BDS,
e) ‘4’ is reserved,
f) ‘5’ is spare,
g) ‘6’ is spare, and
h) ‘7’ is spare.

*DFREI scale table* is providing the mapping between the DFREI parameter (see section 3.5.11.2) and $\sigma_{DFRE}$. This mapping is provided in Table B-93 below.

$\sigma_{DFRE}$ is the standard deviation of the residual ionosphere-free clock and ephemeris range error following application of the DFMC SBAS clock and ephemeris corrections (Type 32 message) or of the SBAS satellite clock and ephemeris (Type 39/40 message).

**Table B-93: Evaluation of $(\sigma_{DFRE})_i$ in metres.**

| Field Value$_{Dec}$ | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Field Value$_{Bin}$ | 0000 | 0001 | 0010 | 0011 | 0100 | 0101 | 0110 | 0111 | 1000 | 1001 | 1010 | 1011 | 1100 | 1101 | 1110 | 1111 |
| $\sigma_{DFRE}$: DFREI=0 | 0.125 | 0.1875 | 0.25 | 0.3125 | 0.375 | 0.4375 | 0.5 | 0.5625 | 0.625 | 0.6875 | 0.75 | 0.8125 | 0.875 | 0.9375 | 1 | 1.0625 |
| $\sigma_{DFRE}$: DFREI=1 | 0.25 | 0.375 | 0.5 | 0.625 | 0.75 | 0.875 | 1.0 | 1.125 | 1.25 | 1.375 | 1.5 | 1.625 | 1.75 | 1.875 | 2.0 | 2.125 |
| $\sigma_{DFRE}$: DFREI=2 | 0.375 | 0.5 | 0.625 | 0.75 | 0.875 | 1.0 | 1.125 | 1.25 | 1.375 | 1.5 | 1.625 | 1.75 | 1.875 | 2.0 | 2.125 | 2.25 |
| $\sigma_{DFRE}$: DFREI=3 | 0.5 | 0.625 | 0.75 | 0.875 | 1.0 | 1.125 | 1.25 | 1.375 | 1.5 | 1.625 | 1.75 | 1.875 | 2.0 | 2.125 | 2.25 | 2.375 |
| $\sigma_{DFRE}$: DFREI=4 | 0.625 | 0.75 | 0.875 | 1.0 | 1.125 | 1.25 | 1.375 | 1.5 | 1.625 | 1.75 | 1.875 | 2.0 | 2.125 | 2.25 | 2.375 | 2.5 |
| $\sigma_{DFRE}$: DFREI=5 | 0.75 | 1.0 | 1.25 | 1.5 | 1.75 | 2.0 | 2.25 | 2.5 | 2.75 | 3.0 | 3.25 | 3.5 | 3.75 | 4.0 | 4.25 | 4.5 |
| $\sigma_{DFRE}$: DFREI=6 | 1.0 | 1.25 | 1.5 | 1.75 | 2.0 | 2.25 | 2.5 | 2.75 | 3.0 | 3.25 | 3.5 | 3.75 | 4.0 | 4.25 | 4.5 | 4.75 |
| $\sigma_{DFRE}$: DFREI=7 | 1.25 | 1.5 | 1.75 | 2 | 2.25 | 2.5 | 2.75 | 3 | 3.25 | 3.5 | 3.75 | 4 | 4.25 | 4.5 | 4.75 | 5 |
| $\sigma_{DFRE}$: DFREI=8 | 1.5 | 1.75 | 2.0 | 2.25 | 2.5 | 2.75 | 3.0 | 3.25 | 3.5 | 3.75 | 4.0 | 4.25 | 4.5 | 4.75 | 5.0 | 5.25 |
| $\sigma_{DFRE}$: DFREI=9 | 1.75 | 2.0 | 2.25 | 2.5 | 2.75 | 3.0 | 3.25 | 3.5 | 3.75 | 4.0 | 4.25 | 4.5 | 4.75 | 5.0 | 5.25 | 5.5 |
| $\sigma_{DFRE}$: DFREI=10 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 | 6.0 | 6.5 | 7.0 | 7.5 | 8.0 | 8.5 | 9.0 | 9.5 |
| $\sigma_{DFRE}$: DFREI=11 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 | 6.0 | 6.5 | 7.0 | 7.5 | 8.0 | 8.5 | 9.0 | 9.5 | 10.0 |
| $\sigma_{DFRE}$: DFREI=12 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 | 16.0 | 17.0 | 18.0 |
| $\sigma_{DFRE}$: DFREI=13 | 4.0 | 7.0 | 10.0 | 13.0 | 16.0 | 19.0 | 22.0 | 25.0 | 28.0 | 31.0 | 34.0 | 37.0 | 40.0 | 43.0 | 46.0 | 49.0 |
| $\sigma_{DFRE}$: DFREI=14 | 10.0 | 16.0 | 22.0 | 28.0 | 34.0 | 40.0 | 46.0 | 52.0 | 58.0 | 64.0 | 70.0 | 76.0 | 82.0 | 88.0 | 94.0 | 100.0 |
| $\sigma_{DFRE}$: DFREI=15 | DO NOT USE THIS SATELLITE IN SBAS MODE | | | | | | | | | | | | | | | |

*Note.— All parameters are broadcast in the Type 37 message.*

3.5.11.5 *SBAS satellite Clock-Ephemeris Corrections and Covariance Matrix parameters*. The SBAS satellite Clock Ephemeris Corrections and Covariance data shall consist of:

*Note 1.— Due to the size of the clock and ephemeris information, the data is distributed over two messages: Type 39 and 40 messages*

*Issue of Data Geo (IODG)* is an Issue of Data indicator that links Type 39 and 40 messages.
*Note 2. – Each message of a paired Type 39/40 message set contains the same 2-bit IODG.*

*SBAS service provider ID*: identifies the SBAS service provider responsible for the signal broadcast by the SBAS satellite. It is defined as in Table B-23.

*Keplerian parameters* are the SBAS broadcasting satellite ephemeris information, where:

a) $C_{uc}$ is the amplitude of cosine harmonic correction terms to the argument of latitude,
b) $C_{us}$ is the amplitude of sine harmonic correction terms to the argument of latitude,
c) $I_{dot}$ is the rate of inclination angle,
d) a is the semi-major axis,
e) ω is the argument of perigee,
f) $\Omega_0$ is longitude of ascending node of orbital plane at $t_e$,
g) $M_0$ is the mean anomaly at $t_e$,
h) I is the inclination at $t_e$,
i) e is the eccentricity, and

*Satellite Slot Delta* identifies the broadcasting SBAS satellite by its position in the SBAS section of the satellite slot numbers in Table B-91.

*Note 3.— The effective range of the Satellite Slot Delta is 1 to 39 mapping the satellite slot number 120 to 158.*

*Note 4.— A satellite slot delta of 0 is used in the Type 47 message to indicate no almanac data follows.*

*SBAS ephemeris time $t_e$* is the time of applicability of the ephemeris message in seconds of day.

*Clock Parameters* are provided for ionosphere free position are as follows:
a) $a_{Gf0}$ is the clock offset
b) $a_{Gf1}$ is the clock rate

*Scale exponent:* See section 3.5.11.2.

*Covariance Matrix:* The covariance matrix terms are defined in 3.5.11.2

*DFREI* is the Dual Frequency Error Indicator is defined in section 3.5.11.2

*$\delta R_{CORR}$ :* See section 3.5.11.2.

*Note 5.— All parameters are broadcast in a combined Type 39 and Type 40 messages.*

3.5.11.6 *GNSS time offsets parameters.* The GNSS time parameters shall be as follows.

*The common UTC parameters* for all GNSS systems are:
a) $A_{1SNT}$ is drift coefficient of the SBAS Network Time scale for DFMC SBAS relative to UTC,
b) $A_{0SNT}$ is the bias coefficient of the SBAS Network Time scale for DFMC SBAS relative to UTC time scale,
c) $t_{0t}$ is the time data reference Time of Week,
d) $WN_t$ is the time data reference Week Number,
e) $\Delta t_{LS}$ is the current or past leap second count,
f) $WN_{LSF}$ is the leap second reference Week Number
g) DN is the leap second reference Day Number,
h) $\Delta t_{LSF}$ is the current or future leap second count, and
i) UTC Standards Identifier (the UTC Standards Identifier is defined in section 3.5.4.8).

*Note 1.— All parameters are broadcast in a Type 42 message.*

*Note 2. — It is not intended that Type 42 message is used for positioning services with integrity as no integrity budget is defined in SBAS system for the time offset parameters.*

3.5.11.7 *SBAS satellite parameters.* The SBAS satellite parameters shall be as follows:

*Satellite Slot Delta*: See section 3.5.11.5.

*SBAS service provider ID*: See section 3.5.11.5.

*Broadcast Indicator:* when set to 1, it identifies the almanac data of the broadcasting satellite. It is set to 0 otherwise

*Almanac parameters*: are broadcast using Keplerian parameters, with the following information:

a) a is the semi-major axis,
b) e is the eccentricity,
c) I is the inclination,
d) ω is the argument of perigee,
e) $\Omega_0$ is the longitude of ascending node of orbital plane at beginning of week.
f) $\dot{\Omega}$ is the rate of right ascension of the ascending node ,
g) $M_0$ is the mean anomaly at $t_a$, and
h) $t_a$ is SBAS almanac time being the almanac reference epoch in seconds of day.

*Week number roll-over count* ($WNRO_{count}$) is the number of week number roll-overs already elapsed for the GNSS constellation identified by the Time Reference Identifier. $WNRO_{count}$ value of 15 is used to indicate that the parameter is not valid and will be updated. The starting time per constellation with respect to UTC is:

a) For GPS: midnight on the night of 5 January 1980 / morning of 6 January 1980 (see section 3.1.4)
b) For GLONASS: Midnight between 31 December 1995 and 1 January 1996 (see section TBD)
c) For Galileo: 13 seconds before midnight between 21 august 1999 and 22 august 1999 (see section 3.3.5.1).
d) For BDS: Midnight on the night of 31 December 2005 / morning of 1 January 2006 (see section TBD)

*Note 1.— All parameters are broadcast in a Type 47 message.*

*Note 2.— Type 47 provides the capacity to transmit the SBAS almanacs parameters of 2 SBAS satellites.*

## 3.5.12 DEFINITION OF PROTOCOL FOR L5 DATA APPLICATION

*Note.— This section provides the definitions of parameters used by SBAS (non-aircraft and aircraft elements) that are needed to compute the navigation solution and associated integrity (protection levels).*

### 3.5.12.1 Constants used in SBAS L5 data protocol

The conventional values to be used for the computation of the earth-fixed coordinates of the space vehicle antenna phase centre are:

a) π is the ratio of a circle's circumference to its diameter. It takes the value of 3.1415926535898

b) $\mu$ is the earth gravitational parameter. It takes the value of 3.986005 x $10^{14}$ $m^3/s^2$

c) $\dot{\Omega}_e$ is the earth rotation rate. It takes the value of 7.2921151467 x $10^{-5}$ rad/s

d) c is the speed of light in vacuum. It takes the value of 299 792 458 m/s.

*Note.— The values of these parameters are not broadcast by SBAS, but use of the correct values is necessary to ensure interoperability between different SBAS implementations.*

### 3.5.12.2 Determination of SBAS satellite position based on its almanac

The parameters described in section 3.5.11.7 are used in the computation of the SBAS satellite position based on its almanac such as:

| | |
|---|---|
| $t_a$: | SBAS almanac time being the reference epoch of the almanac (s) as a time of day |
| a: | semi-major axis (m) |
| e: | eccentricity (dimensionless) |
| $M_0$: | mean anomaly (rad) at $t_a$ |
| ω: | argument of perigee (rad) |
| I: | inclination angle (rad) |
| $\Omega_0$: | longitude of ascending node of orbital plane at beginning of week (rad) |
| $\dot{\Omega}$ : | rate of right ascension of the ascending node (rad/s) |

The computation of the SBAS satellite position is made for the epoch t, expressed in the SBAS Network Time frame for DFMC SBAS. The "almanac reference epoch" is broadcast as a time-of-day through $t_a$. The SBAS users need to account for the truncated nature of the $t_a$ parameter.

#### 3.5.12.2.1 Computation of the mean anomaly ($M_t$)

The mean anomaly ($M_t$) at the epoch t is computed as:

$$M_t = M_0 + n_0 \Delta_t$$

With:

$$n_0 = \sqrt{\frac{\mu}{a^3}}$$

and

$$\Delta_t = t - t_a$$

*Note.— The SBAS user needs to ensure that t and ta have the same time reference when computing Δt. The broadcast parameter ta being a time of day, conversion will need to occur to account for day or week changes.*

#### 3.5.12.2.2 Computation of the eccentric anomaly ($E_t$)

The eccentric anomaly ($E_t$) for epoch t is computed solving:

$$M_t = E_t - e \sin(E_t)$$

*Note.— This equation may be solved by iteration*

#### 3.5.12.2.3 Computation of the argument of latitude ($\Phi_t$)

The eccentric anomaly (Φt) for epoch t is computed as:

$$\phi_t = v_t + \omega$$

With $v_t$ being the true anomaly at epoch t:

$$v_t = \tan^{-1}\left[\frac{(\sin E_t)\sqrt{1-e^2}}{(\cos E_t) - e}\right]$$

3.5.12.2.4 Computation of the coordinates in the orbital plane ($\mathbf{x'_t}$;$\mathbf{y'_t}$)

The coordinates in the orbital plane ($x'_t$;$y'_t$) for epoch t is computed as:

$$x'_t = r_t \cos\phi_t$$
$$y'_t = r_t \sin\phi_t$$

With $r_t$ being the orbit radius at epoch t:

$$r_t = a * [1 - (e\cos E_t)]$$

3.5.12.2.5 Computation of the space vehicle fixed earth's coordinates ($x_t$**;** $y_t$; $z_t$**)**

The space vehicle fixed earth's coordinates ($x_t$; $y_t$; $z_t$) for epoch t is computed as:

$$x_t = (x'_t \cos\Omega_t) - (y'_t \cos I \sin\Omega_t)$$
$$y_t = (x'_t \sin\Omega_t) + (y'_t \cos I \cos\Omega_t)$$
$$z_t = y'_t \sin I$$

With $\mathbf{\Omega_t}$ being the corrected longitude of the ascending node at epoch t:

$$\Omega_t = \Omega_0 + \left[\left(\dot{\Omega} - \dot{\Omega}_e\right)\Delta_t\right] - \left(\dot{\Omega}_e t_{aTOW}\right)$$

Where $t_{aTOW}$ is $t_a$ expressed in seconds as a time of week (or elapsed time since the beginning of the almanac week).

3.5.12.3 Determination of SBAS satellite position based on its ephemeris

The parameters described in section 3.5.11.5 are used in the computation of the SBAS satellite position based on its ephemeris such as:

$t_e$ : SBAS ephemeris time being the reference epoch of the ephemeris (s) as a time of day
a: semi-major axis (m)
e: eccentricity (dimensionless)
$M_0$: mean anomaly (rad) at $t_e$
ω: argument of perigee (rad)
I: inclination angle at $t_e$ (rad)
$I_{dot}$: rate of inclination angle (rad/s)
$\Omega_0$: longitude of the ascending node of orbital plane at $t_e$ (rad)
$C_{uc}$: amplitude of the cosine harmonic correction to the argument of latitude (rad)
$C_{us}$: amplitude of the sine harmonic correction to the argument of latitude (rad)

The computation of the SBAS satellite position is made for the epoch t, expressed in the SBAS Network Time frame for DFMC SBAS. The "ephemeris reference epoch" is broadcast as a time-of-day through $t_e$. The SBAS users need to account for the truncated nature of the $t_e$ parameter.

3.5.12.3.1 Computation of the mean anomaly ($M_t$)

The mean anomaly ($M_t$) at the epoch t is computed as:

$$M_t = M_0 + n_0\Delta_t$$

With:

$$n_0 = \sqrt{\frac{\mu}{a^3}}$$

and

$$\Delta_t = t - t_e$$

*Note.— The SBAS user needs to ensure that t and $t_e$ have the same time reference when computing Δt. The broadcast parameter $t_e$ being a time of day, a conversion will be needed to account for day or week changes.*

3.5.12.3.2 Computation of the eccentric anomaly ($E_t$)

The eccentric anomaly ($E_t$) for epoch t is computed solving:

$$M_t = E_t - e\sin(E_t)$$

*Note.— This equation may be solved by iteration*

3.5.12.3.3 Computation of the argument of latitude ($\Phi_t$)

The eccentric anomaly ($\Phi_t$) for epoch t is computed as:

$$\phi_t = v_t + \omega$$

With $v_t$ being the true anomaly at epoch t:

$$v_t = \tan^{-1}\left[\frac{(\sin E_t)\sqrt{1-e^2}}{(\cos E_t) - e}\right]$$

3.5.12.3.4 Computation of the corrected argument of latitude ($u_t$)

The corrected argument of latitude ($u_t$) for epoch t is computed as:

$$u_t = \phi_t + \delta u_t$$

With $\delta u_t$ being the argument of latitude second harmonic perturbation at epoch t:

$$\delta u_t = [cu_s \sin(2\phi_t)] + [cu_c \cos(2\phi_t)]$$

3.5.12.3.5 Computation of the coordinates in the orbital plane ($\mathbf{x'_t}$;$\mathbf{y'_t}$)

The coordinates in the orbital plane ($x'_t$;$y'_t$) for epoch t is computed as:

$$x'_t = r_t \cos u_t$$
$$y'_t = r_t \sin u_t$$

With $r_t$ being the orbit radius at epoch t:

$$r_t = a[1 - (e\cos E_t)]$$

3.5.12.3.6 Computation of the space vehicle fixed earth's coordinates ($x_t$**;** $y_t$; $z_t$**)**

The space vehicle fixed earth's coordinates (**$x_t$;** $y_t$; $z_t$) for epoch t is computed as:

$$x_t = (x'_t \cos\Omega_t) - (y'_t \cos i_t \sin\Omega_t)$$
$$y_t = (x'_t \sin\Omega_t) + (y'_t \cos i_t \cos\Omega_t)$$
$$z_t = y'_t \sin i_t$$

With $\mathbf{\Omega_t}$ being the corrected longitude of the ascending node at epoch t:

$$\Omega_t = \Omega_0 - (\dot{\Omega}_e \Delta_t)$$

And $i_t$ being the corrected inclination for epoch t:

$$i_t = I + (I_{dot}\Delta_t)$$

*Note 1.— The Sagnac correction (Earth's rotation) need to be taken into account.*

*Note 2.— The rate of right ascension of the ascending node is assumed to be zero.*

3.5.12.4 SBAS DFMC Navigation Solution

*Note 1.— Section 3.5.12.4 provides formulas for the SBAS DFMC navigation solution of an SBAS system augmenting 2 core constellations, Constellation 1 and Constellation 2.*

*a) Constellation 1 is the constellation used as time referenced for SNT for DFMC SBAS identified through the Time Reference Identifier under MT37 (see section 3.5.11.4).*

*b) If more than two constellations are being augmented, then equations need to be updated by adding "N-2" columns in the G matrix, where "N" (N being equal to 3 or 4) is the number of constellations being augmented.*

*c) When only one constellation is being augmented, the navigation position is derived solving only the clock bias of the used constellation. It reduces the size of $\hat{X}$, defined below, by 1 removing the second clock bias unknown*

The weighted least square navigation solution takes the following form:

$$\hat{X} = (G^T \cdot W \cdot G)^{-1} \cdot G^T \cdot W \cdot Y$$

Where

a) $\hat{X}$ is the weighted least square estimate of the error in the estimated location of the user about which the linearization has been made:

$$X = [x, y, z, ct_{C1}, ct_{C1\text{-}C2}]$$

With

$t_{C1}$ is the clock bias of the receiver with respect to Constellation 1 reference time;

$t_{C1\text{-}C2}$ is the time difference observed by the receiver between the reference constellation 2 and the constellation 1, namely $t_{C1\text{-}C2} = t_{C2} - t_{C1}$;

b) Y is the P dimensional vector containing the corrected ionosphere free pseudorange measurements $PR_{i,corrected}$, minus the expected ranging values based on the location of the satellites and the estimated location of the user (X).

With

P being the number of satellites used in the navigation solution;

$PR_{i,corrected}$ being the corrected ionosphere free pseudorange measurement for the satellite i computed as follows:

$$PR_{i,corrected}(t) = PR_{i,measured}(t) + c \cdot (\delta\Delta t_{SV,i} + \Delta t_{SV,i}) + TC_i$$

With

$PR_{i,measured}(t)$ being the ionosphere-free measurement computed as indicated in 3.5.15.1.1.2.

$\delta\Delta t_{SV}$ being the time error estimate at time t computed with the parameters described in section 3.5.11.2 as follows:

$$c * \delta\Delta t_{SV} = \delta B + \delta\dot{B}(t - t_D)$$

$\Delta t_{SV}$ being the satellite time correction described in section 3.5.15.1.1.2.

$TC_i$ being the tropospheric correction as defined in section 3.5.5.3;

$t_D$ being the reference time of the corrections.

The satellite position error correction vector [δx(t), δy(t), δz(t)] is expressed in the WGS-84 ECEF coordinate frame as follows and is added to the satellite coordinate vector [x(t), y(t), z(t)].

$$\begin{bmatrix}\delta x(t)\\ \delta y(t)\\ \delta z(t)\end{bmatrix} = \begin{bmatrix}\delta x\\ \delta y\\ \delta z\end{bmatrix} + \begin{bmatrix}\delta\dot{x}\\ \delta\dot{y}\\ \delta\dot{z}\end{bmatrix}(t - t_D)$$

With $\delta x$, $\delta y$, $\delta z$, $\delta\dot{x}$, $\delta\dot{y}$ and $\delta\dot{z}$ defined in section 3.5.11.2.

*Note 2.— The SBAS user needs to ensure that t and $t_D$ have the same time reference when computing t-$t_D$. The broadcast parameter $t_D$ being a time of day, a conversion will be needed to account for day or week changes.*

*Note 3.— In case of SBAS ranging, for the SBAS ionosphere-free measurements of the SBAS providing the correction and integrity information, the time error estimate $\delta\Delta t_{SV}$ is zero as there is no correction provided for this satellite.*

c) G is the observation matrix:

$$G_i = [-\cos El_i \cdot \sin Az_i \quad -\cos El_i \cdot \cos Az_i \quad -\sin El_i \quad 1 \quad n_i] = i^{th} \text{ row of } G$$

With

$El_i$ being the elevation for satellite i after correction of its position using the parameters described in section 3.5.11.2;

$Az_i$ being the azimuth for satellite i after correction of its position using the parameters transmitted described in section 3.5.11.2. The positive azimuth is defined clockwise from North.

$n_i$ being ‘0’ if satellite is part of reference constellation C1 or ‘1’ if satellite is part of constellation C2.

*Note 4.— When augmenting 3 or more constellations , $G_i$ and X need to be expanded to account for the additional constellations reference times. Additional information is available in guidance material, attachment D section 6.7.13.*

*Note 5.— The DFMC SBAS standards have no provisions for the augmentation of DFMC SBAS ranging signals from other service providers.*

d) W is weighting matrix:

$$W = \begin{bmatrix} w_1 & 0 & \dots & 0 \\ 0 & w_2 & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \dots & w_P \end{bmatrix}$$

With

$$w_i = 1/\sigma_i^2$$

And

$$\sigma_i^2 = \sigma_{i,DFC}^2 + \sigma_{i,tropo}^2 + \sigma_{i,air\_DF}^2 + \sigma_{i,iono}^2$$

Where

$\sigma_{i,DFC}^2$ is the model variance for the residual error associated to SBAS corrections for satellite i as defined in section 3.5.12.4.1.

$\sigma_{i,tropo}^2$ is the model variance for the troposphere residual error for satellite i, as defined in section 3.5.8.4.2.5.

$\sigma_{i,air\_DF}^2$ is the model variation for the combined measurement noise and multipath residual errors applicable to the ionosphere-free combination of dual-frequency range measurements (see section 3.5.15.3.4.2) for satellite i

$\sigma_{i,iono}^2$ is the model variance for the ionosphere-free residual error for satellite i, as defined in section 3.5.15.3.4.3.

3.5.12.4.1 Computation of the model variance for the residual error associated to SBAS corrections $\boldsymbol{\sigma_{DFC}^2}$

*Note.— The following calculations are done for each satellite, for convenience the index i used in 3.5.12.4 has been dropped from the equations.*

The user location factor ($\delta_{DFRE}$) is obtained via the clock ephemeris covariance matrix C as follows:

$$C = R^T R$$

With

$$R = 2^{(\text{scale exponent} -5)} \begin{bmatrix} E_{1,1} & E_{1,2} & E_{1,3} & E_{1,4} \\ 0 & E_{2,2} & E_{2,3} & E_{2,4} \\ 0 & 0 & E_{3,3} & E_{3,4} \\ 0 & 0 & 0 & E_{4,4} \end{bmatrix}$$

Then

$$\delta_{DFRE} = \sqrt{I^T C I} + \varepsilon_C$$

With

| | |
|---|---|
| I | being the 4-D line of sight vector from the user to the satellite in the WGS-84 coordinate frame, where the first three components are the unit vector from the user to the satellite and the fourth component is a one |
| $\varepsilon_C$ | being derived from $C_{COVARIANCE}$ (defined in section 3.5.11.4) as: $\varepsilon_C = C_{COVARIANCE} 2^{scale\ exponent-5}$ |
| Scale exponent | being defined in section 3.5.11.2 transmitted through Type 32 message for core constellation satellite and Type 40 message for SBAS satellite. |

The model variance for the residual error associated to SBAS corrections($\sigma^2_{DFC}$) at the time t is computed using the SBAS corrections parameters described in sections 3.5.11.2 (for core constellations satellites) and 3.5.11.5 (for SBAS satellite) associated to the OBAD parameters described in section 3.5.11.4 as follows:

$$\sigma^2_{DFC} = (\sigma_{DFRE} * \delta_{DFRE})^2 + \varepsilon^2_{corr} + \varepsilon^2_{er}$$

And

$$\varepsilon^2_{corr} = \left\lfloor \frac{t - t_{CORR}}{I_{CORR}} \right\rfloor C_{CORR} + (t - t_{CORR}) \frac{(R_{CORR})_{SV}}{1000}$$

With

| | |
|---|---|
| $\sigma_{DFRE}$ | being the standard deviation of the residual ionosphere-free clock and ephemeris range error as defined in section 3.5.11.4. |
| $\varepsilon_{CORR}$ | being the degradation parameter for corrections |
| $\varepsilon_{er}$ | being the degradation parameter for en-route through non-precision approach applications. It is equal to 0 if the corrections have not timed out for approach applications (APV-I or CAT-I). It is equal to $C_{er}$ (see section 3.5.11.4) if the corrections have timed out for approach application but still valid for en-route through non-precision approach applications. |
| $t_{CORR}$ | being the time of reception (being the time of arrival at the antenna port of the last bit of the message) of the latest satellite or SBAS clock ephemeris correction information received mapping with the satellite ephemeris. |
| $I_{CORR}$ | being the time interval for application of $C_{CORR}$ (see section 3.5.11.4) |
| $C_{CORR}$ | being the step degradation parameter for precision approach applications (see section 3.5.11.4) |
| $(R_{CORR})_{SV}$ | being the satellite specific degradation factor computed from $R_{CORR}$ (see section 3.5.11.4) and $\delta R_{CORR}$ as in section 3.5.11.2 (for the augmented satellites) or in section 3.5.11.5 (for SBAS): If $t - t_{CORR} \le I_{CORR}$, then $(R_{CORR})_{SV} = R_{CORR}\delta R_{CORR}$ If $t - t_{CORR} > I_{CORR}$, then $(R_{CORR})_{SV} = R_{CORR}$ |
| $\lfloor x \rfloor$ | being the floor or greater integer less than x |

3.5.12.5 Protection level calculation

For a general least squares position solution, the projection matrix S is defined as:

$$S = \begin{bmatrix} s_{east,1} & s_{east,2} & \cdots & s_{east,P} \\ s_{north,1} & s_{north,2} & \cdots & s_{north,P} \\ s_{U,1} & s_{U,2} & \cdots & s_{U,P} \\ s_{t_{C_1},1} & s_{t_{C_1},2} & \cdots & s_{t_{C_1},P} \\ s_{t_{C_1C_2},1} & s_{t_{C_1C_2},2} & \cdots & s_{t_{C_1C_2},P} \end{bmatrix} = (G^T \cdot W \cdot G)^{-1} \cdot G^T \cdot W$$

With

G being the observation matrix defined in 3.5.12.4.
W being the weighting matrix defined in 3.5.12.4.

The horizontal (HPL) and vertical protection levels (VPL) are computed as follows:

$$HPL = K_H d_{major}$$

$$VPL = K_V d_U$$

Where

$$K_H = \begin{cases} 6.18 & \text{for en route through non precision approach operations} \\ 6.0 & \text{for APV} - \text{I and CAT} - \text{I operations} \end{cases}$$

$$K_V = 5.33$$

$d_{major}$ is the error uncertainty along the semi-major axis of the error ellipse defined as

$$d_{major} \equiv \sqrt{\frac{d_{east}^2 + d_{north}^2}{2} + \sqrt{\left(\frac{d_{east}^2 - d_{north}^2}{2}\right)^2 + d_{EN}^2}}$$

$d_U$ is the variance of model distribution that over bounds the true error distribution in the vertical axis defined as:

$$d_U^2 = \sum_{i=1}^{P} s_{U,i}^2 \sigma_i^2$$

With

$d_{east}^2$ being the variance of model distribution that over bounds the true error distribution in the east axis:

$$d_{east}^2 = \sum_{i=1}^{P} s_{east,i}^2 \sigma_i^2$$

$d_{north}^2$ being the variance of model distribution that over bounds the true error distribution in the north axis:

$$d_{north}^2 = \sum_{i=1}^{P} s_{north,i}^2 \sigma_i^2$$

$d_{EN}$ being the covariance of model distribution in the east and north axis:

$$d_{EN} = \sum_{i=1}^{P} s_{east,i} s_{north,i} \sigma_i^2$$

$s_{east,i}$ being the partial derivative of position error in the east direction with respect to the pseudorange error on the $i^{th}$ satellite.

$s_{north,i}$ being the partial derivative of position error in the north direction with respect to the pseudorange error on the $i^{th}$ satellite.

$s_{U,i}$ being the partial derivative of position error in the vertical direction with respect to the pseudorange error on the $i^{th}$ satellite.

$\sigma_i$ being defined in section 3.5.12.4.

### 3.5.13 DFMC SBAS MESSAGE TABLES

Each SBAS message shall be coded in accordance with the corresponding message format defined in Tables B-94 through B-106. All signed parameters in these tables shall be represented in two's complement, with the sign bit occupying the MSB.

**Table B-94. Type 0 "Do Not Use" message broadcast on L5**

| Section | Name | Length | Scale factor | Effective Range min | Effective Range max | Unit | Comment |
|---|---|---|---|---|---|---|---|
| Spare | Spare bit | 216 | - | - | - | - | |

*Note 1.— This message is the equivalent of the SBAS L1 Type 0 message but with application for the messages broadcast on L5 only.*
*Note 2.— When broadcast it indicates that the signal doesn't support safety-of-life operation. SBAS may broadcast any message type in each Type 0 message.*

**Table B-95. Type 31 SBAS Satellite Mask**

| Section | Name | Length | Scale factor | Effective Range min | Effective Range max | Unit | Comment |
|---|---|---|---|---|---|---|---|
| GPS mask | Satellite Slot Number 1 | 1 | 1 | 0 | 1 | - | Bit for 1st GPS satellite |
| | to Satellite Slot Number 32 | 1 | 1 | 0 | 1 | - | to Bit for 32nd GPS satellite |
| | Satellite Slot Number 33 | 1 | 1 | 0 | 1 | - | GPS reserved, bit 1 |
| | to Satellite Slot Number 37 | 1 | 1 | 0 | 1 | - | to GPS reserved, bit 5 |
| GLONASS mask | Satellite Slot Number 38 | 1 | 1 | 0 | 1 | - | Bit for 1st GLONASS satellite |
| | to Satellite Slot Number 69 | 1 | 1 | 0 | 1 | - | to Bit for 32nd GLONASS satellite |
| | Satellite Slot Number 70 | 1 | 1 | 0 | 1 | - | GLONASS reserved, bit 1 |
| | to Satellite Slot Number 74 | 1 | 1 | 0 | 1 | - | to GLONASS reserved, bit 5 |
| Galileo mask | Satellite Slot Number 75 | 1 | 1 | 0 | 1 | - | Bit for 1st Galileo satellite |
| | to Satellite Slot Number 110 | 1 | 1 | 0 | 1 | - | to Bit for 36th Galileo satellite |
| | Satellite Slot Number 111 | 1 | 1 | 0 | 1 | - | Galileo reserved |
| Spare | Satellite Slot Number 112 | 1 | 1 | 0 | 1 | - | |
| | to Satellite Slot Number 119 | 1 | 1 | 0 | 1 | - | |
| SBAS mask | Satellite Slot Number 120 | 1 | 1 | 0 | 1 | - | Bit for 1st GEO SBAS satellite |
| | to Satellite Slot Number 158 | 1 | 1 | 0 | 1 | - | to Bit for 39th GEO SBAS satellite |
| BeiDou mask | Satellite Slot Number 159 | 1 | 1 | 0 | 1 | - | Bit for 1st BeiDou satellite |
| | to Satellite Slot Number 195 | 1 | 1 | 0 | 1 | - | to Bit for 37th BeiDou satellite |
| Reserved | Satellite Slot Number 196 | 1 | 1 | 0 | 1 | - | reserved, bit 1 |
| | to Satellite Slot Number 207 | 1 | 1 | 0 | 1 | - | to reserved, bit 12 |
| Spare | Satellite Slot Number 208 | 1 | 1 | 0 | 1 | - | |
| | to Satellite Slot Number 214 | 1 | 1 | 0 | 1 | - | |
| IOD | IODM | 2 | 1 | 0 | 3 | - | |

*Note.— All parameters are defined in 3.5.11.1*

**Table B-96 Type 32 Satellite Clock-Ephemeris Corrections and covariance matrix**

| Section | Name | Length | Scale factor | Effective Range | | Unit | Comment |
|---|---|---|---|---|---|---|---|
| | | | | min | max | | |
| Message Header | Satellite slot number | 8 | 1 | 1 | 214 | - | Coding range exceeds the effective range (0 to 255) |
| | IODN | 10 | 1 | 0 | 1023 | - | |
| Orbit param. | $\delta x_{(ECEF)}$ | 11 | 0.0625 | -64 | 63.9375 | m | Coded as two's complement |
| | $\delta y_{(ECEF)}$ | 11 | 0.0625 | -64 | 63.9375 | m | Coded as two's complement |
| | $\delta z_{(ECEF)}$ | 11 | 0.0625 | -64 | 63.9375 | m | Coded as two's complement |
| | $\delta B_{(ECEF)}$ | 12 | 0.03125 | -64 | 63.96875 | m | Coded as two's complement |
| | $\delta \dot{x}_{(ECEF)}$ | 8 | $2^{-11}$ | -0.0625 | 0.06201171875 | m/s | Coded as two's complement |
| | $\delta \dot{y}_{(ECEF)}$ | 8 | $2^{-11}$ | -0.0625 | 0.06201171875 | m/s | Coded as two's complement |
| | $\delta \dot{z}_{(ECEF)}$ | 8 | $2^{-11}$ | -0.0625 | 0.06201171875 | m/s | Coded as two's complement |
| | $\delta \dot{B}_{(ECEF)}$ | 9 | $2^{-12}$ | -0.0625 | 0.062255859375 | m/s | Coded as two's complement |
| | $t_D$ | 13 | 16 | 0 | 86384 | s | Coding range exceeds the effective range (0 to 131056) |
| Covariance param. | Scale exponent | 3 | 1 | 0 | 7 | - | |
| | $E_{1,1}$ | 9 | 1 | 0 | 511 | - | |
| | $E_{2,2}$ | 9 | 1 | 0 | 511 | - | |
| | $E_{3,3}$ | 9 | 1 | 0 | 511 | - | |
| | $E_{4,4}$ | 9 | 1 | 0 | 511 | - | |
| | $E_{1,2}$ | 10 | 1 | -512 | 511 | - | Coded as two's complement |
| | $E_{1,3}$ | 10 | 1 | -512 | 511 | - | Coded as two's complement |
| | $E_{1,4}$ | 10 | 1 | -512 | 511 | - | Coded as two's complement |
| | $E_{2,3}$ | 10 | 1 | -512 | 511 | - | Coded as two's complement |
| | $E_{2,4}$ | 10 | 1 | -512 | 511 | - | Coded as two's complement |
| | $E_{3,4}$ | 10 | 1 | -512 | 511 | - | Coded as two's complement |
| Integrity param. | DFREI | 4 | 1 | 0 | 15 | - | |
| $\delta R_{CORR}$ | $R_{CORR}$ scale factor | 4 | 1/15 | 0 | 1 | - | |

*Note 1. — . This message contains the correction parameters for a single satellite identified by the Satellite Slot parameter.*

*Note 2. — . All parameters are defined in 3.5.11.2.*

**Table B-97. Type 34 Integrity Information Message**

| Section | Name | Length | Scale factor | Effective Range | | Unit | Comment |
|---|---|---|---|---|---|---|---|
| | | | | min | max | | |
| DFRECI | DFRECI 1 | 2 | 1 | 0 | 3 | - | |
| | to DFRECI 92 | 2 | 1 | 0 | 3 | - | |
| DFREI | DFREI 1 | 4 | 1 | 0 | 15 | - | |
| | to DFREI 7 | 4 | 1 | 0 | 15 | - | |
| Reserved | Reserved | 2 | - | - | - | - | |
| IOD | IODM | 2 | 1 | 0 | 3 | - | |

*Note 1.— DFREI is defined in 3.5.11.2*
*Note 2.— IODM is defined in 3.5.11.1*
*Note 3.— DFRECI is defined in 3.5.11.3*
*Note 4.— Spare bits can take any value. See Attachment D section TBD for further guidance*

**Table B-98. Type 35 Integrity Information Message**

| Section | Name | Length | Scale factor | Effective Range | | Unit | Comment |
|---|---|---|---|---|---|---|---|
| | | | | min | max | | |
| DFREI | DFREI 1 | 4 | 1 | 0 | 15 | - | |
| | to DFREI 53 | 4 | 1 | 0 | 15 | - | |
| Reserved | Reserved | 2 | - | - | - | - | |
| IOD | IODM | 2 | 1 | 0 | 3 | - | |

*Note 1.— DFREI is defined in 3.5.11.2*
*Note 2.— IODM is defined in 3.5.11.1*
*Note 3.— Spare bits can take any value. See Attachment D section TBD for further guidance*

**Table B-99. Type 36 Integrity Information Message**

| Section | Name | Length | Scale factor | Effective Range | | Unit | Comment |
|---|---|---|---|---|---|---|---|
| | | | | min | max | | |
| DFREI | DFREI 54 | 4 | 1 | 0 | 15 | - | |
| | to DFREI 92 | 4 | 1 | 0 | 15 | - | |
| Spare | Spare Bits | 56 | - | - | - | - | |
| Reserved | Reserved | 2 | - | - | - | - | |
| IOD | IODM | 2 | 1 | 0 | 3 | - | |

*Note 1.— DFREI is defined in 3.5.11.2*
*Note 2.— IODM is defined in 3.5.11.1*
*Note 3.— Spare bits can take any value. See Attachment D section TBD for further guidance*

**Table B-100. Type 37 Degradation Parameters and DFREI scale table**

| Section | Name | Length | Scale factor | Effective Range min | Effective Range max | Unit | Comment |
|---|---|---|---|---|---|---|---|
| Common OBAD param. | $(I_{VALID})_{32}$ | 6 | 6 | 30 | 408 | s | |
| | $(I_{VALID})_{39/40}$ | 6 | 6 | 30 | 408 | s | |
| | $C_{ER}$ | 6 | 0.5 | 0 | 31.5 | m | |
| | $C_{COVARIANCE}$ | 7 | 0.1 | 0 | 12.7 | - | |
| GPS OBAD param. | $I_{CORR}$ | 5 | 6 | 30 | 216 | s | |
| | $C_{CORR}$ | 8 | 0.01 | 0 | 2.55 | m | |
| | $R_{CORR}$ | 8 | 0.2 | 0 | 51 | mm/s | |
| GLONASS OBAD param. | $I_{CORR}$ | 5 | 6 | 30 | 216 | s | |
| | $C_{CORR}$ | 8 | 0.01 | 0 | 2.55 | m | |
| | $R_{CORR}$ | 8 | 0.2 | 0 | 51 | mm/s | |
| Galileo OBAD param. | $I_{CORR}$ | 5 | 6 | 30 | 216 | s | |
| | $C_{CORR}$ | 8 | 0.01 | 0 | 2.55 | m | |
| | $R_{CORR}$ | 8 | 0.2 | 0 | 51 | mm/s | |
| BeiDou OBAD param. | $I_{CORR}$ | 5 | 6 | 30 | 216 | s | |
| | $C_{CORR}$ | 8 | 0.01 | 0 | 2.55 | m | |
| | $R_{CORR}$ | 8 | 0.2 | 0 | 51 | mm/s | |
| SBAS OBAD param. | $I_{CORR}$ | 5 | 6 | 30 | 216 | s | |
| | $C_{CORR}$ | 8 | 0.01 | 0 | 2.55 | m | |
| | $R_{CORR}$ | 8 | 0.2 | 0 | 51 | mm/s | |
| Reserved OBAD param. | $I_{CORR}$ | 5 | 6 | 30 | 216 | s | |
| | $C_{CORR}$ | 8 | 0.01 | 0 | 2.55 | m | |
| | $R_{CORR}$ | 8 | 0.2 | 0 | 51 | mm/s | |
| DFREI Scale Table | $\sigma_{DFRE}$: DFREI = 0 | 4 | 0.0625 | 0.125 | 1.0625 | m | |
| | $\sigma_{DFRE}$: DFREI = 1 | 4 | 0.125 | 0.25 | 2.125 | m | |
| | $\sigma_{DFRE}$: DFREI = 2 | 4 | 0.125 | 0.375 | 2.25 | m | |
| | $\sigma_{DFRE}$: DFREI = 3 | 4 | 0.125 | 0.5 | 2.375 | m | |
| | $\sigma_{DFRE}$: DFREI = 4 | 4 | 0.125 | 0.625 | 2.5 | m | |
| | $\sigma_{DFRE}$: DFREI = 5 | 4 | 0.25 | 0.75 | 4.5 | m | |
| | $\sigma_{DFRE}$: DFREI = 6 | 4 | 0.25 | 1 | 4.75 | m | |
| | $\sigma_{DFRE}$: DFREI = 7 | 4 | 0.25 | 1.25 | 5 | m | |
| | $\sigma_{DFRE}$: DFREI = 8 | 4 | 0.25 | 1.5 | 5.25 | m | |
| | $\sigma_{DFRE}$: DFREI = 9 | 4 | 0.25 | 1.75 | 5.5 | m | |
| | $\sigma_{DFRE}$: DFREI = 10 | 4 | 0.5 | 2 | 9.5 | m | |
| | $\sigma_{DFRE}$: DFREI = 11 | 4 | 0.5 | 2.5 | 10 | m | |
| | $\sigma_{DFRE}$: DFREI = 12 | 4 | 1 | 3 | 18 | m | |
| | $\sigma_{DFRE}$: DFREI = 13 | 4 | 3 | 4 | 49 | m | |
| | $\sigma_{DFRE}$: DFREI = 14 | 4 | 6 | 10 | 100 | m | |
| Time ref. ID | Time reference Identifier | 3 | 1 | 0 | 7 | - | |
| Spare | Spare | 2 | - | - | - | - | |

*Note 1 .— All information is defined in 3.5.11.4*
*Note 2.— Spare bits can take any value*

**Table B-101. Type 39 SBAS Satellite Clock, Ephemeris and Covariance Matrix - 1**

| Section | Name | Length | Scale factor | Effective Range | | Unit | Comment |
|---|---|---|---|---|---|---|---|
| | | | | min | max | | |
| Message Header | Satellite Slot Delta | 6 | 1 | 1 | 39 | - | Coding range exceeds the effective range (0 to 63) |
| | IODG | 2 | 1 | 0 | 3 | - | |
| | SBAS provider ID | 5 | 1 | 0 | 31 | - | |
| Orbit Parameters | $C_{uc}$ | 19 | $\pi \times 2^{-19} \times 10^{-4}$ | $-\pi/2 \times 10^{-4}$ | $\pi/2 \times 10^{-4} \times (1-2^{-18})$ | rad | Coded as two's complement |
| | $C_{us}$ | 19 | $\pi \times 2^{-19} \times 10^{-4}$ | $-\pi/2 \times 10^{-4}$ | $\pi/2 \times 10^{-4} \times (1-2^{-18})$ | rad | Coded as two's complement |
| | Idot | 22 | $7\pi/6 \times 2^{-21} \times 10^{-6}$ | $-7\pi/6 \times 10^{-6}$ | $7\pi/6 \times 10^{-6} \times (1-2^{-21})$ | rad/s | Coded as two's complement |
| | $\omega$ | 34 | $\pi \times 2^{-33}$ | $-\pi$ | $\pi \times (1-2^{-33})$ | rad | Coded as two's complement |
| | $\Omega_o$ | 34 | $\pi \times 2^{-33}$ | $-\pi$ | $\pi \times (1-2^{-33})$ | rad | Coded as two's complement |
| | $M_0$ | 34 | $\pi \times 2^{-33}$ | $-\pi$ | $\pi \times (1-2^{-33})$ | rad | Coded as two's complement |
| Clock param. | $a_{Gf0}$ | 25 | 0.02 | -292766.06 | 292766.06 | m | Coded as two's complement. Coding range exceeds the effective range (-335544.32 to 335544.30) |
| | $a_{Gf1}$ | 16 | $4 \times 10^{-5}$ | -1.31072 | 1.31068 | m/s | Coded as two's complement |

*Note 1.— All information is defined in 3.5.11.5*
*Note 2. — Section 3.5.9.6 limits* $a_{Gf0}$ *to ±292766.07m.*

**Table B-102. Type 40 SBAS Satellite Clock, Ephemeris and Covariance Matrix - 2**

| Section | Name | Length | Scale factor | Effective Range | | Unit | Comment |
|---|---|---|---|---|---|---|---|
| | | | | min | max | | |
| Message Header | IODG | 2 | 1 | 0 | 3 | - | |
| Orbit Parameters | I | 33 | $\pi \times 2^{-33}$ | 0 | $\pi \times (1-2^{-33})$ | rad | |
| | e | 30 | $2^{-30}$ | 0 | $1-2^{-30}$ | - | |
| | a | 31 | 0.02 | 6370000 | 49319672.94 | m | |
| SBAS Ephemeris Time | $t_e$ | 13 | 16 | 0 | 86384 | s | Coding range exceeds the effective range (0 to 131056) |
| Covariance param. | Scale exponent | 3 | 1 | 0 | 7 | | |
| | $E_{1,1}$ | 9 | 1 | 0 | 511 | - | |
| | $E_{2,2}$ | 9 | 1 | 0 | 511 | - | |
| | $E_{3,3}$ | 9 | 1 | 0 | 511 | - | |
| | $E_{4,4}$ | 9 | 1 | 0 | 511 | - | |
| | $E_{1,2}$ | 10 | 1 | -512 | 511 | - | Coded as two's complement |
| | $E_{1,3}$ | 10 | 1 | -512 | 511 | - | Coded as two's complement |
| | $E_{1,4}$ | 10 | 1 | -512 | 511 | - | Coded as two's complement |
| | $E_{2,3}$ | 10 | 1 | -512 | 511 | - | Coded as two's complement |
| | $E_{2,4}$ | 10 | 1 | -512 | 511 | - | Coded as two's complement |
| | $E_{3,4}$ | 10 | 1 | -512 | 511 | - | Coded as two's complement |
| Integrity param. | DFREI | 4 | 1 | 0 | 15 | - | |
| $\delta R_{CORR}$ | $R_{CORR}$ scale factor | 4 | 1/15 | 0 | 1 | - | |

*Note 1.— DFREI $\delta R_{CORR}$ are defined in section 3.5.11.2*
*Note 2.— All other information is defined in 3.5.11.5*

**Table B-103. Type 42 GNSS Time Offsets RESERVED**

**Table B-104. Type 47 SBAS Satellites Almanacs**

| Section | Name | Length | Scale factor | Effective Range | | Unit | Comment |
|---|---|---|---|---|---|---|---|
| | | | | min | max | | |
| SBAS I Header | Satellite slot delta | 6 | 1 | 0 | 39 | - | Coding range exceeds the effective range (0 to 63) |
| | SBAS provider ID | 5 | 1 | 0 | 31 | - | |
| | Broadcast Indicator | 1 | - | - | - | - | |
| SBAS I Keplerian param. | a | 16 | 650 | 6370000 | 48967750 | m | |
| | e | 8 | $2^{-8}$ | 0 | 0.99609375 | - | |
| | I | 13 | $\pi \times 2^{-13}$ | 0 | $\pi \times (1-2^{-13})$ | rad | |
| | $\omega$ | 14 | $\pi \times 2^{-13}$ | $-\pi$ | $\pi \times (1-2^{-13})$ | rad | Coded as two's complement |
| | $\Omega_0$ | 14 | $\pi \times 2^{-13}$ | $-\pi$ | $\pi \times (1-2^{-13})$ | rad | Coded as two's complement) |
| | $\dot{\Omega}$ | 8 | $1 \times 10^{-9}$ | $-1.28\times10^{-7}$ | $1.27\times10^{-7}$ | rad/s | Coded as two's complement) |
| | $M_0$ | 15 | $\pi \times 2^{-14}$ | $-\pi$ | $\pi \times (1-2^{-14})$ | rad | Coded as two's complement) |
| | $t_a$ | 6 | 1800 | 0 | 84600 | s | Coding range exceeds the effective range (0 to 113400) |
| SBAS II Header | Satellite slot delta | 6 | 1 | 0 | 39 | - | Coding range exceeds the effective range (0 to 63) |
| | SBAS provider ID | 5 | 1 | 0 | 31 | - | |
| | Broadcast Indicator | 1 | - | - | - | - | |
| SBAS II Keplerian param. | a | 16 | 650 | 6370000 | 48967750 | m | |
| | e | 8 | $2^{-8}$ | 0 | 0.99609375 | - | |
| | I | 13 | $\pi \times 2^{-13}$ | 0 | $\pi \times (1-2^{-13})$ | rad | |
| | $\omega$ | 14 | $\pi \times 2^{-13}$ | $-\pi$ | $\pi \times (1-2^{-13})$ | rad | Coded as two's complement) |
| | $\Omega_0$ | 14 | $\pi \times 2^{-13}$ | $-\pi$ | $\pi \times (1-2^{-13})$ | rad | Coded as two's complement) |
| | $\dot{\Omega}$ | 8 | $1 \times 10^{-9}$ | $-1.28\times10^{-7}$ | $1.27\times10^{-7}$ | rad/s | Coded as two's complement) |
| | $M_0$ | 15 | $\pi \times 2^{-14}$ | $-\pi$ | $\pi \times (1-2^{-14})$ | rad | Coded as two's complement) |
| | $t_a$ | 6 | 1800 | 0 | 84600 | s | Coding range exceeds the effective range (0 to 113400) |
| WN rollover count | $WNRO_{count}$ | 4 | 1 | 0 | 15 | - | 15 indicates that the parameter is invalid. |

*Note 1.— SBAS service provider identifiers are defined in 3.5.1.1*
*Note 2.— All other parameters are defined in 3.5.11.7*

**Table B-105. Reserved**

**Table B-106. Type 63 Null Message Broadcast on L5**

| Section | Name | Length | Scale factor | Effective Range | | Unit | Comment |
|---|---|---|---|---|---|---|---|
| | | | | min | max | | |
| Spare | Spare bit | 216 | - | - | - | - | |

*Note 1.— The Null message is used as a filler message if no other message is available for broadcast for the one-second time slot.*
*Note 2.— Spare bits can take any value and these bits are not to be used by aviation receivers*

**Table B-107. L5 Message Data time-out intervals**

| Data | Associated message types | Maximum Update Interval | En-route, terminal, NPA time-out | Precision approach, APV time-out |
|---|---|---|---|---|
| "Do Not Use" | 0 | 6 s | N/A | N/A |
| Satellite mask | 31 | 120 s | 600 s | 600 s |
| DFREI and DFRECI | 32 | 6 s | 18 s | 12 s |
| | 34 | 6 s | 18 s | 12 s |
| | 35 | 6 s | 18 s | 12 s |
| | 35 and 36 | 6 s | 18 s | 12 s |
| | 40 | 6 s | 18 s | 12 s |
| Satellite Clock-Ephemeris Corrections and co-variance matrix | 32 | 120 s | $1.5x(I_{Valid})_{32}$ | $(I_{Valid})_{32}$ |
| SBAS Satellite clock, ephemeris and co-variance matrix | 39<br>40 | 120 s | $1.5x(I_{Valid})_{39/40}$ | $(I_{Valid})_{39/40}$ |
| Degradation Parameters | 37 | 120 s | 360 s | 240 s |
| DFREI scale table | 37 | 120 s | 360 s | 240 s |
| Time Reference Identifier | 37 | 120 s | 360 s | 240 s |
| Broadcast indicator and SBAS service provider Identifier | 47 | 120 s | 360 s | 240 s |
| Week Number Roll-Over Count | 47 | 120 s | 360 s | 360 s |

*Note 1.— The time-out intervals are defined from the time of arrival at the receiver's antenna port of the last bit of the message.*

*Note 2.— There is no time-out requirement for other parameters of Type 47 message than those listed above.*

### 3.5.14 DFMC SBAS NON AIRCRAFT ELEMENTS

*Note .— The parameters that are referred to in this section are defined in 3.5.11.*

3.5.14.1 *General*

3.5.14.1.1 *Required data and broadcast intervals*. SBAS shall broadcast the data required for the supported functions described in Chapter 3, 3.7.3.4.2 as shown in Table B-108.

*Note.— SBAS may broadcast null messages (Type 63 messages) in each time slot for which no other data are broadcast.*

3.5.14.1.1.1 All data broadcast by SBAS, whether required or not for a particular function, shall meet the update requirements in Table B-108.

Table B-108. L5-Data broadcast intervals and supported functions

| Data type | Maximum broadcast interval | SBAS L5 Ranging | Iono-free differential correction | Associated message types |
|---|---|---|---|---|
| “Do not Use” | 6 s | | | 0 |
| Clock-Ephemeris error corrections | 120 s | | R | 32 |
| Covariance matrix | 120 s | R | R | 32 and 40 |
| SBAS satellite mask | 120 s | R | R | 31 |
| Integrity Information (DFREI and optionally DFRECI) | 6 s | R | R | 32, 34, 35, 36 and 40 |
| SBAS satellite Clock-Ephemeris Corrections and Covariance Matrix data | 120 s | R | | 39 and 40 |
| OBAD, DFREI scale table and time reference identifier | 120 s | R | R | 37 |
| SBAS Almanac data, Broadcast indicator and SBAS service provider ID parameters | 120 s | R | R | 47 |

*Note 1.—.“R” indicates that the data must be broadcast to support the function.*
*Note 2.—.Integrity information includes DFRECI only if Type 34 message is broadcast otherwise it is limited to DFREI.*

3.5.14.1.2 *SBAS radio frequency monitoring*. The SBAS shall monitor the L5 SBAS satellite parameters shown in Table B 109 and take the indicated action.

Table B-109. SBAS L5 radio frequency monitoring

| Parameter | Reference | Alarm limit | Required action |
|---|---|---|---|
| Signal power level | Chapter 3, sections 3.7.3.4.5.3 and 3.7.3.4.6.3 | minimum specified power<br>maximum specified power<br>(*Note 2*) | Minimum: cease SBAS L5 ranging function (*Note 1*).<br>Maximum: cease broadcast. |
| Modulation | Chapter 3, sections 3.7.3.4.5.5 and | Monitor for waveform distortion | Cease SBAS L5 ranging function (*Note 1*). |

| Parameter | Reference | Alarm limit | Required action |
|---|---|---|---|
| | 3.7.3.4.6.5 | | |
| Carrier frequency stability | 3.5.2.1 and 3.5.9.1 | N/A (*Note 3*) | Cease SBAS L5 ranging function unless $\sigma^2_{DFRE}$ reflect error. |
| Code/frequency Coherence | 3.5.2.4 and 3.5.9.4.2 | N/A (*Note 3*) | Cease SBAS L5 ranging function unless $\sigma^2_{DFRE}$ reflects error. |
| Maximum code phase deviation | 3.5.2.6 and 3.5.9.6 | N/A (*Notes 2* and *3*) | Cease SBAS L5 ranging function unless $\sigma^2_{DFRE}$ reflects error. |
| Convolutional and bi-binary encoding | 3.5.2.9 and 3.5.9.9 | All transmit messages are erroneous | Cease broadcast. |

*Notes.—*

1. *Ceasing the ranging function is accomplished by broadcasting a DFREI of "Do Not Use for SBAS" for that SBAS satellite.*
2. *These parameters can be monitored by their impact on the received signal quality ($C/N_0$ impact), since that is the impact on the user.*
3. *Alarm limits are not specified because the induced error is acceptable, provided it is represented in the $\sigma^2_{DFRE}$ parameter. If the error cannot be represented, the ranging function must cease.*

3.5.14.1.3 *"Do Not Use"*. SBAS shall broadcast a "Do Not Use" message (Type 0 message) when necessary to inform users not to use the SBAS satellite broadcast data on L5 and dual-frequency ranging function.

3.5.14.1.4 *Doppler shift in SBAS satellite*. The Doppler shift in the SBAS satellite signal seen at any fixed location within the footprint for any satellite shall not exceed

a) ±337 Hz for GEO satellite signal, and
b) ±7 kHz for non-GEO satellite signal.

3.5.14.1.5 *SBAS ephemeris parameters*. When broadcasting ephemeris parameters, each SBAS satellite shall broadcast ephemeris parameters for itself as defined in 3.5.11.5.

3.5.14.1.5.1 SBAS service provider shall ensure that the SBAS ephemeris time parameter $t_e$ in the Type 40 message is set within -43 200 s and +43 199s of the broadcast time and adjusted for day crossovers.

*Note. — $t_e$ is encoded as a time of day and the applicable day/week complies with the [-43 200 s; +43 199 s] time window.*

3.5.14.1.6 *Almanac data*. Each SBAS satellite shall broadcast almanac data as defined in 3.5.11.7 for all SBAS satellites of the same service provider.

*Note. — Additional information in the guidance material are provided for certain SBAS orbits (see Attachment D section 6.7.5).*

3.5.14.1.6.1 The error in the estimated position of the satellite derived from any Type 47 message broadcast within the previous 15 minutes, with respect to the true satellite position, shall not exceed 3 000 km.

3.5.14.1.6.2 The error in the predicted Doppler shift computed from the Type 47 message shall not exceed +/- 337Hz for a period of 7 days after the broadcast of Type 47 message.

*Note. — SBAS receivers can expect this almanac accuracy for seven days from receipt of the almanac message. The receiver needs to account for day and week crossovers since the almanac reference time is only in seconds of day.*

3.5.14.1.6.3 If only one SBAS satellite almanac is provided in Type 47 message, the bits from 118 to 225 assigned to the second SBAS satellite almanac shall be coded with "0".

3.5.14.1.6.4 SBAS shall set the Broadcast Indicator to "1" for the SBAS satellite broadcasting the Type 47 message, and set the Broadcast Indicator to "0" for all other SBAS satellites.

3.5.14.1.6.5 SBAS service provider shall ensure the correctness of the SBAS service provider ID using the value allocated to the SBAS service provider as per Table B-27 in any Type 47 message.

3.5.14.1.6.6 SBAS service provider shall ensure that the SBAS almanac time parameter $t_a$ in the Type 47 message is set within -43 200 s and +43 199s of the broadcast time and adjusted for day crossovers.

*Note. — $t_a$ is encoded as a time of day and the applicable day/week complies with the [-43 200 s; +43 199 s] time window.*

3.5.14.2 *Ranging function.* If an SBAS provides a ranging function, it shall also comply with the requirements contained in this section.

3.5.14.2.1 *Performance requirements*

*Note.— See Chapter 3, 3.7.3.4.3.*

3.5.14.2.2 *Ranging function data.* SBAS shall broadcast the ephemeris parameters, covariance matrix and DFREI value of the broadcasting SBAS satellite through Type 39 and Type 40 messages both linked by their IODG.

3.5.14.2.3 *Active IODG.* SBAS shall have no more than three active IODG. An active IODG corresponds to an IODG parameter broadcast in Type 39 or 40 message which has not timed out as per Table B-107.

3.5.14.3 *Ionosphere-free differential correction function.* If an SBAS provides an ionosphere-free differential correction function, it shall also comply with the requirements contained in this section.

3.5.14.3.1 *Performance of the ionosphere-free differential correction.*

a) For en-route, terminal and non-precision approach, given any valid combination of active data, the probability of a horizontal error exceeding the HPL (as defined in 3.5.12.5) for longer than 8 consecutive seconds shall be less than $10^{-7}$ in any hour, assuming a user with zero latency.
b) Given any valid combination of active data, the probability of an out of tolerance condition (e.g. horizontal error exceeding the HPL or vertical error exceeding the VPL, as defined in 3.5.12.5), for longer than 5.2 consecutive seconds time-to-alert shall be less than $2 \times 10^{-7}$ during any approach, assuming a user with zero latency.
c) When SBAS detects that the probability of error exceeding the protection level is above the integrity risk requirement for one of the SBAS operations, the resulting alert

information (DFREI or DFRECI set to "Do Not Use for SBAS"), broadcast in a Type 32, 34, 35, 36 or 40 messages, shall be repeated three times in a row after the initial notification of the alert condition for a total of four times in 4 seconds. Type 0 message can also be sent 4 times in a row to indicate an alert condition.

*Note 1.— Active data is defined to be data that has not timed out per 3.5.15.1.2. This requirement includes core satellite constellation(s) and SBAS failures.*

*Note 2.— Subsequent messages can be transmitted at the normal update rate.*

3.5.14.3.2 *SBAS satellite mask and Issue of Data – Mask (IODM).* SBAS shall broadcast an SBAS satellite mask and IODM (Type 31 message). The satellite slot values indicate whether or not data are provided for each GNSS satellite.

3.5.14.3.2.1 SBAS shall change the IODM when there is a change in the SBAS satellite mask by increasing by 1 the IODM modulo 4 from the latest transmitted value.

3.5.14.3.2.2 The IODM in Type 34, 35 and 36 messages shall equal the IODM broadcast in the satellite mask message (Type 31 message) used to designate the satellites for which data are provided in that messages.

3.5.14.3.2.3 SBAS shall have no more than two active IODM. An active IODM corresponds to a satellite mask broadcast in Type 31 message which has not time out as per Table B-107.

3.5.14.3.3 *Satellite corrections and covariance matrix data.*

3.5.14.3.3.1 Except for the broadcasting SBAS satellite, SBAS shall broadcast clock/ephemeris correction and covariance matrix (Type 32 message) for any satellite in the SBAS satellite mask (i.e. with satellite slot value equal to "1") when SBAS sets a DFREI between 0 and 14.

*Note .— The Type 39/40 message from the broadcasting satellite does not require further correction and therefore SBAS broadcasting satellite will not send correction data for itself.*

3.5.14.3.3.2 SBAS shall broadcast clock and ephemeris correction and covariance matrix data with an Issue Of Data Navigation (IODN) matching to the clock and ephemeris data from GNSS satellites being corrected (IODs). The IODN value shall be derived from the IODs of GNSS satellite clock and ephemeris data as described in 3.5.11.2.

3.5.14.3.3.3 In order to enable all SBAS users to acquire the new GNSS data upon transmission of new valid clock and ephemeris data from the GNSS satellites, the SBAS shall continue to broadcast corrections and covariance matrix with respect to the old clock and ephemeris data for a period of time of

a) 120 to 240 seconds for GPS,
b) 150 to 320 seconds for GLONASS,
c) 150 to 350 seconds for Galileo,
d) TBC seconds for BDS.

*Note.— "valid clock and ephemeris data" means that the information broadcast by the GNSS satellites is in line with its signal ICD, performance standard and SARPs.*

3.5.14.3.3.4 For any satellite, SBAS shall only broadcast a Type 32 message when SBAS has continuously monitored that satellite's ephemeris and clock data for at least 300 seconds.

*Note .— IOD is defined in section 3.5.11.2 and includes a comparison of the GPS LNAV IODE with the 8 LSB of the GPS LNAV IODC. Ephemeris and clock data is derived from the* *core constellation navigation message being augmented by DFMC SBAS as mentioned in section 3.5.11.1.*

3.5.14.3.3.5 SBAS service provider shall ensure that the correction time of applicability parameter $t_D$ in the Type 32 message is set within -43 200 s and +43 199s of the broadcast time and adjusted for day crossovers

*Note. — $t_D$ is encoded as a time of day and the applicable day/week complies with the [-43 200 s; +43 199 s] time window.*

3.5.14.3.4 *Integrity data.* For each satellite set in the SBAS satellite mask, SBAS shall broadcast DFREI information using DFREI or DFRECI parameters, covariance matrix, scale exponent and degradation parameters such that the integrity requirement in 3.5.14.3.1 is met. If the corrections exceed their coding range or if $\boldsymbol{\sigma}^2_{\mathbf{DFC}}$ (as described in section 3.5.12.4.1) cannot be determined, SBAS shall indicate that the satellite is not appropriate for SBAS position (“Do Not Use for SBAS”).

*Note .— The SBAS receiver will apply the DFRECI to its current active DFREI which can be any active broadcast DFREI.*

3.5.14.3.4.1 SBAS shall provide DFREI information, directly via DFREI parameter or indirectly via DFRECI parameter, allowing the computation of $\boldsymbol{\sigma}_{\mathbf{DFRE}}$ (as defined in 3.5.11.4) for the satellite set in the satellite mask and monitored by SBAS using Type 34, 35 or 36 messages at least every 6 seconds.

3.5.14.3.4.1.1 When using a Type 34 message, the SBAS shall transmit at most 7 DFRECIs set to “1”.

*Note 1.— Instead of transmitting updated DFREI values in the Type 34 message, the SBAS can set some DFRECI values to “2” or “3” to change DFREIs on more than 7 satellites and still use the Type 34 message. Type 35 or 36 message can also be used instead of Type 34 messages to provide more DFREI value updates.*

*Note 2.— The DFRECIs are in augmented slot index order derived from the Type 31 message with a matching IODM.*

3.5.14.3.4.1.2 When using a Type 34 message with DFRECI set to “1”, the SBAS shall broadcast the new DFREI values in the order corresponding to the order of DFRECI set to “1” across the DFRECI field. The new DFREI value shall apply to the augmented slot index of the corresponding DFRECI value set to “1”.

3.5.14.3.4.2 SBAS shall set to 15 any DFREI value in the associated data field of Type 35 and 36 messages which corresponds to satellite slot number not set in the mask.

3.5.14.3.4.2.1 When using a Type 34 message, SBAS shall set DFRECI value to 3 for DFRECI slots exceeding the maximum augmented slot index.

3.5.14.3.4.2.2 If in a given Type 34 message, the number N of DFRECI set to 1 is below 7, the last 7-N DFREI values of the type 34 message shall be set to 15.

3.5.14.3.4.3 When using a Type 34 message, SBAS shall transmit a DFRECI of 3 (“Do Not Use for SBAS”) instead of transmitting a DFRECI of 2 (“DFREI increased by one”) when the most recent active DFREI was set to 14 and the corresponding DFRE value is no longer adequate to ensure integrity as per 3.5.14.3.1.

3.5.14.3.4.4 SBAS shall send $(I_{VALID})_{32}$ and $(I_{VALID})_{39/40}$ in the Type 37 messages corresponding to the time intervals during which the integrity data of Type 32 and Type 39/40 messages can be used.

*Note.— These time intervals are measured from the time of arrival of the last bit of Type 32 or the last bit of the last message in the paired Type 39/40 messages being received at the antenna port of the SBAS receiver.*

3.5.14.3.4.5 Integrity requirement as in section 3.5.14.3.1 shall apply throughout update of parameters in Type 37 message.

*Note.— It is expected that change in the DFREI scale table will be a rare event in the lifetime of an SBAS.*

3.5.14.3.4.5.1 For each DFREI, the $\sigma_{DFRE}$ value shall always be greater than the $\sigma_{DFRE}$ value specified for lower DFREI in the Scale Table in the Type 37 message.

3.5.14.3.5 *Old But Active Data (OBAD).* SBAS shall broadcast Old But Active Data parameters (Type 37 message) such that the integrity requirement in 3.5.14.3.1 is met.

3.5.14.3.6 *Timing data.*

3.5.14.3.6.1 SBAS shall indicate on which reference time the SBAS Network Time for DFMC SBAS is aligned through the time reference identifier field of the Type 37 message.

3.5.14.3.6.2 If an SBAS provides the $WNRO_{count}$ information with a parameter not permanently set to 15, the SBAS shall monitor the week number rollover by updating the week number rollover count ($WNRO_{count}$) in Type 47 message for the GNSS constellation identified by the Time reference Identifier in Type 37 message.

*Note.— The week number roll-over count is used to solve the possible ambiguity of the Week Number value transmitted through the GNSS navigation data. Information on the reference time per constellation to compute the $WNRO_{count}$ is in section 3.5.11.7.*

3.5.14.4 *Monitoring*

3.5.14.4.1 *SBAS radio frequency monitoring.* The SBAS shall monitor the SBAS satellite parameters shown in Table B-109 and take the indicated action.

*Note.— In addition to the radio frequency monitoring requirements in this section, it will be necessary to make special provisions to monitor pseudo-range acceleration specified in Chapter 3, 3.7.3.4.3.5, carrier phase noise specified in 3.5.9.2, and correlation loss in 3.5.9.5, unless analysis and testing shows that these parameters cannot exceed the stated limits.*

3.5.14.4.2 *Data monitoring.* The SBAS shall monitor GNSS ranging signals to ensure that active data meets the requirements of section 3.5.14.3.1.

3.5.14.4.2.1 The ground subsystem shall lock on main correlation peaks of the tracked signals used for the SBAS augmentation.

3.5.14.4.2.2 The ground subsystem shall ensure that broadcast data bound the residual error for airborne receivers according to DFMC SBAS receiver design constraints defined in 3.5.15.1.1.3 when exposed to GNSS signal distortions defined in Attachment D, Section 8.

*Note. – SBAS receiver locks on the main correlation peak of the tracked signal following requirement in section 3.5.15.1.5.*

3.5.14.4.2.3 The monitor action shall be to set DFREI to “Do Not Use for SBAS” for the satellite.

3.5.14.4.2.4 SBAS shall monitor all active data that can be used by any user within the coverage area.

3.5.14.4.2.5 SBAS shall raise an alert within 5.2 seconds if any combination of active data and GNSS signals-in-space results in a horizontal or vertical position error exceeding respectively the HPL or VPL (as per 3.5.14.3.1).

*Note.— The monitoring applies to all failure conditions, including failures in core satellite constellation(s) or SBAS satellites. This monitoring assumes that the aircraft element complies with the requirements of 3.5.15.*

3.5.14.4.3 *IOD monitoring.* SBAS shall take appropriate action to ensure integrity of the broadcast information when the active IODN as described in 3.5.11.2 can be linked to more than one valid ephemeris.

*Note 1.—Active data is defined to be data that has not timed out per Table B-107. This requirement includes core satellite constellation(s) and SBAS failures.*
*Note 2.— Section 3.5.15.1.4.8 provides additional information on the application of SBAS corrections by an SBAS receiver which is valuable to assess the time during which a mismatch of IODN and core constellation can be considered by SBAS.*

3.5.14.5 *Robustness to core constellation(s) failures.* SBAS shall continue to provide SBAS services after removal of one or several satellites, including a complete core constellation.

*Note. – SBAS systems are expected to maintain operation in the presence of failures or anomalies on one or several satellites, or failure of a complete core constellation. The level of supported service degrades as more satellites are removed. Removal of a failed or unhealthy satellite does not impact the ability to monitor and correct other satellites.*

## 3.5.15 DFMC SBAS AIRCRAFT ELEMENTS

*Note 1.— The parameters that are referred to in this section are defined in 3.5.11.*

*Note 2.— Some of the requirements of this section may not apply to equipment that integrates additional navigation sensors, such as equipment that integrates SBAS with inertial navigation sensors.*

*Note 3.— Whereas all SBAS receivers process signals from SBAS GEO satellites, processing non-GEO SBAS signals is optional.*

3.5.15.1 DFMC SBAS-capable GNSS receiver.

3.5.15.1.1 *SBAS-capable GNSS receiver*. Except as specifically noted, the SBAS-capable GNSS receiver shall process the signals of the SBAS and meet the requirements applicable to the core constellations it tracks as specified in 3.1.3.1 (GPS receiver), and/or 3.2.3.1 (GLONASS receiver), and/or xxx (Galileo receivers), and/or yyy (BDS receivers). Pseudo-range measurements for each satellite shall be smoothed using carrier measurements and the following filter:

$$P_{proj} = P_{n-1} + \frac{\frac{\lambda_2}{2\pi}\left(\varphi_{2,n} - \varphi_{2,n-1}\right) - \gamma_{12}\frac{\lambda_1}{2\pi}\left(\varphi_{1,n} - \varphi_{1,n-1}\right)}{1-\gamma_{12}}$$

$$P_n = \alpha\frac{\rho_{2,n} - \gamma_{12}\rho_{1,n}}{1-\gamma_{12}} + (1-\alpha)P_{proj}$$

Where:

a) $P_n$ is the ionosphere-free dual-frequency carrier-smoothed pseudorange in meters,

b) $P_{n-1}$ is the previous ionosphere-free dual-frequency carrier-smoothed pseudorange in meters,

c) $P_{proj}$ is the projected ionosphere-free dual-frequency pseudorange in meters,

d) $\rho_{1,n}$ is the L1 C/A or L1OCd or E1-C or B1Cp or SBAS L1 raw pseudorange measurement in meters,

e) $\rho_{2,n}$ is the L5-Q or L3OC or E5a-Q or B2a or SBAS L5 raw pseudorange measurement in meters,

f) $\varphi_{1,n}$ is the accumulated L1 C/A or L1OCd or E1-C or B1Cp or SBAS L1 raw carrier phase measurement in radians,

g) $\varphi_{1,n-1}$ is the previous accumulated L1 C/A or L1OCd or E1-C or B1Cp or SBAS L1 raw carrier phase measurement in radians,

h) $\varphi_{2,n}$ is the accumulated L5-Q or L3OC or E5a-Q or B2a or SBAS L5 raw carrier phase measurement in radians,

i) $\varphi_{2,n-1}$ is the previous accumulated L5-Q or L3OC or E5a-Q or B2a or SBAS L5 raw carrier phase measurement in radians,

j) $\lambda_1$ is the L1 wavelength in meters,

k) $\lambda_2$ is the L5 or L3 wavelength in meters,

l) $\gamma_{12} = \left(\frac{f_1}{f_2}\right)^2$ is the L1 C/A or L1OCd or E1-C or B1Cp or SBAS L1to L5-Q or L3OC or E5a-Q or B2a or SBAS L5 frequency ratio, and

m) $\alpha$ is the filter weighting function: after 100 seconds have elapsed since filter initialization, $\alpha$ is equal to the sample interval in seconds divided by the time constant of 100 seconds. In the first 100 seconds since filter initialization, $\alpha$ is equal to the sample interval in seconds divided by the time in seconds since filter initialization.

3.5.15.1.1.1 The receiver shall process the augmented signals as follows:

a) For GPS: The receiver shall use a BPSK(1) replica for L1 C/A signal and a BPSK(10) replica for L5-Q signal. The satellite position and satellite clock shall be based on ephemeris in LNAV message on L1. Group delay correction from LNAV message on L1 shall be applied.
b) For GLONASS: The receiver shall use a BPSK(1) replica for L1OCd and BPSK(10) replica for L3OC signal. The satellite position and satellite clock shall be based on ephemeris in Strings 10, 11 and 12 of L1OC or L3OC.
c) For Galileo: The receiver shall use a BOC(1,1) replica for E1-C signal and a BPSK(10) replica for E5a-Q signal. The satellite position and satellite clock shall be based on ephemeris in F/NAV message on E5a.
d) For BDS: The receiver shall use a BOC(1,1) replica for B1Cp (pilot signal) and BPSK(10) replica for B2a_pilot signal (pilot signal) . The satellite position and satellite clock shall be based on ephemeris in B-CNAV2 message on B2a.

3.5.15.1.1.2 The ionosphere-free measurement for satellite i ($\mathbf{PR_{i,measured}}$) and the satellite time correction ($\mathbf{\Delta t_{SV,i}}$) for satellite i, defined in section 3.5.12.4, shall be computed using the following information:

$$\mathrm{PR_{i,measured}} = \frac{f_2^{\,2}\rho_{i,2} - f_1^{\,2}\rho_{i,1}}{f_2^{\,2} - f_1^{\,2}}$$

With:

a) For GPS: $f_1$ and $\rho_{i,1}$ respectively the carrier frequency and pseudo-range measurement of the GPS L1/CA signal on satellite i. $f_2$ and $\rho_{i,2}$ respectively the carrier frequency and pseudo-range measurement of the GPS L5-Q signal on satellite i.
In addition, the GPS satellite clock correction $\Delta t_{SV,i}$ shall be computed as described in IS-GPS-200H section 20.3.3.3.3.1 taking into account the group delay correction broadcast in LNAV message as per IS-GPS-200H section 20.3.3.3.3.2.
b) For GLONASS: $f_1$ and $\rho_{i,1}$ respectively the carrier frequency and pseudo-range measurement of the GLONASS L1OCd signal on satellite i. $f_2$ and $\rho_{i,2}$ respectively the carrier frequency and pseudo-range measurement of the GLONASS L3OC signal on satellite i.
In addition, the GLONASS satellite clock correction $\Delta t_{SV,i}$ shall be computed as described in ICD GLONASS CDMA General Appendix D.
c) For Galileo: $f_1$ and $\rho_{i,1}$ respectively the carrier frequency and pseudo-range measurement of the Galileo E1-C signal on satellite i. $f_2$ and $\rho_{i,2}$ respectively the carrier frequency and pseudo-range measurement of the Galileo E5a-Q signal on satellite i.
In addition, the Galileo satellite clock correction $\Delta t_{SV,i}$ shall be computed as described in OS-SIS-ICD section 5.1.4.
d) For BDS: $f_1$ and $\rho_{i,1}$ respectively the carrier frequency and pseudo-range measurement (corrected by B1C pilot group delay) of the BDS B1C-pilot signal on satellite i. $f_2$ and $\rho_{i,2}$ respectively the carrier frequency and pseudo-range measurement (corrected by B2a pilot group delay) of the BDS B2a-pilot signal on satellite i. The equivalent specific ionosphere-free computation is described in BDS-SIS-ICD-B2a (V1.0) section 7.8.3 taking into account the group delays broadcast in B-CNAV2 message.
In addition, the BDS satellite clock correction $\Delta t_{SV,i}$ shall be computed as described in BDS-SIS-ICD-B2a (V1.0) section 7.5.2.
e) For SBAS ranging satellite: $f_1$ and $\rho_{i,1}$ respectively the carrier frequency and pseudo-range measurement of the SBAS L1 signal on satellite i. $f_2$ and $\rho_{i,2}$ respectively the carrier frequency and pseudo-range measurement of the SBAS L5 signal on satellite i.
In addition, the SBAS satellite clock correction $\Delta t_{SV,i}$ shall be computed as $\Delta t_{SV,i} = a_{Gf0} + a_{Gf1}\Delta_t$ with $a_{Gf0}$ and $a_{Gf1}$ broadcast in Type 39 message and $\Delta_t$ defined in section 3.5.12.3.1.

3.5.15.1.1.3 *DFMC SBAS receiver design constraints.* For processing of L1, L5, E1, E5a, L1OC and L3OC signals, the receiver shall comply with the following constraints:

a) 3 dB bandwidth between 12 and 24 MHz with a minimum of 30 dB per octave (TBC) gain roll-off,
b) Differential group delay not greater than 150 ns.
c) Early minus late discriminator,
d) L1/E1/L1OC correlator spacing between 0.08 and 0.12 chips,
e) L5/E5a/L3OC correlator spacing between 0.9 chips and 1.1 chips

3.5.15.1.2 *GEO SBAS satellite acquisition on L5*. The receiver shall be able to acquire and track GEO satellites for which a stationary receiver at the user receiver location would experience a Doppler shift as large as ±337 Hz.

**3.5.15.1.3** *Non-GEO SBAS satellite acquisition on L5*. The non-GEO SBAS capable receiver shall be able to acquire and track non-GEO satellites for which a stationary receiver at the user receiver location would experience a Doppler shift as large as ±7 kHz.

*Note.— Information on non-GEO Doppler range is available in attachment D section 6.7.5.*

3.5.15.1.4 *Conditions of use data on L5*.

3.5.15.1.4.1 The receiver shall use data from an SBAS message only if the CRC of this message has been verified.

3.5.15.1.4.2 The receiver shall use the information transmitted in DFMC messages only if the current time minus the time of arrival at the antenna port of the last bit of the latest message of the same type is below the requirement in Table B-107.

3.5.15.1.4.3 On reception of a Type 0 message, the receiver shall cease use and immediately time out all SBAS L5 data listed in Table B-107, from the broadcasting satellite.

*Note.— Upon reception of Type 0 message, the receiver can retain the SBAS service provider identifier and only use it for SBAS acquisition.*

3.5.15.1.4.4 The receiver shall only apply integrity data for which Type 34, 35 or 36 messages IODM matches an active Type 31 message IODM.

3.5.15.1.4.5 Reception of new DFREI shall replace the old DFREI and reset the time out of the associated DFREI (see Table B-107). Reception of DFRECI shall be applied to the active DFREI and reset the time out of the associated DFREI.

3.5.15.1.4.6 The receiver shall treat the receipt of a DFRECI = 0 or a DFRECI = 2 as though it had received a new copy of the most recent, active DFREI previously received through Type 32, 34, 35, 36 or 40 messages. Upon receipt of a DFRECI = 2, the equipment shall refer back to the most recent, active DFREI received through MT 32, 34, 35, 36 or 40 and use the DFRE sigma corresponding to the active DFREI increased by one. The receiver shall not include the satellite corresponding to a received DFRECI = 3 in the SBAS position solution. The receiver shall update the DFREI value and associated time out upon receipt of DFRECI = 1 by decoding the corresponding DFREI slot in the order of a Type 34 message DFRECI set to “1” across the DFRECI field and applying to the corresponding satellite.

*Note.— DFRECI of 2 (“value increase of 1”) is not cumulative.*

3.5.15.1.4.7 The receiver shall use the DFREI table through the latest decoded Type 37 message for the computation of $\sigma_{DFRE}$ based on received DFREI.

3.5.15.1.4.8 Upon reception of the initial valid Type 32 message applicable to a given satellite, the receiver shall invalidate for this satellite any retained clock/ephemeris data set containing at least one parameter received for the last time more than 5 minutes before the reception of the initial valid Type 32 message.

*Note.— The "initial valid Type 32 message " is the first Type 32 message received when there is no active Type 32 message from the SBAS L5 signal in use.*

3.5.15.1.4.9 The receiver shall apply the ephemeris and clock parameters, the covariance matrix parameters, the OBAD parameters and the integrity parameters as described in section 3.5.12.4 and 3.5.12.5.

3.5.15.1.4.10 The receiver shall use the content of Type 39 and Type 40 messages only when Type 39 and Type 40 messages with the same IODG have been received and have not time out.

3.5.15.1.4.11 The receiver shall solve constellation time offset as described in section 3.5.12.4.

3.5.15.1.4.12 The receiver shall correctly account for the day and week rollover change when observed after the last received Type 47 message.

3.5.15.1.4.13 The receiver shall only use SBAS augmented satellite ranges from satellites with elevation angles at or above 5 degrees in the SBAS position computation.

3.5.15.1.4.14 The receiver shall only use correction, integrity and other data obtained from a single SBAS satellite L5 signal (PRN code) for all satellites used in the position solution.

*Note.— When using additional SBAS satellites for ranging, one uses the Type 39/40 from the ranging SBAS satellites and the Type 32 corrections from the SBAS satellite being used for corrections.*

3.5.15.1.4.15 The receiver shall verify that the tracked SBAS PRN code matches the PRN code derived from the Satellite Slot delta field within the almanac data in the Type 47 message with the Broadcast Indicator set to “1” or derived from the Satellite Slot delta field in the Type 39 message.

3.5.15.1.4.16 In the event of a loss of four successive SBAS messages during SBAS approach, the receiver shall invalidate all DFREIs and DFRECIs.

3.5.15.1.4.17 The receiver shall ignore any received message if the value of one parameter exceeds its defined effective range in section 3.5.13.

3.5.15.1.5 The SBAS receiver shall lock on main correlation peaks of the tracked signals augmented by the SBAS and used in the SBAS position solution.

3.5.15.2 SBAS satellite position

3.5.15.2.1 *Position computation with ephemeris*. When using SBAS ranging, the receiver shall decode Type 39/40 messages and determine position ($X_G$, $Y_G$, $Z_G$) of the SBAS satellite using the protocol described in section 3.5.12.3.

3.5.15.2.2 *Position computation with almanac*. When computing the SBAS satellite position using a Type 47 message, the receiver shall determine position ($X_G$, $Y_G$, $Z_G$) of the SBAS satellite using the protocol described in section 3.5.12.2.

3.5.15.3 Iono-free differential functions

**3.5.15.3.1** ***GNSS satellite status function***. The receiver shall exclude satellites from the SBAS position solution if they are identified as "Do Not Use for SBAS".

*Note 1.— In the case of a satellite designated marginal or unhealthy by the core satellite constellation(s) health flag(s), SBAS may broadcast ephemeris and clock corrections that will allow the user to continue using the satellite.*

*Note 2.— If satellites identified as "Do Not Use for SBAS" by SBAS are used in the position solution, integrity is not provided by SBAS.*

3.5.15.3.2 *Core satellite constellation(s) ranging accuracy for precision approach*. The root-mean-square (1 sigma) of the total airborne contribution to the error in a corrected pseudo-range for a GPS satellite at the minimum and maximum received signal power level (Chapter 3, 3.7.3.1.7.4) under the worst interference environment as defined in 3.7 shall be less than or equal to 0.4 metres for minimum signal level and 0.3 metres for maximum signal level, excluding multipath effects, tropospheric and ionospheric residual errors. The RMS of the total airborne contribution to the error in a corrected pseudo-range for a GLONASS satellite at the minimum received signal power level (Chapter 3, 3.X.X.X) under the worst interference environment as defined in 3.7 shall be less than or equal to 0.65 metres for minimum signal level and 0.3 metres for maximum signal level, excluding multipath effects, tropospheric and ionospheric residual errors. The RMS of the total airborne contribution to the error in a corrected pseudo-range for a Galileo satellite at the minimum received signal power level (Chapter 3, 3.X.X.X) under the worst interference environment as defined in 3.7 shall be less than or equal to 0.4 metres for minimum signal level and 0.3 metres for maximum signal level, excluding multipath effects, tropospheric and ionospheric residual errors. The RMS of the total airborne contribution to the error in a corrected pseudo-range for a BDS satellite at the minimum received signal power level (Chapter 3, 3.X.X.X) under the worst interference environment as defined in 3.7 shall be less than or equal to 0.8 metres for minimum signal level and TBD metres for maximum signal level, excluding multipath effects, tropospheric and ionospheric residual errors.

3.5.15.3.3 The receiver shall use the protocol described in section 3.5.12.4 for the SBAS position solution.

3.5.15.3.4 The receiver shall compute horizontal and vertical protection levels as defined in 3.5.12.5:

3.5.15.3.4.1 The airborne receiver error variance, $\boldsymbol{\sigma^2_{air,DF}}$ for satellite (i) shall be computed as follows:

$$\sigma^2_{air,DF}[i] = \sigma^2_{noise}[i] + \sigma^2_{MP\&AGDV,DF}[i]$$

a) $\sigma^2_{noise}[i]$, is defined in 3.5.15.3.2

b) $\sigma^2_{MP\&AGDV,DF}$, the multipath and antenna group delay variation error for ionosphere-free dual-frequency 100-second smoothed measurements is described by a normal distribution with zero mean and a standard deviation of $\sigma_{MP\&AGDV,DF} = 2.59\sigma_{MP\&AGDV,SF}$ (in meters).

$\sigma_{MP\&AGDV,SF}$, is defined as:

a) $\sigma_{MP\&AGDV,SF}[i] = 0.13 + 0.53\exp\left(-El_{\deg}[i]/10°\right)$ (in meters);

b) $El_{\deg}[i]$ is the elevation angle of satellite i (in degrees).

*Note.— The multipath and antenna group delay variation standard deviation models are valid down to 2 degrees. They are very conservative and could be reduced with new dual-frequency antennas.*

3.5.15.3.4.2 For ionosphere-free dual-frequency measurements, the residual ionospheric uncertainty shall be defined as:

$$\sigma_{i,iono} = \frac{40.0}{261.0 + \left(El_{\deg}[i]\right)^2} + 0.018 \text{ (in meters)}$$

where $El_{\deg}[i]$ is the elevation angle (in degrees) of satellite i.

3.5.15.3.5 The avionics shall manage the FAS data block and FAS parameters as described in section 3.5.8.4.2.6.

3.5.15.3.5.1 The cross-checked between the FAS data block SBAS service provider ID and the SBAS service provider ID parameter broadcast in type 47 message shall be realized as described in section 3.5.8.4.2.6.2.

3.5.15.4 Ranging function

3.5.15.4.1 *SBAS satellite ranging accuracy.* The root-mean-square (1 sigma) of the total airborne error contribution to the error in a corrected pseudo-range for an SBAS satellite at the minimum received signal power level (Chapter 3, 3.7.3.4.6.3) under the worst interference environment as defined in 3.7 shall be less than or equal to 4.7 metres, excluding multipath effects, tropospheric and ionospheric residual errors.

3.5.16 ~~3.5.9~~INTERFACE BETWEEN SBAS

*Note.— Guidance material on the interface between different SBAS service providers is given in Attachment D, 6.3.*

***3.6 Ground-based augmentation system (GBAS) and ground-based regional augmentation system (GRAS)***

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*3.7* ***Resistance to interference***

3.7.1 PERFORMANCE OBJECTIVES

*Note 1.— For unaugmented GPS and GLONASS receivers the resistance to interference is measured with respect to the following performance parameters:*

| | *GPS* | *GLONASS* |
|---|---|---|
| *Tracking error (1 sigma)* | *0.36 m* | *0.8 m* |

*Note 2.— This tracking error neither includes contributions due to signal propagation such as multipath, tropospheric and ionospheric effects nor ephemeris and GPS and GLONASS satellite clock errors.*

*Note 3.— For SBAS receivers, the resistance to interference is measured with respect to parameters specified in 3.5.8.2.1, ~~and~~ 3.5.8.4.1 and 3.5.15.3.2.*

*Note 4.— For GBAS receivers, the resistance to interference is measured with respect to parameters specified in 3.6.7.1.1 and 3.6.8.2.1.*

*Note 5.— The signal levels specified in this section are defined at the antenna port. Assumed maximum aircraft antenna gain in the lower hemisphere is –10 dBic.*

*Note 6.— The performance requirements are to be met in the interference environments defined below. This defined interference environment is relaxed during initial acquisition of GNSS signals when the receiver cannot take advantage of a steady-state navigation solution to aid signal acquisition.*

*Note 7.— The equipment performance objectives and requirements specified for a particular constellation apply whether the equipment supports only that constellation (single constellation equipment) or that constellation and other constellation(s) (multiple constellation equipment).*

### 3.7.2 CONTINUOUS WAVE (CW) INTERFERENCE

#### 3.7.2.1 *GPS L1 AND SBAS L1 RECEIVERS*

3.7.2.1.1 After steady-state navigation has been established, GPS L1 and SBAS L1 receivers shall meet the performance objectives with CW interfering signals present with a power level at the antenna port equal to the interference thresholds specified in Table B-83 and shown in Figure B-15 and with a desired signal level of –164 dBW at the antenna port.

3.7.2.1.2 During initial acquisition of the GPS L1 and SBAS L1 signals prior to steady-state navigation, GPS L1 and SBAS L1 receivers shall meet the performance objectives with interference thresholds 6 dB less than those specified in Table B-83.

#### 3.7.2.2 *GLONASS FDMA RECEIVERS*

3.7.2.2.1 After steady-state navigation has been established, GLONASS receivers (except those identified in 3.7.2.2.1.1) shall meet the performance objectives with CW interfering signals present with a power level at the antenna port equal to the interference thresholds specified in Table B-84 and shown in Figure B-16 and with a desired signal level –166.5 dBW at the antenna port.

Table B-83. CW interference thresholds for GPS L1 and SBAS L1 receivers in steady-state navigation

| Frequency range $f_i$ of the interference signal | Interference thresholds for receivers in steady-state navigation |
|---|---|
| $f_i \leq$ 1 315 MHz | –4.5 dBW |
| 1 315 MHz < $f_i \leq$ 1 500 MHz | Linearly decreasing from –4.5 dBW to –38 dBW |
| 1 500 MHz < $f_i \leq$ 1 525 MHz | Linearly decreasing from –38 dBW to –42 dBW |
| 1 525 MHz < $f_i \leq$ 1 565.42 MHz | Linearly decreasing from –42 dBW to –150.5 dBW |
| 1 565.42 MHz < $f_i \leq$ 1 585.42 MHz | –150.5 dBW |
| 1 585.42 MHz < $f_i \leq$ 1 610 MHz | Linearly increasing from –150.5 dBW to –60 dBW |
| 1 610 MHz < $f_i \leq$ 1 618 MHz | Linearly increasing from –60 dBW to –42 dBW* |
| 1 618 MHz < $f_i \leq$ 2 000 MHz | Linearly increasing from –42 dBW to –8.5 dBW* |
| 1 610 MHz < $f_i \leq$ 1 626.5 MHz | Linearly increasing from –60 dBW to –22 dBW** |
| 1 626.5 MHz < $f_i \leq$ 2 000 MHz | Linearly increasing from –22 dBW to –8.5 dBW** |
| $f_i$ > 2 000 MHz | –8.5 dBW |

* Applies to aircraft installations where there are no on-board satellite communications.

* Applies to aircraft installations where there is on-board satellite communications.

3.7.2.2.1.1 After steady-state navigation has been established, GLONASS receivers used for all phases of flight (excluding those used for the precision approach phase of flight) and put into operation before 1 January 2017 shall meet the performance objectives with CW interfering signals present with a power level at the antenna port 3 dB less than the interference thresholds specified in Table B-84 and shown in Figure B-16 and with a desired signal level of –166.5 dBW at the antenna port.

Table B-84. CW interference thresholds for GLONASS receivers in steady-state navigation

| Frequency range $f_i$ of the interference signal | Interference thresholds for receivers in steady-state navigation |
|---|---|
| $f_i \leq$ 1 315 MHz | –4.5 dBW |
| 1 315 MHz < $f_i \leq$ 1 562.15625 MHz | Linearly decreasing from –4.5 dBW to –42 dBW |
| 1 562.15625 MHz < $f_i \leq$ 1 583.65625 MHz | Linearly decreasing from –42 dBW to –80 dBW |
| 1 583.65625 MHz < $f_i \leq$ 1 592.9525 MHz | Linearly decreasing from –80 dBW to –149 dBW |
| 1 592.9525 MHz < $f_i \leq$ 1 609.36 MHz | –149 dBW |
| 1 609.36 MHz < $f_i \leq$ 1 613.65625 MHz | Linearly increasing from –149 dBW to –80 dBW |
| 1 613.65625 MHz < $f_i \leq$ 1 635.15625 MHz | Linearly increasing from –80 dBW to –42 dBW* |
| 1 613.65625 MHz < $f_i \leq$ 1 626.15625 MHz | Linearly increasing from –80 dBW to –22 dBW** |
| 1 635.15625 MHz < $f_i \leq$ 2 000 MHz | Linearly increasing from –42 dBW to –8.5 dBW* |
| 1 626.15625 MHz < $f_i \leq$ 2 000 MHz | Linearly increasing from –22 dBW to –8.5 dBW** |
| $f_i$ > 2 000 MHz | –8.5 dBW |

* Applies to aircraft installations where there are no on-board satellite communications.

** Applies to aircraft installations where there is on-board satellite communications.

3.7.2.2.2 During initial acquisition of the GLONASS signals prior to steady-state navigation, GLONASS receivers shall meet the performance objectives with interference thresholds 6 dB less than those specified in Table B-84.

*3.7.2.3 DFMC SBAS receivers*

3.7.2.3.1 After steady-state navigation has been established, DFMC SBAS receivers processing signals centred on L1 and L5 frequency only shall meet the performance objectives with CW interfering signals present with a power level at the antenna port equal to the interference thresholds specified in Tables B-111a and B-111b and shown in Figure B-21 and with a desired SBAS L5 signal level of -158 dBW at the output of the antenna and other signal as specified in TBD.

3.7.2.3.2 During initial acquisition of the DFMC SBAS signal prior to steady-state navigation, DFMC SBAS receivers processing signals centred on L1 and L5 frequency only shall meet the performance objectives with interference thresholds 6 dB less than those specified in Table B-111.

Table B-111a. CW interference thresholds for DFMC SBAS receivers processing L5 signal in steady-state navigation

| Frequency range $f_i$ of the interference signal | Interference thresholds for receivers in steady-state navigation |
|---|---|
| 1 166.45 MHz < $f_i \leq$ 1 186.45MHz | TBD |
| TBD | |

* Applies to aircraft installations where there are no on-board satellite communications.

** Applies to aircraft installations where there is on-board satellite communications.

Table B-111b. CW interference thresholds for DFMC SBAS receivers processing L1 signal in steady-state navigation

| Frequency range $f_i$ of the interference signal | Interference thresholds for receivers in steady-state navigation |
|---|---|
| $f_i \leq$ 1 315 MHz TBC | –4.5 dBW |
| 1 315 MHz < $f_i \leq$ 1 500 MHz | Linearly decreasing from –4.5 dBW to –38 dBW |
| 1 500 MHz < $f_i \leq$ 1 525 MHz | Linearly decreasing from –38 dBW to –42 dBW |
| 1 525 MHz < $f_i \leq$ 1 565.42 MHz | Linearly decreasing from –42 dBW to –150.5 dBW |
| 1 565.42 MHz < $f_i \leq$ 1 585.42 MHz | –150.5 dBW |
| 1 585.42 MHz < $f_i \leq$ 1 610 MHz | Linearly increasing from –150.5 dBW to –60 dBW |
| 1 610 MHz < $f_i \leq$ 1 618 MHz | Linearly increasing from –60 dBW to –42 dBW* |
| 1 618 MHz < $f_i \leq$ 2 000 MHz | Linearly increasing from –42 dBW to –8.5 dBW* |
| 1 610 MHz < $f_i \leq$ 1 626.5 MHz | Linearly increasing from –60 dBW to –22 dBW** |
| 1 626.5 MHz < $f_i \leq$ 2 000 MHz | Linearly increasing from –22 dBW to –8.5 dBW** |
| $f_i$ > 2 000 MHz | –8.5 dBW |

* Applies to aircraft installations where there are no on-board satellite communications.

** Applies to aircraft installations where there is on-board satellite communications.

Figure B-21. CW interference thresholds for DFMC SBAS receivers in steady-state navigation
TBD

### 3.7.3 BAND-LIMITED NOISE-LIKE INTERFERENCE

#### 3.7.3.1 *GPS L1 AND SBAS L1 RECEIVERS*

3.7.3.1.1 After steady-state navigation has been established, GPS L1 and SBAS L1 receivers shall meet the performance objectives with noise-like interfering signals present in the frequency range of 1 575.42 MHz $\pm Bw_i/2$ and with power levels at the antenna port equal to the interference thresholds specified in Table B-85 and shown in Figure B-17 and with the desired signal level of –164 dBW at the antenna port.

*Note.— $Bw_i$ is the equivalent noise bandwidth of the interference signal.*

3.7.3.1.2 During initial acquisition of the GPS and SBAS signals prior to steady-state navigation, GPS L1 and SBAS L1 receivers shall meet the performance objectives with interference thresholds 6 dB less than those specified in Table B-85.

#### 3.7.3.2 *GLONASS FDMA RECEIVERS*

3.7.3.2.1 After steady-state navigation has been established, GLONASS receivers (except those identified in 3.7.3.2.1.1) shall meet the performance objectives while receiving noise-like interfering signals in the frequency band $f_k \pm Bw_i/2$, with power levels at the antenna port equal to the interference thresholds specified in Table B-86 and shown in Figure B-18 and with a desired signal level of –166.5 dBW at the antenna port.

3.7.3.2.1.1 After steady-state navigation has been established, GLONASS receivers used for all phases of flight (excluding those used for the precision approach phase of flight) and put into operation before 1 January 2017 shall meet the performance objectives while receiving noise-like interfering signals in the frequency band $f_k \pm Bw_i/2$, with power levels at the antenna port 3 dB less than the interference thresholds specified in Table B-86 and shown in Figure B-18 and with a desired signal level of –166.5 dBW at the antenna port.

*Note.— $f_k$ is the centre frequency of a GLONASS channel with $f_k$ = 1 602 MHz + k × 0.5625 MHz and k = –7 to + 6 as defined in Table B-16 and $Bw_i$ is the equivalent noise bandwidth of the interference signal.*

3.7.3.2.2 During initial acquisition of the GLONASS signals prior to steady-state navigation, GLONASS receivers shall meet the performance objectives with interference thresholds 6 dB less than those specified in Table B-86.

#### 3.7.3.3 *DFMC SBAS RECEIVER*

3.7.3.3.1 After steady-state navigation has been established, DFMC SBAS receivers processing signals centred on L1 and L5 frequencies only shall meet the performance objectives with noise-like interfering signals present in the frequency range of 1 176.45 MHz ±Bwi/2 and with power levels at the antenna port equal to the interference thresholds specified in Table B-112 and shown in Figure B-22 and with the desired signal level of –158 dBW at the antenna port.

*Note.— $Bw_i$ is the equivalent noise bandwidth of the interference signal.*

3.7.3.3.2 During initial acquisition of the SBAS L5 signals prior to steady-state navigation, DFMC SBAS receivers processing signals centred on L1 and L5 frequencies only shall meet the performance objectives with interference thresholds 6 dB less than those specified in Table B-112.

Table B-112. Interference threshold for band-limited noise-like interference to SBAS L5 receivers in steady-state navigation

| Interference bandwidth | Interference threshold for receivers in steady-state navigation |
|---|---|
| TBD | |

TBD

Figure B-22. Interference thresholds versus bandwidth for GPS L5 and SBAS L5 receivers

3.7.3.~~3~~4 *Pulsed interference*. After steady-state navigation has been established, the receiver shall meet the performance objectives while receiving pulsed interference signals with characteristics according to Table B-87 where the interference threshold is defined at the antenna port.

3.7.3.~~4~~5 SBAS and GBAS receivers shall not output misleading information in the presence of interference including interference levels above those specified in 3.7.

*Note.— Guidance material on this requirement is given in Attachment D, 10.5.*

Table B-85. Interference threshold for band-limited noise-like interference to GPS L1 and SBAS L1 receivers in steady-state navigation

| Interference bandwidth | Interference threshold for receivers in steady-state navigation |
|---|---|
| 0 Hz < $Bw_i \leq$ 700 Hz | –150.5 dBW |
| 700 Hz < $Bw_i \leq$ 10 kHz | Linearly increasing from –150.5 to –143.5 dBW |
| 10 kHz < $Bw_i \leq$ 100 kHz | Linearly increasing from –143.5 to –140.5 dBW |
| 100 kHz < $Bw_i \leq$ 1 MHz | –140.5 dBW |
| 1 MHz < $Bw_i \leq$ 20 MHz | Linearly increasing from –140.5 to –127.5 dBW* |
| 20 MHz < $Bw_i \leq$ 30 MHz | Linearly increasing from –127.5 to –121.1 dBW* |
| 30 MHz < $Bw_i \leq$ 40 MHz | Linearly increasing from –121.1 to –119.5 dBW* |
| 40 MHz < $Bw_i$ | –119.5 dBW* |

* The interference threshold is not to exceed –140.5 dBW/MHz in the frequency range 1 575.42 ±10 MHz.

Table B-86. Interference threshold for band-limited noise-like interference to GLONASS receivers in steady-state navigation

| Interference bandwidth | Interference threshold |
|---|---|
| 0 Hz < $Bw_i \leq$ 1 kHz | –149 dBW |
| 1 kHz < $Bw_i \leq$ 10 kHz | Linearly increasing from –149 to –143 dBW |
| 10 kHz < $Bw_i \leq$ 0.5 MHz | –143 dBW |
| 0.5 MHz < $Bw_i \leq$ 10 MHz | Linearly increasing from –143 to –130 dBW |
| 10 MHz < $Bw_i$ | –130 dBW |

Table B-87. Interference thresholds for pulsed interference

| | GPS L1 and SBAS L1 | GLONASS | SBAS L5 |
|---|---|---|---|
| Frequency range for in-band and near-band | 1 575.42 MHz ± 20 MHz | 1 592.9525 MHz to 1 609.36 MHz | TBD |
| Interference threshold (Pulse peak power) for in-band and near-band interference | –20 dBW | –20 dBW | |
| Interference threshold (Pulse peak power) outside the in-band and near-band frequency ranges (out-of-band interference) | 0 dBW | 0 dBW | |
| Pulse width | ≤125 µs | ≤250 µs | |
| Pulse duty cycle | ≤1% | ≤1% | |
| Interference signal bandwidth for in-band and near-band interference | ≥1 MHz | ≥500 kHz | |

*Note 1.— The interference signal is additive white Gaussian noise centred around the carrier frequency and with bandwidth and pulse characteristics specified in the table.*

*Note 2.— In-band, near-band and out-of-band interference refers to the centre frequency of the interference signal.*

Table B-88. Minimum L1 antenna gain — GPS, GLONASS and SBAS

| Elevation angle degrees | Minimum gain dBic |
|---|---|
| 0 | –7 |
| 5 | –5.5 |
| 10 | –4 |
| 15 to 90 | –2.5 |

*Note.— The –5.5 dBic gain at 5 degrees elevation angle is appropriate for an L1 antenna. A higher gain may be required in the future for GNSS signals in the L5/E5 band.*

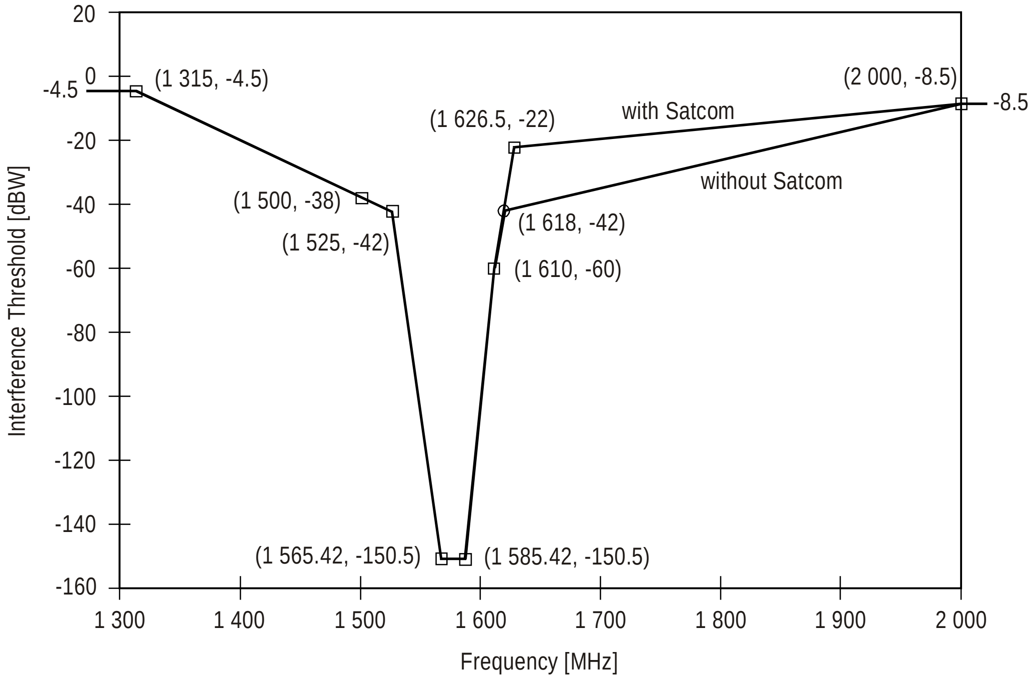


Figure B-15. CW interference thresholds for GPS L1 and SBAS L1 receivers in steady-state navigation

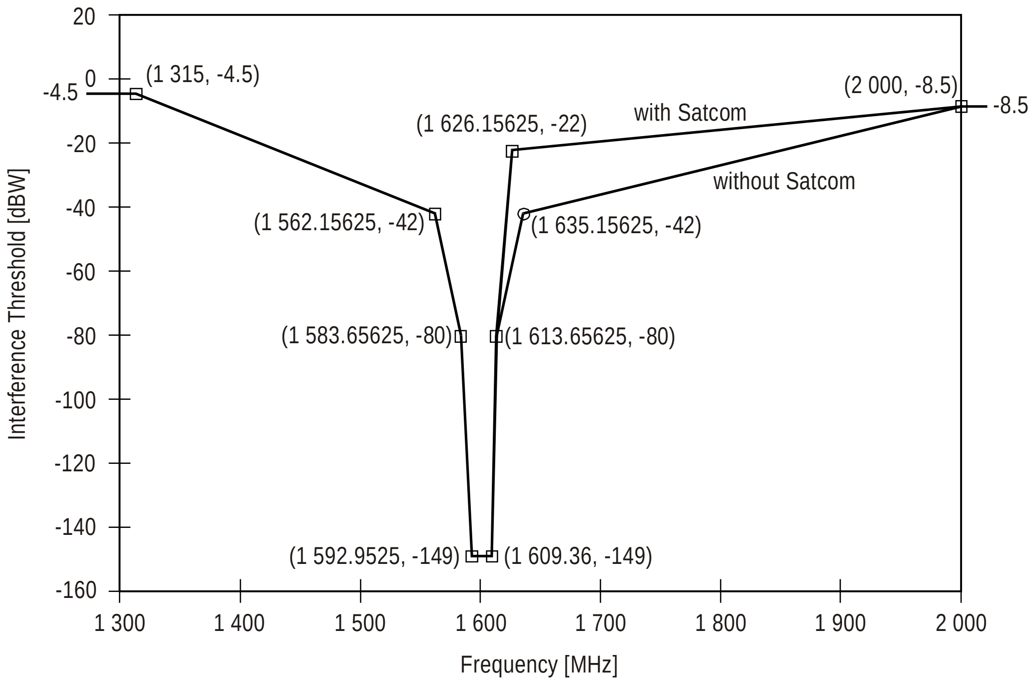


Figure B-16. CW interference thresholds for GLONASS receivers in steady-state navigation

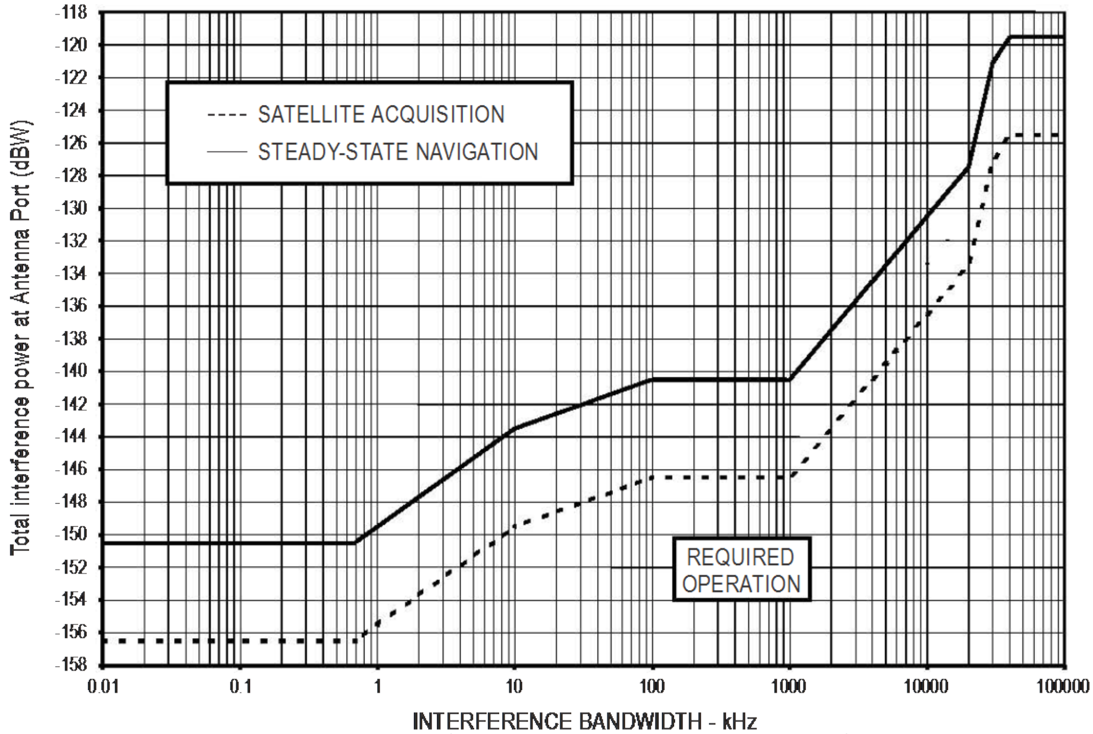


Figure B-17. Interference thresholds versus bandwidth for GPS L1 and SBAS L1 receivers

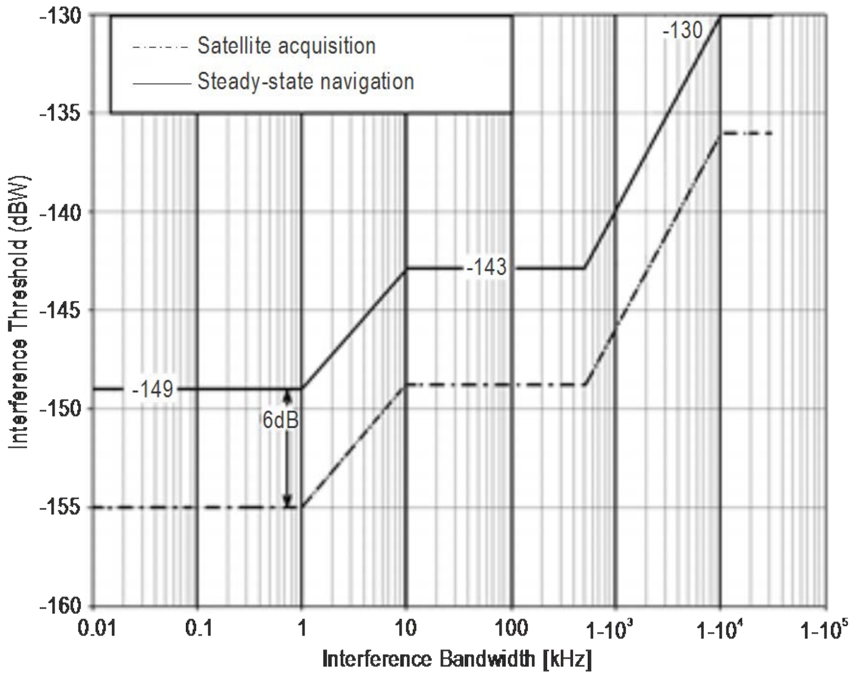


Figure B-18. Interference thresholds versus bandwidth for GLONASS receivers

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