Table A-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 A-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 A-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 Non-Aircraft Elements

Note 1. — Depending on the level of service offered by a particular SBAS, different functions can be implemented as described in 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 A-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 A-54.

3.5.7.1.2 SBAS radio frequency monitoring. The SBAS shall monitor the SBAS satellite parameters shown in Table A-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 3.7.3.4.2.1.

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.

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 radio frequency monitoring

Parameter	Reference	Alarm limit	Required action
Signal power level	Chapter 3, 3.7.3.4.4.3	minimum specified power maximum specified power *(Note 2)*	Cease ranging function (*Note 1*). Cease broadcast.
Modulation	Chapter 3, 3.7.3.4.4.5	monitor for waveform distortion	Cease ranging function (*Note 1*).
SNT-to-GPS time	Chapter 3, 3.7.3.4.5	N/A *(Note 3)*	Cease ranging function unless σ_{UDRE} reflects error.
Carrier frequency stability	3.5.2.1	N/A *(Note 3)*	Cease ranging function unless σ_{UDRE} reflects error.
Code/frequency coherence	3.5.2.4	N/A *(Note 3)*	Cease ranging function unless σ_{UDRE} reflects error.
Maximum code phase deviation	3.5.2.6	N/A *(Notes 2 and 3)*	Cease ranging function unless σ_{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 σ^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/N₀ 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 σ^2_{UDRE} and URA parameters. If the error cannot be represented, the ranging function must cease.*

3.5.7.3.2.1 When the PRN mask is changed, SBAS shall 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 3.5.5.2 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 To ensure accurate range rate corrections, SBAS shall 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 A-44.

3.5.7.4.5 Integrity data. For each satellite for which corrections are provided, SBAS shall broadcast integrity data ($UDREI_i$ 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 2×10^{-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 When the IGP mask is changed, SBAS shall 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 $IODI_k$ shall 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 A-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, 3.7.3.4.2.1.5, 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 ICAO Annex 10, Vol. I, Attachment C, 8.11.

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

3.5.7.7.2.2 The ground subsystem shall also detect conditions that causes more than one zero crossing for airborne receivers that use the Early-Late discriminator function as defined in ICAO Annex 10, Vol. I, Attachment C, 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 ICAO Annex 10, Vol. I, Attachment C, 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 **Aircraft Elements**

Note 1. — The parameters that are referred to in this section are defined in 3.5.4.

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.

3.5.8.1 SBAS-capable GNSS receiver. Except as specifically noted, the SBAS-capable GNSS receiver shall process the signals of the SBAS and meet the requirements specified in 3.1.3.1 (GPS receiver) and/or 3.2.3.1 (GLONASS receiver). Pseudo-range measurements for each satellite shall be smoothed using carrier measurements and a smoothing filter which deviates less than 0.25 metre within 200 seconds after initialization, relative to the steady-state response of the filter defined in 3.6.5.1 in the presence of drift between the code phase and integrated carrier phase of up to 0.018 metre per second.

3.5.8.1.1 GEO satellite acquisition. 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 ±450 Hz.

3.5.8.1.2 Conditions for use of data. The receiver shall use data from an SBAS message only if the CRC of this message has been verified. Reception of a Type 0 message from an SBAS satellite shall result in deselection of that satellite for at least one minute and all data from that satellite shall be discarded, except that there is no requirement to discard data from Type 12 and Type 17 messages. For GPS satellites, the receiver shall apply long-term corrections only if the IOD matches both the IODE and 8 least significant bits of the IODC. For GLONASS satellites, the receiver shall apply long-term corrections only if the time of reception (t_r) of the GLONASS ephemeris is inside the following IOD validity interval, as defined in 3.5.4.4.1:

$$t_{LT} - L - V \leq t_r \leq t_{LT} - L$$

Note 1. — For SBAS satellites, there is no mechanism that links GEO ranging function data (Type 9 message) and longterm corrections.

Note 2. — This requirement does not imply that the receiver has to stop tracking the SBAS satellite.

3.5.8.1.2.1 SBAS satellite identification. Upon acquisition or re-acquisition of an SBAS satellite, the receiver shall not use SBAS satellite data unless the calculated separation between the satellite position derived from its GEO ranging function parameters and the satellite position derived from the almanac message most recently received from the same service provider within the last 15 minutes is less than 200 km.

Note. — This check ensures that a receiver will not mistake one SBAS satellite for another due to cross-correlation during acquisition or re-acquisition.

3.5.8.1.2.2 The receiver shall use integrity or correction data only if the IODP associated with that data matches the IODP associated with the PRN mask.

3.5.8.1.2.3 The receiver shall use SBAS-provided ionospheric data (IGP vertical delay estimate and $GIVEI_i$) only if the $IODI_k$ associated with that data in a Type 26 message matches the $IODI_k$ associated with the relevant IGP band mask transmitted in a Type 18 message.

3.5.8.1.2.4 The receiver shall use the most recently received integrity data for which the $IODF_j$ equals 3 or the $IODF_j$ matches the $IODF_j$ associated with the fast correction data being applied (if corrections are provided).

3.5.8.1.2.5 The receiver shall apply any regional degradation to the $\sigma^2_{i,UDRE}$ as defined by a Type 27 service message. If a Type 27 message with a new IODS indicates a higher δ_{UDRE} for the user location, the higher δ_{UDRE} shall be applied immediately. A lower δ_{UDRE} in a new Type 27 message shall not be applied until the complete set of messages with the new IODS has been received.

3.5.8.1.2.6 The receiver shall apply satellite-specific degradation to the $\sigma^2_{i,UDRE}$ as defined by a Type 28 clockephemeris covariance matrix message. The δ_{UDRE} derived from a Type 28 message with an IODP matching that of the PRN mask shall be applied immediately.

3.5.8.1.2.7 In the event of a loss of four successive SBAS messages during an SBAS-based approach operation with a HAL of 40 m or a VAL of 50 m or less, the receiver shall invalidate all UDREI data from that SBAS satellite.

3.5.8.1.2.8 The receiver shall not use a broadcast data parameter after it has timed out as defined in Table A-56.

3.5.8.1.2.9 The receiver shall not use a fast correction if Δt for the associated RRC exceeds the time-out interval for fast corrections, or if the age of the RRC exceeds 8Δt.

3.5.8.1.2.10 The calculation of the RRC shall be reinitialized if a "Do Not Use" or "Not Monitored" indication is received for that satellite.

3.5.8.1.2.11 For SBAS-based precision approach or APV operations, the receiver shall only use satellites with elevation angles at or above 5 degrees.

3.5.8.1.2.12 The receiver shall no longer support SBAS-based precision approach or APV operation using a particular satellite if the $UDREI_i$ received is greater than or equal to 12.

Table B-56. Data time-out intervals

Data	Associated message types	En-route, terminal, NPA time-out	Precision approach, APV time-out
Clock-ephemeris covariance matrix	28	360	240
SBAS in test mode	0	N/A	N/A
PRN mask	1	600 s	600 s
UDREI	2 to 6, 24	18 s	12 s
Fast corrections	2 to 5, 24	(see Table B-57)	(see Table B-57)
Long-term corrections	24, 25	360 s	240 s
GEO ranging function data	9	360 s	240 s
Fast correction degradation	7	360 s	240 s
Degradation parameters	10	360 s	240 s
Ionospheric grid mask	18	1 200 s	1 200 s
Ionospheric corrections, GIVEI	26	600 s	600 s
Timing data	12	86 400 s	86 400 s
GLONASS time offset	12	600 s	600 s
Almanac data	17	None	None
Service level	27	86 400 s	86 400 s

Note.— The time-out intervals are defined from the end of the reception of a message.

Table B-57. Fast correction time-out interval evaluation

Fast correction degradation factor indicator (ai_i)	NPA time-out interval for fast corrections (I_{fc})	PA/APV time-out interval for fast corrections (I_{fc})
0	180 s	120 s
1	180 s	120 s
2	153 s	102 s
3	135 s	90 s
4	135 s	90 s
5	117 s	78 s
6	99 s	66 s
7	81 s	54 s
8	63 s	42 s
9	45 s	30 s
10	45 s	30 s
11	27 s	18 s
12	27 s	18 s
13	27 s	18 s
14	18 s	12 s
15	18 s	12 s

3.5.8.2 Ranging Function

3.5.8.2.1 Precision approach and APV operations. 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 (3.7.3.4.4.3) under the worst interference environment as defined in 3.7 shall be less than or equal to 1.8 metres, excluding multipath effects, tropospheric and ionospheric residual errors.

Note. — The aircraft element will bound the errors caused by multipath and troposphere (3.5.8.4.1). For the purpose of predicting service, the multipath error is assumed to be less than 0.6 metres (1 sigma).

3.5.8.2.2 Departure, en-route, terminal, and non-precision approach operations. The root-mean-square (1 sigma) of the total airborne contribution to the error in a corrected pseudo-range for an SBAS satellite at the minimum received signal power level (3.7.3.4.4.3) under the worst interference environment as defined in 3.7 shall be less than or equal to 5 metres, excluding multipath, tropospheric and ionospheric errors.

3.5.8.2.3 SBAS satellite position

3.5.8.2.3.1 Position computation. The receiver shall decode Type 9 message and determine the code phase offset and position (X_G, Y_G, Z_G) of the SBAS satellite.

3.5.8.2.3.2 SBAS satellite identification. The receiver shall discriminate between SBAS satellites.

Note. — This requirement applies to false acquisition of a satellite due to cross-correlation.

3.5.8.2.4 Almanac data

3.5.8.2.4.1 The almanac data provided by the SBAS shall be used for acquisition.

Note. — Health and status information provided in the GEO almanac data does not override or invalidate data provided in other SBAS messages. The use of bits 0 to 2 by airborne equipment is optional; there are no requirements covering their usage.

3.5.8.3 GNSS satellite status function. The receiver shall exclude satellites from the position solution if they are identified as "Do Not Use" by SBAS. If SBAS-provided integrity is used, the receiver shall not be required to exclude GPS satellites based on the GPS-provided ephemeris health flag as required in 3.1.3.1.1 or to exclude GLONASS satellites based on GLONASS-provided ephemeris health flag as required in 3.2.3.1.1.

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

Note 2. — If satellites identified as "Not Monitored" by SBAS are used in the position solution, integrity is not provided by SBAS. ABAS or GBAS may be used to provide integrity, if available.

3.5.8.4 Basic and Precise Differential Functions

3.5.8.4.1 Core satellite constellation(s) ranging accuracy. 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 (3.7.3.1.7.4) under the worst interference environment as defined in 3.7 shall be less than or equal to 0.36 metres for minimum signal level and 0.15 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 (3.2.5.4) under the worst interference environment as defined in 3.7 shall be less than or equal to 0.8 metres, excluding multipath effects, tropospheric and ionospheric residual errors.

3.5.8.4.2 Precision approach and APV operations

3.5.8.4.2.1 The receiver shall obtain correction and integrity data for all satellites in the position solution from the same SBAS signal (PRN code).

3.5.8.4.2.2 The receiver shall compute and apply long-term corrections, fast corrections, range rate corrections and the broadcast ionospheric corrections. For GLONASS satellites, the ionospheric corrections received from the SBAS shall be multiplied by the square of the ratio of GLONASS to GPS frequencies $(f_{GLONASS}/f_{GPS})^2$.

3.5.8.4.2.3 The receiver shall use a weighted-least-squares position solution.

3.5.8.4.2.4 The receiver shall apply a tropospheric model such that residual pseudo-range errors have a mean value (μ) less than 0.15 metres and a 1 sigma deviation less than 0.07 metres.

Note. — A model was developed that meets this requirement. Guidance is provided in ICAO Annex 10, Vol. I, Attachment C, 6.5.4.

3.5.8.4.2.5 The receiver shall compute and apply horizontal and vertical protection levels defined in 3.5.5.6. In this computation, $\sigma_{i,tropo}$ shall be:

$$\frac{1.001}{\sqrt{0.002001 + \sin^2(\theta_i)}} \times 0.12 \text{ m}$$

where θ_i is the elevation angle of the i^{th} satellite

In addition, $\sigma_{i,air}$ shall satisfy the condition that a normal distribution with zero mean and a standard deviation equal to $\sigma_{i,air}$ bounds the error distribution for residual aircraft pseudo-range errors as follows:

$$\int_{y}^{\infty} f_n(x)dx \leq Q\left(\frac{y}{\sigma}\right) \text{ for all } \frac{y}{\sigma} \geq 0 \text{ and}$$

$$\int_{-\infty}^{-y} f_n(x)dx \leq Q\left(\frac{y}{\sigma}\right) \text{ for all } \frac{y}{\sigma} \geq 0$$

where

$f_n(x)$ = probability density function of the residual aircraft pseudo-range error and

$Q(x)$ = $\frac{1}{\sqrt{2\pi}}\int_{x}^{\infty} e^{-\frac{t^2}{2}}dt$

Note.— The standard allowance for airborne multipath defined in 3.6.5.5.1 may be used to bound the multipath errors.

3.5.8.4.2.6 The parameters that define the approach path for a single precision approach or APV shall be contained in the FAS data block.

Note 1.— The FAS path is a line in space defined by the landing threshold point/fictitious threshold point (LTP/FTP), flight path alignment point (FPAP), threshold crossing height (TCH) and glide path angle (GPA). The local level plane for the approach is a plane perpendicular to the local vertical passing through the LTP/FTP (i.e. tangent to the ellipsoid at the LTP/FTP). Local vertical for the approach is normal to the WGS-84 ellipsoid at the LTP/FTP. The glide path intercept point (GPIP) is where the final approach path intercepts the local level plane.

Note 2. — For SBAS, FAS data blocks are stored in airborne databases. The format of the data for validation of a cyclic redundancy check is shown in ICAO Annex 10, Vol. I, Attachment C, 6.6. It differs from the GBAS FAS data block in 3.6.4.5.

3.5.8.4.2.6.1 FAS data block parameters shall be as follows (see Table A-57A):

Operation type: straight-in approach procedure or other operation types.

Coding: 0 = straight-in approach procedure

1 to 15 = spare

SBAS service provider ID: indicates the service provider associated with this FAS data block.

Coding: See Table A-27.

14 = FAS data block is to be used with GBAS only.

15 = FAS data block can be used with any SBAS service provider.

Airport ID: the three- or four-letter designator used to designate an airport.

Coding: Each character is coded using the lower 6 bits of its IA-5 representation. For each character, b_1 is transmitted first, and 2 zero bits are appended after b_6, so that 8 bits are transmitted for each character. Only upper case letters, numeric digits and IA-5 "space" are used. The rightmost character is transmitted first. For a three-character airport ID, the rightmost (first transmitted) character shall be IA-5 "space".

Runway number: the runway orientation, point-in-space final approach course, or SBAS circling only procedure course rounded to the nearest 10 degrees and truncated to two characters.

Coding: 01 to 36 = runway number

Note. — For heliport operations, the runway number value is the integer nearest to one tenth of the final approach course, except when that integer is zero, in which case the runway number is 36.

Runway letter: the one-letter designator used, as necessary, to differentiate between parallel runways.

Coding: 0 = no letter
1 = R (right)
2 = C (centre)
3 = L (left)

Approach performance designator: this field is not used by SBAS.

Table B-57A.   Final approach segment (FAS) data block

Data content	Bits used	Range of values	Resolution
Operation type	4	0 to 15	1
SBAS service provider ID	4	0 to 15	1
Airport ID	32	—	—
Runway number	6	01 to 36	1
Runway letter	2	—	—
Approach performance designator	3	0 to 7	1
Route indicator	5	—	—
Reference path data selector	8	0 to 48	1
Reference path identifier	32	—	—
LTP/FTP latitude	32	±90.0°	0.0005 arcsec
LTP/FTP longitude	32	±180.0°	0.0005 arcsec
LTP/FTP height	16	–512.0 to 6 041.5 m	0.1 m
ΔFPAP latitude	24	±1.0°	0.0005 arcsec
ΔFPAP longitude	24	±1.0°	0.0005 arcsec
Approach TCH (*Note 1*)	15	0 to 1 638.35 m or 0 to 3 276.7 ft	0.05 m or 0.1 ft
Approach TCH units selector	1	—	—
Glide path angle (GPA)	16	0 to 90.0°	0.01°
Course width	8	80 to 143.75 m	0.25 m
ΔLength offset	8	0 to 2 032 m	8 m
Horizontal alert limit (HAL)	8	0 to 51.0 m	0.2 m
Vertical alert limit (VAL) (*Note 2*)	8	0 to 51.0 m	0.2 m
Final approach segment CRC	32		—

Note 1.— Information can be provided in either feet or metres as indicated by the approach TCH unit selector.

Note 2.— A VAL of 0 indicates that the vertical deviations cannot be used (i.e., a lateral only approach). This does not preclude providing advisory vertical guidance on such approaches, refer to FAA AC 20-138.

Route indicator: a "blank" or the one-letter identifier used to differentiate between multiple procedures to the same runway end.

Note. — Procedures are considered to be different even if they only differ by the missed approach segment.

Coding: The letter is coded using bits b_1 through b_5 of its IA-5 representation. Bit b_1 is transmitted first. Only upper case letters, excluding "I" and "O", or IA-5 "space" (blank) are used. Blank indicates that there is only one procedure to the runway end. For multiple procedures to the same runway end, the route indicator is coded using a letter starting from Z and moving backward in the alphabet for additional procedures.

Reference path data selector (RPDS): this field is not used by SBAS.

Reference path identifier (RPI): four characters used to uniquely designate the reference path. The four characters consist of three alphanumeric characters plus a blank or four alphanumeric characters.

Note. — The best industry practice matches the 2nd and 3rd character encoding to the encoded runway number. The last character is a letter starting from A or a "blank."

Coding: Each character is coded using bits b_1 through b_6 of its IA-5 representation. For each character, b_1 is transmitted first, and 2 zero bits are appended after b_6 so that 8 bits are transmitted for each character. Only upper case letters, numeric digits and IA-5 "space" are used. The rightmost character is transmitted first. For a three-character reference path identifier, the rightmost (first transmitted) character shall be IA-5 "space".

Note.— The LTP/FTP is a point over which the FAS path passes at a height above the LTP/FTP height specified by the TCH.

LTP/FTP latitude: the latitude of the LTP/FTP point in arc seconds.

Coding: positive value denotes north latitude.
negative value denotes south latitude.

LTP/FTP longitude: the longitude of the LTP/FTP point in arc seconds.

Coding: positive value denotes east longitude.
negative value denotes west longitude.

LTP/FTP height: the height of the LTP/FTP above the WGS-84 ellipsoid.

Coding: This field is coded as an unsigned fixed-point number with an offset of −512 metres. A value of zero in this field places the LTP/FTP 512 metres below the earth ellipsoid.

Note.— The FPAP is a point at the same height as the LTP/FTP that is used to define the alignment of the approach. The origin of angular deviations in the lateral direction is defined to be 305 metres (1 000 ft) beyond the FPAP along the lateral FAS path. For an approach aligned with the runway, the FPAP is at or beyond the stop end of the runway.

ΔFPAP latitude: the difference of latitude of the runway FPAP from the LTP/FTP in arc seconds.

Coding: Positive value denotes the FPAP latitude north of LTP/FTP latitude.
Negative value denotes the FPAP latitude south of the LTP/FTP latitude.

ΔFPAP longitude: the difference of longitude of the runway FPAP from the LTP/FTP in arc seconds.

Coding: Positive value indicates the FPAP longitude east of LTP/FTP longitude.
Negative value indicates the FPAP longitude west of LTP/FTP longitude.

Approach TCH: the height of the FAS path above the LTP/FTP defined in either feet or metres as indicated by the TCH units selector.

Approach TCH units selector: the units used to describe the TCH.

Coding: 0 = feet
1 = metres

Glide path angle (GPA): the angle of the FAS path with respect to the horizontal plane tangent to the WGS-84 ellipsoid at the LTP/FTP.

Course width: the lateral displacement from the path defined by the FAS at the LTP/FTP at which full-scale deflection of a course deviation indicator is attained.

Coding: This field is coded as an unsigned fixed-point number with an offset of 80 metres. A value of zero in this field indicates a course width of 80 metres at the LTP/FTP.

ΔLength offset: the distance from the stop end of the runway to the FPAP.

Coding: 1111 1111 = not provided

HAL: Horizontal alert limit to be used during the approach in metres.

VAL: Vertical alert limit to be used during the approach in metres.

Final approach segment CRC: the 32-bit CRC appended to the end of each FAS data block in order to ensure approach data integrity. The 32-bit final approach segment CRC shall be calculated in accordance with 3.9. The length of the CRC code shall be k = 32 bits.

The CRC generator polynomial shall be:

$$G(x) = x^{32} + x^{31} + x^{24} + x^{22} + x^{16} + x^{14} + x^{8} + x^{7} + x^{5} + x^{3} + x + 1$$

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

$$M(x) = \sum_{i=1}^{288} m_i x^{288-i} = m_1 x^{287} + m_2 x^{286} + \ldots + m_{288} x^0$$

M(x) shall be formed from all bits of the associated FAS data block, excluding the CRC. Bits shall be arranged in the order transmitted, such that m_1 corresponds to the LSB of the operation type field, and m_{288} corresponds to the MSB of the Vertical Alert Limit (VAL) field. The CRC shall be ordered such that r_1 is the LSB and r_{32} is the MSB.

3.5.8.4.2.6.2 For precision approach and APV operations, the service provider ID broadcast Type 17 message shall be identical to the service provider ID in the FAS data block, except if ID equals 15 in the FAS data block.

Note. — If the service provider ID in the FAS data block equals 15, then any service provider can be used. If the service provider ID in the FAS data block equals 14, then SBAS precise differential corrections cannot be used for the approach.

3.5.8.4.2.6.3 SBAS FAS data points accuracy. The survey error of all the FAS data points, relative to WGS-84, shall be less than 0.25 metres vertical and 1 metre horizontal.

3.5.8.4.3 Departure, en-route, terminal, and non-precision approach operations

3.5.8.4.3.1 The receiver shall compute and apply long-term corrections, fast corrections and range rate corrections.

3.5.8.4.3.2 The receiver shall compute and apply ionospheric corrections.

Note. — Two methods of computing ionospheric corrections are provided in 3.1.2.4 and 3.5.5.5.2.

3.5.8.4.3.3 The receiver shall apply a tropospheric model such that residual pseudo-range errors have a mean value (μ) less than 0.15 metres and a standard deviation less than 0.07 metres.

Note. — A model was developed that meets this requirement. Guidance is provided in ICAO Annex 10, Vol. I, Attachment C, 6.5.4.

3.5.8.4.3.4 The receiver shall compute and apply horizontal and vertical protection levels as defined in 3.5.5.6. In this computation, σ_{tropo} shall be obtained either from the formula in 3.5.8.4.2.5, which can be used for elevation angles not less than 4 degrees, or from the alternate formula below, which can be used for elevation angles not less than 2 degrees:

$$\frac{1.001}{\sqrt{0.002001 + \sin^2(\theta_i)}} \times (1 + 0.015 \times (\max(0, 4 - \theta_i))^2) \times 0.12 \text{ m}$$

where θ_i is the elevation angle of the i^{th} satellite.

In addition, $\sigma_{i,air}$ shall satisfy the condition that a normal distribution with zero mean and standard deviation equal to $\sigma_{i,air}$ bounds the error distribution for residual aircraft pseudo-range errors as follows:

$$\int_{y}^{\infty} f_i(x)dx \leq Q\left(\frac{y}{\sigma}\right) \quad \text{for all } \frac{y}{\sigma} \geq 0 \text{ and}$$

$$\int_{-\infty}^{-y} f_i(x)dx \leq Q\left(\frac{y}{\sigma}\right) \quad \text{for all } \frac{y}{\sigma} \geq 0$$

where

$f_i(x)$ = probability density function of the residual aircraft pseudo-range error and

$$Q(x) = \frac{1}{\sqrt{2\pi}} \int_{x}^{\infty} e^{-\frac{t^2}{2}} dt$$

Note. — The standard allowance for airborne multipath defined in 3.6.5.5.1 may be used to bound the multipath errors.

3.5.8.4.4 For departure, en-route, terminal, and non-precision approach operations, the receiver shall use the broadcast ionospheric corrections, when available, and a tropospheric model with performance equal to that specified in 3.5.8.4.3.

3.5.9 Interface between SBAS

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

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

Note.— In this section, except where specifically annotated, reference to approach with vertical guidance (APV) means APV-I and APV-II.

3.6.1 General

The GBAS shall consist of a ground subsystem and an aircraft subsystem. The GBAS ground subsystem shall provide data and corrections for the GNSS ranging signals over a digital VHF data broadcast to the aircraft subsystem. The GRAS ground subsystem shall consist of one or more GBAS ground subsystems.

Note.— Guidance material is provided in ICAO Annex 10, Vol. I, Attachment C, 7.1.

3.6.2 RF Characteristics

3.6.2.1 Carrier frequency stability. The carrier frequency of the data broadcast shall be maintained within ±0.0002 per cent of the assigned frequency.

3.6.2.2 Bit-to-phase-change encoding. GBAS messages shall be assembled into symbols, each consisting of 3 consecutive message bits. The end of the message shall be padded by 1 or 2 fill bits if necessary to form the last 3-bit symbol of the message. Symbols shall be converted to D8PSK carrier phase shifts ($\Delta\varphi_k$) in accordance with Table A-58. ,

Note. — The carrier phase for the k^{th} symbol (φ_k) is given by: $\varphi_k = \varphi_{k-1} + \Delta\varphi_k$. The D8PSK signal may be produced as shown in Figure B-19 by combining two quadrature RF signals which are independently suppressed-carrier amplitudemodulated by base band filtered impulses. A positive increase in $\Delta\varphi_k$ represents a counterclockwise rotation in the complex I-Q plane of Figure B-19.

3.6.2.3 Modulation wave form and pulse shaping filters. The output of differential phase encoder shall be filtered by a pulse shaping filter whose output, s(t), is described as follows:

$$s(t)=\sum_{k=-\infty}^{k=\infty} e^{j\phi_k} h(t-kT)$$

where

h = the impulse response of the raised cosine filter;

φ_k = (as defined in 3.6.2.2);

t = time; and

T = the duration of each symbol = 1/10 500 second.

This pulse shaping filter shall have a nominal complex frequency response of a raised-cosine filter with α = 0.6. The time response, h(t), and frequency response, H(f), of the base band filters shall be as follows:

$$h(t)=\frac{\sin\left(\frac{\pi t}{T}\right)\cos\left(\frac{\pi\alpha t}{T}\right)}{\frac{\pi t}{T}\left[1-\left(\frac{2\alpha t}{T}\right)^2\right]}$$

$$H(f)=\begin{cases} 1 & \text{for} \quad 0\le f<\frac{1-\alpha}{2T} \\ \frac{1-\sin\left(\frac{\pi}{2\alpha}(2fT-1)\right)}{2} & \text{for} \quad \frac{1-\alpha}{2T}\le f\le\frac{1+\alpha}{2T} \\ 0 & \text{for} \quad f>\frac{1+\alpha}{2T} \end{cases}$$

The output s(t) of the pulse shaping filter shall modulate the carrier.

3.6.2.4 Error vector magnitude. The error vector magnitude of the transmitted signal shall be less than 6.5 per cent root-mean-square (1 sigma).

3.6.2.5 RF data rate. The symbol rate shall be 10 500 symbols per second ±0.005 per cent, resulting in a nominal bit rate of 31 500 bits per second.

Table B-58. Data encoding

Message bits			Symbol phase shift
I_{3k-2}	I_{3k-1}	I_{3k}	$\Delta\phi_k$
0	0	0	$0\pi/4$
0	0	1	$1\pi/4$
0	1	1	$2\pi/4$
0	1	0	$3\pi/4$
1	1	0	$4\pi/4$
1	1	1	$5\pi/4$
1	0	1	$6\pi/4$
1	0	0	$7\pi/4$

Note.— I_j is the j^{th} bit of the burst to be transmitted, where I_1 is the first bit of the training sequence.

3.6.2.6 Emissions in unassigned time slots. Under all operating conditions, the maximum power over a 25 kHz channel bandwidth, centred on the assigned frequency, when measured over any unassigned time slot, shall not exceed –105 dBc referenced to the authorized transmitter power.

Note. — If the authorized transmitter power is higher than 150 W, the –105 dBc may not protect reception of emissions in a slot assigned to another desired transmitter for receivers within 200 metres from the undesired transmitting antenna.

3.6.3 **Data Structure**

3.6.3.1 Transmitter Timing

3.6.3.1.1 Data broadcast timing structure. The time division multiple access (TDMA) timing structure shall be based on frames and time slots. Each frame shall be 500 milliseconds in duration. There shall be 2 such frames contained in each 1-second UTC epoch. The first of these frames shall start at the beginning of the UTC epoch and the second frame shall start 0.5 seconds after the beginning of the UTC epoch. The frame shall be time division multiplexed such that it shall consist of 8 individual time slots (A to H) of 62.5-millisecond duration.

3.6.3.1.2 Bursts. Each assigned time slot shall contain at most 1 burst. To initiate the use of a time slot, the GBAS shall broadcast a burst in that time slot in each of 5 consecutive frames. For each time slot in use, the ground subsystem shall broadcast a burst in at least 1 frame of every 5 consecutive frames.

Note 1.— Bursts contain one or more messages and may be of variable length up to the maximum allowed within the slot as required by 3.6.3.2.

Note 2. — During time slot initiation, the airborne receiver may not receive the first 4 bursts.

3.6.3.1.3 Timing budget for bursts

3.6.3.1.3.1 Each burst shall be contained in a 62.5-millisecond time slot.

3.6.3.1.3.2 The beginning of the burst shall occur 95.2 microseconds after the beginning of the time slot with a tolerance of ±95.2 microseconds.

3.6.3.1.3.3 For GBAS/E equipment, the start of the synchronization and ambiguity resolution portion of the burst, transmitted with horizontal polarization (HPOL), shall occur within 10 microseconds of the start of the burst transmitted with vertical polarization (VPOL).

Note. — Table A-59 illustrates the burst timing.

3.6.3.1.4 Ramp-up and transmitter power stabilization. The transmitter shall ramp up to 90 per cent of the steady-state power level within 190.5 microseconds after the beginning of the burst (2 symbols). The transmitter shall stabilize at the steady-state power within 476.2 microseconds after the beginning of the burst (5 symbols).

Note. — The transmitter power stabilization period may be used by the aircraft receiver to settle its automatic gain control.

3.6.3.1.5 Ramp-down. After the final information symbol is transmitted in an assigned time slot, the transmitter output power level shall decrease to at least 30 dB below the steady-state power within 285.7 microseconds (3 symbols).

3.6.3.2 Burst organization and coding. Each burst shall consist of the data elements shown in Table A-60. Encoding of the messages shall follow the sequence: application data formatting, training sequence forward error correction (FEC) generation, application FEC generation and bit scrambling.

3.6.3.2.1 Synchronization and ambiguity resolution. The synchronization and ambiguity resolution field shall consist of the 48-bit sequence shown below, with the rightmost bit transmitted first:

010 001 111 101 111 110 001 100 011 101 100 000 011 110 010 000

Table B-59. Burst timing

Event	Nominal event duration	Nominal percentage of steady-state power
Ramp-up	190.5 μs	0% to 90%
Transmitter power stabilization	285.7 μs	90% to 100%
Synchronization and ambiguity resolution	1 523.8 μs	100%
Transmission of scrambled data	58 761.9 μs	100%
Ramp-down	285.7 μs (*Note 1*)	100% to 0%

Notes.—

1. *Event duration indicated for transmission of scrambled data is for maximum application data length of 1 776 bits, 2 fill bits and nominal symbol duration.*

2. *These timing requirements provide a propagation guard time of 1 259 microseconds, allowing for a one-way propagation range of approximately 370 km (200 NM).*

3. *Where bursts from a GBAS broadcast antenna can be received at a range more than 370 km (200 NM) greater than the range from another broadcast antenna using the next adjacent slot, a longer guard time is required to avoid loss of both bursts. To provide a longer guard time, it is necessary to limit the application data length of the first burst to 1 744 bits. This allows a difference in propagation ranges of up to 692 km (372 NM) without conflict.*

Table A-60. Burst data content

Element	Data content	Number of bits
Beginning of burst Power stabilization	all zeros	15
Synchronization and ambiguity resolution	3.6.3.2.1	48
Scrambled data:	3.6.3.3	
station slot identifier (SSID)	3.6.3.3.1	3
transmission length	3.6.3.3.2	17
training sequence FEC	3.6.3.3.3	5
application data	3.6.3.3.4	up to 1 776
application FEC	3.6.3.3.5	48
fill bits (Note)	3.6.2.2	0 to 2

Note. — Data scrambling of the fill bits is optional (3.6.3.3.6).

3.6.3.3 Scrambled Data Content

3.6.3.3.1 Station slot identifier (SSID). The SSID shall be a numeric value corresponding to the letter designation A to H of the first time slot assigned to the GBAS ground subsystem, where slot A is represented by 0, B by 1, C by 2, ... and H by 7. The identifier is transmitted LSB first.

3.6.3.3.2 Transmission length. The transmission length shall indicate the total number of bits in both application data and application FEC. The transmission length is transmitted LSB first.

3.6.3.3.3 Training sequence FEC. The training sequence FEC shall be computed over the SSID and transmission length fields, using a (25, 20) block code, in accordance with the following equation:

$$[P_1, \ldots, P_5] = [SSID_1, \ldots, SSID_3, TL_1, \ldots, TL_{17}]\, H^T$$

where

P_n = the n^{th} bit of the training sequence FEC (P_1 shall be transmitted first);
$SSID_n$ = the n^{th} bit of the station slot identifier ($SSID_1$ = LSB);
TL_n = the n^{th} bit in the transmission length (TL_1 = LSB); and
H^T = the transpose of the parity matrix, defined below:

$$H^T = \begin{bmatrix} 0&0&0&0&0&0&0&0&1&1&1&1&1&1&1&1&1&1&1&1 \\ 0&0&1&1&1&1&1&1&0&0&0&0&1&1&1&1&1&1&1&1 \\ 1&1&0&0&0&1&1&1&0&0&1&1&0&0&0&0&1&1&1&1 \\ 1&1&0&1&1&0&1&1&0&1&0&1&0&0&1&1&0&0&1&1 \\ 0&1&1&0&1&0&0&1&1&1&1&0&0&1&0&1&0&1&0&1 \end{bmatrix}^T$$

Note.— This code is capable of correcting all single bit errors and detecting 75 of 300 possible double bit errors.

3.6.3.3.4 Application data. The application data shall consist of one or more message blocks, as defined in 3.6.3.4. The message blocks shall be mapped directly into the application data with no additional overhead of intervening layers.

3.6.3.3.5 Application FEC. The application FEC shall be calculated using the application data by means of a systematic, fixed-length, Reed-Solomon (R-S) (255, 249) code.

3.6.3.3.5.1 The field-defining primitive, p(x), of the R-S code shall be:

$$p(x) = x^8 + x^7 + x^2 + x + 1$$

3.6.3.3.5.2 The generator polynomial of the R-S code, g(x), shall be:

$$g(x) = \prod_{i=120}^{125} (x - \alpha^i) = x^6 + \alpha^{176}x^5 + \alpha^{186}x^4 + \alpha^{244}x^3 + \alpha^{176}x^2 + \alpha^{156}x + \alpha^{225}$$

where α is a root of p(x) used for construction of the Galois Field of size 2^8, GF(256), and α^i is the i^{th} primitive element in GF(256).

3.6.3.3.5.3 In generating the application FEC, the data to be encoded, m(x), shall be grouped into 8-bit R-S symbols. All data fields in the message blocks that define the application data shall be ordered such as specified in Tables B-61 and B-62, and in the message tables in 3.6.6. However, since the R-S code is a block code, application data blocks shorter than 249 bytes (1 992 bits) shall be extended to 249 bytes by virtual fill bits set to zero and appended to the application data. These virtual fill bits shall not be transferred to the bit scrambler. The data to be encoded, m(x), shall be defined by:

$$m(x) = a_{248}x^{248} + a_{247}x^{247} + ... + a_{248\text{-}length+1}\,x^{248\text{-}length+1} + a_{248\text{-}length}\,x^{248\text{-}length} + ... + a_1x + a_0$$

where

length represents the number of 8-bit bytes in the application data block;

a_{248} represents the message block identifier, with the rightmost bit defined as the LSB and the first bit of the application data sent to the bit scrambler;

$a_{248\text{-}length+1}$ represents the last byte of the message block CRC, with the leftmost bit defined as the MSB and the last bit of the application data sent to the bit scrambler; and

$a_{248\text{-}length}$, ..., a_1, a_0 are the virtual fill bits (if any).

3.6.3.3.5.4 The 6 R-S check symbols (b_i) shall be defined as the coefficients of the remainder resulting from dividing the message polynomial $x^6m(x)$ by the generator polynomial g(x):

$$b(x) = \sum_{i=0}^{5} b_i x^i + b_5x^5 + b_4x^4 + b_3x^3 + b_2x^2 + b_1x^1 + b_0 = [x^6m(x)] \bmod g(x)$$

3.6.3.3.5.5 The 8-bit R-S check symbols shall be appended to the application data. Each 8-bit R-S check symbol shall be transmitted MSB first from b_0 to b_5, i.e. the first application FEC bit transferred to the bit scrambler shall be the MSB of b_0 and the last application FEC bit transferred to the bit scrambler shall be the LSB of b_5.

Note 1. — This R-S code is capable of correcting up to 3 symbol errors.

Note 2. — The order of the transmitted 8-bit R-S check symbols of the appended application FEC differs from the VHF data link (VDL) Mode 2. Moreover, for VDL Mode 2 each R-S check symbol is transmitted LSB first.

Note 3. — Example results of application FEC encoding are given in ICAO Annex 10, Vol. I, Attachment C, 7.15.

Table B-61. Format of a GBAS message block

Message block	Bits
Message block header	48
Message	up to 1 696
CRC	32

Table A-62. Format of message block header

Data field	Bits
Message block identifier	8
GBAS ID	24
Message type identifier	8
Message length	8

3.6.3.3.6 Bit scrambling

3.6.3.3.6.1 The output of a pseudo-noise scrambler with a 15-stage generator register shall be exclusive OR'ed with the burst data starting with the SSID and ending with the application FEC. Bit scrambling of the fill bits is optional and the set value of the fill bits is optional.

Note. — The fill bits are not used by the aircraft receiver and their values have no impact on the system.

3.6.3.3.6.2 The polynomial for the register taps of the scrambler shall be $1 + x + x^{15}$. The register content shall be rotated at the rate of one shift per bit. The initial status of the register, prior to the first SSID bit of each burst, shall be "1101 0010 1011 001", with the leftmost bit in the first stage of the register. The first output bit of the scrambler shall be sampled prior to the first register shift.

Note. — A diagram of the bit scrambler is given in ICAO Annex 10, Vol. I, Attachment C, 7.4.

3.6.3.4 Message block format. The message blocks shall consist of a message block header, a message and a 32-bit CRC. Table A-61 shows the construction of the message block. All signed parameters shall be two's complement numbers and all unsigned parameters shall be unsigned fixed point numbers. The scaling of the data shall be as shown in the message tables in 3.6.6. All data fields in the message block shall be transmitted in the order specified in the message tables, with the LSB of each field transmitted first.

Additional message flag: an identification of whether the set of measurement blocks in a single frame for a particular measurement type is contained in a single Type 1 message or a linked pair of messages.

Coding: 0 = All measurement blocks for a particular measurement type are contained in one Type 1 message.

1 = This is the first transmitted message of a linked pair of Type 1 messages that together contain the set of all measurement blocks for a particular measurement type.
2 = Spare
3 = This is the second transmitted message of a linked pair of Type 1 messages that together contain the set of all measurement blocks for a particular measurement type.

Note.— When a linked pair of Type 1 messages is used for a particular measurement type, the number of measurements and low-frequency data are computed separately for each of the two individual messages.

Number of measurements: the number of measurement blocks in the message.

Measurement type: the type of ranging signal from which the corrections have been computed.

Table A-63. GBAS VHF data broadcast messages

Message type identifier	Message name
0	Spare
1	Pseudo-range corrections
2	GBAS-related data
3	Null message
4	Final approach segment (FAS) data
5	Predicted ranging source availability
6	Reserved
7	Reserved for national applications
8	Reserved for test applications
9 to 100	Spare
101	GRAS pseudo-range corrections
102 to 255	Spare

Note.— See 3.6.6 for message formats.

Note. — See 3.6.6 for message formats

Coding: 0 = C/A or CSA code L1

1 = reserved
2 = reserved
3 = reserved
4 to 7 = spare

Ephemeris decorrelation parameter (P): a parameter that characterizes the impact of residual ephemeris errors due to decorrelation for the first measurement block in the message.

For a SBAS geostationary satellite, the ephemeris decorrelation parameter, if transmitted, shall be coded as all zeros.

For GBAS ground subsystems that do not broadcast the additional data block 1 in the Type 2 message, the ephemeris decorrelation parameter shall be coded as all zeros.

Ephemeris CRC: the CRC computed with the ephemeris data used to determine corrections for the first measurement block in the message. The ephemeris CRC for core satellite constellation(s) ranging sources shall be calculated in accordance with third schedule, section 3.9. The length of the CRC code shall be k = 16 bits. The CRC generator polynomial shall be:

$$G(x) = x^{16} + x^{12} + x^5 + 1$$

The CRC information field, M(x), for a given satellite shall be:

$$M(x) = \sum_{i=1}^{n} m_i x^{n-i} + m_1 x^{n-1} + m_2 x^{n-2} + \ldots + m_n x^0$$

For a GPS satellite, M(x) shall be of length n = 576 bits. M(x) for a GPS satellite shall be calculated using the first 24 bits from each of words 3 to S10 of subframes 1, 2 and 3 of the data transmission from that satellite, ANDed with the GPS satellite ephemeris mask of Table A-64. M(x) shall be arranged in the order that bytes are transmitted by the GPS satellite, but with each byte ordered LSB first, such that m_1 corresponds to bit 68 of subframe 1, and m_{576} corresponds to bit 287 of subframe 3.

Note. — M(x) for a GPS satellite does not include word 1 (TLM) or word 2 (HOW), which start each subframe, or the 6 parity bits at the end of each word.

For a GLONASS satellite, M(x) shall be of length $n = 340$ bits. M(x) for a GLONASS satellite shall be calculated using strings 1, 2, 3 and 4 of the data transmission from that satellite, ANDed with the GLONASS satellite ephemeris mask of Table A-65. Bits shall be arranged in transmission order such that m_1 corresponds to bit 85 of string 1, and m_{340} corresponds to bit 1 of string 4.

For a SBAS geostationary satellite, the ephemeris CRC, if transmitted shall be coded as all zeros.

The CRC shall be transmitted in the order $r_9, r_{10}, r_{11}, \ldots, r_{16}, r_1, r_2, r_3 \ldots r_8$, where r_i is the i^{th} coefficient of the remainder R(x) as defined in third schedule, section 3.9.

Source availability duration: the predicted duration for which corrections for the ranging source are expected to remain available, relative to the modified Z-count for the first measurement block.

Coding: 1111 1110 = The duration is greater than or equal to 2 540 seconds.

1111 1111 = Prediction of source availability duration is not provided by this ground subsystem.

3.6.4.2.4 The measurement block parameters shall be as follows:

Ranging source ID: the identity of the ranging source to which subsequent measurement block data are applicable.

Table A-64. GPS satellite ephemeris mask

Subframe 1:	Byte 1	Byte 2	Byte 3		Byte 1	Byte 2	Byte 3
Word 3	0000	0000	0000 0011	Word 4	0000	0000	0000
	0000	0000			0000	0000	0000
Word 5	0000	0000	0000 0000	Word 6	0000	0000	0000
	0000	0000			0000	0000	0000
Word 7	0000	0000	1111 1111	Word 8	1111	1111	1111
	0000	0000			1111	1111	1111
Word 9	1111	1111	1111 1111	Word 10	1111	1111	1111
	1111	1111			1111	1111	1100
Subframe 2:	Byte 1	Byte 2	Byte 3		Byte 1	Byte 2	Byte 3
Word 3	1111	1111	1111 1111	Word 4	1111	1111	1111
	1111	1111			1111	1111	1111
Word 5	1111	1111	1111 1111	Word 6	1111	1111	1111
	1111	1111			1111	1111	1111
Word 7	1111	1111	1111 1111	Word 8	1111	1111	1111

	1111	1111			1111	1111	1111
Word 9	1111	1111	1111 1111	Word 10	1111	1111	0000
	1111	1111			1111	1111	0000
Subframe 3:	Byte 1	Byte 2	Byte 3		Byte 1	Byte 2	Byte 3
Word 3	1111	1111	1111 1111	Word 4	1111	1111	1111
	1111	1111			1111	1111	1111
Word 5	1111	1111	1111 1111	Word 6	1111	1111	1111
	1111	1111			1111	1111	1111
Word 7	1111	1111	1111 1111	Word 8	1111	1111	1111
	1111	1111			1111	1111	1111
Word 9	1111	1111	1111 1111	Word 10	1111	1111	1111
	1111	1111			1111	1111	1100

Table A-65. GLONASS satellite ephemeris mask

String 1:
0 0000 0000 0000 0000 0000 1111 1111 1111 1111 1111 1111 1111 1111
1111 1111 1111 1111 1111 1111 0000 0000
String 2:
0 0000 0000 0000 0000 0000 1111 1111 1111 1111 1111 1111 1111 1111
1111 1111 1111 1111 1111 1111 0000 0000
String 3:
0 0000 0111 1111 1111 0000 1111 1111 1111 1111 1111 1111 1111 1111
1111 1111 1111 1111 1111 1111 0000 0000
String 4:
0 0000 1111 1111 1111 1111 1111 1100 0000 0000 0000 0000 0000
0000 0000 0000 0000 0000 0000 0000 0000 0000

Coding:

Coding:	**1 to 36**	=	**GPS satellite IDs (PRN)**
	37	=	**reserved**
	38 to 61	=	**GLONASS satellite IDs (slot number plus 37)**
	62 to 119	=	**spare**
	120 to 138	=	**SBAS satellite IDs (PRN)**
	139 to 255	=	**spare**

Issue of data (IOD): The issue of data associated with the ephemeris data used to determine pseudo-range and range rate corrections.

Coding:	for GPS, IOD	=	GPS IODE parameter (3.1.1.3.2.2)
	for GLONASS, IOD	=	GLONASS "t_b" parameter (see 3.2.1.3.1)
	for SBAS, IOD	=	1111 1111

Note.— For GLONASS insert 0 in the MSB of the IOD.

Pseudo-range correction (PRC): the correction to the ranging source pseudo-range.

Range rate correction (RRC): the rate of change of the pseudo-range correction.

σ_{pr_gnd}: the standard deviation of a normal distribution associated with the signal-in-space contribution of the pseudo-range error at the GBAS reference point (3.6.5.5.1, 3.6.5.5.2 and 3.6.7.2.2.4).

Coding: 1111 1111 = Ranging source correction invalid.

B_1 through B_4: are the integrity parameters associated with the pseudo-range corrections provided in the same measurement block. For the i^{th} ranging source these parameters correspond to $B_{i,1}$ through $B_{i,4}$ (3.6.5.5.1.2, 3.6.5.5.2.2 and 3.6.7.2.2.4). The indices "1-4" correspond to the same physical reference receiver for every frame transmitted from a given ground subsystem during continuous operation.

Coding: 1000 0000 = Reference receiver was not used to compute the pseudo-range correction.

Note. — Some airborne receivers may expect a static correspondence of the reference receivers to the indices for short service interruptions. However, the B-value indices may be reassigned after the ground subsystem has been out of service for an extended period of time, such as for maintenance.

3.6.4.3 Type 2 message – GBAS-related data. Type 2 message shall identify the location of the GBAS reference point at which the corrections provided by the GBAS apply and shall give other GBAS-related data (Table A-71). GBAS-related data parameters shall be as follows:

Note. — Additional data blocks may be included in the Type 2 message. Additional data block 1 and additional data block 2 are defined. In the future, other additional data blocks may be defined. Data blocks 2 through 255 are variable length and may be appended to the message after additional data block 1 in any order.

GBAS reference receivers: the number of GNSS reference receivers installed in this GBAS ground subsystem.

Coding: 0 = GBAS installed with 2 reference receivers
1 = GBAS installed with 3 reference receivers
2 = GBAS installed with 4 reference receivers
3 = The number of GNSS reference receivers installed in this GBAS ground subsystem is not applicable

Ground accuracy designator letter: the letter designator indicating the minimum signal-in-space accuracy performance provided by GBAS (3.6.7.1.1).

Coding: 0 = accuracy designation A
1 = accuracy designation B
2 = accuracy designation C
3 = spare

GBAS continuity/integrity designator (GCID): numeric designator indicating the operational status of the GBAS

Coding: 0 = spare
1 = GCID 1
2 = GCID 2
3 = GCID 3
4 = GCID 4
5 = spare
6 = spare
7 = unhealthy

Note 1. — The values of GCID 2, 3 and 4 are specified in order to ensure compatibility of equipment with future GBAS.

Note 2. — The value of GCID 7 indicates that a precision approach or APV cannot be initiated.

Local magnetic variation: the published magnetic variation at the GBAS reference point.

Coding: Positive value denotes east variation (clockwise from true north), Negative value denotes west variation (counterclockwise from true north)

100 0000 0000 = Precision approach procedures supported by this GBAS are published based on true bearing.

Note. – Local magnetic variation is chosen to be consistent with procedure design and is updated during magnetic epoch years.

$\sigma_{vert\_iono\_gradient}$: the standard deviation of a normal distribution associated with the residual ionospheric uncertainty due to spatial decorrelation (3.6.5.4).

Refractivity index (N_r): the nominal tropospheric refractivity index used to calibrate the tropospheric correction associated with the GBAS ground subsystem (3.6.5.3).

Coding: This field is coded as two's complement number with an offset of +400. A value of zero in this field indicates a refractivity index of 400.

Scale height (h_0): a scale factor used to calibrate the tropospheric correction and residual tropospheric uncertainty associated with the GBAS ground subsystem (3.6.5.3).

Refractivity uncertainty (σ_n): the standard deviation of a normal distribution associated with the residual tropospheric uncertainty (3.6.5.3).

Latitude: the latitude of the GBAS reference point defined in arc seconds.

Coding: Positive value denotes north latitude.

Negative value denotes south latitude.

Longitude: the longitude of the GBAS reference point defined in arc seconds.

Coding: Positive value denotes east longitude.

Negative value denotes west longitude.

Reference point height: the height of the GBAS reference point above the WGS-84 ellipsoid.

3.6.4.3.1 Additional data block 1 parameters. Additional data block 1 parameters shall be as follows:

REFERENCE STATION DATA SELECTOR (RSDS): the numerical identifier that is used to select the GBAS ground subsystem.

Note. — The RSDS is different from every other RSDS and every reference path data selector (RPDS) broadcast on the same frequency by every GBAS ground subsystem within the broadcast region.

Coding: 1111 1111 = GBAS positioning service is not provided

MAXIMUM USE DISTANCE (D_{max}): the maximum distance (slant range) from the GBAS reference point for which the integrity is assured.

Note. — This parameter does not indicate a distance within which VHF data broadcast field strength requirements are met.

Coding: 0 = No distance limitation

GPS EPHEMERIS MISSED DETECTION PARAMETER, GBAS Positioning Service ($K_{md\_e\_POS,GPS}$): the multiplier for computation of the ephemeris error position bound for the GBAS positioning service derived from the probability of missed detection given that there is an ephemeris error in a GPS satellite.

For GBAS ground subsystems that do not broadcast corrections for GPS ranging sources or that do not provide the GBAS positioning service, this parameter shall be coded as all zeros.

GPS EPHEMERIS MISSED DETECTION PARAMETER, Category I Precision Approach and APV ($K_{md\_e,GPS}$): the multiplier for computation of the ephemeris error position bound for Category I precision approach and APV derived from the probability of missed detection given that there is an ephemeris error in a GPS satellite.

For GBAS ground subsystems that do not broadcast corrections for GPS ranging sources, this parameter shall be coded as all zeros.

GLONASS EPHEMERIS MISSED DETECTION PARAMETER, GBAS Positioning Service ($K_{md\_e\_POS,GLONASS}$): the multiplier for computation of the ephemeris error position bound for the GBAS positioning service derived from the probability of missed detection given that there is an ephemeris error in a GLONASS satellite.

For GBAS ground subsystems that do not broadcast corrections for GLONASS ranging sources or that do not provide positioning service, this parameter shall be coded as all zeros.

GLONASS EPHEMERIS MISSED DETECTION PARAMETER, Category I Precision Approach and APV ($K_{md\_e\_,GLONASS}$): the multiplier for computation of the ephemeris error position bound for Category I precision approach and APV derived from the probability of missed detection given that there is an ephemeris error in a GLONASS satellite.

For GBAS ground subsystems that do not broadcast corrections for GLONASS ranging sources, this parameter shall be coded as all zeros.

3.6.4.3.2 Additional data blocks. For additional data blocks other than additional data block 1, the parameters for each data block shall be as follows:

ADDITIONAL DATA BLOCK LENGTH: the number of bytes in the additional data block, including the additional data block length and additional data block number fields.

ADDITIONAL DATA BLOCK NUMBER: the numerical identifier of the type of additional data block.

Coding: 0 to 1	=	reserved
2	=	additional data block 2, GRAS broadcast stations
3	=	reserved for future services supporting Category II/III operations
4	=	additional data block 4, VDB authentication parameters
5 to 255	=	spare

ADDITIONAL DATA PARAMETERS: the set of data defined in accordance with the additional data block number.

3.6.4.3.2.1 GRAS broadcast stations

Parameters for additional data block 2 shall include data for one or more broadcast stations as follows (Table A-65A):

CHANNEL NUMBER: the channel number, as defined in 3.6.5.7, associated with a GBAS broadcast station.

Note.— The channel number in this field refers to a frequency and an RSDS.

ΔLATITUDE: the difference of latitude of a GBAS broadcast station, measured from the latitude provided in the latitude parameter of Type 2 message.

Coding: Positive value denotes that the GBAS broadcast station is north of the GBAS reference point.

Negative value denotes that the GBAS broadcast station is south of the GBAS reference point.

ΔLONGITUDE: the difference of longitude of a GBAS broadcast station, measured from the longitude provided in the longitude parameter of Type 2 message.

Coding: Positive value denotes that the GBAS broadcast station is east of the GBAS reference point.

Negative value denotes that the GBAS broadcast station is west of the GBAS reference point.

Note. — Guidance material concerning additional data block 2 is provided in ICAO Annex 10, Vol. I, Attachment C, 7.17.

3.6.4.3.2.2 VDB authentication parameters

Additional data block 4 includes information needed to support VDB authentication protocols (Table A-65B).

Slot group definition: This 8-bit field indicates which of the 8 slots (A-H) are assigned for use by the ground station. The field is transmitted LSB first. The LSB corresponds to slot A, the next bit to slot B, and so on. A "1" in the bit position indicates the slot is assigned to the ground station. A "0" indicates the slot is not assigned to the ground station.

Table B-65A. GRAS broadcast station data

Data content	Bits used	Range of values	Resolution
Channel number	16	20001 to 39999	1
ΔLatitude	8	±25.4°	0.2°
ΔLongitude	8	±25.4°	0.2°

Table B-65B. VDB authentication parameters

Data content	Bits used	Range of values	Resolution
Slot group definition	8	—	—

3.6.4.4 Type 3 Message — Null Message

3.6.4.4.1 The Type 3 message is a variable length "null message" which is intended to be used by ground subsystems that support the authentication protocols (see section 3.6.7.4).

3.6.4.4.2 The parameters for the Type 3 message shall be as follows:

Filler: a sequence of bits alternating between "1" and "0" with a length in bytes that is 10 less than the value in the message length field in the message header.

3.6.4.5 Type 4 message — Final approach segment (FAS). Type 4 message shall contain one or more sets of FAS data, each defining a single precision approach (Table A-72). Each Type 4 message data set shall include the following:

Data set length: the number of bytes in the data set. The data set includes the data set length field and the associated FAS data block, FAS vertical alert limit (FASVAL)/approach status and FAS lateral alert limit (FASLAL)/approach status fields.

FAS data block: the set of parameters to identify a single precision approach or APV and define its associated approach path.

Coding: See 3.6.4.5.1 and Table A-66.

Note. — Guidance material for FAS path definition is contained in Attachment C, 7.11.

FASVAL/approach status: the value of the parameter FASVAL as used in 3.6.5.6.

Coding: 1111 1111 = Do not use vertical deviations.

Note. — The range and resolution of values for FASVAL depend upon the approach performance designator in the associated FAS data block.

FASLAL/approach status: the value of the parameter FASLAL as used in 3.6.5.6.

Coding: 1111 1111 = Do not use approach.

3.6.4.5.1 FAS data block. The FAS data block shall contain the parameters that define a single precision approach or APV. The FAS path is a line in space defined by the landing threshold point/fictitious threshold point (LTP/FTP), flight path alignment point (FPAP), threshold crossing height (TCH) and glide path angle (GPA). The local level plane for the approach is a plane perpendicular to the local vertical passing through the LTP/FTP (i.e. tangent to the ellipsoid at the LTP/FTP). Local vertical for the approach is normal to the WGS-84 ellipsoid at the LTP/FTP. The glide path intercept point (GPIP) is where the final approach path intercepts the local level plane. FAS data block parameters shall be as follows:

Operation type: straight-in approach procedure or other operation types.

Coding: 0 = straight-in approach procedure

1 to 15 = spare

Table A-66. Final approach segment (FAS) data block

Data content	Bits used	Range of values	Resolution
Operation type	4	0 to 15	1
SBAS provider ID	4	0 to 15	1
Airport ID	32		—
Runway number	6	1 to 36	1
Runway letter	2	—	—
Approach performance designator	3	0 to 7	1
Route indicator	5	—	—
Reference path data selector	8	0 to 48	1
Reference path identifier	32	—	—
LTP/FTP latitude	32	±90.0°	0.0005 arcsec
LTP/FTP longitude	32	±180.0°	0.0005 arcsec
LTP/FTP height	16	–512.0 to 6 041.5 m	0.1 m
ΔFPAP latitude	24	±1.0°	0.0005 arcsec
ΔFPAP longitude	24	±1.0°	0.0005 arcsec

Approach TCH (Note)	15	0 to 1 638.35 m or 0 to 3 276.7 ft	0.05 m or 0.1 ft
Approach TCH units selector	1	—	—
GPA	16	0 to 90.0°	0.01°
Course width	8	80 to 143.75 m	0.25 m
ΔLength offset	8	0 to 2 032 m	8 m
Final approach segment CRC	32		

Note. — Information can be provided in either feet or metres as indicated by the approach TCH unit selector.

SBAS service provider ID: indicates the service provider associated with this FAS data block.

Coding: See Table A-27.

14 = FAS data block is to be used with GBAS only.
15 = FAS data block can be used with any SBAS service provider.

Note. — This parameter is not used for approaches conducted using GBAS or GRAS pseudo-range corrections.

Airport ID: the three- or four-letter designator used to designate an airport.

Coding: Each character is coded using the lower 6 bits of its IA-5 representation. For each character, b_1 is transmitted first, and 2 zero bits are appended after b_6, so that 8 bits are transmitted for each character. Only upper case letters, numeric digits and IA-5 "space" are used. The rightmost character is transmitted first. For a three-character airport ID, the rightmost (first transmitted) character shall be IA-5 "space".

Runway number: the approach runway number.

Coding: 1 to 36 = runway number

Note. — For heliport and point-in-space operations, the runway number value is the integer nearest to one tenth of the final approach course, except when that integer is zero, in which case the runway number is 36.

Runway letter: the one-letter designator used, as necessary, to differentiate between parallel runways.

Coding:
0 = no letter
1 = R (right)
2 = C (centre)
3 = L (left)

Approach performance designator: the general information about the approach design.

Coding:
0 = APV
1 = Category I
2 = reserved for Category II
3 = reserved for Category III
4 to 7 = spare

Note. — Some airborne equipment designed for Category I performance is insensitive to the value of the APD. It is intended that airborne equipment designed for Category I performance accepts APD values of at least 1-4 as valid to accommodate future extensions to higher performance types using the same FAS data block.

Route indicator: the one-letter identifier used to differentiate between multiple approaches to the same runway end.

Coding: The letter is coded using bits b_1 through b_5 of its IA-5 representation. Bit b_1 is transmitted first. Only upper case letters, excluding "I" and "O", or IA-5 "space" are used.

Reference path data selector (RPDS): the numeric identifier that is used to select the FAS data block (desired approach).

Note. — The RPDS for a given FAS data block is different from every other RPDS and every reference station data selector (RSDS) broadcast on the same frequency by every GBAS within the broadcast region.

Reference path identifier (RPI): the three or four alphanumeric characters used to uniquely designate the reference path.

Coding: Each character is coded using bits b_1 through b_6 of its IA-5 representation. For each character, b_1 is transmitted first, and 2 zero bits are appended after b_6 so that 8 bits are transmitted for each character. Only upper case letters, numeric digits and IA-5 "space" are used. The rightmost character is transmitted first. For a three-character reference path identifier, the rightmost (first transmitted) character shall be IA-5 "space".

Note. — The LTP/FTP is a point over which the FAS path passes at a relative height specified by the TCH. LTP is normally located at the intersection of the runway centreline and the threshold.

LTP/FTP latitude: the latitude of the LTP/FTP point in arc seconds.

Coding: Positive value denotes north latitude.

Negative value denotes south latitude.

LTP/FTP longitude: the longitude of the LTP/FTP point in arc seconds.

Coding: Positive value denotes east longitude.

Negative value denotes west longitude.

LTP/FTP height: the height of the LTP/FTP above the WGS-84 ellipsoid.

Coding: This field is coded as an unsigned fixed-point number with an offset of −512 metres. A value of zero in this field places the LTP/FTP 512 metres below the earth ellipsoid.

Note. — The FPAP is a point at the same height as the LTP/FTP that is used to define the alignment of the approach. The origin of angular deviations in the lateral direction is defined to be 305 metres (1 000 ft) beyond the FPAP along the lateral FAS path. For an approach aligned with the runway, the FPAP is at or beyond the stop end of the runway.

ΔFPAP latitude: the difference of latitude of the runway FPAP from the LTP/FTP in arc seconds.

Coding: Positive value denotes the FPAP latitude north of LTP/FTP latitude.

Negative value denotes the FPAP latitude south of the LTP/FTP latitude.

ΔFPAP longitude: the difference of longitude of the runway FPAP from the LTP/FTP in arc seconds.

Coding: Positive value indicates the FPAP longitude east of LTP/FTP longitude.

Negative value indicates the FPAP longitude west of LTP/FTP longitude.

Approach TCH: the height of the FAS path above the LTP/FTP defined in either feet or metres as indicated by the TCH units selector.

Approach TCH units selector: the units used to describe the TCH.

Coding: 0 = feet

1 = metres

Glide path angle (GPA): the angle of the FAS path with respect to the horizontal plane tangent to the WGS-84 ellipsoid at the LTP/FTP.

Course width: the lateral displacement from the path defined by the FAS at the LTP/FTP at which full-scale deflection of a course deviation indicator is attained.

Coding: This field is coded as an unsigned fixed-point number with an offset of 80 metres. A value of zero in this field indicates a course width of 80 metres at the LTP/FTP.

ΔLength offset: the distance from the stop end of the runway to the FPAP.

Coding: 1111 1111 = not provided

Final approach segment CRC: the 32-bit CRC appended to the end of each FAS data block in order to ensure approach data integrity. The 32-bit final approach segment CRC shall be calculated in accordance with third schedule, section 3.9. The length of the CRC code shall be k = 32 bits.

The CRC generator polynomial shall be:

$$G(x) = x^{32} + x^{31} + x^{24} + x^{22} + x^{16} + x^{14} + x^{8} + x^{7} + x^{5} + x^{3} + x + 1$$

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

$$M(x)=\sum_{i=1}^{272} m_i x^{272-i} = m_1x^{271} + m_2x^{270} + \ldots + m_{272}x^0$$

M(x) shall be formed from all bits of the associated FAS data block, excluding the CRC. Bits shall be arranged in the order transmitted, such that m_1 corresponds to the LSB of the operation type field, and m_{272} corresponds to the MSB of the Δlength offset field. The CRC shall be ordered such that r_1 is the LSB and r_{32} is the MSB.

3.6.4.6 Type 5 message — predicted ranging source availability. When used, the Type 5 message shall contain rising and setting information for the currently visible or soon to be visible ranging sources. Predicted ranging source availability parameters shall be as follows:

Modified Z-count: indicates the time of applicability of the parameters in this message.

Coding: Same as modified Z-count field in Type 1 message (third schedule, section 3.6.4.2).

Number of impacted sources: the number of sources for which duration information applicable to all approaches is provided.

Coding: 0 = Only specified obstructed approaches have limitations.

1 to 31 = The number of ranging sources impacted.

Ranging source ID: as for Type 1 message (third schedule, section 3.6.4.2).

Source availability sense: indicates whether the ranging source will become available or cease to be available.

Coding: 0 = Differential corrections will soon cease to be provided for the associated ranging source.

1 = Differential corrections will soon start to be provided for the associated ranging source.

Source availability duration: the predicted minimum ranging source availability duration relative to the modified Z-count.

Coding: 111 1111 = The duration is greater than or equal to 1 270 seconds.

Number of obstructed approaches: the number of approaches for which the corrections will be reduced due to approach unique constellation masking.

Reference path data selector: an indication of the FAS data block to which the source availability data applies (3.6.4.5.1).

Number of impacted sources for this approach: the number of sources for which duration information applicable only to this approach is provided.

3.6.4.7 Type 6 Message

Note. — Type 6 message is reserved for future use to provide the information required for Category II/III precision approaches.

3.6.4.8 Type 7 Message

Note. — Type 7 message is reserved for national applications.

3.6.4.9 Type 8 Message

Note. — Type 8 message is reserved for local and regional test applications.

3.6.4.10 Type 101 Message — GRAS Pseudo-Range Corrections

3.6.4.10.1 The Type 101 message shall provide the differential correction data for individual GNSS ranging sources (Table A-70A). The message shall contain three sections:

a) message information (time of validity, additional message flag, number of measurements and the measurement type);

b) low-frequency information (ephemeris decorrelation parameter, satellite ephemeris CRC and satellite availability information); and

c) satellite data measurement blocks.

3.6.4.10.2 Each Type 101 message shall include ephemeris decorrelation parameter, ephemeris CRC and source availability duration parameters for one satellite ranging source. The ephemeris decorrelation parameter, ephemeris CRC and source availability duration shall apply to the first ranging source in the message.

3.6.4.10.3 Pseudo-range correction parameters shall be as follows:

Modified Z-count: as defined in 3.6.4.2.3.

Additional message flag: as defined in 3.6.4.2.3 except applicable to Type 101 messages.

Number of measurements: as defined in 3.6.4.2.3.

Measurement type: as defined in 3.6.4.2.3.

Ephemeris decorrelation parameter (P): as defined in 3.6.4.2.3.

Ephemeris CRC: as defined in 3.6.4.2.3.

Source availability duration: as defined in 3.6.4.2.3.

Number of B parameters: an indication of whether the B parameters are included in the measurement block for each ranging source.

Coding: 0 = B parameters are not included

1 = 4 B parameters per measurement block

3.6.4.10.4 The measurement block parameters shall be as follows:

Ranging source ID: as defined in 3.6.4.2.4.

Issue of data (IOD): as defined in 3.6.4.2.4.

Pseudo-range correction (PRC): as defined in 3.6.4.2.4.

Range rate correction (RRC): as defined in 3.6.4.2.4.

σ_{pr_gnd}: as defined in 3.6.4.2.4, with the exception of the range of values and resolution.

B1 through B4: as defined in 3.6.4.2.4.

Note. — Inclusion of the B parameters in the measurement block is optional for Type 101 messages.

3.6.5 Definitions of Protocols for Data Application

Note. — This section defines the inter-relationships of the data broadcast message parameters. It provides definitions of parameters that are not transmitted, but are used by either or both non-aircraft and aircraft elements, and that define terms applied to determine the navigation solution and its integrity.

3.6.5.1 Measured and carrier smoothed pseudo-range. The broadcast correction is applicable to carrier smoothed code pseudo-range measurements that have not had the satellite broadcast troposphere and ionosphere corrections applied to them. The carrier smoothing is defined by the following filter:

$$P_{CSC_n} = \alpha P + (1 - \alpha)\left(P_{CSC_{n-1}} + \frac{\lambda}{2\pi}(\phi_n - \phi_{n-1})\right)$$

where

P_{CSC_n} = the smoothed pseudo-range;
$P_{CSC_{n-1}}$ = the previous smoothed pseudo-range;
P = the raw pseudo-range measurement where the raw pseudo-range measurements are obtained from a carrier driven code loop, first order or higher and with a one-sided noise bandwidth greater than or equal to 0.125 Hz;
λ = the L1 wavelength;
ϕ_n = the carrier phase;
ϕ_{n-1} = the previous carrier phase; and
α = the filter weighting function equal to the sample interval divided by the time constant of 100 seconds, except as specified in 3.6.8.3.5.1 for airborne equipment.

3.6.5.2 Corrected pseudo-range. The corrected pseudo-range for a given satellite at time t is:

$$PR_{corrected} = P_{CSC} + PRC + RRC \times (t - \text{tz-count}) + TC + c \times (\Delta t_{sv})_{L1}$$

where

P_{CSC} = the smoothed pseudo-range (defined in 3.6.5.1);
PRC = the pseudo-range correction (defined in 3.6.4.2);
RRC = the pseudo-range correction rate (defined in 3.6.4.2);
t = the current time;
tz-count = the time of applicability derived from the modified Z-count (defined in 3.6.4.2);
TC = the tropospheric correction (defined in 3.6.5.3); and
c and $(\Delta t_{sv})_{L1}$ are as defined in 3.1.2.2 for GPS satellites.

3.6.5.3 Tropospheric Delay

3.6.5.3.1 The tropospheric correction for a given satellite is:

$$TC = N_r h_0 \frac{10^{-6}}{\sqrt{0.002 + \sin^2(El_i)}} (1 - e^{-\Delta h/h_0})$$

where

N_r =
Δh =
El_i =
h_0 =

3.6.5.3.2 The residual tropospheric uncertainty is:

$$\sigma_{tropo} = \sigma_n h_0 \frac{10^{-6}}{\sqrt{0.002 + \sin^2(El_i)}} (1 - e^{-\Delta h/h_0})$$

where σ_n = the refractivity uncertainty from the Type 2 message (3.6.4.3).

3.6.5.4 Residual ionospheric uncertainty. The residual ionospheric uncertainty for a given satellite is:

$$\sigma_{iono} = F_{pp} \times \sigma_{vert\_iono\_gradient} \times (x_{air} + 2 \times \tau \times v_{air})$$

where

F_{pp} = the vertical-to-slant obliquity factor for a given satellite (3.5.5.5.2);
$\sigma_{vert\_iono\_gradient}$ = (as defined in 3.6.4.3);
x_{air} = the distance (slant range) in metres between current aircraft location and the GBAS reference point indicated in the Type 2 message;
τ = 100 seconds (time constant used in 3.6.5.1); and
v_{air} = the aircraft horizontal approach velocity (metres per second).

3.6.5.5 Protection Levels

3.6.5.5.1 Category I precision approach and APV. The signal-in-space vertical and lateral protection levels (VPL and LPL) are upper confidence bounds on the error in the position relative to the GBAS reference point defined as:

$$VPL = MAX\{VPL_{H0}, VPL_{H1}\}$$

$$LPL = MAX\{LPL_{H0}, LPL_{H1}\}$$

3.6.5.5.1.1 Normal measurement conditions

3.6.5.5.1.1.1 The vertical protection level (VPL_{H0}) and lateral protection level (LPL_{H0}), assuming that normal measurement conditions (i.e. no faults) exist in all reference receivers and on all ranging sources, is calculated as:

$$VPL_{H0} = K_{ffmd}\sqrt{\sum_{i=1}^{N} s\_vert_i^2 \times \sigma_i^2}$$

$$LPL_{H0} = K_{ffmd}\sqrt{\sum_{i=1}^{N} s\_lat_i^2 \times \sigma_i^2}$$

where

K_{ffmd}	=	the multiplier derived from the probability of fault-free missed detection;
s_vert_i	=	$s_{v,i} + s_{x,i} \times \tan(GPA)$;
s_lat_i	=	$s_{y,i}$;
$s_{x,i}$	=	the partial derivative of position error in the x-direction with respect to pseudo-range error on the i^{th} satellite;
$s_{y,i}$	=	the partial derivative of position error in the y-direction with respect to pseudo-range error on the i^{th} satellite;
$s_{v,i}$	=	the partial derivative of position error in the vertical direction with respect to pseudo-range error on the i^{th} satellite;
GPA	=	the glidepath angle for the final approach path (3.6.4.5.1);
N	=	the number of ranging sources used in the position solution; and
i	=	the ranging source index for ranging sources used in the position solution.

Note.— The coordinate reference frame is defined such that x is along track positive forward, y is crosstrack positive left in the local level tangent plane and v is the positive up and orthogonal to x and y.

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

$$S \equiv \begin{matrix} S_{x,1} & S_{x,2} & \cdots & S_{x,N} \\ S_{y,1} & S_{y,2} & \cdots & S_{y,N} \\ S_{v,1} & S_{v,2} & \cdots & S_{v,N} \\ S_{t,1} & S_{t,2} & \cdots & S_{t,N} \end{matrix} = (G^T \times W \times G)^{-1} \times G^T \times W$$

+

where

G_i = $[-\cos El_i \cos Az_i \; -\cos El_i \sin Az_i \; -\sin El_i \; 1]$ = i^{th} row of G; and

$$W=\begin{bmatrix} \sigma_1^2 & 0 & \cdots & 0 \\ 0 & \sigma_2^2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \sigma_N^2 \end{bmatrix}^{-1}$$

where $\sigma_i^2 = \sigma^2_{pr\_gnd,i} + \sigma^2_{tropo,i} + \sigma^2_{pr\_air,i} + \sigma^2_{iono,i}$;

where

$\sigma_{pr\_gnd,i}$ = σ_{pr_gnd} for the i^{th} ranging source (3.6.4.2);
$\sigma_{tropo,i}$ = the residual tropospheric uncertainty for the i^{th} ranging source (3.6.5.3);
$\sigma_{iono,i}$ = the residual ionospheric delay (due to spatial decorrelation) uncertainty for the i^{th} ranging source (3.6.5.4); and
$\sigma_{pr\_air,i}$ = $\sqrt{\sigma^2_{receiver}(El_i) + \sigma^2_{multipath}(El_i)}$, the standard deviation of the aircraft contribution to the corrected pseudo-range error for the i^{th} ranging source. The total aircraft contribution includes the receiver contribution (3.6.8.2.1) and a standard allowance for airframe multipath;

where

$\sigma_{multipath}(El_i)$ = $0.13 + 0.53e^{-El_i/10\,deg}$, the standard model for the contribution of airframe multipath (in metres);
El_i = the elevation angle for the i^{th} ranging source (in degrees); and
Az_i = the azimuth for the i^{th} ranging source taken counterclockwise for the x axis (in degrees).

Note.— To improve readability, the subscript i *was omitted from the projection matrix's equation.*

3.6.5.5.1.2 Faulted measurement conditions. When the Type 101 message is broadcast without B parameter blocks, the values for VPL_{H1} and LPL_{H1} are defined as zero. Otherwise, the vertical protection level (VPL_{H1}) and lateral protection level (LPL_{H1}), assuming that a latent fault exists in one, and only one reference receiver, are:

$$VPL_{H1} = \max\,[VPL_j]$$

$$LPL_{H1} = \max\,[LPL_j]$$

where VPL_j and LPL_j for j = 1 to 4 are

VPL_j = $|B\_vert_j| + K_{md}\,\sigma_{vert,H1}$ and
LPL_j = $|B\_lat_j| + K_{md}\,\sigma_{lat,H1}$

and

B_vert_j = $\sum_{i=1}^{N}(s\_vert_i \times B_{i,j})$;

B_lat_j = $\sum_{i=1}^{N}(s\_lat_i \times B_{i,j})$;

$B_{i,j}$ = the broadcast differences between the broadcast pseudo-range corrections and the corrections obtained excluding the j^{th} reference receiver measurement for the i^{th} ranging source;

K_{md} = the multiplier derived from the probability of missed detection given that the ground subsystem is faulted;

$\sigma^2_{vert,H1}$ = $\sum_{i=1}^{N}(s\_vert_i^2 \times \sigma\_H1_i^2)$;

$\sigma^2_{lat,H1}$ = $\sum_{i=1}^{N}(s\_lat_i^2 \times \sigma\_H1_i^2)$;

$\sigma\_H1_i^2$ = $\left(\frac{M_i}{U_i}\right)\sigma^2_{pr\_gnd,i} + \sigma^2_{pr\_air,i} + \sigma^2_{tropo,i} + \sigma^2_{iono,i}$

M_i = the number of reference receivers used to compute the pseudo-range corrections for the i^{th} ranging source (indicated by the B values); and

U_i = the number of reference receivers used to compute the pseudo-range corrections for the i^{th} ranging source, excluding the j^{th} reference receiver.

Note.— A latent fault includes any erroneous measurement(s) that is not immediately detected by the ground subsystem, such that the broadcast data are affected and there is an induced position error in the aircraft subsystem.

3.6.5.5.1.3 Definition of K multipliers for Category I precision approach and APV. The multipliers are given in Table A-67.

Table A-67. K-multipliers for Category I precision approach and APV

Multiplier	M_i			
	1(Note)	2	3	4
Kffmd	6.86	5.762	5.81	5.847
K_{md}	Not used	2.935	2.898	2.878

Note.— For APV I approaches supported by Type 101 messages broadcast without the B parameter block.

3.6.5.5.2 GBAS positioning service. The signal-in-space horizontal protection level is an upper confidence bound on the horizontal error in the position relative to the GBAS reference point defined as:

$$HPL = MAX\{HPL_{H0}, HPL_{H1}\}$$

3.6.5.5.2.1 Normal measurements conditions. The horizontal protection level (HPL_{H0}), assuming that normal measurement conditions (i.e. no faults) exist in all reference receivers and on all ranging sources, is calculated as:

$$HPL_{H0} = K_{ffmd,POS}\, d_{major}$$

where: $$d_{major} = \sqrt{\frac{d_x^2 + d_y^2}{2} + \sqrt{\left(\frac{d_x^2 - d_y^2}{2}\right)^2 + d_{xy}^2}}$$

$$d_x^2 = \sum_{i=1}^{N} s_{x,i}^2 \sigma_i^2$$

$$d_y^2 = \sum_{i=1}^{N} s_{y,i}^2 \sigma_i^2$$

$$d_{xy} = \sum_{i=1}^{N} s_{x,i} s_{y,i} \sigma_i^2$$

$s_{x,i}$ = the partial derivative of position error in the x-direction with respect to pseudo-range error on the i[th] satellite

$s_{y,i}$ = the partial derivative of position error in the y-direction with respect to pseudo-range error on the i[th] satellite

$K_{ffmd,POS}$ = the multiplier derived from the probability of fault-free missed detection

N = the number of ranging sources used in the position solution

i = the ranging source index for ranging sources used in the position solution

σ_i = the pseudo-range error term as defined in 3.6.5.5.1.1

Note. — For the GBAS positioning service, the x and y axes define an arbitrary orthogonal basis in the horizontal plane.

3.6.5.5.2.2 Faulted measurement conditions. When the Type 101 message is broadcast without B parameter blocks, the value for HPL_{H1} is defined as zero. Otherwise, the horizontal protection level (HPL_{H1}), assuming that a latent fault exists in one and only one reference receiver, is:

$$HPL_j = |B\_horz_j| + K_{md\_POS}\, d_{major,H1}$$

and

$$B\_horz_j = \sqrt{\left(\sum_{i=1}^{N} S_{x,i} B_{ij}\right)^2 + \left(\sum_{i=1}^{N} S_{y,i} B_{ij}\right)^2}$$

B_{ij} = the broadcast differences between the broadcast pseudo-range corrections and the corrections obtained excluding the j^{th} reference receiver measurement for the i^{th} ranging source.

K_{md_POS} = the multiplier derived from the probability of missed detection given that the ground subsystem is faulted.

$$d_{major,H1} = \sqrt{\frac{d\_H1_x^2 + d\_H1_y^2}{2} + \sqrt{\left(\frac{d\_H1_x^2 - d\_H1_y^2}{2}\right)^2 + d\_H1_{xy}^2}}$$

$$d\_H1_x^2 = \sum_{i=1}^{N} s_{x,i}^2 \sigma\_H1_i^2$$

$$d\_H1_y^2 = \sum_{i=1}^{N} s_{y,i}^2 \sigma\_H1_i^2$$

$$d\_H1_{xy} = \sum_{i=1}^{N} s_{x,i} s_{y,i} \sigma\_H1_i^2$$

Note. — For the GBAS positioning service, the x and y axes define an arbitrary orthogonal basis in the horizontal plane.

$$\sigma\_H1_i^2 = \left(\frac{M_i}{U_i}\right)\sigma_{pr\_gnd,i}^2 + \sigma_{pr\_air,i}^2 + \sigma_{tropo,i}^2 + \sigma_{iono,i}^2$$

M_i = the number of reference receivers used to compute the pseudo-range corrections for the i^{th} ranging source (indicated by the B values).

U_i = the number of reference receivers used to compute the pseudo-range corrections for the i^{th} ranging source, excluding the j^{th} reference receiver.

Note. — A latent fault includes any erroneous measurement(s) that is not immediately detected by the ground subsystem, such that the broadcast data are affected and there is an induced position error in the aircraft subsystem.

3.6.5.5.2.3 Definition of K multipliers for GBAS positioning service. The multiplier K_{ffmd_POS} is equal to 10.0 and the multiplier K_{md_POS}, is equal to 5.3.

3.6.5.6 Alert Limits

Note. — Guidance concerning the calculation of alert limits, including approaches associated with channel numbers 40 000 to 99 999, is provided in Attachment C, 7.13.

3.6.5.6.1 Category I precision approach alert limits. The alert limits are defined in Tables B-68 and B-69. For aircraft positions at which the lateral deviation exceeds twice the deviation at which full-scale lateral deflection of a course deviation indicator is achieved, or vertical deviation exceeds twice the deviation at which full-scale fly-down deflection of a course deviation indicator is achieved, both the lateral and vertical alert limits are set to the maximum values given in the tables.

3.6.5.6.2 APV alert limits. The alert limits are equal to the FASLAL and FASVAL for approaches with channel numbers in the range of 20 001 to 39 999. For approaches with channel numbers in the range 40 000 to 99 999, the alert limits are stored in the on-board database.

3.6.5.7 Channel number. Each GBAS approach transmitted from the ground subsystem is associated with a channel number in the range of 20 001 to 39 999. If provided, the GBAS positioning service is associated with a separate channel number in the range of 20 001 to 39 999. The channel number is given by:

$$\text{Channel number} = 20\,000 + 40(F - 108.0) + 411(S)$$

where

F = the data broadcast frequency (MHz)
S = RPDS or RSDS

and

RPDS = the reference path data selector for the FAS data block (as defined in 3.6.4.5.1)
RSDS = the reference station data selector for the GBAS ground subsystem (as defined in 3.6.4.3.1)

Table B-68. Category I lateral alert limit

Horizontal distance of aircraft position from the LTP/FTP as translated along the final approach path (metres)	Lateral alert limit (metres)
$291 < D \leq 873$	FASLAL
$873 < D \leq 7\,500$	0.0044D (m) + FASLAL – 3.85
$D > 7\,500$	FASLAL + 29.15

Table B-69. Category I vertical alert limit

Height above LTP/FTP of aircraft position translated onto the final approach path (feet)	Vertical alert limit (metres)
$100 < H \leq 200$	FASVAL
$200 < H \leq 1\,340$	0.02925H (ft) + FASVAL – 5.85
$H > 1\,340$	FASVAL + 33.35

For channel numbers transmitted in the additional data block 2 of Type 2 message (as defined in 3.6.4.3.2.1), only RSDS are used.

Note 1. — When the FAS is not broadcast for an APV, the GBAS approach is associated with a channel number in the range 40 000 to 99 999.

Note 2. — Guidance material concerning channel number selection is provided in Attachment C, 7.7.

3.6.5.8 Ephemeris Error Position Bound

Note.— Ephemeris error position bounds are computed only for core satellite constellation ranging sources used in the position solution (j index) and not for other types of ranging sources (SBAS satellites or pseudolites) that are not subject to undetected ephemeris failures. However, the calculations of these position bounds use information from all ranging sources used in the position solution (i index).

3.6.5.8.1 Category I precision approach and APV. The vertical and lateral ephemeris error position bounds are defined as:

$$VEB = \max_j \{VEB_j\}$$

$$LEB = \max_j \{LEB_j\}$$

The vertical and lateral ephemeris error position bounds for the j^{th} core satellite constellation ranging source used in the position solution are given by:

$$VEB_j = |s\_vert_j| x_{air} P_j + K_{md\_e,j} \sqrt{\sum_{i=1}^{N} s\_vert_i^2 \times \sigma_i^2}$$

$$LEB_j = |s\_lat_j| x_{air} P_j + K_{md\_e,j} \sqrt{\sum_{i=1}^{N} s\_lat_i^2 \times \sigma_i^2}$$

where:

$s\_vert_{i\ or\ j}$	is defined in 3.6.5.5.1.1
$s\_lat_{i\ or\ j}$	is defined in 3.6.5.5.1.1
x_{air}	is defined in 3.6.5.4
N	is the number of ranging sources used in the position solution
σ_i	is defined in 3.6.5.5.1.1
P_j	is the broadcast ephemeris decorrelation parameter for the j^{th} ranging source
$K_{md\_e,j}$	is the broadcast ephemeris missed detection multiplier for Category I precision approach and APV associated with the satellite constellation for the j^{th} ranging source ($K_{md\_e,GPS}$ or $K_{md\_e,GLONASS}$)

3.6.5.8.2 GBAS positioning service. The horizontal ephemeris error position bound is defined as:

$$HEB = \underset{j}{MAX}\{HEB_j\}$$

The horizontal ephemeris error position bound for the j^{th} core satellite constellation ranging source used in the position solution is given by:

$$HEB_j = |s_{horz,j}| x_{air} P_j + K_{md\_e\_POS} d_{major}$$

where:

$s_{horz,j}^2 = s_{xj}^2 + s_{yj}^2$

s_{xj}	is as defined in 3.6.5.5.2.1
s_{yj}	is as defined in 3.6.5.5.2.1
x_{air}	is defined in 3.6.5.4
P_j	is the broadcast ephemeris decorrelation parameter for the j^{th} ranging source
$K_{md\_e\_POS}$	is the broadcast ephemeris missed detection multiplier for the GBAS positioning service associated with the satellite constellation for the j^{th} ranging source ($K_{md\_e\_POS,GPS}$ or $K_{md\_e\_POS,GLONASS}$)
d_{major}	is as defined in 3.6.5.5.2.1

ables B-70 through B-73.

pe structure is defined in 3.6.4.1.

B-70. Type 1 pseudo-range corrections message

	Bits used	Range of values	Resolution
	14	0 to 1 199.9 s	0.1 s
	2	0 to 3	1
)	5	0 to 18	1
	3	0 to 7	1
meter (P)	8	0 to 1.275 × 10^{-3} m/m	5 × 10^{-6} m/m
	16	—	—
	8	0 to 2 540 s	10 s
	8	1 to 255	1
	8	0 to 255	1
PRC)	16	±327.67 m	0.01 m
C)	16	±32.767 m/s	0.001 m/s
	8	0 to 5.08 m	0.02 m
	8	±6.35 m	0.05 m
	8	±6.35 m	0.05 m
	8	±6.35 m	0.05 m
	8	±6.35 m	0.05 m

Table B-70A. Type 101 GRAS pseudo-range corrections message

Data content	Bits used	Range of values	Resolution
Modified Z-count	14	0 to 1 199.9 s	0.1 s
Additional message flag	2	0 to 3	1
Number of measurements (N)	5	0 to 18	1
Measurement type	3	0 to 7	1
Ephemeris decorrelation parameter (P)	8	0 to 1.275 × 10^{-3} m/m	5 × 10^{-6} m/m
Ephemeris CRC	16	—	—
Source availability duration	8	0 to 2540 s	10 s
Number of B parameters	1	0 or 4	—
Spare	7	—	—
For N measurement blocks			
Ranging source ID	8	1 to 255	1
Issue of data (IOD)	8	0 to 255	1
Pseudo-range correction (PRC)	16	±327.67 m	0.01 m
Range rate correction (RRC)	16	±32.767 m/s	0.001 m/s
σ_{pr_gnd}	8	0 to 50.8 m	0.2 m
B parameter block (if provided)			
B_1	8	±25.4 m	0.2 m
B_2	8	±25.4 m	0.2 m
B_3	8	±25.4 m	0.2 m
B_4	8	±25.4 m	0.2 m

Table B-71A. Type 2 GBAS-related data message

Data content	Bits used	Range of values	Resolution
GBAS reference receivers	2	2 to 4	—
Ground accuracy designator letter	2	—	—
Spare	1	—	—
GBAS continuity/integrity designator	3	0 to 7	1
Local magnetic variation	11	±180°	0.25°
Spare	5	—	—
$\sigma_{vert\_iono\_gradient}$	8	0 to 25.5 × 10^{-6} m/m	0.1 × 10^{-6} m/m
Refractivity index	8	16 to 781	3
Scale height	8	0 to 25 500 m	100 m
Refractivity uncertainty	8	0 to 255	1
Latitude	32	±90.0°	0.0005 arcsec
Longitude	32	±180.0°	0.0005 arcsec
GBAS reference point height	24	±83 886.07 m	0.01 m
Additional data block 1 (if provided)			
Reference station data selector	8	0 to 48	1
Maximum use distance (D_{max})	8	2 to 510 km	2 km
$K_{md\_e\_POS,GPS}$	8	0 to 12.75	0.05
$K_{md\_e,GPS}$	8	0 to 12.75	0.05
$K_{md\_e\_POS,GLONASS}$	8	0 to 12.75	0.05
$K_{md\_e,GLONASS}$	8	0 to 12.75	0.05
Additional data block 2 (if provided)			
Additional data block length	8	2 to 255	1
Additional data block number	8	2 to 255	1
Additional data parameters	Variable	—	—

Table A-71B. Type 3 null message

Data content	Bits used	Range of values	Resolution
Filler	Variable (Note)	N/A	N/A

Note. — The number of bytes in the filler field is 10 less than the message length field in the message header as defined in section 3.6.3.4.

Table A-72. Type 4 FAS data message

Data content	Bits used	Range of values	Resolution
For N data sets			
Data set length	8	2 to 212	1 byte
FAS data block	304	—	—
FAS vertical alert limit/approach status	8		
(1) when associated approach performance designator indicates APV-I (APD coded as 0)		0 to 50.8 m	0.2 m
(2) when associated approach performance designator does not indicate APV-I (APD not coded as 0)		0 to 25.4 m	0.1 m
FAS lateral alert limit/approach status	8	0 to 50.8 m	0.2 m

Table B-73. Type 5 predicted ranging source availability message

Data content	Bits used	Range of values	Resolution
Modified Z-count	14	0 to 1 199.9 s	0.1 s
Spare	2	—	—
Number of impacted sources (N)	8	0 to 31	1
For N impacted sources			
Ranging source ID	8	1 to 255	1
Source availability sense	1	—	—
Source availability duration	7	0 to 1 270 s	10 s
Number of obstructed approaches (A)	8	0 to 255	1
For A obstructed approaches			
Reference path data selector	8	0 to 48	—
Number of impacted sources for this approach (N_A)	8	1 to 31	1
For N_A impacted ranging sources for this approach			
Ranging source ID	8	1 to 255	1
Source availability sense	1	—	—
Source availability duration	7	0 to 1 270 s	10 s

3.6.7 **Non-Aircraft Elements**

3.6.7.1 Performance

3.6.7.1.1 Accuracy

3.6.7.1.1.1 The root-mean-square (RMS) (1 sigma) of the ground subsystem contribution to the corrected pseudo-range accuracy for GPS and GLONASS satellites shall be:

$$RMS_{pr\_gnd} \leq \sqrt{\frac{(a_0 + a_1 e^{-\theta_n/\theta_0})^2}{M} + (a_2)^2}$$

where

M = the number of GNSS reference receivers, as indicated in the Type 2 message parameter (3.6.4.3), or, when this parameter is coded to indicate "not applicable", the value of M is defined as 1;

n	= n^{th} ranging source;
θ_n	= elevation angle for the n^{th} ranging source; and
a_0, a_1, a_2, and θ_0	= parameters defined in Tables B-74 and B-75 for each of the defined ground accuracy designators (GADs).

Note 1.— The GBAS ground subsystem accuracy requirement is determined by the GAD letter and the number of installed reference receivers.

Note 2.— The ground subsystem contribution to the corrected pseudo-range error specified by the curves defined in Tables B-74 and B-75 and the contribution to the SBAS satellites do not include aircraft noise and aircraft multipath.

Table B-74. GBAS — GPS accuracy requirement parameters

Ground accuracy designator letter	θ_n (degrees)	a_0 (metres)	a_1 (metres)	θ_0 (degrees)	a_2 (metres)
A	≥ 5	0.5	1.65	14.3	0.08
B	≥ 5	0.16	1.07	15.5	0.08
C	> 35	0.15	0.84	15.5	0.04
	5 to 35	0.24	0	—	0.04

Table B-75. GBAS — GLONASS accuracy requirement parameters

Ground accuracy designator letter	θ_n (degrees)	a_0 (metres)	a_1 (metres)	θ_0 (degrees)	a_2 (metres)
A	≥ 5	1.58	5.18	14.3	0.078
B	≥ 5	0.3	2.12	15.5	0.078
C	> 35	0.3	1.68	15.5	0.042
	5 to 35	0.48	0	—	0.042

3.6.7.1.1.2 The RMS of the ground subsystem contribution to the corrected pseudo-range accuracy for SBAS satellites shall be:

$$RMS_{pr\_gnd} \leq \frac{1.8}{\sqrt{M}} \text{(metres)}$$

where M is as defined in 3.6.7.1.1.1.

Note. — GAD classifications for SBAS ranging sources are under development.

3.6.7.1.2 Integrity

3.6.7.1.2.1 GBAS ground subsystem integrity risk

3.6.7.1.2.1.1 Category I precision approach and APV. For a GBAS ground subsystem that provides the Category I precision approach or APV, the integrity risk shall be less than 1.5×10^{-7} per approach.

Note 1. — The integrity risk assigned to the GBAS ground subsystem is a subset of the GBAS signal-in-space integrity risk, where the protection level integrity risk (3.6.7.1.2.2.1) has been excluded and the effects of all other GBAS, SBAS and core satellite constellations failures are included. The GBAS ground subsystem integrity risk includes the integrity risk of satellite signal monitoring required in 3.6.7.2.6 and *the integrity risk associated with the monitoring in 3.6.7.3.*

Note 2.— GBAS signal-in-space integrity risk is defined as the probability that the ground subsystem provides information which when processed by a fault-free receiver, using any GBAS data that could be used by the aircraft, results in an out-of-tolerance lateral or vertical relative position error without annunciation for a period longer than the maximum time-to-alert. An out-of-tolerance lateral or vertical relative position error is defined as an error that exceeds the Category I precision approach or APV protection level and, if additional data block 1 is broadcast, the ephemeris error position bound.

3.6.7.1.2.1.1.1 The GBAS ground subsystem maximum time-to-alert shall be less than or equal to 3 seconds when Type 1 messages are broadcast.

Note. — The time-to-alert above is the time between the onset of the out-of-tolerance lateral or vertical relative position error and the transmission of the last bit of the message that contains the integrity data that reflects the condition.

3.6.7.1.2.1.1.2 The GBAS ground subsystem maximum time-to-alert shall be less than or equal to 5.5 seconds when Type 101 messages are broadcast.

3.6.7.1.2.1.1.3 For Category I precision approach, the value FASLAL for each FAS block, as defined in the FAS lateral alert limit field of the Type 4 message shall be no greater than 40 metres, and the value FASVAL for each FAS block, as defined in the FAS vertical alert limit field of the Type 4 message, shall be no greater than 10 metres.

3.6.7.1.2.1.1.4 For APV, the value FASLAL and FASVAL shall be no greater than the lateral and vertical alert limits given in Annex 10, Volume I, 3.7.2.4.

3.6.7.1.2.1.2 GBAS positioning service. For GBAS ground subsystem that provides the GBAS positioning service, integrity risk shall be less than 9.9×10^{-8} per hour.

Note 1. — The integrity risk assigned to the GBAS ground subsystem is a subset of the GBAS signal-in-space integrity risk, where the protection level integrity risk (3.6.7.1.2.2.2) has been excluded and the effects of all other GBAS, SBAS and core satellite constellations failures are included. The GBAS ground subsystem integrity risk includes the integrity risk of satellite signal monitoring required in 3.6.7.2.6 and the integrity risk associated with the monitoring in 3.6.7.3.

Note 2.— GBAS signal-in-space integrity risk is defined as the probability that the ground subsystem provides information which when processed by a fault-free receiver, using any GBAS data that could be used by the aircraft, results in an out-of-tolerance horizontal relative position error without annunciation for a period *longer than the maximum time-toalert. An out-of-tolerance horizontal relative position error is defined as an error that exceeds both the horizontal protection level and the horizontal ephemeris error position bound.*

3.6.7.1.2.1.2.1 The GBAS ground subsystem maximum time-to-alert shall be less than or equal to 3 seconds when Type 1 messages are broadcast and less than or equal to 5.5 seconds when Type 101 messages are broadcast.

Note. — The time-to-alert above is the time between the onset of the out-of-tolerance horizontal relative position error and the transmission of the last bit of the message that contains the integrity data that reflects the condition.

3.6.7.1.2.2 Protection level integrity risk

3.6.7.1.2.2.1 For a GBAS ground subsystem that provides the Category I precision approach or APV, the protection level integrity risk shall be less than 5×10^{-8} per approach.

Note.— The Category I precision approach and APV protection level integrity risk is the integrity risk due to undetected errors in position relative to the GBAS reference point greater than the associated protection levels under the two following conditions:

a) *normal measurement conditions defined in 3.6.5.5.1.1; and*

b) *faulted measurement conditions defined in 3.6.5.5.1.2.*

3.6.7.1.2.2.2 For a GBAS ground subsystem that provides the positioning service, protection level integrity risk shall be less than 10^{-9} per hour.

Note.— The GBAS positioning service protection level integrity risk is the integrity risk due to undetected errors in the horizontal position relative to the GBAS reference point greater than the GBAS positioning service protection level under the two following conditions:

a) *normal measurement conditions defined in 3.6.5.5.2.1; and*

b) *faulted measurement conditions defined in 3.6.5.5.2.2.*

3.6.7.1.3 Continuity of service

3.6.7.1.3.1 Continuity of service for Category I precision approach and APV. The GBAS ground subsystem continuity of service shall be greater than or equal to $1 - 8.0 \times 10^{-6}$ per 15 seconds.

Note.— The GBAS ground subsystem continuity of service is the average probability per 15-second period that the VHF data broadcast transmits data in tolerance, VHF data broadcast field strength is within the specified range and the protection levels are lower than the alert limits, including configuration changes that occur due to the space segment. This continuity of service requirement is the entire allocation of the signal-in-space continuity requirement from Chapter 3, Table 3.7.2.4-1, and therefore all continuity risks included in that requirement must be accounted for by the ground subsystem provider.

3.6.7.1.3.2 Continuity of service for positioning service

Note.— For GBAS ground subsystems that provide the GBAS positioning service, there may be additional continuity requirements depending on the intended operations.

3.6.7.2 Functional Requirements

3.6.7.2.1 General

3.6.7.2.1.1 Data broadcast rates

3.6.7.2.1.1.1 A GBAS ground subsystem that supports Category I precision approach or APV-II shall broadcast Type 1 messages. A GBAS ground subsystem that does not support Category I precision approach or APV-II shall broadcast either Type 1 or Type 101 messages. A GBAS ground subsystem shall not broadcast both Type 1 and Type 101 messages.

Note.— Guidance material concerning usage of the Type 101 message is provided in Attachment C, 7.18.

3.6.7.2.1.1.2 Each GBAS ground subsystem shall broadcast Type 2 messages.

3.6.7.2.1.1.3 Each GBAS ground subsystem shall broadcast FAS blocks in Type 4 messages for all Category I precision approaches supported by that GBAS ground subsystem. If a GBAS ground subsystem supports APV and does not broadcast FAS blocks for the corresponding approaches, it shall broadcast additional data block 1 in the Type 2 message.

Note. — FAS blocks for APV procedures may be held within a database on board the aircraft. Broadcasting additional data block 1 allows the airborne receiver to select the GBAS ground subsystem that supports the approach procedures in the airborne database. FAS blocks may also be broadcast to support operations by aircraft without an airborne database. These procedures use different channel numbers as *described in Attachment C, 7.7.*

3.6.7.2.1.1.4 When the Type 5 message is used, the ground subsystem shall broadcast the Type 5 message at a rate in accordance with Table A-76.

Note. — When the standard 5 degree mask is not adequate to describe satellite visibility at either the ground subsystem antennas or at an aircraft during a specific approach, the Type 5 message may be used to broadcast additional information to the aircraft.

3.6.7.2.1.1.5 Data broadcast rates. For all message types required to be broadcast, messages meeting the field strength requirements of Chapter 3, 3.7.3.5.4.4.1.2 and 3.7.3.5.4.4.2.2 and the minimum rates shown in Table A-76 shall be provided at every point within the coverage. The total message broadcast rates from all antenna systems of the ground subsystem combined shall not exceed the maximum rates shown in Table A-76.

Note. — Guidance material concerning the use of multiple antenna systems is provided in Attachment C, 7.12.4.

3.6.7.2.1.2 Message block identifier. The MBI shall be set to either normal or test according to the coding given in 3.6.3.4.1.

Table B-76. GBAS VHF data broadcast rates

Message type	Minimum broadcast rate	Maximum broadcast rate
1 or 101	For each measurement type: All measurement blocks once per frame (Note)	For each measurement type: All measurement blocks once per slot
2	Once per 20 consecutive frames	Once per frame
4	All FAS blocks once per 20 consecutive frames	All FAS blocks once per frame
5	All impacted sources once per 20 consecutive frames	All impacted sources once per 5 consecutive frames

Note. — One Type 1 or Type 101 message or two Type 1 or Type 101 messages that are linked using the additional message flag described in 3.6.4.1.

3.6.7.2.1.3 VDB authentication

Note. — This section is reserved for forward compatibility with future authentication functions.

3.6.7.2.2 Pseudo-range corrections

3.6.7.2.2.1 Message latency. The time between the time indicated by the modified Z-count and the last bit of the broadcast Type 1 or Type 101 message shall not exceed 0.5 seconds.

3.6.7.2.2.2 Low-frequency data. Except during an ephemeris change, the first ranging source in the message shall sequence so that the ephemeris decorrelation parameter, ephemeris CRC and source availability duration for each core satellite constellation's ranging source are transmitted at least once every 10 seconds. During an ephemeris change, the first ranging source shall sequence so that the ephemeris decorrelation parameter, ephemeris CRC and source availability duration for each core satellite constellation's ranging source are transmitted at least once every 27 seconds. When new ephemeris data are received from a core satellite constellation's ranging source, the ground subsystem shall use the previous ephemeris data from each satellite until the new ephemeris data have been continuously received for at least 2 minutes but shall make a transition to the new ephemeris data before 3 minutes have passed. When this transition is made to using the new ephemeris data for a given ranging source, the ground subsystem shall broadcast the new ephemeris CRC for all occurrences of that ranging source in the low-frequency information of Type 1 or Type 101 message in the next 3 consecutive frames. For a given ranging source, the ground subsystem shall continue to transmit data corresponding to the previous ephemeris data until the new CRC ephemeris is transmitted in the low-frequency data of Type 1 or Type 101 message (see Note). If the ephemeris CRC changes and the IOD does not, the ground subsystem shall consider the ranging source invalid.

Note.— The delay before the ephemeris transition allow sufficient time for the aircraft subsystem to collect new ephemeris data.

3.6.7.2.2.2.1 The ephemeris decorrelation parameter and the ephemeris CRC for each core satellite constellation's ranging source shall be broadcast as frequently as possible.

3.6.7.2.2.3 Broadcast pseudo-range correction. Each broadcast pseudo-range correction shall be determined by combining the pseudo-range correction estimates for the relevant ranging source calculated from each of the reference receivers. For each satellite, the measurements used in this combination shall be obtained from the same ephemeris data. The corrections shall be based on smoothed code pseudo-range measurements for each satellite using the carrier measurement from a smoothing filter in accordance with 3.6.5.1.

3.6.7.2.2.4 Broadcast signal-in-space integrity parameters. The ground subsystem shall provide σ_{pr_gnd} and B parameters for each pseudo-range correction in Type 1 message such that the protection level integrity risk requirements defined in 3.6.7.1.2.2 are satisfied. The ground subsystem shall provide σ_{pr_gnd} and, if necessary, B parameters for each pseudo-range correction in Type 101 message such that the protection level integrity risk requirements defined in 3.6.7.1.2.2 are satisfied.

Note.— Broadcast of the B parameters are optional for Type 101 messages. Guidance material regarding the B parameters in Type 101 messages is contained in Attachment C, 7.5.11.

3.6.7.2.2.5 Reference receiver measurements shall be monitored. Faulted measurements or failed reference receivers shall not be used to compute the pseudo-range corrections.

3.6.7.2.2.6 Repeated transmission of Type 1 or Type 101 messages. For a given measurement type and within a given frame, all broadcasts of Type 1 or Type 101 messages or linked pairs from all GBAS broadcast stations that share a common GBAS identification, shall have identical data content.

3.6.7.2.2.7 Issue of data. The GBAS ground subsystem shall set the IOD field in each ranging source measurement block to be the IOD value received from the ranging source that corresponds to the ephemeris data used to compute the pseudo-range correction.

3.6.7.2.2.8 Application of signal error models. Ionospheric and tropospheric corrections shall not be applied to the pseudo-ranges used to calculate the pseudo-range corrections.

3.6.7.2.2.9 Linked pair of Type 1 or Type 101 messages. If a linked pair of Type 1 or Type 101 messages is transmitted then,

a) the two messages shall have the same modified Z-count;

b) the minimum number of pseudo-range corrections in each message shall be one;

c) the measurement block for a given satellite shall not be broadcast more than once in a linked pair of messages;

d) the two messages shall be broadcast in different time slots; and

e) the order of the B values in the two messages shall be the same.

3.6.7.2.2.10 Modified Z-count update. The modified Z-count for Type 1 or Type 101 messages of a given measurement type shall advance every frame.

3.6.7.2.2.11 Ephemeris decorrelation parameters

3.6.7.2.2.11.1 Category I precision approach and APV. For ground subsystems that broadcast the additional data block 1 in the Type 2 message, the ground subsystem shall broadcast the ephemeris decorrelation parameter for each core satellite constellation ranging source such that the ground subsystem integrity risk of 3.6.7.1.2.1.1 is met.

3.6.7.2.2.11.2 GBAS positioning service. For ground subsystems that provide the GBAS positioning service, the ground subsystem shall broadcast the ephemeris decorrelation parameter for each core satellite constellation's ranging source such that the ground subsystem integrity risk of 3.6.7.1.2.1.2 is met.

3.6.7.2.3 GBAS-related data

3.6.7.2.3.1 Tropospheric delay parameters. The ground subsystem shall broadcast a refractivity index, scale height, and refractivity uncertainty in a Type 2 message such that the protection level integrity risk requirements defined in 3.6.7.1.2.2 are satisfied.

3.6.7.2.3.2 GCID indication. If the ground subsystem meets the requirements of 3.6.7.1.2.1.1, 3.6.7.1.2.2.1 and 3.6.7.1.3.1 the GCID shall be set to 1 otherwise it shall be set to 7.

3.6.7.2.3.3 GBAS reference antenna phase centre position accuracy. For each GBAS reference receiver, the reference antenna phase centre position error shall be less than 8 cm relative to the GBAS reference point.

3.6.7.2.3.4 GBAS reference point survey accuracy. The survey error of the GBAS reference point, relative to WGS-84, shall be less than 0.25 m vertical and 1 m horizontal.

Note. — Relevant guidance material is given in Attachment C, 7.16.

3.6.7.2.3.5 Ionospheric uncertainty estimate parameter. The ground subsystem shall broadcast an ionospheric delay gradient parameter in the Type 2 message such that the protection level integrity risk requirements defined in 3.6.7.1.2.2 are satisfied.

3.6.7.2.3.6 For ground subsystems that provide the GBAS positioning service, the ground subsystem shall broadcast the ephemeris error position bound parameters using additional data block 1 in the Type 2 message.

3.6.7.2.3.7 All ground subsystems shall broadcast the ephemeris error position bound parameters using additional data block 1 in the Type 2 message.

3.6.7.2.3.8 For ground subsystems that broadcast additional data block 1 in the Type 2 message, the following requirements shall apply:

3.6.7.2.3.8.1 Maximum use distance. The ground subsystem shall provide the distance (D_{max}) from the GBAS reference point that defines a volume within which the ground subsystem integrity risk in 3.6.7.1.2.1 and the protection level integrity risk in 3.6.7.1.2.2 are met.

3.6.7.2.3.8.2 Ephemeris missed detection parameters. The ground subsystem shall broadcast the ephemeris missed detection parameters for each core satellite constellation such that the ground subsystem integrity risk of 3.6.7.1.2.1 is met.

3.6.7.2.3.8.3 GBAS positioning service indication. If the ground subsystem does not meet the requirements of 3.6.7.1.2.1.2 and 3.6.7.1.2.2.2, the ground subsystem shall indicate using the RSDS parameter that the GBAS positioning service is not provided.

3.6.7.2.3.9 If the VHF data broadcast is transmitted at more than one frequency within the GRAS service area, each GBAS broadcast station within the GRAS ground subsystem shall broadcast additional data blocks 1 and 2.

3.6.7.2.3.9.1 The VHF data broadcast shall include additional data block 2 parameters to identify channel numbers and locations of adjacent and nearby GBAS broadcast stations within the GRAS ground subsystem.

Note. — This facilitates the transition from one GBAS broadcast station to other GBAS broadcast stations in the GRAS ground subsystem.

3.6.7.2.4 Final approach segment data

3.6.7.2.4.1 FAS data points accuracy. The relative survey error between the FAS data points and the GBAS reference point shall be less than 0.25 metres vertical and 0.40 metres horizontal.

3.6.7.2.4.2 The final approach segment CRC shall be assigned at the time of procedure design, and kept as an integral part of the FAS data block from that time onward.

3.6.7.2.4.3 The GBAS shall allow the capability to set the FASVAL and FASLAL for any FAS data block to "1111 1111" to limit the approach to lateral only or to indicate that the approach must not be used, respectively.

3.6.7.2.5 Predicted ranging source availability data

Note. — Ranging source availability data are optional for Category I and APV and may be required for possible future operations.

3.6.7.2.6 Integrity monitoring for GNSS ranging sources. The ground subsystem shall monitor the satellite signals to detect conditions that will result in improper operation of differential processing for airborne receivers complying with the tracking constraints in Attachment C, 8.11. The ground subsystem shall use the strongest correlation peak in all receivers used to generate the pseudo-range corrections. The monitor time-to-alert shall comply with 3.6.7.1.2. The monitor action shall be to set σ_{pr_gnd} to the bit pattern "1111 1111" for the satellite or to exclude the satellite from the Type 1 or Type 101 message. 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 described in Attachment C, 8.11.

3.6.7.3 Monitoring

3.6.7.3.1 RF monitoring

3.6.7.3.1.1 VHF data broadcast monitoring. The data broadcast transmissions shall be monitored. The transmission of the data shall cease within 0.5 seconds in case of continuous disagreement during any 3-second period between the transmitted application data and the application data derived or stored by the monitoring system prior to transmission.

3.6.7.3.1.2 TDMA slot monitoring. The risk that the ground subsystem transmits a signal in an unassigned slot and fails to detect an out-of-slot transmission, which exceeds that allowed in 3.6.2.6, within 1 second, shall be less than 1×10^{-7} in any 30-second period. If out-of-slot transmissions are detected, the ground subsystem shall terminate all data broadcast transmissions within 0.5 seconds.

3.6.7.3.1.3 VDB transmitter power monitor. The probability that the horizontally or elliptically polarized signal's transmitted power increases by more than 3 dB from the nominal power for more than 1 second shall be less than 2.0×10^{-7} in any 30-second period.

Note. — The vertical component is only monitored for GBAS/E equipment.

3.6.7.3.2 Data monitoring

3.6.7.3.2.1 Broadcast quality monitor. The ground subsystem monitoring shall comply with the time-to-alert requirements given in 3.6.7.1.2.1. The monitoring action shall be one of the following:

a) to broadcast Type 1 or Type 101 messages with no measurement blocks; or

b) to broadcast Type 1 or Type 101 messages with the $\sigma_{pr\_gnd,i}$ field set to indicate the ranging source is invalid for every ranging source included in the previously transmitted frame; or

c) to terminate the data broadcast.

Note. — Monitoring actions a) and b) are preferred to c) if the particular failure mode permits such a response, because actions a) and b) typically have a reduced signal-in-space time-to-alert

3.6.7.4 Functional Requirements for Authentication Protocols .

3.6.7.4.1 Functional requirements for ground subsystems that support authentication.

3.6.7.4.1.1 The ground system shall broadcast the additional data block 4 with the Type 2 message with the slot group definition field coded to indicate which slots are assigned to the ground station.

3.6.7.4.1.2 The ground subsystem shall broadcast every Type 2 message in the slot that corresponds to the SSID coding for the ground subsystem. Slot A is represented by SSID = 0, B by 1, C by 2, and H by 7.

3.6.7.4.1.3 Assigned slot occupancy. The ground subsystem shall transmit messages such that 87 per cent or more of every assigned slot is occupied. If necessary, Type 3 messages will be used to fill unused space in any assigned time slot.

3.6.7.4.1.4 Reference path identifier coding. Every reference path identifier included in every final approach segment data block broadcast by the ground station via the Type 4 messages shall have the first letter selected to indicate the SSID of the ground station in accordance with the following coding.

Coding:	A	=	SSID of 0
	X	=	SSID of 1
	Z	=	SSID of 2
	J	=	SSID of 3
	C	=	SSID of 4
	V	=	SSID of 5
	P	=	SSID of 6
	T	=	SSID of 7

3.6.7.4.2 Functional requirements for ground subsystems that do not support authentication

3.6.7.4.2.1 Reference path indicator coding. Characters in this set: {A X Z J C V P T} shall not be used as the first character of the reference path identifier included in any FAS block broadcast by the ground station via the Type 4 messages.

3.6.8 Aircraft Elements.

3.6.8.1 GNSS receiver. The GBAS-capable GNSS receiver shall process signals of GBAS in accordance with the requirements specified in this section as well as with requirements in 3.1.3.1 and/or 3.2.3.1 and/or 3.5.8.1.

3.6.8.2 Performance Requirements.

3.6.8.2.1 GBAS aircraft receiver accuracy.

3.6.8.2.1.1 The RMS of the total aircraft receiver contribution to the error for GPS and GLONASS shall be:

$$RMS_{pr\_air}(\theta_n) \leq a_0 + a_1 \times e^{-(\theta_n/\theta_0)}$$

where

n = the n^{th} ranging source;
θ_n = the elevation angle for the n^{th} ranging source; and
a_0, a_1, and θ_0 = as defined in Table B-77 for GPS and Table B-78 for GLONASS.

3.6.8.2.1.2 The RMS of the total aircraft receiver contribution to the error for SBAS satellites shall be as defined in 3.5.8.2.1 for each of the defined aircraft accuracy designators.

Note.— The aircraft receiver contribution does not include the measurement error induced by airframe multipath.

Table A-77. Aircraft GPS receiver accuracy requirement

Aircraft accuracy designator	θ_n (degrees)	a_0 (metres)	a_1 (metres)	θ_0 (degrees)
A	≥5	0.15	0.43	6.9
B	≥5	0.11	0.13	4

Table A-78. Aircraft GLONASS receiver accuracy requirement

Aircraft accuracy designator	θ_n (degrees)	a_0 (metres)	a_1 (metres)	θ_0 (degrees)
A	≥5	0.39	0.9	5.7
B	≥5	0.105	0.25	5.5

3.6.8.2.2 VHF data broadcast receiver performance

3.6.8.2.2.1 VHF data broadcast tuning range. The VHF data broadcast receiver shall be capable of tuning frequencies in the range of 108.000 – 117.975 MHz in increments of 25 kHz.

3.6.8.2.2.2 VHF data broadcast capture range. The VHF data broadcast receiver shall be capable of acquiring and maintaining lock on signals within ±418 Hz of the nominal assigned frequency.

Note.— The frequency stability of the GBAS ground subsystem, and the worst-case doppler shift due to the motion of the aircraft, are reflected in the above requirement. The dynamic range of the automatic frequency control shall also consider the frequency-stability error budget of the aircraft VHF data broadcast receiver.

3.6.8.2.2.3 VHF data broadcast sensitivity, range and message failure rate. The VHF data broadcast receiver shall achieve a message failure rate less than or equal to one failed message per 1 000 full-length (222 bytes) application data messages, while operating over a range from −87 dBm to −1 dBm, provided that the variation in the average received signal power between successive bursts in a given time slot does not exceed 40 dB. Failed messages include those lost by the VHF data broadcast receiver system or which do not pass the CRC after application of the FEC.

Note. — Aircraft VHF data broadcast receiving antenna can be horizontally or vertically polarized. Due to the difference in the signal strength of horizontally and vertically polarized components of the broadcast signal, the total aircraft implementation loss is limited to 15 dB for horizontally polarized receiving antennas and 11 dB for vertically polarized receiving antennas.

3.6.8.2.2.4 VHF data broadcast time slot decoding. The VHF data broadcast receiver shall meet the requirements of 3.6.8.2.2.3 for all Type 1, 2 and 4 messages from the selected GBAS ground subsystem. These requirements shall be met in the presence of other GBAS transmissions in any and all time slots respecting the levels as indicated in 3.6.8.2.2.5.1 b).

Note. — Other GBAS transmissions may include: a) messages other than Type 1, 2 and 4 with the same SSID, and b) messages with different SSIDs.

3.6.8.2.2.4.1 Decoding of Type 101 messages. A VHF data broadcast receiver capable of receiving Type 101 messages, shall meet the requirements of 3.6.8.2.2.3 for all Type 101 messages from the selected GBAS ground subsystem. These requirements shall be met in the presence of other GBAS transmissions in any and all time slots respecting the levels as indicated in 3.6.8.2.2.5.1 b).

3.6.8.2.2.5 Co-channel rejection

3.6.8.2.2.5.1 VHF data broadcast as the undesired signal source. The VHF data broadcast receiver shall meet the requirements specified in 3.6.8.2.2.3 in the presence of an undesired co-channel VHF data broadcast signal that is either:

a) assigned to the same time slot(s) and 26 dB below the desired VHF data broadcast signal power or lower; or

b) assigned different time slot(s) and whose power is up to 15 dBm at the receiver input.

3.6.8.2.2.5.2 VOR as the undesired signal. The VHF data broadcast receiver shall meet the requirements specified in 3.6.8.2.2.3 in the presence of an undesired co-channel VOR signal that is 26 dB below the desired VHF data broadcast signal power.

3.6.8.2.2.6 Adjacent channel rejection

3.6.8.2.2.6.1 First adjacent 25 kHz channels (±25 kHz). The VHF data broadcast receiver shall meet the requirements specified in 3.6.8.2.2.3 in the presence of a transmitted undesired signal offset by 25 kHz on either side of the desired channel that is either:

a) 18 dB above the desired signal power when the undesired signal is another VHF data broadcast signal assigned to the same time slot(s); or

b) equal in power when the undesired signal is VOR.

3.6.8.2.2.6.2 Second adjacent 25 kHz channels (±50 kHz). The VHF data broadcast receiver shall meet the requirements specified in 3.6.8.2.2.3 in the presence of a transmitted undesired signal offset by 50 kHz on either side of the desired channel that is either:

a) 43 dB above the desired signal power when the undesired signal is another VHF data broadcast source assigned to the same time slot(s); or

b) 34 dB above the desired signal power when the undesired signal is VOR.

3.6.8.2.2.6.3 Third and beyond adjacent 25 kHz channels (±75 kHz or more). The VHF data broadcast receiver shall meet the requirements specified in 3.6.8.2.2.3 in the presence of a transmitted undesired signal offset by 75 kHz or more on either side of the desired channel that is either:

a) 46 dB above the desired signal power when the undesired signal is another VHF data broadcast signal assigned to the same time slot(s); or

b) 46 dB above the desired signal power when the undesired signal is VOR.

3.6.8.2.2.7 Rejection of off-channel signals from sources inside the 108.000 – 117.975 MHz band. With no on-channel VHF data broadcast signal present, the VHF data broadcast receiver shall not output data from an undesired VHF data broadcast signal on any other assignable channel.

3.6.8.2.2.8 Rejection of signals from sources outside the 108.000 117.975 MHz band

3.6.8.2.2.8.1 VHF data broadcast interference immunity. The VHF data broadcast receiver shall meet the requirements specified in 3.6.8.2.2.3 in the presence of one or more signals having the frequency and total interference levels specified in Table A-79.

3.6.8.2.2.8.2 Desensitization. The VHF data broadcast receiver shall meet the requirements specified in 3.6.8.2.2.3 in the presence of VHF FM broadcast signals with signal levels shown in Tables B-80 and B-81.

Table A-79. Maximum levels of undesired signals

Frequency	Maximum level of undesired signals at the receiver input (dBm)
50 kHz up to 88 MHz	–13
88 MHz – 107.900 MHz	(see 3.6.8.2.2.8.2)
108.000 MHz – 117.975 MHz	excluded
118.000 MHz	–44
118.025 MHz	–41
118.050 MHz up to 1 660.5 MHz	–13

Notes.—

1. *The relationship is linear between single adjacent points designated by the above frequencies.*

2. *These interference immunity requirements may not be adequate to ensure compatibility between VHF data broadcast receivers and VHF communication systems, particularly for aircraft that use the vertically polarized component of the VHF data broadcast. Without coordination between COM and NAV frequencies assignments or respect of a guard band at the top end of the 112 – 117.975 MHz band, the maximum levels quoted at the lowest COM VHF channels (118.000, 118.00833, 118.01666, 118.025, 118.03333, 118.04166, 118.05) may be exceeded at the input of the VDB receivers. In that case, some means to attenuate the COM signals at the input of the VDB receivers (e.g. antenna separation) will have to be implemented. The final compatibility will have to be assured when equipment is installed on the aircraft.*

Table A-80. Desensitization frequency and power requirements that apply for VDB frequencies from 108.025 to 111.975 MHz

Frequency	Maximum level of undesired signals at the receiver input (dBm)
88 MHz ≤ f ≤ 102 MHz	15
104 MHz	10
106 MHz	5
107.9 MHz	–10

Notes.—

1. *The relationship is linear between single adjacent points designated by the above frequencies.*
2. *This desensitization requirement is not applied for FM carriers above 107.7 MHz and VDB channels at 108.025 or 108.050 MHz. See Attachment D, 7.2.1.2.2.*

Table A-81. Desensitization frequency and power requirements that apply for VDB frequencies from 112.000 to 117.975 MHz

Frequency	Maximum level of undesired signals at the receiver input (dBm)
88 MHz ≤ f ≤ 104 MHz	15
106 MHz	10
107 MHz	5
107.9 MHz	0

Note.— The relationship is linear between single adjacent points designated by the above frequencies.

3.6.8.2.2.8.3 VHF data broadcast FM intermodulation immunity. The VHF data broadcast receiver shall meet the requirements specified in 3.6.8.2.2.3 in the presence of interference from two-signal, third-order intermodulation products of two VHF FM broadcast signals having levels in accordance with the following:

$$2N_1 + N_2 + 72 \leq 0$$

for VHF FM sound broadcasting signals in the range 107.7 – 108.0 MHz and

$$2N_1 + N_2 + 3\left(24 - 20\log\frac{\Delta f}{0.4}\right) \leq 0$$

for VHF FM sound broadcasting signals below 107.7 MHz

where the frequencies of the two VHF FM sound broadcasting signals produce, within the receiver, a two signal, third-order intermodulation product on the desired VDB frequency.

N_1 and N_2 are the levels (dBm) of the two VHF FM sound broadcasting signals at the VHF data broadcast receiver input. Neither level shall exceed the desensitization criteria set forth in 3.6.8.2.2.8.2.

$\Delta f = 108.1 - f_1$, where f_1 is the frequency of N_1, the VHF FM sound broadcasting signal closer to 108.1 MHz.

Note. — The FM intermodulation immunity requirements are not applied to a VHF data broadcast channel operating below 108.1 MHz, hence frequencies below 108.1 MHz are not intended for general assignments. Additional information is provided in ICAO Annex 10, Vol. I, Attachment C, 7.2.1.2.

3.6.8.3 Aircraft Functional Requirements

3.6.8.3.1 Conditions for use of data

3.6.8.3.1.1 The receiver shall use data from a GBAS message only if the CRC of that message has been verified.

3.6.8.3.1.2 The receiver shall use message data only if the message block identifier is set to the bit pattern

"1010 1010".

3.6.8.3.1.2.1 GBAS message processing capability. The GBAS receiver shall at a minimum process GBAS message types in accordance with Table A-82.

Table A-82. Airborne equipment message type processing

Airborne equipment designed performance	Minimum message types processed
APV-I	MT 1 or 101, MT 2 (including ADB 1 and 2 if provided)
APV-II	MT 1, MT 2 (including ADB 1 and 2 if provided), MT 4
Category I	MT 1, MT 2 (including ADB 1 if provided), MT 4

3.6.8.3.1.2.2 Airborne processing for forward compatibility

Note. — Provisions have been made to enable future expansion of the GBAS Standards to support new capabilities. New message types may be defined, new additional data blocks for message Type 2 may be defined and new data blocks defining reference paths for inclusion within message Type 4 may be defined. To facilitate these future expansions, all equipment shall be designed to properly ignore all data types that are not recognized.

3.6.8.3.1.2.2.1 Processing of unknown message types. The existence of messages unknown to the airborne receiver shall not prevent correct processing of the required messages.

3.6.8.3.1.2.2.2 Processing of unknown Type 2 extended data blocks. The existence of message Type 2 additional data blocks unknown to the airborne receiver shall not prevent correct processing of the required messages.

3.6.8.3.1.2.2.3 Processing of unknown Type 4 data blocks. The existence of message Type 4 data blocks unknown to the airborne receiver shall not prevent correct processing of the required messages.

Note. — While the current SARPs include only one definition of a data block for inclusion within a Type 4 message, future GBAS Standards may include other reference path definitions.

3.6.8.3.1.3 The receiver shall use only ranging source measurement blocks with matching modified Z-counts.

3.6.8.3.1.4 If D_{max} is broadcast by the ground subsystem, the receiver shall only apply pseudo-range corrections when the distance to the GBAS reference point is less than D_{max}.

3.6.8.3.1.5 The receiver shall only apply pseudo-range corrections from the most recently received set of corrections for a given measurement type. If the number of measurement fields in the most recently received Type 1 or Type 101 message indicates that there are no measurement blocks, then the receiver shall not apply

GBAS corrections for that measurement type.

3.6.8.3.1.6 The receiver shall exclude from the differential navigation solution any ranging sources for which σ_{pr_gnd} is set to the bit pattern "1111 1111".

3.6.8.3.1.7 The receiver shall only use a ranging source in the differential navigation solution if the time of applicability indicated by the modified Z-count in the Type 1 or Type 101 message containing the ephemeris decorrelation parameter for that ranging source is less than 120 seconds old.

3.6.8.3.1.8 Conditions for use of data to support Category I precision approach and APV

3.6.8.3.1.8.1 During the final stages of a Category I or APV approach, the receiver shall use only measurement blocks from Type 1 or Type 101 messages that were received within the last 3.5 seconds.

3.6.8.3.1.8.2 The receiver shall use message data from a GBAS ground subsystem for Category I precision approach or APV guidance only if the GCID indicates 1, 2, 3 or 4 prior to initiating the final stages of an approach.

3.6.8.3.1.8.3 The receiver shall ignore any changes in GCID during the final stages of an approach.

3.6.8.3.1.8.4 The receiver shall not provide approach vertical guidance based on a particular FAS data block transmitted in a Type 4 message if the FASVAL received prior to initiating the final stages of the approach is set to "1111 1111".

3.6.8.3.1.8.5 The receiver shall not provide approach guidance based on a particular FAS data block transmitted in a Type 4 message if the FASLAL received prior to initiating the final stages of the approach is set to "1111 1111".

3.6.8.3.1.8.6 Changes in the values of FASLAL and FASVAL data transmitted in a Type 4 message during the final stages of an approach shall be ignored by the receiver.

3.6.8.3.1.8.7 The receiver shall use FAS data only if the FAS CRC for that data has been verified.

3.6.8.3.1.8.8 The receiver shall only use messages for which the GBAS ID (in the message block header) matches the GBAS ID in the header of the Type 4 message which contains the selected FAS data or the Type 2 message which contains the selected RSDS.

3.6.8.3.1.8.9 Use of FAS data

3.6.8.3.1.8.9.1 The receiver shall use the Type 4 messages to determine the FAS for precision approach.

3.6.8.3.1.8.9.2 The receiver shall use the Type 4 messages to determine the FAS for APV associated with a channel number between 20 001 and 39 999.

3.6.8.3.1.8.9.3 The receiver shall use the FAS held within the on-board database for APV associated with a channel number between 40 000 and 99 999.

3.6.8.3.1.8.10 When the GBAS ground subsystem does not broadcast the Type 4 message and the selected FAS data are available to the receiver from an airborne database, the receiver shall only use messages from the intended GBAS ground subsystem.

3.6.8.3.1.9 Conditions for use of data to provide the GBAS positioning service

3.6.8.3.1.9.1 The receiver shall only use measurement blocks from Type 1 messages that were received within the last 7.5 seconds.

3.6.8.3.1.9.2 The receiver shall only use measurement blocks from Type 101 messages that were received within the last 5 seconds.

3.6.8.3.1.9.3 The receiver shall only use message data if a Type 2 message containing additional data block 1 has been received and the RSDS parameter in this block indicates that the GBAS positioning service is provided.

3.6.8.3.1.9.4 The receiver shall only use messages for which the GBAS ID (in the message block header) matches the GBAS ID in the header of the Type 2 message which contains the selected RSDS.

3.6.8.3.2 Integrity

3.6.8.3.2.1 Bounding of aircraft errors. For each satellite used in the navigation solution, the receiver shall compute a $\sigma_{receiver}$ such that a normal distribution with zero mean and a standard deviation equal to $\sigma_{receiver}$ bounds the receiver contribution to the corrected pseudo-range error as follows:

$$\int_{y}^{\infty} f(x)\,dx \leq Q\left(\frac{y}{\sigma}\right) \text{ for all } \frac{y}{\sigma} \geq 0 \text{ and}$$

$$\int_{-\infty}^{-y} f(x)\,dx \leq Q\left(\frac{y}{\sigma}\right) \text{ for all } \frac{y}{\sigma} \geq 0$$

where

$f(x)$ = probability density function of the residual aircraft pseudo-range error and

$$Q(x) = \frac{1}{\sqrt{2\pi}} \int_{x}^{\infty} e^{-\frac{t^2}{2}}\,dt\,.$$

3.6.8.3.2.2 Use of GBAS integrity parameters. The aircraft element shall compute and apply the vertical, lateral and horizontal protection levels described in 3.6.5.5 using the GBAS broadcast σ_{pr_gnd}, σ_N, h_0, $\sigma_{vert\_iono\_gradient}$, and B parameters as well as the σ_{pr_air} parameter. If a $B_{i,j}$ parameter is set to the bit pattern "1000 0000" indicating that the measurement is not available, the aircraft element shall assume that $B_{i,j}$ has a value of zero. For Category I precision approach and APV, the aircraft element shall verify that the computed vertical and lateral protection levels are smaller than the corresponding vertical and lateral alert limits defined in 3.6.5.6.

3.6.8.3.3 Use of satellite ephemeris data

3.6.8.3.3.1 IOD check. The receiver shall only use satellites for which the IOD broadcast by GBAS in the Type 1 or Type 101 message matches the core satellite constellation IOD for the clock and ephemeris data used by the receiver.

3.6.8.3.3.2 CRC check. The receiver shall compute the ephemeris CRC for each core satellite constellation's ranging source used in the position solution. The computed CRC shall be validated against the ephemeris CRC broadcast in the Type 1 or Type 101 messages within one second of receiving a new broadcast CRC. The receiver shall immediately cease using any satellite for which the computed and broadcast CRC values fail to match.

Note. — During initial acquisition of the VHF data broadcast, the receiver may incorporate a satellite into the position solution before receiving the broadcast ephemeris CRC for that satellite.

3.6.8.3.3.3 Ephemeris error position bounds

3.6.8.3.3.3.1 Ephemeris error position bounds for Category I precision approach and APV. If the ground subsystem provides additional data block 1 in the Type 2 messages, the aircraft element shall compute the ephemeris error position bounds defined in 3.6.5.8.1 for each core satellite constellation's ranging source used in the position solution within 1s of receiving the necessary broadcast parameters. The aircraft element shall exclude from the position solution satellites for which the computed vertical or lateral ephemeris error position bounds (VEB_j or LEB_j) are larger than the corresponding vertical and lateral alert limits defined in 3.6.5.6.

Note. — During initial acquisition of the VHF data broadcast, the receiver may incorporate a satellite into the position solution before receiving the necessary broadcast parameters for that satellite to compute the ephemeris error position bounds.

3.6.8.3.3.3.2 Ephemeris error position bound for the GBAS positioning service. The aircraft element shall compute and apply the horizontal ephemeris error position bound (HEB_j) defined in 3.6.5.8.2 for each core satellite constellation's ranging source used in the position solution.

3.6.8.3.4 Message loss

3.6.8.3.4.1 For Category I precision approach, the receiver shall provide an appropriate alert if no Type 1 or Type 101 message was received during the last 3.5 seconds.

3.6.8.3.4.2 For APV, the receiver shall provide an appropriate alert if no Type 1 and no Type 101 message was received during the last 3.5 seconds.

3.6.8.3.4.3 For the GBAS positioning service using Type 1 messages, the receiver shall provide an appropriate alert if no Type 1 message was received during the last 7.5 seconds.

3.6.8.3.4.4 For the GBAS positioning service using Type 101 messages, the receiver shall provide an appropriate alert if no Type 101 message was received during the last 5 seconds.

3.6.8.3.5 Airborne pseudo-range measurements

3.6.8.3.5.1 Carrier smoothing for airborne equipment. Airborne equipment shall utilize the standard 100-second carrier smoothing of code phase measurements defined in 3.6.5.1. During the first 100 seconds after filter start-up, the value of α shall be either:

a) a constant equal to the sample interval divided by 100 seconds; or

b) a variable quantity defined by the sample interval divided by the time in seconds since filter start-up.

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)	*0.36m*	*0.8m*

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.

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.

3.7.2 Continuous Wave (CW) Interference

GPS and SBAS Receivers

3.7.2.1.1 After steady-state navigation has been established, GPS and SBAS 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 A-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 and SBAS signals prior to steady-state navigation, GPS and SBAS receivers shall meet the performance objectives with interference thresholds 6 dB less than those specified in Table A-83.

3.7.2.2 GLONASS 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 A-84 and shown in Figure B-16 and with a desired signal level −166.5 dBW at the antenna port.

Table A-83. CW interference thresholds for GPS and SBAS 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 A-84 and shown in Figure B-16 and with a desired signal level of −166.5 dBW at the antenna port.

Table A-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 A-84.

3.7.3 Band-Limited Noise-Like Interference

3.7.3.1 GPS AND SBAS Receivers

3.7.3.1.1 After steady-state navigation has been established, GPS and SBAS 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 A-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 and SBAS receivers shall meet the performance objectives with interference thresholds 6 dB less than those specified in Table A-85.

3.7.3.2 GLONASS 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 A-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 A-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 A-86.

3.7.3.3 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 A-87 where the interference threshold is defined at the antenna port.

3.7.3.4 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 ICAO Annex 10, Vol. I, Attachment C, 10.5.

3.8 GNSS aircraft satellite receiver antenna

3.8.1 Antenna coverage. The GNSS antenna shall meet the performance requirements for the reception of GNSS satellite signals from 0 to 360 degrees in azimuth and from 0 to 90 degrees in elevation relative to the horizontal plane of an aircraft in level flight.

3.8.2 Antenna gain. The minimum antenna gain shall not be less than that shown in Table A-88 for the specified elevation angle above the horizon. The maximum antenna gain shall not exceed +4 dBic for elevation angles above 5 degrees.

3.8.3 Polarization. The GNSS antenna polarization shall be right-hand circular (clockwise with respect to the direction of propagation).

3.8.3.1 The antenna axial ratio shall not exceed 3.0 dB as measured at boresight.

3.9 **Cyclic redundancy check**

Each CRC shall be calculated as the remainder, R(x), of the Modulo-2 division of two binary polynomials as follows:

Each CRC shall be calculated as the remainder, R(x), of the Modulo-2 division of two binary polynomials as follows:

$$\left\{\frac{[x^k M(x)]}{G(x)}\right\}_{mod\ 2} = Q(x) + \frac{R(x)}{G(x)}$$

where

k = the number of bits in the particular CRC;
M(x) = the information field, which consists of the data items to be protected by the particular CRC represented as a polynomial;
G(x) = the generator polynomial specified for the particular CRC;
Q(x) = the quotient of the division; and
R(x) = the remainder of the division, contains the CRC:

$$R(x) = \sum_{i=1}^{k} r_i x^{k-i} = r_1 x^{k-1} + r_2 x^{k-2} + \ldots + r_k x^0$$

$$\frac{[x^k M(x)]}{G(x)}_{mod\ 2} = Q(x) + \frac{R(x)}{G(x)}$$

Table A-85. Interference threshold for band-limited noise-like interference to GPS and SBAS receivers in steady-state navigation

Interference bandwidth	Interference threshold for receivers in steady-state navigation
0 Hz < Bw_i ≤ 700 Hz	–150.5 dBW
700 Hz < Bw_i ≤ 10 kHz	Linearly increasing from –150.5 to –143.5 dBW
10 kHz < Bw_i ≤ 100 kHz	Linearly increasing from –143.5 to –140.5 dBW
100 kHz < Bw_i ≤ 1 MHz	–140.5 dBW
1 MHz < Bw_i ≤ 20 MHz	Linearly increasing from –140.5 to –127.5 dBW*
20 MHz < Bw_i ≤ 30 MHz	Linearly increasing from –127.5 to –121.1 dBW*
30 MHz < Bw_i ≤ 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 A-86. Interference threshold for band-limited noise-like interference to GLONASS receivers in steady-state navigation

Interference bandwidth	Interference threshold
0 Hz < Bw_i ≤ 1 kHz	–149 dBW
1 kHz < Bw_i ≤ 10 kHz	Linearly increasing from –149 to –143 dBW
10 kHz < Bw_i ≤ 0.5 MHz	–143 dBW
0.5 MHz < Bw_i ≤ 10 MHz	Linearly increasing from –143 to –130 dBW
10 MHz < Bw_i	–130 dBW

Table B-87. Interference thresholds for pulsed interference

	GPS and SBAS	GLONASS
Frequency range for in-band and near-band Interference threshold (Pulse peak power) for in-band and near-band interference	1 575.42 MHz ± 20 MHz –20 dBW	1 592.9525 MHz to 1 609.36 MHz –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 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.

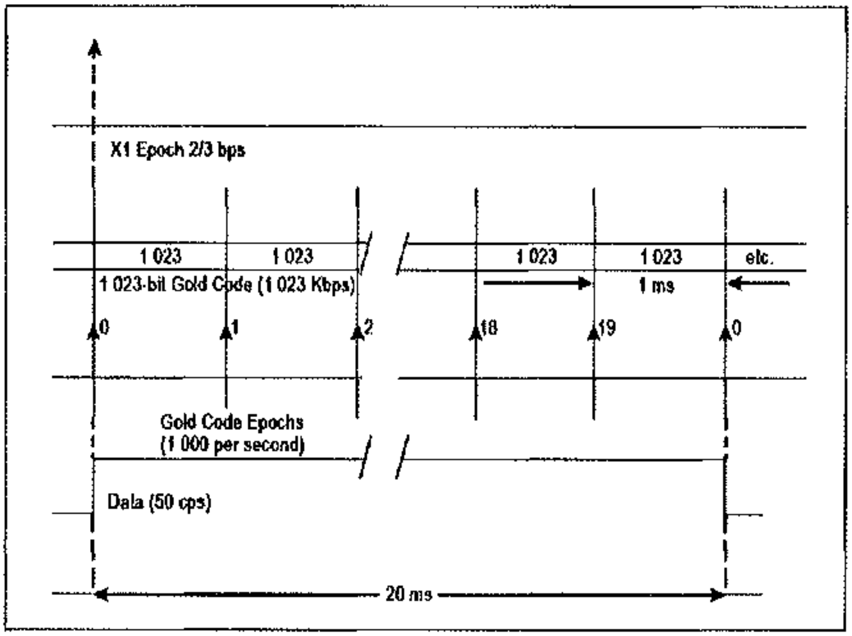


Figure B-1. C/A code timing relationships

SUBFRAME 1	TLM	HOW	GPS week number, SV accuracy and health
SUBFRAME 2	TLM	HOW	Ephemeris parameters
SUBFRAME 3	TLM	HOW	Ephemeris parameters
SUBFRAME 4 (25 pages)	TLM	HOW	Almanac and health for satellites 25–32, special messages, satellite configuration, flags, ionospheric and UTC
SUBFRAME 5 (25 pages)	TLM	HOW	Almanac and health for satellites 1–24 and almanac reference time and GPS week number

Figure B-2. Frame structure

Preamble	Reserved	Parity
1 0 0 0 1 0 1 1	MSB LSB	
1 2 3 4 5 6 7 8	9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	25 26 27 28 29 30

Figure B-3. TLM word format

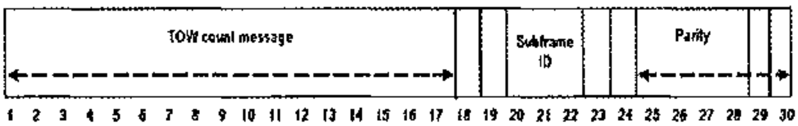


Figure B-4. HOW format

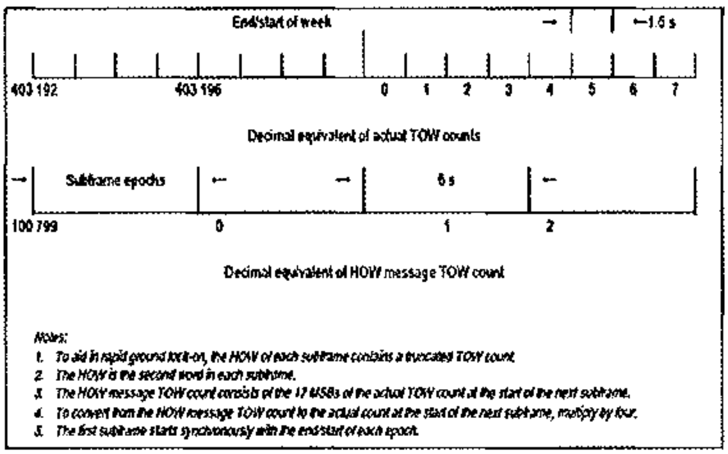
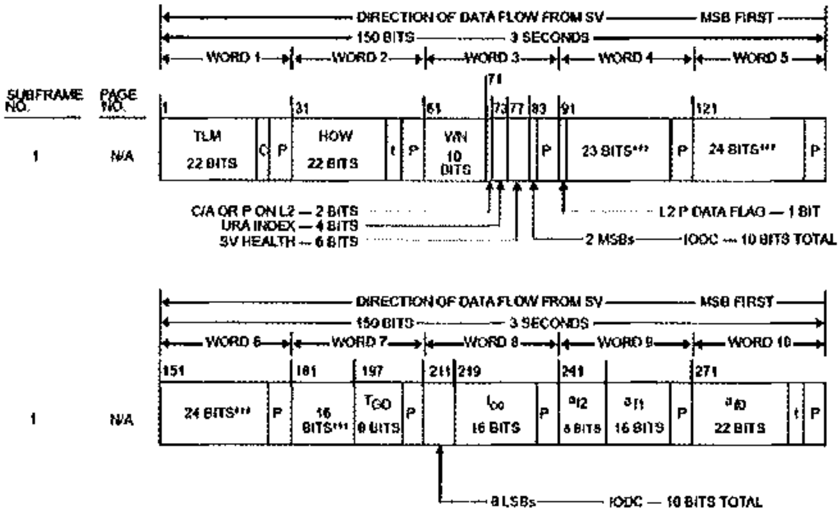
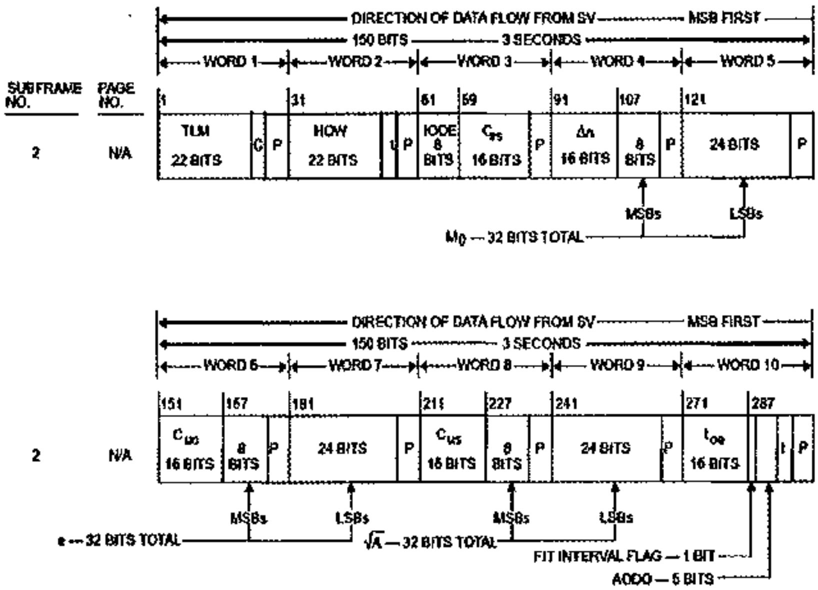


Figure B-8. Time line relationship of HOW



*** RESERVED
P = 6 PARITY BITS
t = 2 NON-INFORMATION BEARING BITS USED FOR PARITY COMPUTATION
C = TLM BITS 23 AND 24 WHICH ARE RESERVED

Figure B-6. Data format (1 of 11)

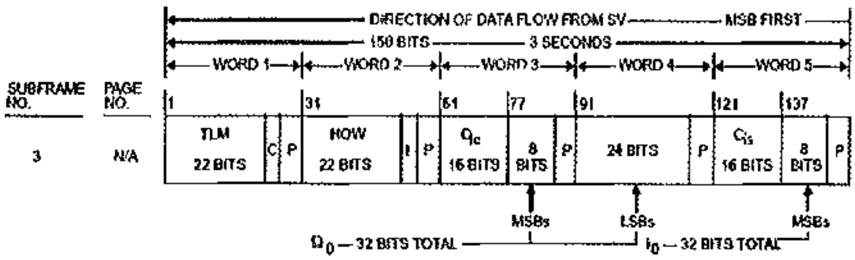


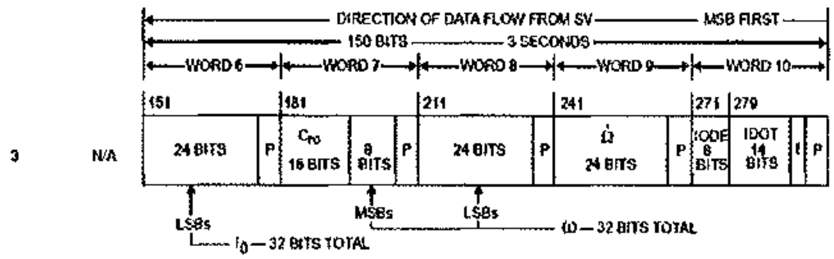
P = 6 PARITY BITS

t = 2 NON-INFORMATION BEARING BITS USED FOR PARITY COMPUTATION

C = TLM BITS 23 AND 24 WHICH ARE RESERVED

Figure B-6. Data format (2 of 11)



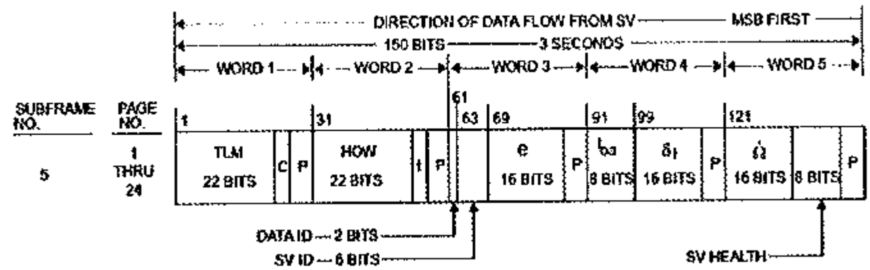


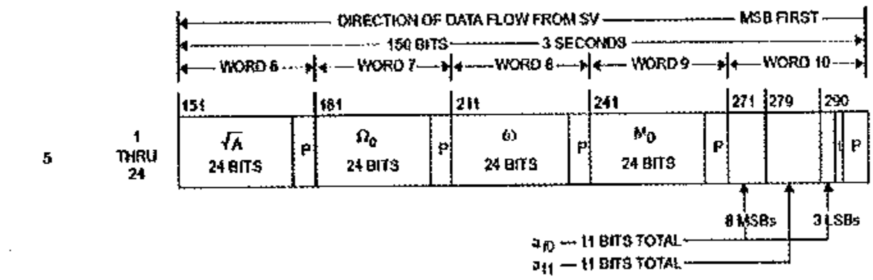
P = 6 PARITY BITS

t = 2 NON-INFORMATION BEARING BITS USED FOR PARITY COMPUTATION

C = TLM BITS 23 AND 24 WHICH ARE RESERVED

Figure B-6. Data format (3 of 11)





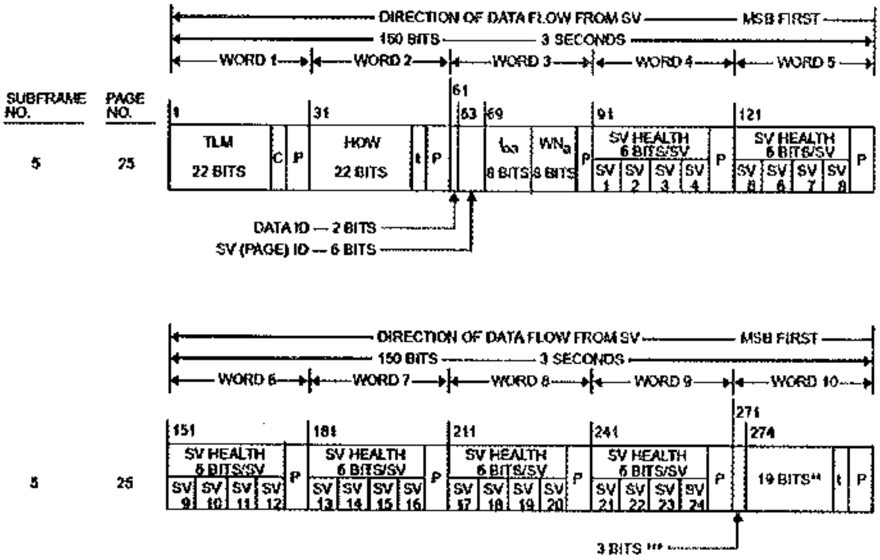
P = 6 PARITY BITS

t = 2 NON-INFORMATION BEARING BITS USED FOR PARITY COMPUTATION

C = TLM BITS 23 AND 24 WHICH ARE RESERVED

Note.— Pages 2, 3, 4, 5, 7, 8, 9 and 10 of subframe 4 have the same format as pages 1 through 24 of subframe 5.

Figure B-6. Data format (4 of 11)



** RESERVED FOR SYSTEM USE

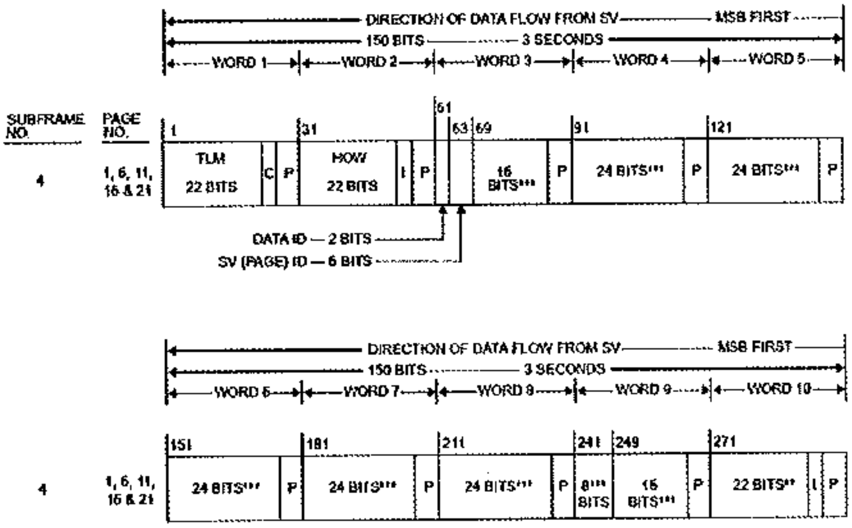
*** RESERVED

P = 6 PARITY BITS

t = 2 NON-INFORMATION BEARING BITS USED FOR PARITY COMPUTATION

C = TLM BITS 23 AND 24 WHICH ARE RESERVED

Figure B-6. Data format (5 of 11)



** RESERVED FOR SYSTEM USE

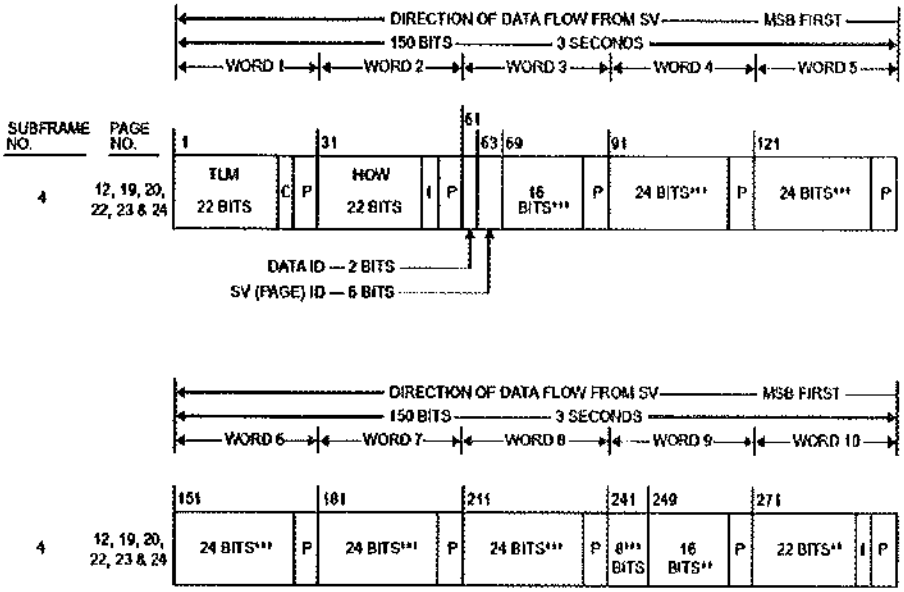
*** RESERVED

P = 6 PARITY BITS

t = 2 NON-INFORMATION BEARING BITS USED FOR PARITY COMPUTATION

C = TLM BITS 23 AND 24 WHICH ARE RESERVED

Figure B-6. Data format (6 of 11)



** RESERVED FOR SYSTEM USE

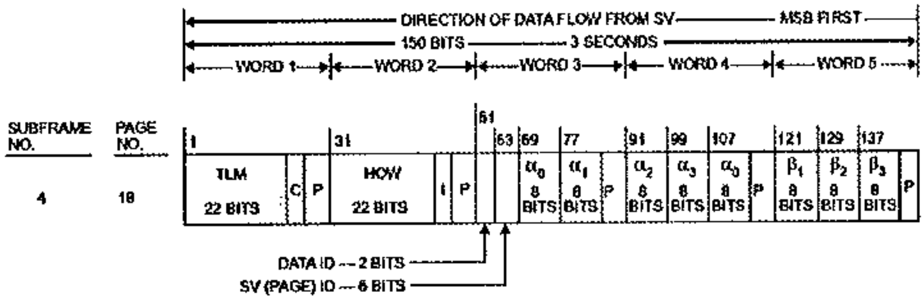
*** RESERVED

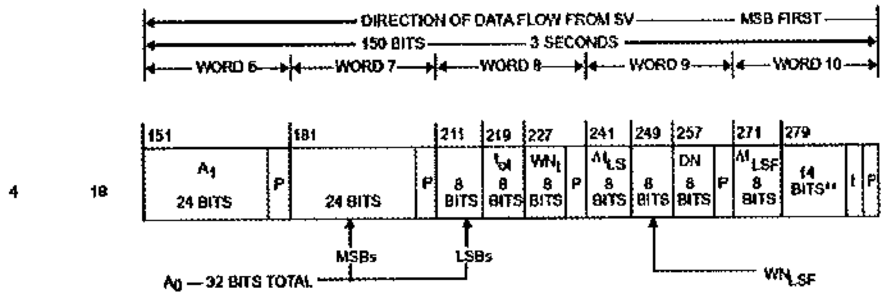
P = 6 PARITY BITS

t = 2 NON-INFORMATION BEARING BITS USED FOR PARITY COMPUTATION

C = TLM BITS 23 AND 24 WHICH ARE RESERVED

Figure B-6. Data format (7 of 11)





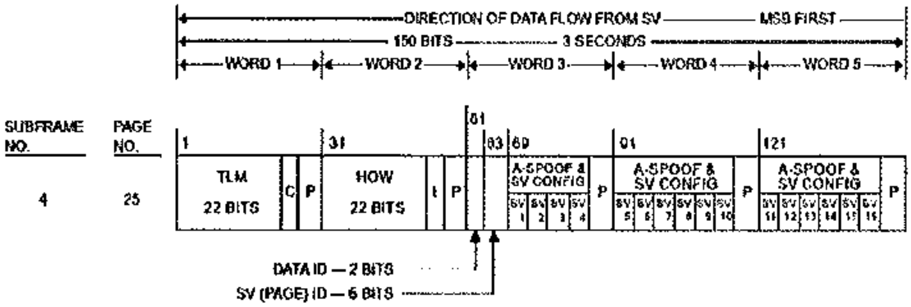
** RESERVED FOR SYSTEM USE

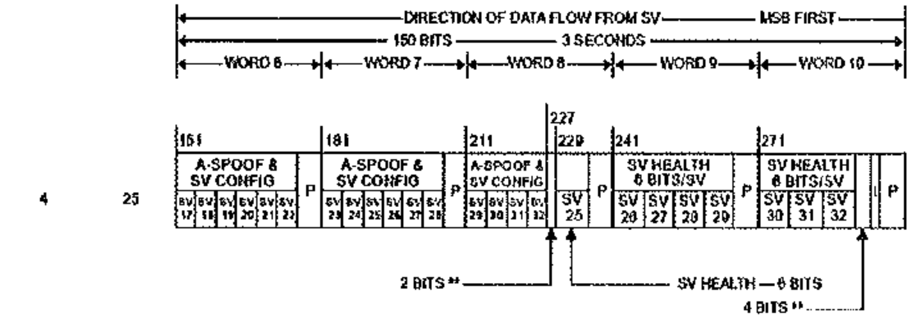
P = 6 PARITY BITS

t = 2 NON-INFORMATION BEARING BITS USED FOR PARITY COMPUTATION

C = TLM BITS 23 AND 24 WHICH ARE RESERVED

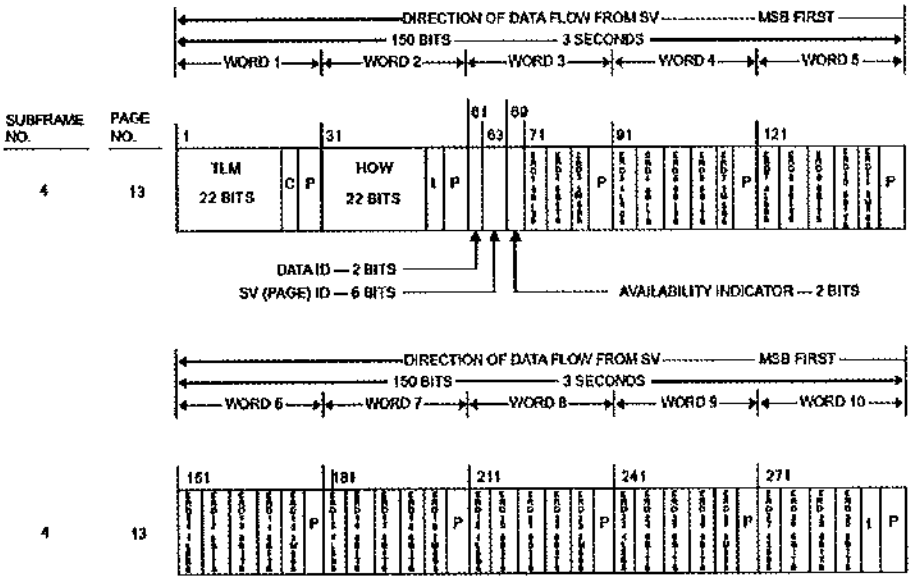
Figure B-6. Data format (8 of 11)





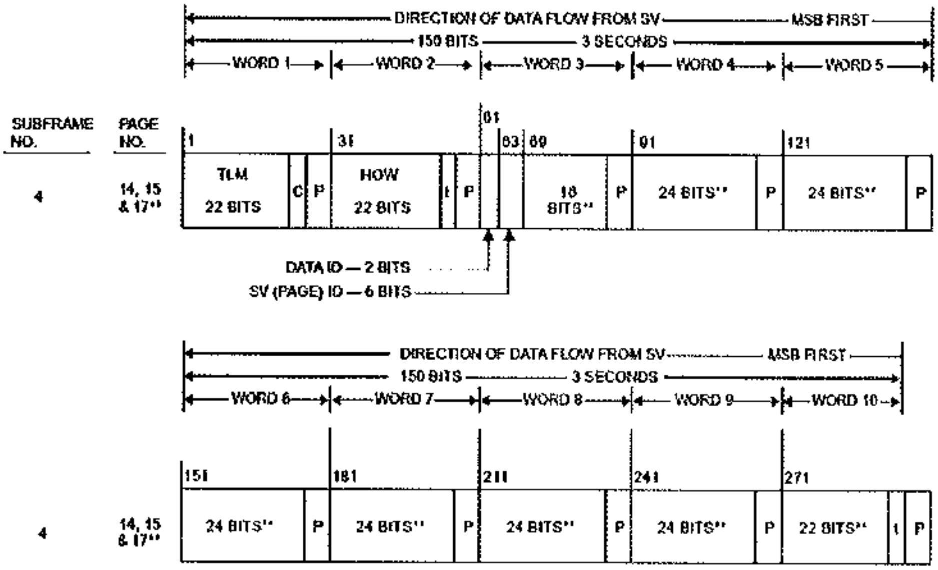
** RESERVED FOR SYSTEM USE
P = 6 PARITY BITS
t = 2 NON-INFORMATION BEARING BITS USED FOR PARITY COMPUTATION
C = TLM BITS 23 AND 24 WHICH ARE RESERVED

Figure B-6. Data format (9 of 11)



P = 6 PARITY BITS
t = 2 NON-INFORMATION BEARING BITS USED FOR PARITY COMPUTATION
C = TLM BITS 23 AND 24 WHICH ARE RESERVED

Figure B-6. Data format (10 of 11)



** THE INDICATED PORTIONS OF WORDS 3 THROUGH 10 OF PAGES 14 AND 15 ARE RESERVED FOR SYSTEM USE, WHILE THOSE OF PAGE 17 ARE RESERVED FOR SPECIAL MESSAGES

P = 6 PARITY BITS

t = 2 NON-INFORMATION BEARING BITS USED FOR PARITY COMPUTATION

C = TLM BITS 23 AND 24 WHICH ARE RESERVED

Figure B-6. Data format (11 of 11)

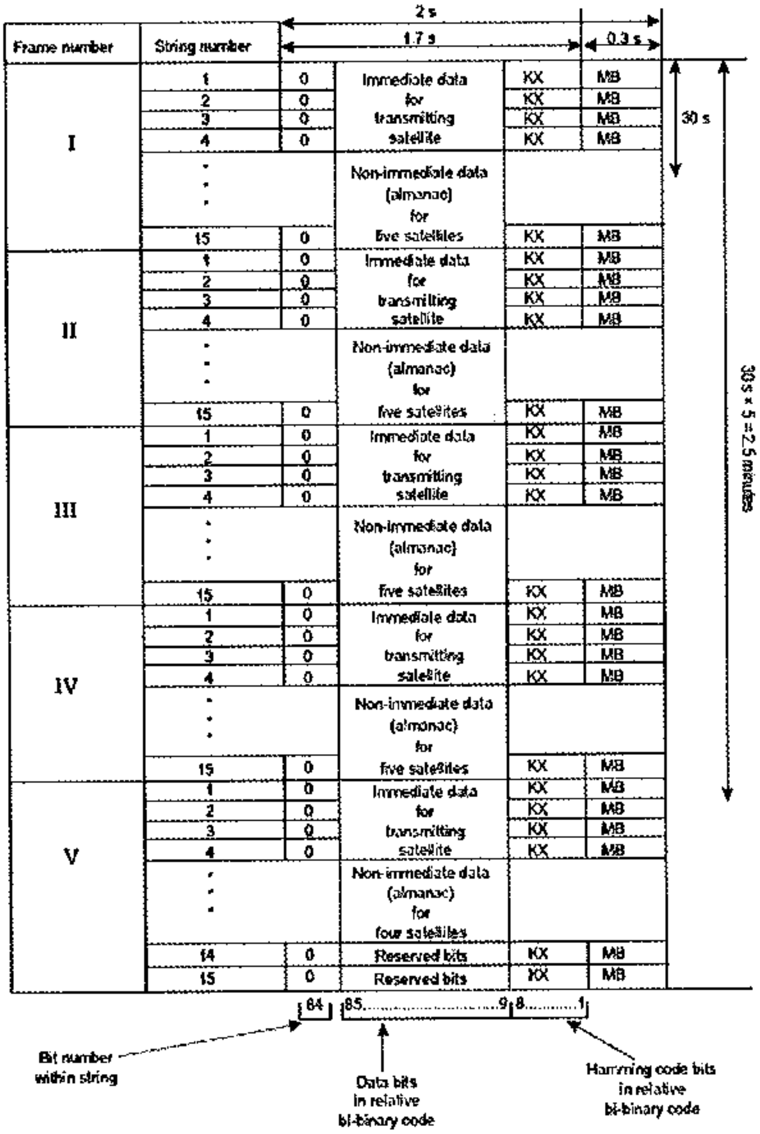
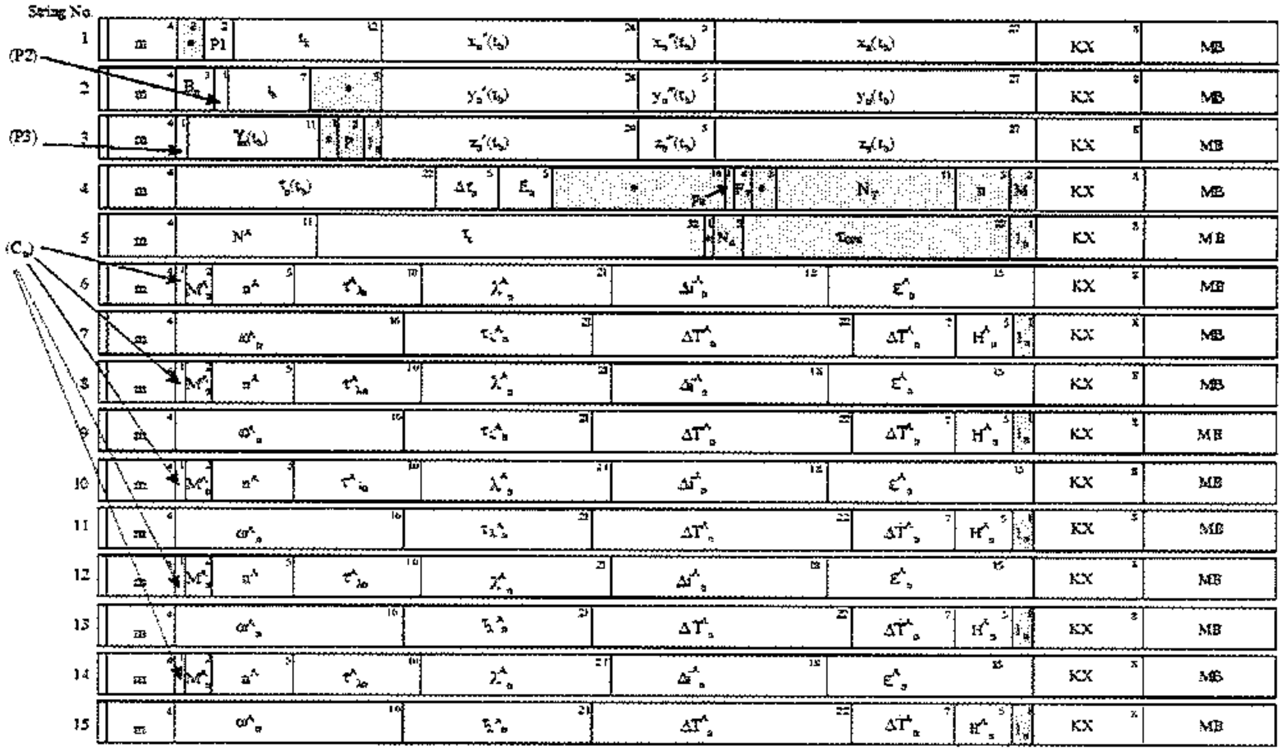


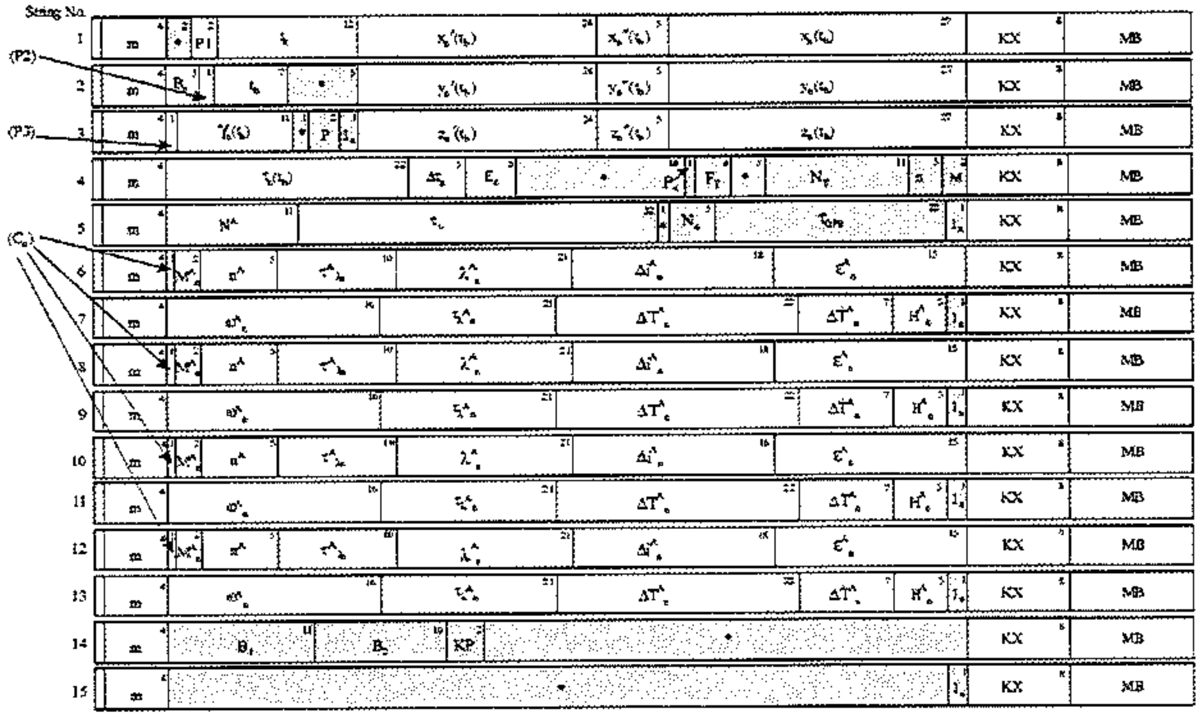
Figure B-7. Superframe structure



* Reserved bits within frame

Note.— Data content, definitions and explanations of parameters are given in 3.2.1.3 and 3.2.1.4. Additional data transmitted by GLONASS-M are highlighted in this figure.

Figure B-8. Frame structure (frames 1 to 4)



* Reserved bits within frame

Note.— Data content, definitions and explanations of parameters are given in 3.2.1.3 and 3.2.1.4. Additional data transmitted by GLONASS-M are highlighted in this figure.

Figure B-9. Frame structure (frame 5)

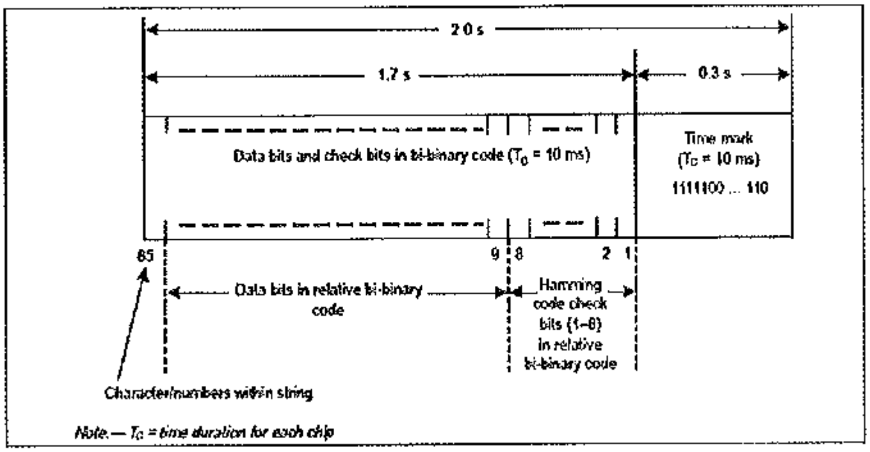


Figure B-10. Data string structure

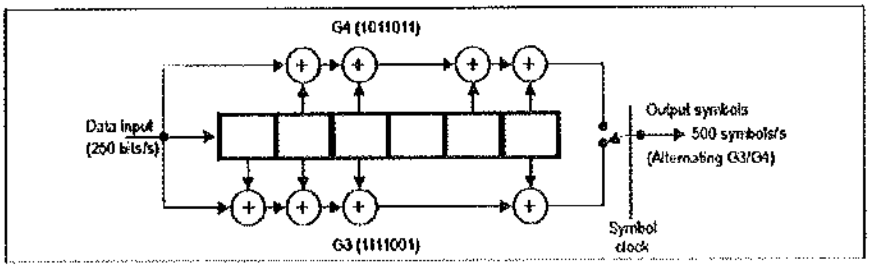


Figure B-11. Convolutional encoding

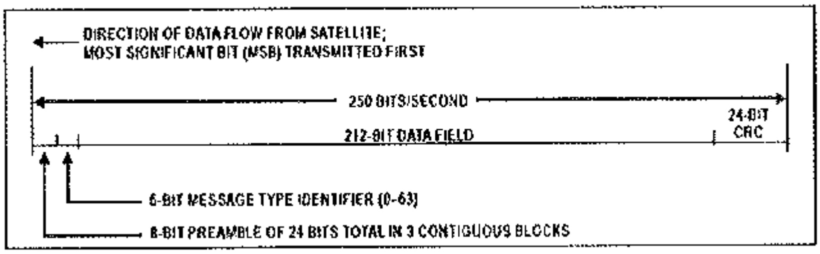


Figure B-12. Data block format

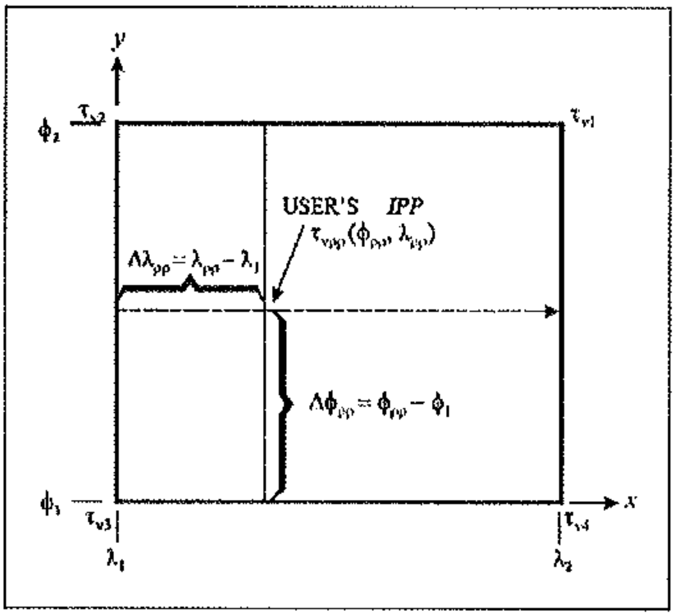


Figure B-13. IGP numbering convention (four IGPs)

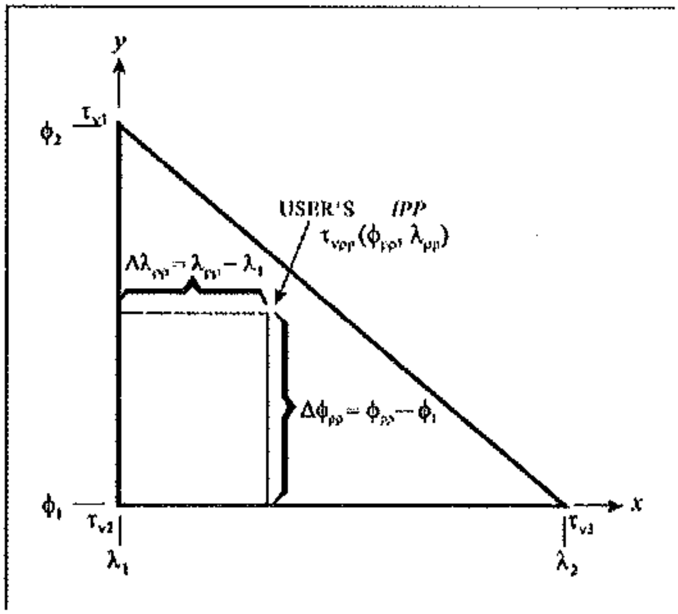


Figure B-14. IGP numbering convention (three IGPs)

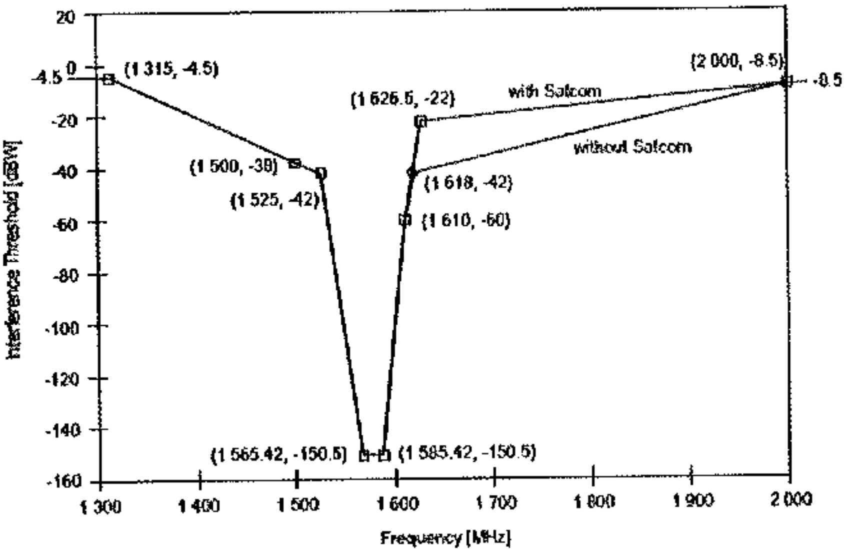


Figure B-15. CW interference thresholds for GPS and SBAS receivers in steady-state navigation

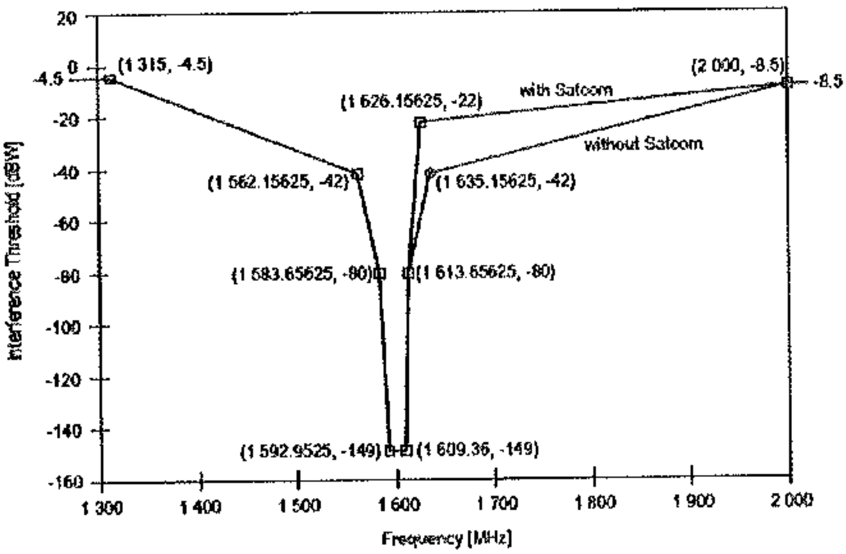


Figure B-16. CW interference thresholds for GLONASS receivers in steady-state navigation

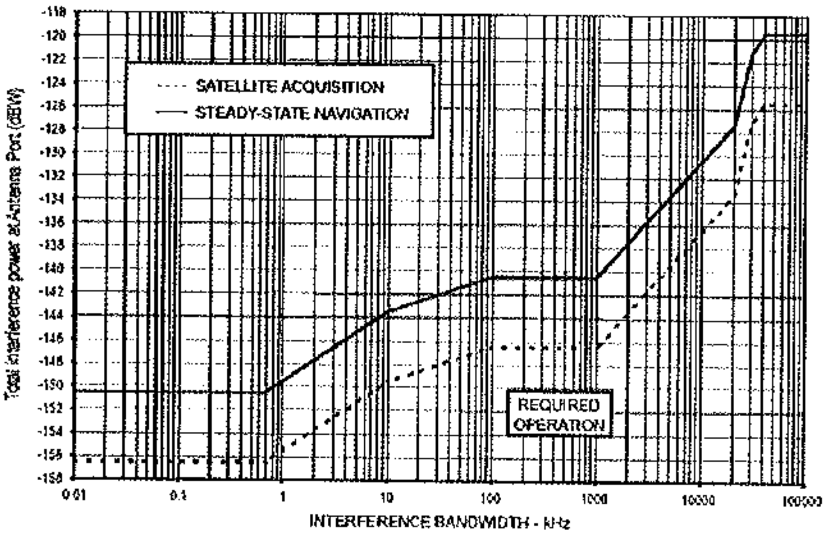


Figure B-17. Interference thresholds versus bandwidth for GPS and SBAS receivers

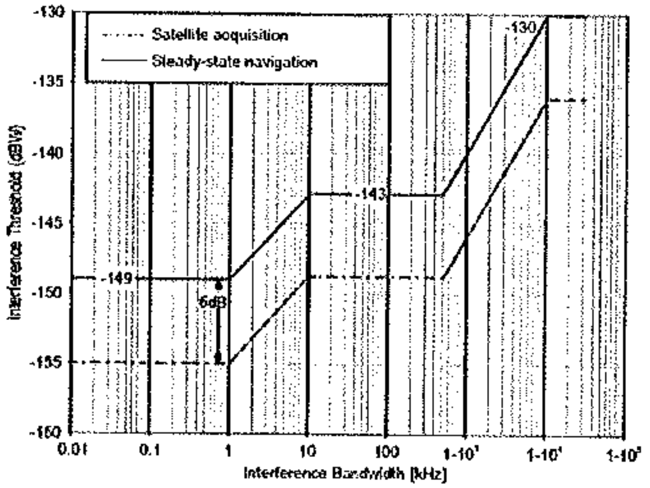


Figure B-18. Interference thresholds versus bandwidth for GLONASS receivers

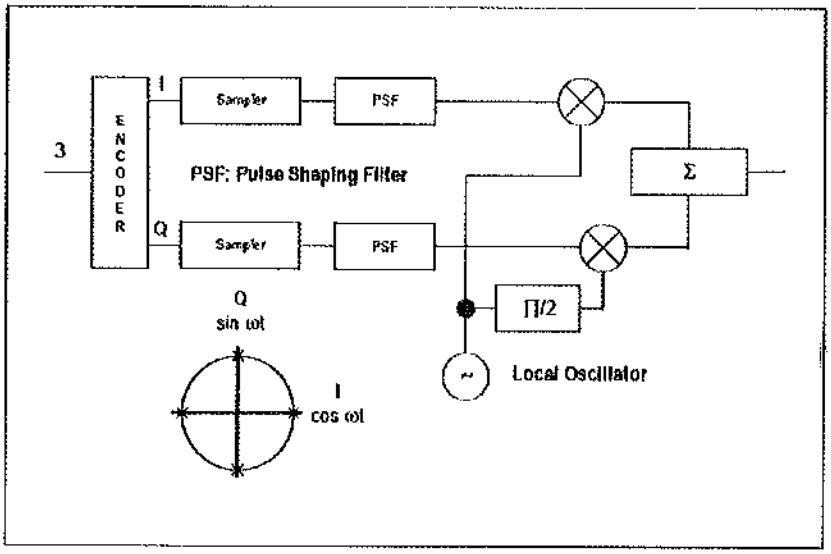


Figure B-19. Example data modulation

SCHEDULE FOUR
(regulation 11)

Requirements of Flight Inspection of Radio Navigation Aids

1.1 Pre- Flight Inspection Preparations

1.1.1 An ANS provider shall notify the Regulator/Authority of the planned flight inspection, detailing the scope of the flight inspection. Other relevant agencies will also be notified of the planned flight inspection.

1.1.2 An ANS provider shall issue a NOTAM for the flight inspection.

1.1.3 Ground technician/engineers shall make preparations prior to a flight inspection to ensure that the flight inspection is effectively conducted.

1.1.4 Ground technician/engineers shall complete equipment adjustments and other technical preparations for the air navigation aid in question

1.1.5 The following are the points to be observed during pre-flight inspection preparation:

a. Ensure that the result of all possible ground calibration and checking of equipment are correct;

b. Competent maintenance personnel are available to make corrections and adjustments during flight inspection;

c. Availability of dedicated transport for equipment and personnel is ensured during the entire course of flight check;

d. Ensure all special tools and instruments are available at the site;

e. Availability of last flight inspection report;

f. Any requirement of special investigation during flight inspection shall be submitted in advance and followed up with Authority during flight inspection;

g. In case the facility is not expected to be ready as per the regular scheduled inspection, the Authority must be informed accordingly; and

h. NOTAM for withdrawal of facility during Flight Inspection shall be issued without fail in coordination with local ATC.

1.2 Coordination during Flight Inspections

1.2.1 When equipment needs to be adjusted while flight inspection is in progress, the ground technical staff shall notify the flight inspector and make the necessary adjustment.

1.2.2 An ANS provider shall notify relevant agencies that the air navigation aid in question is undergoing a flight inspection.

1.3 Types of Flight Inspections

1.3.1 Flight inspections are classified and shall be carried out as follows:

a. **Site Proving:** Inspection to be carried out to confirm that the location selected for installation of a new radion navigation aid is appropriate, which include checks to determine the effects of the environment on the performance of the planned radio navigation aid.

b. **Commissioning:** An extensive flight inspection following ground proof-of-performance inspection to establish the validity of the signals-in-space. The results of this inspection should be correlated with the results of the ground inspection. Together they form the basis for certification/aproval of the facility by the Authority.

c. **Periodic:** Flight inspections to confirm the validity of the signals-in-space on a regular basis or after major scheduled facility maintenance

d. **Surveillance:** surveillance inspection shall be carried out to ensure that Navigational aids facility is being maintained within tolerance limits in spite of the inherent drift in the equipment. Surveillance inspections do not normally involve major adjustments unless the performance is observed to have drifted either close to, or beyond the applicable tolerance limits.

e. **Special Inspections:** Special flight inspection shall be made on special request to confirm satisfactory performance. It may follow a major maintenance on the equipment especially the antenna system and the facility shall not be declared operational without approval by the Authority. Special Flight Inspection may also be carried out for investigation purpose after any incident or accident.

1.4 Flight Inspection Unit

1.4.1 Flight inspection of radio navigation aids shall be conducted by organizations or units that have been certified and approved to carry out the activity.

1.5 Flight Inspection Aircraft

1.5.1 This section describes the concept for the special requirements of the aircraft, flight inspection crew members and ground support equipment used for flight Inspection.

1.5.2 Appropriately equipped aircraft shall be used when required to undertake flight inspection. The general characteristics of a flight inspection aircraft shall be as follows:

a. Aircraft equipped with special instrument for flight check

b. Sufficient capacity for a flight inspection crew, ground maintenance and/or installation personnel, and required electronic equipment.

c. Sufficient range and endurance for a normal mission.

d. Aerodynamically stable throughout the speed range.

e. Low noise and vibration level

f. Adequate and stable electrical system capable of operating required electronic and recording equipment and other aircraft equipment.

g. Wide speed and altitude range to allow the conduct of flight inspections under normal conditions as encountered by the users.

h. Appropriate for modifications for flight inspection of new and improved navigation services.

1.6 Flight Inspection Crew Members

The members of the flight inspection crew shall be experts in their individual fields, have sound knowledge and experience in flight inspection procedures and be capable of working as a team.

1.7 Airborne and Ground Support Equipment

The selection and utilization of flight inspection equipment used to determine the validity of navigation information shall minimize the uncertainty of the measurement being performed. Aircraft and ground support flight inspection equipment shall be calibrated to appropriate standards.

1.8 Preparation of Flight Inspection Plan

1.8.1 ANS provider shall prepare and submit to the Authority an annual flight inspection plan for the following year for all radio navigation aids to be flight inspected.

1.8.2 ANS provider shall send one copy of the flight inspection records of the previous year to the Authority.

1.8.3 When it is necessary to change the flight inspection date, ANS provider shall notify the Authority, of the changed flight inspection date.

1.9 Priority of Flight Inspections

ANS provider shall conduct flight inspections according to the following priorities:

a. Inspection requested from a concerned agency in relation to an aircraft accident

b. Inspection to correct a malfunction of the radio navigation aid, inspection of a reported malfunction, or malfunction inspection after repairs according to a plan

c. Periodic, Commissioning, inspection of instrument flight procedures, and site approval.

1.10 Inspection after upgrading or modification of facility

Inspection shall be carried out when the conditions below prevail:

a. Upgrade/modification of feeders, antennas, and other major components;

b. Change in location of antenna or upgrade/modification of VOR counter poise;

c. Modification or replacement of main components of the transmitter;

d. Change in operation frequency and/or ID code;

e. Change in transmission output following increase or decrease of a radio navigation aid's service area;

f. Where there is concern for signal interruption from construction of a building, a power line, or other obstacles in the vicinity of an operating a radio navigation aid;

g. Partial upgrade/modification or extension of any operating light system (approach light, approach angle indicator light, runway indicator light); and

h. Other special flight inspections deemed necessary.

1.11 Basic Schedule for Periodic Flight Inspection

1.11.1 This section prescribes the minimum frequency of periodic flight inspections. More frequent inspections may be made when deemed necessary. Facilities subject to flight inspections and frequency of their inspections are as follows

NAVAIDS Facility	Maintenance Standards	Periodicity, FI
DVOR	8071 Vol. Annex 10 Vol. 1	1 year
CVOR	8071 Vol. Annex 10 Vol. 1	1 year
ILS	8071 Vol. Annex 10 Vol. 1	6 Months
Landing DME	8071 Vol. Annex 10 Vol. 1	6 Month
Enroute DME	8071 Vol. Annex 10 Vol. 1	1 year
NDB	8071 Vol. Annex 10 Vol. 1	1 year where operationally required

Note: NDBs are not subjected to flight inspection except where operationally required.

1.12 NOTIFICATION OF CHANGE OF STATUS

1.12.1 The ANS provider shall ensure that notification of a permanent change of the radio navigation aids facility status are done through the appropriate Aeronautical Information Publication (AIP);

1.12.2 The ANS provider shall ensure that notification of temporary changes in the status of facilities are promptly and efficiently advertised.

1.12.3 The ANS provider shall ensure that changes in the status of a commissioned facility as a direct result of ground or flight inspection procedures, and resulting in a change of operational status ("unrestricted/restricted/unusable") or "unusable" designation, is advertised immediately by air traffic control (ATC) personnel, and promptly by a Notice to Airmen (NOTAM).

a. **Usable:** is a status assigned to radio navigation aids that are deemed to be operational in a flight inspection and shall be assigned one of the following operational status:

i) **Unrestricted:** Assigned in cases where signals-in-space can be generated within the radio navigation aid's coverage area to maintain safety and continuity of the air navigation aid and precise signals can be sent.

ii) **Limited or Restricted:** Assigned in cases where there are spaces that cannot send normal signals in all or some sections within the coverage area of the radio navigation aid. In such cases, limited/restricted use of radio navigation aid can be assigned in sections where there are no impediments in use of the radio navigation aid in question by an aircraft. However, limited/restricted status shall not be assigned when judged that it is difficulty to secure safety and continuity of the radio navigation aid.

b. **Unusable:** Assigned in cases where it is judged that the radio navigation aid cannot be used due to difficulty in securing safety and continuity of the air navigation aid within its operational range or in cases where there are airspaces wherein flight inspections cannot be conducted because of signal failure, designation as a no fly zone, or airspace use is restricted for other reasons.

1.12.4 The ANS provider shall ensure that a facility having an "unusable" status is removed from service and can operate only for test or troubleshooting purposes.

1.12.5 The ANS provider shall ensure that a particular attention is given to periodic or corrective maintenance procedures that involve false guidance signals being temporarily radiated. The unit responsible shall ensure that these conditions are coordinated with ATC and promulgated to users by NOTAM, before the procedures commence.

1.13 In-Flight Inspection

1.13.1 During the inspection, flight inspector shall advise Engineer on ground of observed conditions which require adjustment of ground equipment. Request for adjustment shall be specific and readily understandable. Normally the flight inspector is not expected to diagnose the fault but shall furnish sufficient information to enable the maintenance team to make the corrective adjustment when the aircraft is airborne and record the adjustments done for post analysis. Relevant measurements on ground for establishing a meaningful correlation with the flight check results after each run shall be taken.

1.14 Post-Flight Inspection Measures

1.14.1 The flight inspector shall determine the operational status of the air navigation aids in question after completing the flight inspection and notify the ground technical staff whether or not the radio navigation aid passed or failed the flight inspection.

1.14.2 Flight inspection unit shall prepare a report of flight inspection results within 14 days after completion of the flight inspection and notify the ANS provider. An immediate report shall be made to the Authority of any radio navigation aid that fails flight inspection.

1.14.3 ANS provider shall keep commissioning data records of the air navigation aid in question until its permanent disuse and shall keep records of scheduled inspections and other flight inspections for at least 5 years.

1.15 Post-Flight Inspection

1.15.1 ANS provider engineer shall complete the following actions:

a. Take action as per the advice of Flight Inspector;

b. Take relevant measurements on ground for establishing a meaningful correlation with the flight check results;

c. Implement the suggestions in the final report; and

d. Inform the Authority and all concerned regarding any major change in the facility performance through NOTAM.

e. Submit Flight Inspection Report to the Authority

1.16 Expiration of nominal intervals

1.16.1 To account for operational restrictions, the Authority shall permit the completion of a recurrent test/inspection within a certain time window following the nominal recommended interval. This extension is not to be intended as a means to systematically extend the test/inspection interval.

1.16.2 If a test/inspection is not conducted prior to the expiration of the appropriate time window, the following actions shall be considered:

a) extension of the expiration after engineering evaluation and/or ground maintenance reinforcement;

b) degrading of the category of ILS (Category III down to Category I) in cases where intervals vary according to the category of ILS; and

c) temporarily removing the radio navigation aid from service.

MADE this 13th day of June, 2022.

ERIC MOTHIBI MOLALE,
Minister of Transport and Public Works.