STATE OF LIBYA
MINISTRY OF TRANSPORT
CIVIL AVIATION AUTHORITY

دولة ليبيا
وزارة المواصلات
مصلحة الطيران المدني

LYCAR Part-GNSS

Libyan Civil Aviation Regulation
Part - GNSS: Global Navigation Satellite System

First issue, March 2026

Approved by and published under the authority of the President of LYCAA.

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RECORD OF REVISIONS

No.	Date	Description / Highlights
Issue 1	March 2026	Initial issue

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FOREWORD

1. The regulation contained herein is adopted under the provision of Article N5 of Libyan Civil Aviation Law N6 of 2005, issued and signed up by the President of Libyan Civil Aviation by virtue of powers vested from the Minister of Transport under the resolution N154 issued on 13.05.2015.

2. This regulation prescribes the technical and operational requirements for Global Navigation Satellite Systems (GNSS) in Libya, in alignment with International Civil Aviation Organization (ICAO) Standards, particularly Annex 10.

3. The purpose of this regulation is to establish the requirements and guidelines for the use of Global Navigation Satellite System (GNSS) technology in aviation operations within Libyan airspace. This regulation ensures that GNSS is used safely, efficiently, and in compliance with international standards set by the International Civil Aviation Organization (ICAO) and other relevant aviation authorities.
4. This regulation applies to all aviation operations within the Libyan Civil Aviation Authority (LYCAA) jurisdiction, including:

- Commercial aviation.
- General aviation.
- Unmanned Aerial Systems (UAS).
- Aircraft operators, pilots, and maintenance personnel.

5. The use of the male gender implies the female gender and vice versa.

6. This regulation aims to ensure the accuracy, integrity, and efficiency of GNSS systems within Libyan airspace and to support global infrastructure integration.

7. Copies of this regulation can be obtained from the ANS Inspectorate Office of the LYCAA or can be downloaded on the official website: www.caa.gov.ly.

8. Transition Period: All operators and service providers shall comply with the requirements of this regulation within three months after its official publication.

Dr. Mohamed Shlibek
President of LYCAA
1st of March 2026

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Abbreviations

ABAS	Aircraft-Based Augmentation System
ADS-B	Automatic Dependent Surveillance-Broadcast
AIC	Aeronautical Information Circular
AIP	Aeronautical Information Publication
AIRAC	Aeronautical Information Regulation and Control
AIS	Aeronautical Information Services
ALT	Altitude
APV	Approach Procedure with Vertical Guidance
APV-I	Approach with Vertical Guidance - Level I
APV-II	Approach with Vertical Guidance - Level II
ARNS	Aeronautical Radio Navigation Service
ATC	Air Traffic Control
BDCS	BeiDou Coordinate System
BDS	BeiDou Navigation Satellite System
BDS OS	BeiDou Open Service
BDT	BeiDou Time
BGD	Broadcast Group Delay
BIPM	International Bureau of Weights and Measures
BOC	Binary Offset Carrier
BPSK	Binary Phase Shift Keying
CAT I	Category I Precision Approach
CBOC	Composite Binary Offset Carrier
CDMA	Code Division Multiple Access
CSA	Channel of Standard Accuracy
DFMC	Dual-Frequency Multi-Constellation
DME	Distance Measuring Equipment
EASA	European Union Aviation Safety Agency
EIRP	Effective Isotropic Radiated Power
EMI	Electromagnetic Interference
FAA	Federal Aviation Administration
FEC	Forward Error Correction
FDMA	Frequency Division Multiple Access
GANP	Global Air Navigation Plan
GASP	Global Aviation Safety Plan
GBAS	Ground-Based Augmentation System
GBAS/E	GBAS with Elliptical Polarization
GBAS/H	GBAS with Horizontal Polarization
GEO	Geostationary Orbit
GLONASS	Global Navigation Satellite System (Russian Federation)
GNSS	Global Navigation Satellite System
GPA	Glide Path Angle
GPIP	Glide Path Interception Point
GPS	Global Positioning System
GPS SPS	GPS Standard Positioning Service

GRAS	Ground-Based Regional Augmentation System
GST	Galileo System Time
GTRF	Galileo Terrestrial Reference Frame
HPOL	Horizontal Polarization
IAURA	Integrity Assured User Range Accuracy
ICAO	International Civil Aviation Organization
ICD	Interface Control Document
IGSO	Inclined Geosynchronous Orbit
ILS	Instrument Landing System
ITU	International Telecommunication Union
LPV	Localizer Performance with Vertical Guidance
LTP/FTP	Landing Threshold Point / Fictitious Threshold Point
LYCAA	Libyan Civil Aviation Authority
MEO	Medium Earth Orbit
MDA	Minimum Descent Altitude
NM	Nautical Mile
NOTAM	Notice to Air Missions
NPA	Non-Precision Approach
NTE	Not-To-Exceed Tolerance
NTSC	National Time Service Center (China)
OS	Open Service
PBN	Performance-Based Navigation
PRN	Pseudo-Random Noise
PZ-90	Parametry Zemli 1990 (GLONASS Coordinate System)
QMBOC	Quadrature Multiplexed Binary Offset Carrier
RF	Radio Frequency
RFI	Radio Frequency Interference
RNSS	Radio Navigation Satellite Service
SARPs	Standards and Recommended Practices
SBAS	Satellite-Based Augmentation System
SIS	Signal-In-Space
SISA	Signal-In-Space Accuracy
SNT	SBAS Network Time
SPS	Standard Positioning Service
TDMA	Time Division Multiple Access
UAS	Unmanned Aircraft Systems
URA	User Range Accuracy
URAI	User Range Accuracy Index
URE	User Range Error
UTC	Universal Time Coordinated
VDB	VHF Data Broadcast
VHF	Very High Frequency
VOR	VHF Omnidirectional Range
VPOL	Vertical Polarization
WGS-84	World Geodetic System 1984

Definitions

Aircraft-based augmentation system (ABAS). An augmentation system that augments and/or integrates the information obtained from the other GNSS elements with information available on board the aircraft.

Alert. An indication provided to other aircraft systems or annunciation to the pilot to identify that an operating parameter of a navigation system is out of tolerance.

Alert limit. For a given parameter measurement, the error tolerance not to be exceeded without issuing an alert.

Antenna port. A point where the received signal power is specified. For an active antenna, the antenna port is a fictitious point Between the antenna elements and the antenna pre-amplifier. For a passive antenna, the antenna port is the output of the Antenna itself.

Axial ratio. The ratio, expressed in decibels, between the maximum output power and the minimum output power of an antenna to an incident linearly polarized wave as the polarization orientation is varied over all directions perpendicular to the Direction of propagation.

BeiDou Navigation Satellite System (BDS). The satellite navigation system operated by China.

BDS Open Service (BDS OS). The specified level of positioning, velocity and timing accuracy that is available to any BDS User on a continuous, worldwide basis

Channel of standard accuracy (CSA). The specified level of positioning, velocity and timing accuracy that is available to any GLONASS user on a continuous, worldwide basis.

Core satellite constellation(s). The core satellite constellations are GPS and GLONASS.

Galileo. The satellite navigation system operated by the European Union.

Galileo Open Service (Galileo OS). The specified level of positioning, velocity and timing accuracy that is available to any Galileo user on a continuous, worldwide basis

Global navigation satellite system (GNSS). A worldwide position and time determination system that includes one or more satellite constellations, aircraft receivers and system integrity monitoring, augmented as necessary to support the required navigation performance for the intended operation.

Global navigation satellite system (GLONASS). The satellite navigation system operated by the Russian Federation.

Global positioning system (GPS). The satellite navigation system operated by the United States.

GNSS position error. The difference between the true position and the position determined by the GNSS receiver.

Ground-based augmentation system (GBAS). An augmentation system in which the user receives augmentation information directly from a ground-based transmitter.

Ground-based regional augmentation system (GRAS). An augmentation system in which the user receives augmentation information directly from one of a group of ground-based transmitters covering a region.

Integrity. A measure of the trust that can be placed in the correctness of the information supplied by the total system.

Integrity includes the ability of a system to provide timely and valid warnings to the user (alerts).

Ionosphere-free pseudo-range. A pseudo-range in which the first order ionosphere effect on signal propagation has been Removed by a linear combination of pseudo-range measurements from signals on two distinct frequencies from the same Satellite.

Pseudo-range. The difference between the time of transmission by a satellite and reception by a GNSS receiver multiplied by the speed of light in a vacuum, including bias due to the difference between a GNSS receiver and satellite time reference.

Satellite-based augmentation system (SBAS). A wide coverage augmentation system in which the user receives augmentation information from a satellite-based transmitter.

Standard positioning service (SPS). The specified level of positioning, velocity and timing accuracy that is available to any global positioning system (GPS) user on a continuous, worldwide basis.

Time-to-alert. The maximum allowable time elapsed from the onset of the navigation system being out of tolerance until the equipment enunciates the alert.

Subpart A – General Requirements

GNSS.005 Functions

GNSS shall provide position and time data to the aircraft through pseudo range measurements.

GNSS.010 GNSS Elements

The GNSS navigation service shall be provided using various combinations of the following elements installed on the ground, on satellites and/or on board the aircraft:

(a) Global Positioning System (GPS) that provides the Standard Positioning Service (SPS) as defined in GNSS.030;

(b) Global Navigation Satellite System (GLONASS) that provides the Channel of Standard Accuracy (CSA) as defined in GNSS.035;

(c) Galileo that provides a single- and dual-frequency Open Service (OS) as defined in GNSS.040;

(d) BeiDou Navigation Satellite System (BDS) that provides the BDS Open Service (BDS OS) as defined in GNSS.045;

(e) Aircraft-based augmentation system (ABAS) as defined in GNSS.050;

(f) Satellite-based augmentation system (SBAS) as defined in GNSS.055;

(g) Ground-based augmentation system (GBAS) as defined in GNSS.060;

(h) Ground-based regional augmentation system (GRAS) as defined in GNSS.060; and

(i) Aircraft GNSS receiver as defined in GNSS.065.

GNSS.015 References

(a) ICAO Annex 10 - Aeronautical Telecommunications, Volume I (Radio Navigation Aids).

(b) ICAO Annex 6 - Operation of Aircraft.

(c) ICAO Annex 11 - Air Traffic Services.

(d) ICAO Annex 15 - Aeronautical Information Services (AIS).

(e) ICAO Doc 9849 - Global Navigation Satellite System (GNSS) Manual.

(f) ICAO Doc 9613 - Performance-based Navigation (PBN) Manual.

(g) ICAO Doc 9750 - Global Air Navigation Plan (GANP).

(h) ICAO Doc 9760 - Airworthiness Manual.

(i) ICAO Doc 7300 - Convention on International Civil Aviation (Chicago Convention).

(j) ICAO Circular 328 - Unmanned Aircraft Systems (UAS).

(k) ICAO Standards and Recommended Practices (SARPs).

(l) ICAO Global Aviation Safety Plan (GASP).

GNSS.020 Space and time reference

(1) Space reference.

The position information provided by the GNSS to the user shall be expressed in terms of the World Geodetic System — 1984 (WGS-84) geodetic reference datum.

Note 1: *SARPs for WGS-84 are contained in Annex 4, Chapter 2, Annex 11, Chapter 2, Annex 14, Volumes I and II, Chapter 2 and Annex 15, Chapter 3.*

Note 2: *If GNSS elements using other than WGS-84 coordinates are employed, appropriate conversion parameters are to be applied.*

(2) Time reference.

The time data provided by the GNSS to the user shall be expressed in a time scale that takes the Universal Time Coordinated (UTC) as reference.

GNSS.025 Signal in space performance

The combination of GNSS elements and a fault-free GNSS user receiver shall meet the signal-in- space requirements defined in Appendix A (Table A.1).

Note: *The concept of a fault-free user receiver is applied only as a means of defining the performance of combinations of different GNSS elements. The fault-free receiver is assumed to be a receiver with nominal accuracy and time-to-alert performance. Such a receiver is assumed to have no failures that affect the integrity, availability and continuity performance.*

Subpart B – Subsystem Specifications

GNSS.030 GPS Standard Positioning Service (SPS) (L1, L5)

Note: *Unless otherwise specified, the performance standards in GNSS.030 (1) to (7) below apply to single-frequency Ranging, using the L1 coarse acquisition (C/A) code signal or the L5 signal (I5 code or Q5 code), and to dual-frequency ranging Using the combination of L1 and L5 signals. In addition, they only apply to current and consistent ephemeris and clock data Within the respective curve fit intervals.*

(1) Space and control segment accuracy

Note: *The following accuracy standards apply only for healthy GPS SPS signal-in-space (SIS), during normal operations as described in Annex 10 in Attachment D, 4.1.1.9, and do not include atmospheric or receiver errors as described in Annex 10 in Attachment D, 4.1.1.2. GPS SPS SIS health conditions can be found in the United States Department of Defense, Global Positioning System – Standard Positioning Service – Performance Standard, 5th Edition, April 2020 (hereinafter referred to as "GPS SPS PS"), Annex 10 in 2.3.2.*

(a) Positioning Accuracy

The single-frequency L1 C/A code position errors shall not exceed the following Limits:

Item	Global average %95 of the time	Worst site 95% of the time
Horizontal position error	8 m	15 m
Vertical position error	13 m	33 m

(b) Time Transfer Accuracy

The GPS SPS time transfer errors shall not exceed 30 nanoseconds 95 per cent of the time.

(c) Range domain Accuracy

The range domain error shall not exceed the following limits during normal Operations over all ages of data:

i. Range error of any satellite — 30 m with reliability specified in GNSS.30 (3);

ii. 95th percentile range rate error of any satellite — 0.006 m per second (global average);

iii. 95th percentile range acceleration error of any satellite — 0.002 m per second-squared (global average);

iv. 95th percentile range error for any satellite7.0 m (global average); and

v. 95th percentile range error across all satellites occupying defined slots in the constellation — 2.0 m (global average).

(2) Availability

The availability for single-frequency L1 C/A code users shall be as follows:

(a) ≥99 per cent horizontal service availability, average location (15 m 95 per cent threshold);
(b) ≥99 per cent vertical service availability, average location (33 m 95 per cent threshold)
(c) 90≥per cent horizontal service availability, worst-case location (15 m 95 per cent threshold);
(d) ≥90 per cent vertical service availability, worst-case location (33 m 95 per cent threshold).

(3) Reliability

The GPS SPS reliability relative to the 30 m user range error (URE) statistic in GNSS.30 (1-C) Shall be within the following limits:

(a) Reliability — at least 99.94 per cent (global average); and

(b) Reliability — at least 99.79 per cent (worst single point average).

(4) Probability of Major Service Failure

(a) Satellite major service failure onset rate (Rsat).

The probability that the instantaneous user range error (URE) Of any satellite will exceed 4.42 times the relevant integrity assured user range accuracy (IAURA) value broadcast by that Satellite without an alert received at the user receiver antenna within 10 seconds shall not exceed 1×10-5 per hour.

(b) Probability of a satellite major service failure condition (Psat).

The probability at any given instant that the Instantaneous URE of any satellite will exceed 4.42 times the relevant IAURA value broadcast by that satellite without an alert Received at the user receiver antenna within 10 seconds shall not exceed 1×10-5.

(c) Probability of a common-cause major service failure condition (Pconst).

The probability at any given instant That the instantaneous URE of two or more satellites will exceed 4.42 times the relevant IAURA broadcast by each satellite due To a common fault without an alert received at the user receiver antenna within 10 seconds shall not exceed 1×10-8.

(5) Continuity

The probability of losing L1 C/A SIS availability from a slot of the 24-slot constellation due to Unscheduled interruption shall not exceed 2×10-4 per hour.

(6) Coverage

The GPS SPS shall cover the surface of the earth up to an altitude of 3 000 kilometers.

Note: *Guidance material on GPS accuracy, availability, reliability, major service failure, continuity and coverage is Given in annex 10 in Attachment D, 4.1.1. Additional information is given in the GPS SPS PS.*

(7) Constellation Availability

The probability that 21 or more of the 24 slots will be occupied by either a satellite Broadcasting a trackable and healthy L1 C/A signal in the baseline slot configuration or by a pair of satellites each broadcasting A trackable and healthy L1 C/A signal in the expanded slot configurations, shall be at least 0.98. The probability that 20 or more Of the 24 slots will be occupied by either a satellite broadcasting a trackable and healthy L1 C/A signal in the baseline slot Configuration or by a pair of satellites each broadcasting a trackable and healthy L1 C/A signal in the expanded slot Configurations, shall be at least 0.99999.

Note: *There is currently no corresponding standard for the L5 signal or for the combined L1 C/A and L5 signals since older satellites in the constellation do not have the capability to broadcast an L5 signal.*

(8) Radio Frequency (RF) Characteristics

Note: *Detailed RF characteristics are specified in NAVSTAR GPS Space Segment/Navigation User Segment Interfaces, IS No. IS-GPS-200, Rev K (hereinafter referred to as "IS-GPS-200K") for L1 and NAVSTAR GPS Space Segment/User Segment L5 Interfaces, IS No. IS-GPS-705, Rev F (hereinafter referred to as "IS-GPS-705F"); selected characteristics are Specified in annex 10 Appendix B, 3.1.1.1.1 for L1 and Appendix B, 3.1.1.1.4 for L5.*

(a) L1 carrier frequency

Each GPS satellite shall broadcast an SPS ranging signal at the carrier frequency of 1 575.42 MHz (GPS L1) using code division multiple access (CDMA).

(b) L5 carrier frequency

Some GPS satellites shall, in addition, broadcast an SPS ranging signal at the carrier frequency of 1 176.45 MHz (GPS L5) using CDMA.

(c) Signal spectrum

The L1 and L5 signal power shall be contained within ±12 MHz bands centered on the respective carrier frequencies: 1 563.42 –1 587.42 MHz for L1 and 1 164.45 – 1 188.45 for L5.

(d) Polarization

The transmitted L1 and L5 RF signals shall be right-hand circularly polarized

(e) Signal structure

The L1 C/A signal shall consist of one carrier component. The L5 signal shall consist of two carrier components: an in-phase component (I5) and a quadrature component lagging the in-phase component by 90 degrees (Q5).

(f) Signal power level

Each GPS satellite shall broadcast SPS navigation signals with sufficient power such that, at all unobstructed locations near the ground from which the satellite is observed at an elevation angle of 5 degrees or higher, the level of the received RF signal at the antenna port of a 3 dBi linearly- polarized antenna is within the following ranges for all antenna orientations orthogonal to the direction of propagation: –158.5 dBW to –153 dBW for L1

C/A and –157.9 dBW to –150 dBW for each of the I5 and Q5 channels on L5.

(g) Modulation

Each SPS L1 and L5 signal shall be bipolar phase shift key (BPSK) modulated with a pseudo random noise (PRN) code. The C/A code on L1 shall have a rate of 1.023 mega chips per second. The codes on I5 and Q5 shall have a rate of 10.23 mega chips per second.

i. The C/A, I5, and Q5 code sequences shall be repeated each millisecond.
ii. The transmitted code sequence on L1 shall be the Modulo-2 addition of a 50-bit-per- second legacy navigation (LNAV) message and the C/A code.
iii. The transmitted code sequence on I5 shall be the Modulo-2 addition of a 50-bit-per- second civil navigation (CNAV) message (rate 1/2 convolution encoded into a 100 symbol per second stream), a 10-bit Neuman-Hofman overlay code clocked at 1 kbps, and the I5 code. The transmitted code sequence on Q5 shall be the Modulo-2 addition of a 20-bit Neuman-Hofman overlay code clocked at 1 kbps and the Q5 code.

Note: *The Q5 signal is not modulated with navigation data.*

(h) Signal coherence

All transmitted signals for any satellite shall be coherently derived from the same onboard frequency standard. On the L5 channel, the chip transitions of the two modulating signals, I5 and Q5, shall be such that the average time difference between them does not exceed 10 nanoseconds.

(9) GPS Time

GPS time shall be referenced to UTC (as maintained by the U.S. Naval Observatory).

(10) Coordinate System

The GPS coordinate system shall be WGS-84.

(11) Navigation Information

The navigation data transmitted by the satellites on L1 and L5 shall include the necessary information to determine:

(a) satellite time of transmission;
(b) satellite position;
(c) satellite health;
(d) satellite clock correction;
(e) Propagation delay effects;
(f) Time transfer to UTC; and
(g) Constellation status.

Note: *Structure and contents of data are specified in annex 10 Appendix B, 3.1.1.1.2 and 3.1.1.1.3 for L1, and 3.1.1.1.5 and 3.1.1.1.6 for L5.*

GNSS.035 GLONASS Channel of Standard Accuracy (CSA)(L1/L3)

Note: *The GLONASS signals for CSA are broadcast in two frequency bands identified as L1 and L3. In the L1 band, two Types of signals are broadcast: L1OF with frequency division multiple access (FDMA) and L1OC with code division multiple Access (CDMA). In the L3 band, only CDMA signals (L3OC) are broadcast. Except where otherwise specified, the term GLONASS refers to all satellites in the constellation transmitting either FDMA or CDMA signals.*

(1) Space and control segment accuracy

Note: *The single-frequency accuracy Standards do not include atmospheric or receiver errors; ionosphere errors are Included for dual-frequency combinations, as described in annex 10 Attachment D, 4.1.2.2.*

(a) Positioning accuracy

The GLONASS CSA position errors shall not exceed the following limits:

Signals	L1OF	L1OC	L3OC	L1OF – L3OC	L1OC – L3OC
Global average 95% of the time: Horizontal position error Vertical position error	5 m	5 m	5 m	5 m	5 m
	9 m	9 m	9 m	9 m	9 m
Worst site 95% of the time: Horizontal position error Vertical position error	12 m	12 m	12 m	12 m	12 m
	25 m	25 m	25 m	25 m	25 m

(b) Time transfer accuracy

The GLONASS CSA time transfer errors shall not exceed the following 95 per cent of the time:

Signals	L1OF	L1OC	L3OC	L1OF – L3OC	L1OC – L3OC
	40 ns	40 ns	40 ns	40 ns	40 ns

(c) Range domain accuracy

The range domain error shall not exceed the following limits:

Signals	L1OF	L1OC	L3OC	L1OF – L3OC	L1OC – L3OC
Range error of any satellite with reliability specified in 3	18 m	18 m	18 m	18 m	18 m
95th percentile range error of any satellite	11.7 m	11.7 m	11.7 m	11.7 m	11.7 m
95th percentile range error over all satellites	7.8 m	7.8 m	7.8 m	7.8 m	7.8 m
95th percentile range rate error of any satellite	0.014 m/s	0.014 m/s	0.014 m/s	0.014 m/s	0.014 m/s
95th percentile range acceleration error of any satellite	0.005 m/s2	0.005 m/s2	0.005 m/s2	0.005 m/s2	0.005 m/s2

(2) Availability

The GLONASS CSA reliability shall be within the following limits:

Signals	L1OF	L1OC	L3OC	L1OF – L3OC	L1OC – L3OC
Average location: Horizontal service Availability	99%, (12 m 95% threshold)	99%, (12 m 95% threshold)	99%, (12 m 95% threshold)	99%, (12 m 95% threshold)	99%, (12 m95% Threshold)
Vertical service availability	99%, (25 m 95% threshold)	99%, (25 m 95% threshold)	99%, (25 m 95% threshold)	99%, (25 m 95% threshold)	99%, (25 m 95% threshold)
Worst-case location: Horizontal service Availability	90%, (12 m 95% threshold)	90%, (12 m 95% threshold)	90%, (12 m 95% threshold)	90%, (12 m 95% threshold)	90%, (12 m 95% threshold)
Vertical service availability	90%, (25 m 95% Threshold)	90%, (25 m 95% Threshold)	90%, (25 m 95% Threshold)	90%, (25 m 95% Threshold)	90%, (25 m 95% Threshold)

(3) Reliability

The GLONASS CSA reliability shall be within the following limits:

Signals	L1OF	L1OC	L3OC	L1OF – L3OC	L1OC – L3OC
Global average	99.37%	99.37%	99.37%	99.37%	99.37%
Global Worst single point average	99.14%	99.14%	99.14%	99.14%	99.14%

(4) Probability of major service failure

The probability that the user range error (URE) of any satellite will exceed the following tolerance without an alert received at the user receiver antenna within 10 seconds shall not exceed the following probability:

Signals	L1OF	L1OC	L3OC	L1OF – L3OC	L1OC – L3OC
Single satellite failure (Psat)	1×10-4 , (70 m threshold)	1×10-4 , (70 m threshold)	1×10-4 , (70 m threshold)	1×10-4 , (70 m threshold)	1×10-4 , (70 m threshold)

(5) Probability of constellation fault

The probability that the user range error (URE) of more than one satellite will exceed the following tolerance simultaneously without an alert received at the user receiver antenna within 10 seconds shall not exceed the following probability:

Signals	L1OF	L1OC	L3OC	L1OF – L3OC	L1OC – L3OC
Constellation fault (Pconst)	1×10-4 , (70 m threshold)	1×10-4 , (70 m threshold)	1×10-4 , (70 m threshold)	1×10-4 , (70 m threshold)	1×10-4 , (70 m threshold)

(6) Continuity

The probability of losing GLONASS CSA healthy signal availability from a slot of the nominal 24-slot constellation due to unscheduled interruption shall not exceed the following limit:

Signals	L1OF	L1OC	L3OC	L1OF – L3OC	L1OC – L3OC
Signal continuity	2×10-3	2×10-3	2×10-3	2×10-3	2×10-3

(7) Coverage

The GLONASS CSA shall cover the surface of the earth up to an altitude of 2 000 km.

Note: *Guidance material on GLONASS accuracy, availability, reliability and coverage is given in Annex 10 Attachment D, 4.1.2.*

(8) L1OF RF characteristics

Note: *Detailed RF characteristics are specified in annex 10 Appendix B, 3.1.2.1.1*

(a) Carrier frequency

Each GLONASS satellite shall broadcast CSA navigation signal at its own carrier frequency in the L1 (1.6 GHz) frequency band using frequency division multiple access (FDMA).

Note 1: *GLONASS satellites may have the same carrier frequency but, in this case, they are located in antipodal slots of the same orbital plane.*

Note 2: *GLONASS-M satellites will broadcast an additional ranging code at carrier frequencies in the L2 (1.2 GHz) frequency band using FDMA.*

(b) Signal spectrum

GLONASS CSA signal power shall be contained within a ±5.75 MHz band centred on each GLONASS carrier frequency.

(c) Polarization

The transmitted RF signal shall be right-hand circularly polarized.

(e) Signal power level

Each GLONASS satellite shall broadcast CSA navigation signals with sufficient power such that, at all unobstructed locations near the ground from which the satellite is observed at an elevation angle of 5 degrees or higher, the level of the received RF signal at the antenna port of a 3 dBi linearly polarized antenna is within the range of –161 dBW to –155.2 dBW for all antenna orientations orthogonal to the direction of propagation.

Note 1: *The power limit of 155.2 dBW is based on the predetermined characteristics of a user antenna, atmospheric losses of 0.5 dB and an error of an angular position of a satellite that does not exceed one degree (in the direction causing the signal level to increase).*

Note 2: *GLONASS-M satellites will also broadcast a ranging code on L2 with sufficient power such that, at all unobstructed locations near the ground from which the satellite is observed at an elevation angle of 5 degrees or higher, the level of the received RF signal at the antenna port of a 3 dBi linearly polarized antenna is not less then –167 dBW for all antenna orientations orthogonal to the direction of propagation.*

(d) Modulation

i. Each GLONASS satellite shall transmit at its carrier frequency the navigation RF signal using a BPSK modulated binary train. The phase shift keying of the carrier shall be performed at radians with the maximum error ±0.2 radian. The pseudo-random code sequence shall be repeated each millisecond.

ii. The modulating navigation signal shall be generated by the Modulo-2 addition of the following three binary signals:

- ranging code transmitted at 511 kbits/s;
- navigation message transmitted at 50 bits/s; and
- 100 Hz auxiliary meander sequence.

(9) L3OC RF characteristics

Note: *Detailed RF characteristics are specified in annex 10 Appendix B, 3.1.2.1.5.*

(a) Carrier frequency. GLONASS L3OC navigation signals shall be broadcast at the carrier frequency of 1 202.025 MHz using code division multiple access (CDMA).

(b) Signal spectrum

GLONASS CSA L3OC signal power shall be contained within the 1 190.35 – 1 212.23 MHz band.

(c) Polarization

The transmitted L3OC signal shall be right-hand circularly polarized.

(d) Signal power level

GLONASS L3OC navigation signals shall be broadcast with sufficient power such that, at all unobstructed locations near the ground from which the satellite is observed at an elevation angle of 5 degrees or higher, the level of the received RF signal at the antenna port of a 3 dBi linearly polarized antenna is within the range of –158.5 dBW to –155.2 dBW for all antenna orientations orthogonal to the direction of propagation.

Note: *The power limit of 155.2 dBW is based on the predetermined characteristics of a user antenna, atmospheric losses of 0.5 dB and an error of an angular position of a satellite that does not exceed one degree (in the direction causing the signal level to increase).*

(e) Modulation

Note: *Additional information concerning the modulation is given in the GLONASS CDMA ICD Open Service Navigation Signal in L3 frequency band (Edition 1.0), dated 2016 (hereinafter referred to as “GLONASS CDMA ICD L3 band”).*

i. GLONASS L3OC navigation signals shall contain two components using the same BPSK (10)-modulated binary train: an in-phase data component and a quadrature-phase pilot component identified as L3OCd and L3OCp, respectively. The pilot component leads the data component by $\pi/2$ radians.

ii. The L3OCd signal component shall be generated by the Modulo-2 addition of the following three binary signals:

- ranging code with length N=10230, period T=1 ms, clock rate 10.23 MHz;
- 100 bits/s navigation message encoded using a convolutional encoder with constraint length 7 and code rate 1/2 to yield 200 symbols per second; and
- overlay code “00010” with period T=5 ms.

iii. The L3OCp signal component shall be generated by the Modulo-2 addition of the following two binary signals:

- ranging code with length N=10230, period T=1 ms, clock rate 10.23 MHz; and
- overlay code ”0000110101” with period T=10 ms.

(10) L1OC RF characteristics

Note: *Detailed RF characteristics are specified in Annex 10 Appendix B, 3.1.2.1.5.*

(a) Carrier frequency.

GLONASS L1OC navigation signals shall be broadcast at the carrier frequency of 1600.995 MHz using code division multiple access (CDMA).

(b) Signal spectrum.

GLONASS CSA L1OC signal power shall be contained within the 1 592.9 – 1 610 MHz band.

(c) Polarization.

The transmitted L1OC signal shall be right-hand circularly polarized.

(d) Signal power level.

GLONASS L1OC navigation signals shall be broadcast with sufficient power such that, at all unobstructed locations near the ground from which the satellite is observed at an elevation angle of 5 degrees or higher, the level of the received RF signal at the antenna port of a 3 dBi linearly polarized antenna is within the range of –158.5 dBW to –155.2 dBW for all antenna orientations orthogonal to the direction of propagation.

Note: *The power limit of 155.2 dBW is based on the predetermined characteristics of a user antenna, atmospheric losses of 0.5 dB and an error of an angular position of a satellite that does not exceed one degree (in the direction causing the signal level to increase).*

(e) **Modulation**

Note: *Additional information concerning the modulation is given in the GLONASS CDMA ICD Open Service Navigation Signal in L1 frequency band (Edition 1.0), dated 2016 (hereinafter referred to as "GLONASS CDMA ICD L1 band").*

i. GLONASS L1OC navigation signals shall contain two components: a data component and a pilot component identified as L1OCd and L1OCp, respectively. Both components shall be at one phase quadrature using time division multiplexing. L1OCd shall be modulated using binary phase-shift keying BPSK (1), while L1OCp shall be modulated by binary offset carrier BOC (1,1) modulation.

ii. The L1OCd signal component shall be generated by the Modulo-2 addition of the following three binary signals:

- ranging code with length N=1023, period T=2 ms, clock rate 0.5115 MHz;
- 125 bits/s navigation message encoded using a convolutional encoder with constraint length 7 and code rate 1/2 to yield 250 symbols per second; and
- overlay code "01" with period T=4 ms.

iii. The L1OCp signal component shall be generated by the Modulo-2 addition of the following two binary signals:

- ranging code with length N=4092, period T=8 ms, clock rate 0.5115 MHz; and
- meander sequence "0101" with clock rate 2.046 MHz.

(11) GLONASS time.

GLONASS time shall be referenced to UTC (SU) (as maintained by the National Time Service of Russia).

(12) Coordinate system.

The GLONASS coordinate system shall be PZ-90.

> ***Note:*** *Conversion from the PZ-90 coordinate system used by GLONASS to the WGS-84 coordinates is defined in annex 10 Appendix B, 3.1.2.5.2.*

(13) Navigation information.

The navigation data transmitted by the satellite shall include the necessary information to determine:

(a) satellite time of transmission;
(b) satellite position;
(c) satellite health;
(d) satellite clock correction;
(e) time transfer to UTC;
(f) constellation status;
(g) ionospheric delay effects (L1OC, L3OC only); and
(h) Satellite orientation in umbra (L1OC, L3OC only).

> ***Note:*** *Structure and contents of data are specified in annex 10 Appendix B, 3.1.2.1.2 and 3.1.2.1.3, respectively.*

GNSS.040 Galileo Open Service (Galileo OS) (E1, E5)

> ***Note 1:*** *The Galileo signals for Galileo OS are broadcast in two frequency bands identified as E1 and E5. In the E5 Band, two types of signals are broadcast with code division multiple access (CDMA): E5a and E5b. For aviation purposes, the Galileo single-frequency OS is based on either E1 or E5a signals; and the Galileo dual-frequency OS is based on a combination Of E1 and E5a signals.*
>
> ***Note 2:*** *The E5b signal component is described in this Annex since it is a subset of the overall Galileo signal modulated On the E5 frequency carrier. However, there is currently no intention that the E5b signal be used by aviation receivers.*
>
> ***Note 3:*** *The following performance standards only apply if "healthy" signals-in-space are used (see annex 10 Appendix B,3.1.3.1.3.4).*
>
> ***Note 4:*** *The following performance standards do not include atmospheric or receiver errors such as ionosphere, Troposphere, interference, receiver noise or multipath.*
>
> ***Note 5:*** *Guidance material on Galileo OS accuracy, availability, continuity, probability of satellite/constellation failure and coverage, is given in annex 10 Attachment D, 4.1.3.*

(1) Positioning accuracy.

The Galileo position errors shall not exceed the following limits:

Signals	E1	E5a	E1-E5a
Global average 95% of the time:			
Horizontal position error over a measurement period of 30 days	5 m	5 m	5 m
Vertical position error over a measurement period of 30 days	8 m	8 m	8 m
Worst site 95% of the time:			
Horizontal position error over a measurement period of 30 days	10 m	10 m	10 m
Vertical position error over a measurement period of 30 days	16 m	16 m	16 m

(2) Time determination accuracy.

The Galileo UTC time determination error shall not exceed 30 nanoseconds, 95 per cent of the time.

(3) Range domain accuracy.

The Galileo range domain error shall not exceed the following limits:

Signals	E1	E5a	E1-E5a
99.9th percentile range error of any satellite (worst-case location)	20 m	20 m	20 m
99.9th percentile range error of any satellite (global average)	10 m	10 m	10 m
95th percentile range error of any satellite (global average)	7 m	7 m	7 m
95th percentile range error over all satellites (global average)	2 m	2 m	2 m
95th percentile range rate error of any satellite (global average)	5 mm/s	5 mm/s	5 mm/s

Note 1: *The ranging accuracy considers only healthy Galileo OS SIS above a minimum elevation angle of 5 degrees.*

Note 2: *Single-frequency (E1 or E5a) ranging accuracy includes broadcast group delay (BGD) errors. BGD definition is specified in annex 10 Attachment D, 4.1.3.3.2.*

(4) Availability.

The Galileo OS availability shall be as follows:

Signals	E1	E5a	E1-E5a
Average location:			
Horizontal service availability over a measurement period of 30 days	99% (10 m 95% threshold)	99% (10 m 95% threshold)	99% (10 m 95% threshold)
Vertical service availability over a measurement period of 30 days	99% (16 m 95% threshold) 99%	99% (16 m 95% threshold) 99%	99% ((16 m 95% threshold) 99%
Worst-case location:			
Vertical service availability over a measurement period of 30 days	90% (10 m 95% threshold)	90% (10 m 95% threshold)	90% (10 m 95% threshold)
Horizontal service availability over a measurement period of 30 days	90% (16 m 95% threshold)	90% (16 m 95% threshold)	90% (16 m 95% threshold)

(5) Probability of satellite failure (Psat).

The probability that one satellite of Galileo operational core constellation provides an instantaneous SIS range error higher than k times the Galileo user range accuracy (Galileo URA) and no notification is given to the user, shall not exceed 3×10-5**.**

Note 1: *A change in the SIS health status is notified through the flags contained in the navigation message. The mapping between Galileo SIS status and flags contained in the navigation data message is specified in annex 10 Appendix B, 3.1.3.1.3.4. In the future, these flags may be complemented with an additional flag specific for aircraft-based augmentation system (ABAS) users.*

Note 2: *Galileo URA corresponds either to σURA,DF for dual-frequency users or to σURA,SF for single-frequency users.*

Note 3: *Psat definition is further specified in annex 10 Attachment D, 4.1.3.6.1.*

(6) Probability of constellation failure (Pconst).

The probability that, due to a common cause, any subset of two or more satellites within Galileo operational constellation provides an instantaneous SIS range error higher than k times the Galileo URA and no notification is given to the user, shall not exceed 2×10-4.

Note 1: *A change in the SIS health status is notified through the flags contained in the navigation message. The mapping Between Galileo SIS status and flags contained in the navigation data message is specified in annex 10 Appendix B, 3.1.3.1.3.4. In the Future, these flags may be complemented with an additional flag specific for ABAS users.*

Note 2: *Galileo URA corresponds either to σURA,DF for dual-frequency users or to σURA,SF for single-frequency users.*

Note 3: *Pconst definition is further specified in annex 10 Attachment D, 4.1.3.6.2.*

(7) Galileo URA for dual-frequency (σURA,DF).

Galileo σURA,DF shall not exceed 6 m.

Note 1: *σURA,DF applies to a dual-frequency E1-E5a signal combination.*

Note 2: *σURA,DF is defined in annex 10 Attachment D, 4.1.3.6.3.*

(8) Galileo URA for single-frequency (σURA,SF).

Galileo σURA,SF shall not exceed 7.5 m.

Note 1: *σURA,SF applies to a single-frequency user, either E1 or E5a.*

Note 2: *σURA,SF is defined in annex 10 Attachment D, 4.1.3.6.4.*

(9) Continuity.

The probability of losing Galileo OS SIS availability from a slot of the nominal 24-slot Constellation due to unscheduled interruption, shall not exceed the following limit:

Signals	E1	E5a	E1-E5a
Continuity	4×10-4 per hour	4×10-4 per hour	4×10-4 per hour

(10) Coverage.

The Galileo OS shall cover the surface of the earth up to an altitude of 30.48 km.

(11) Radio frequency (RF) characteristics.

All Galileo satellites shall broadcast Galileo OS signals E1, E5a and E5b.

Note 1: *E5a and E5b signals are multiplexed together through an AltBOC scheme and transmitted at the E5 carrier Frequency centred at 1191.795 MHz. AltBOC modulation allows E5a signal components and E5b signal components to be*

Recovered separately by using a QPSK receiver centred on the individual E5a and E5b frequencies.

Note 2: *AltBOC modulation is specified in annex 10 Appendix B, 3.1.3.1.1.3.13.*

Note 3: *Detailed Galileo signals RF characteristics are specified in annex 10 Appendix B,* 3.1.3.1.1.

(a) E1 radio frequency (RF) characteristics

i. E1 carrier frequency. Each Galileo satellite shall broadcast E1 signal at the carrier frequency of 1575.420 MHz using CDMA.

ii. E1 signal spectrum. The Galileo signal power on E1 shall be contained within a 24.552 MHz band Centred on the E1 frequency.

iii. **E1 signal polarization.**

The transmitted E1 RF signal shall be right-hand circularly polarized**.**

iv. **E1 minimum signal power level.**

Each Galileo satellite shall broadcast an E1 navigation signal with sufficient power such that, at all unobstructed locations near the ground from which the satellite is observed at an elevation angle of 5 degrees or higher, the level of the received RF signal at the antenna port of a 3 dBi linearly- polarized antenna shall not be less than –157.9 dBW for all antenna orientations orthogonal to the direction of propagation.

v. **E1 maximum signal power level.**

Each Galileo satellite shall broadcast an E1 navigation signal such that the level of the received RF signal at the antenna port of a 3 dBi linearly-polarized antenna shall not exceed –151.45 dBW.

vi. **E1 signal modulation.**

The E1 signal shall be a composite binary offset carrier (CBOC) generated by multiplexing a wideband binary offset carrier (BOC) signal BOC (6,1) with a narrowband signal BOC (1,1) in such a way that 1/11 of the power is allocated, in average, to the high frequency component.

Note: *CBOC modulation is specified in annex 10 Appendix B, 3.1.3.1.1.2.7.*

(b) E5a radio frequency (RF) characteristics

Note: *Additional information concerning the overall E5 signal modulation is given in the European GNSS (Galileo) Open Service Signal-In-Space Interface Control Document (Issue 2.0), dated January 2021 (hereinafter referred to as "Galileo OS SIS ICD").*

i. **E5a carrier frequency.**

Each Galileo satellite shall broadcast E5a signal at the carrier frequency of 1 176.45 MHz using CDMA**.**

ii. **E5a signal spectrum.**

The Galileo signal power on E5a shall be contained within a 20.460 MHz band centred on the E5a frequency.

iii. **E5a signal polarization.**

The transmitted E5a RF signal shall be right-hand circularly polarized**.**

iv. **E5a minimum signal power level.**

Each Galileo satellite shall broadcast an E5a navigation signal with sufficient power such that, at all unobstructed locations near the ground from which the satellite is observed at an elevation angle of 5 degrees or higher, the level of the received RF signal at the antenna port of a 3 dBi linearly-polarized antenna shall not be less than –155.90 dBW for all antenna orientations orthogonal to the direction of propagation.

v. E5a maximum signal power level.

Each Galileo satellite shall broadcast an E5a navigation signal such that the level of the received RF signal at the antenna port of a 3 dBi linearly-polarized antenna shall not exceed –149.45 dBW.

vi. E5a signal modulation.

The E5a signal shall be generated from Modulo-2 addition of the E5a navigation data stream with the 10.23 megachips per second E5a data channel ranging code (E5a-I), and the 10.23megachips per second E5a pilot channel ranging code (E5a-Q).

(c) E5b radio frequency (RF) characteristics

Note: *Additional information concerning the overall E5 signal modulation is given in Galileo OS SIS ICD.*

i. E5b carrier frequency.

Each Galileo satellite shall broadcast E5b signal at the carrier frequency of 1207.14 MHz using CDMA.

ii. E5b signal spectrum.

The Galileo signal power on E5b shall be contained within a 20.460 MHz band centred on the E5b frequency.

iii. E5b signal polarization.

The transmitted E5b RF signal shall be right-hand circularly polarized.

iv. E5b minimum signal power level.

Each Galileo satellite shall broadcast an E5b navigation signal with sufficient power such that, at all unobstructed locations near the ground from which the satellite is observed at an elevation angle of 5 degrees or higher, the level of the received RF signal at the antenna port of a 3 dBi linearly-polarized antenna shall not be less than –155.90 dBW for all antenna orientations orthogonal to the direction of propagation.

v. E5b maximum signal power level.

Each Galileo satellite shall broadcast an E5b navigation signal such that the level of the received RF signal at the antenna port of a 3 dBi linearly-polarized antenna shall not exceed –149.45 dBW.

vi. E5b signal modulation.

The E5b signal shall be generated from Modulo-2 addition of the E5b navigation data stream with the 10.23 megachips per second E5b data channel ranging code (E5b-I), and the 10.23 megachips per second E5b pilot channel ranging code (E5b-Q).

(12) Galileo system time.

Galileo system time (GST) shall be referenced to UTC BIPM (UTC as coordinated by the International Bureau of Weights and Measures).

Note: *Further details on GST are specified in annex 10 Appendix B, 3.1.3.4.1.*

(13) Coordinate system.

The Galileo coordinate system shall be Galileo Terrestrial Reference Frame (GTRF).

Note: *GTRF details are specified in annex 10 Appendix B, 3.1.3.5.2.*

(14) Navigation information.

The navigation data transmitted by the satellites shall include the necessary information to determine:

(a) satellite time of transmission;
(b) satellite position;
(c) satellite health;
(d) satellite clock correction;
(e) ionospheric delay effects;
(f) time transfer to UTC; and
(g) constellation status.

Note: *Structure and contents of data are specified in Annex 10 Appendix B, 3.1.3.1.2 and 3.1.3.1.3, respectively.*

GNSS.045 BDS Open Service (BDS OS) (B1I, B1C, B2a)

Note 1: *The BDS OS signals are broadcast in three frequency bands identified as B1I, B1C and B2a. The single-frequency BDS OS is based on any one of the B1I, B1C or B2a signals. The dual- frequency BDS OS is based on a combination of the B1C and B2a signals.*

Note 2: *BDS OS signals B1I, B1C and B2a are broadcast by all BDS-3 (BDS third-phase) medium earth orbit (MEO)and inclined geosynchronous orbit (IGSO) satellites.*

Note 3: *All requirements specified in this section are based on the BDS-3 constellation configuration of 24 MEO and 3 IGSO satellites.*

(1) Space and control segment accuracy

Note: *The following accuracy standards do not include atmospheric or receiver errors as described in annex 10 Attachment D, 4.1.4.2. They only apply under the condition that the aircraft receiver uses healthy satellites.*

(a) Positioning accuracy.

The BDS position errors shall not exceed the following limits:

Signals	B1I	B1C	B2a	B1C-B2a
Global average 95% threshold:				
Horizontal position over a Measurement period of 7 days	9 m	9 m	9 m	9 m
Vertical position error over a Measurement period of 7 days	15 m	15 m	15 m	15 m
Worst site 95% threshold:				
Horizontal position error over a Measurement period of 7 days	15 m	15 m	15 m	15 m
Vertical position error over a Measurement period of 7 days	22 m	22 m	22 m	22 m

(b) Time transfer accuracy.

The BDS OS time transfer error shall not exceed 50 nanoseconds, 95 per cent of the time.

(c) Range domain accuracy.

The BDS range domain error shall not exceed the following limits:

Signals	B1I	B1C	B2a	B1C-B2a
Range error of any satellite with Reliability specified in 5.1.4.3	15 m	15 m	15 m	15 m
95^{th} percentile error of any Satellite over Period of 7 days (global average)	4.6 m	4.6 m	4.6 m	4.6 m
95^{th} percentile range rate error of Any satellite (global average)	0.02 m per Second	0.02 m per Second	0.02 m per Second	0.02 m per Second
95th percentile range acceleration Error of any satellite (global Average)	0.008 m per Second Squared	0.008 m per Second Squared	0.008 m per Second Squared	0.008 m per Second Squared

(2) Availability.

The BDS OS availability shall be as follows:

Signals	B1I	B1C	B2a	B1C-B2a
Average location:				
Horizontal service availability over a measurement period of 7 days	≥ 99% (15 m 95% threshold)	≥ 99% (15 m 95% threshold)	≥ 99% (15 m 95% threshold)	≥ 99% (15 m 95% threshold)
Vertical service availability over a measurement period of 7 days	≥ 99% (22 m 95% threshold)	≥ 99% (22 m 95% threshold)	≥ 99% (22 m 95% threshold)	≥ 99% (22 m 95% threshold)
Worst-case location:				
Horizontal service availability over a measurement period of 7 days	≥ 90% (15 m 95% threshold)	≥ 90% (15 m 95% threshold)	≥ 90% (15 m 95% threshold)	≥ 90% (15 m 95% threshold)
Vertical service availability over a measurement period of 7 days	≥ 90% (22 m 95% threshold)	≥ 90% (22 m 95% threshold)	≥ 90% (22 m 95% threshold)	≥ 90% (22 m 95% threshold)

Note: *Availability applies under the condition that the aircraft receiver uses healthy satellites.*

(3) Reliability.

The BDS OS reliability relative to the 15 m range error requirement in GNSS.045 (2) shall be within the following limits:

(a) reliability — at least 99.94 per cent (global average); and

(b) reliability — at least 99.79 per cent (worst single point average).

Note: *Reliability applies under the condition that the satellite is broadcasting a healthy indication.*

(4) Probability of major service failure

Note: *The standards apply under the condition that the satellite is broadcasting a healthy indication.*

(a) Probability of a satellite major service failure condition (Psat).

The probability that the BDS OS SIS user range error of any satellite will exceed the not-to-exceed (NTE) tolerance without an alert received at the user receiver antenna within 300 seconds, shall not exceed 1×10-5.

(b) Probability of a common-cause major service failure condition (Pconst).

The probability that the BDS OS SIS user range error of two or more satellites will exceed the NTE tolerance due to a common fault without an alert received at the user receiver antenna within 300 seconds, shall not exceed 6×10-5.

Note 1*: For B1I signals, the NTE tolerance is defined to be 4.42 times the upper bound of the URA range corresponding to the URA index (URAI) value being broadcast in D1 navigation messages, as described in annex 10 Appendix B, 3.1.4.1.3.1.2.*

Note 2: *For B1C and B2a signals, the NTE tolerance is defined to be 4.42 times the signal-in- space accuracy (SISA) value calculated as described in annex 10 Appendix B, 3.1.4.2.5.*

Note 3: *The mapping between BDS B1I SIS status and BDS B1I flags contained in the navigation data message is specified in annex 10 Appendix B, 3.1.4.1.3.1.3. The mapping between BDS B1C and B2a SIS status and BDS B1C and B2a flags contained in the navigation data message is specified in annex 10 Appendix B, 3.1.4.1.3.2.7.2.*

(5) Continuity.

The probability of losing BDS OS SIS availability from a slot of the nominal 27-slot constellation due to unscheduled interruption, shall not exceed the following limits:

Signals	B1I	B1C	B2a
MEO	2×10-3 per hour	2×10-3 per hour	2×10-3 per hour
IGSO	5×10-3 per hour	2×10-3 per hour	2×10-3 per hour

Note: *Continuity applies under the condition that the satellite is broadcasting a healthy indication.*

(6) Coverage.

BDS OS shall cover the surface of the earth up to an altitude of 1 000 km.

(7) Radio frequency (RF) characteristics

Note: *Detailed BDS OS signals RF characteristics are specified in annex 10 Appendix B, 3.1.4.1.1.*

(8) B1I radio frequency (RF) characteristics

(a) B1I carrier frequency.

Each BDS-3 MEO or IGSO satellite shall broadcast a BDS B1I OS signal at the carrier frequency of 1 561.098 MHz using code division multiple access (CDMA).

(b) B1I signal spectrum.

The BDS OS B1I signal power shall be contained within a ±2.046 MHz band (1 559.052 – 1 563.144 MHz) centred on the 1 561.098 MHz frequency.

(c) B1I signal polarization.

The transmitted B1I RF signal shall be right-hand circularly polarized.

(d) B1I signal power levels

i. Each BDS-3 MEO satellite shall broadcast a B1I navigation signal with sufficient power such that, at all unobstructed locations near the ground from which the satellite is observed at an elevation angle of 5 degrees or higher, the level of the received RF signal at the antenna port of a 3 dBi linearly-polarized antenna is within the range of –163 dBW to –154.8 dBW for all antenna orientations orthogonal to the direction of propagation.

ii. Each BDS-3 IGSO satellite shall broadcast a B1I navigation signal with sufficient power such that, at all unobstructed locations near the ground from which the satellite is observed at an elevation angle of 5 degrees or higher, the level of the received RF signal at the antenna port of a 3 dBi linearly-polarized antenna is within the range of –163 dBW to –156.5 dBW for all antenna orientations orthogonal to the direction of propagation.

(e) B1I signal modulation.

The BDS OS B1I signal shall be binary phase shift key (BPSK) modulated.

(9) B1C radio frequency (RF) characteristics

(a) B1C carrier frequency.

Each BDS-3 MEO or IGSO satellite shall broadcast a BDS OS B1C signal at the carrier frequency of 1 575.42 MHz using CDMA.

(b) B1C signal spectrum.

The BDS OS signal power on B1C shall be contained within a 32.736 MHz band centered on the B1C frequency.

(c) B1C signal polarization.

The transmitted B1C RF signal shall be right-hand circularly polarized.

(d) B1C signal power levels

i. Each BDS-3 MEO satellite shall broadcast a B1C navigation signal with sufficient power such that, at all unobstructed locations near the ground from which the satellite is observed at an elevation angle of 5 degrees or higher, the level of the received RF signal at the antenna port of a 3 dBi linearly-polarized antenna is within the range of –159 dBW to –152.5 dBW for all antenna orientations orthogonal to the direction of propagation.

ii. Each BDS-3 IGSO satellite shall broadcast a B1C navigation signal with sufficient power such that, at all unobstructed locations near the ground from which the satellite is observed at an elevation angle of 5 degrees or higher, the level of the received RF signal at the antenna port of a 3 dBi linearly-polarized antenna is within the range of –161 dBW to –153.5 dBW for all antenna orientations orthogonal to the direction of propagation.

(e) B1C signal modulation.

The B1C signal shall comprise two components, known as B1C data component and B1C pilot component. The B1C data component shall be sine-phased binary offset carrier (BOC) modulated with the Modulo-2 addition of the ranging code and the navigation data. The B1C pilot component shall be quadrature multiplexed BOC (QMBOC) modulated with the ranging code. Ranging codes on B1C data component and B1C pilot component shall have the same chipping rate of 1.023 megachips per second.

Note: *Additional information concerning B1C modulation is given in the BeiDou Navigation Satellite System Signal in Space Interface Control Document Open Service Signal B1C (Version 1.0), dated December 2017 (hereinafter referred to as "BDS OS B1C ICD"), Subpart A GNSS.010.*

(10) B2a radio frequency (RF) characteristics

(a) B2a carrier frequency.

Each BDS-3 MEO and IGSO satellite shall broadcast a BDS OS B2a signal at the carrier frequency of 1 176.45 MHz using CDMA.

(b) B2a signal spectrum.

The BDS OS signal power on B2a shall be contained within a 20.46 MHz band centred on the B2a frequency.

(c) B2a signal polarization.

The transmitted B2a RF signal shall be right-hand circularly polarized.

(d) B2a signal power levels

i. Each BDS-3 MEO satellite shall broadcast a B2a navigation signal with sufficient power such that, at all unobstructed locations near the ground from which the satellite is observed at an elevation angle of 5 degrees or higher, the level of the received RF signal at the antenna port of a 3 dBi linearly-polarized antenna is within the range of –156 dBW to -148.5 dBW for all antenna orientations orthogonal to the direction of propagation.

ii. Each BDS-3 IGSO satellite shall broadcast a B2a navigation signal with sufficient power such that, at all unobstructed locations near the ground from which the satellite is observed at an elevation angle of 5 degrees or higher, the level of the received RF signal at the antenna port of a 3 dBi linearly-polarized antenna is within the range of –158 dBW to -150.5 dBW for all antenna orientations orthogonal to the direction of propagation.

(e) B2a signal modulation.

The B2a signal shall comprise two components, known as B2a data component and B2a pilot component. The B2a data component shall be BPSK modulated with the Modulo-2 addition of the ranging code and the navigation data. The B2a pilot component shall be BPSK modulated with the ranging code. Ranging codes on B2a data component and B2a pilot component shall have the same chipping rate of 10.23 megachips per second.

Note: *Additional information concerning B2a modulation is given in the BeiDou Navigation Satellite System Signal in Space Interface Control Document Open Service Signal B2a (Version 1.0), dated December 2017 (hereinafter referred to as "BDS OS B2a ICD"), Subpart A GNSS.010.*

(11) BDS time.

BDS time (BDT) shall be referenced to UTC as maintained by the National Time Service Center (NTSC), Chinese Academy of Sciences.

Note: *BDT details are specified in annex 10 Appendix B, 3.1.4.4.*

(12) Coordinate system.

The BDS coordinate system shall be BeiDou Coordinate System (BDCS).

Note: *BDCS details are specified in annex 10 Appendix B, 3.1.4.5.*

(13) Navigation information.

The navigation data transmitted by the satellites shall include the necessary information to determine:

(a) satellite time of transmission;
(b) satellite position;
(c) satellite health;
(d) satellite clock correction;
(e) ionospheric delay effects;
(f) time transfer to UTC; and
(g) constellation status.

GNSS.050 Aircraft-based augmentation system (ABAS)

The ABAS function combined with one or more of the other GNSS elements and both a fault free GNSS receiver and fault-free aircraft system used for the ABAS function shall meet the requirements for accuracy, integrity, continuity and availability as stated in Annex 10 3.7.2.4 for the intended operation.

Note: *For GNSS receivers supporting the ABAS function, the requirements to be resistant to interference, as specified in GNSS.070, apply.*

GNSS.055 Satellite-based augmentation system (SBAS)

***Note**:All SBAS have to fulfil the requirements introduced in this section and in Annex 10 Appendix B, 3.5 except when a specific condition is mentioned in the requirement such as the provision of optional functions.*

(1) Performance.

SBAS combined with one or more of the other GNSS elements and a fault-free receiver shall Meet the requirements for system accuracy, integrity, continuity and availability for the intended operation as stated in annex 10 in 3.7.2.4, Throughout the corresponding service area see GNSS.055 (4).

***Note:** SBAS complements the core satellite constellation(s) by increasing accuracy, integrity, continuity and availability of navigation provided within a service area, typically including multiple aerodromes.*

(a) SBAS combined with one or more of the other GNSS elements and a fault-free receiver shall meet the Requirements for signal-in-space integrity as stated in annex 10 in 3.7.2.4, throughout the SBAS coverage area.

***Note:** For L1 SBAS, message Types 27 or 28 can be used to comply with the integrity requirements in the coverage area. Additional guidance on the rationale and interpretation of this requirement is provided in annex 10 Attachment D, 3.3 and 6.2.3.*

(2) Functions.

SBAS shall perform one or more of the following functions:

(a) L1 SBAS ranging: provide an additional L1 ranging signal with an accuracy indicator from an SBAS satellite (GNSS.055 (3) and annex 10 Appendix B, 3.5.7.2);

(b) L1 SBAS GNSS satellite status: determine and transmit the GNSS satellite health status (annex 10 Appendix B, 3.5.7.3);

(c) L1 SBAS basic differential correction: provide GNSS satellite ephemeris and clock corrections (fast and long-term) To be applied to the L1 pseudo-range measurements from satellites (annex 10 Appendix B, 3.5.7.4);

(d) L1 SBAS precise differential correction: determine and transmit the L1 ionospheric corrections and associated Integrity data (annex 10 Appendix B, 3.5.7.5);

(e) Dual-frequency, multi-constellation (DFMC) SBAS ranging: provide additional ionosphere- free ranging capability Using L1 and L5 signals from SBAS satellites (annex 10 Appendix B, 3.5.14.2); and DFMC SBAS ionosphere-free differential correction: determine and transmit GNSS satellite health status, satellite Ephemeris and clock corrections to be applied to the ionosphere-free pseudo-range measurements from satellites (Annex 10 Appendix B, 3.5.14.3) and associated integrity data.

Note 1: *For single-frequency users, if functions b) and c) are provided, SBAS in combination with core satellite Constellation(s) can support departure, en-route, terminal and non-precision approach operations, and if function d) is Provided in addition to b) and c), then SBAS can also support precision approach operations including Category I. The level of performance that can be achieved depends upon the infrastructure incorporated into SBAS and the ionospheric conditions in the geographic area of interest.*

Note 2: *For dual-frequency users, if function f) is provided, SBAS in combination with core satellite constellation(s) can Support departure, en-route, terminal, non-precision approach operations and precision approach operations including Category I.*

Note 3: *In order to provide function e), SBAS needs to broadcast an L1 signal that meets the requirements for ionosphere free ranging using L1 and L5 pseudo-range measurements.*

Note 4: *The ionospheric corrections are only broadcast on L1. Dual-frequency users will use an ionosphere-free pseudo range measurement and not require ionospheric corrections. Ionosphere- free pseudo-range combination for DFMC SBAS is Further defined in annex 10 Appendix B, 3.5.15.1.*

(3) Ranging.

When SBAS is providing a ranging service, the following Standards shall apply:

(a) Excluding atmospheric effects, the range error for the ranging signal from SBAS satellites shall not exceed 25 m (82 ft) (95 per cent).
(b) The probability that the SBAS L1 range error exceeds 150 m (490 ft) in any hour shall not exceed 10–5.
(c) The probability of unscheduled outages of the ranging function from an SBAS satellite in any hour shall not exceed 10–3.
(d) The range rate error shall not exceed 2 m (6.6 ft) per second.
(e) The range acceleration error shall not exceed 0.019 m (0.06 ft) per second-squared.

(4) Service area.

An SBAS service area for any approved type of operation shall be a declared area within the SBAS coverage area where SBAS meets the corresponding requirements of Appendix A.

Note 1: *An SBAS system can have different service areas corresponding to different types of operation (e.g. APV-I, Category I, etc.).*

Note 2: *The coverage area is that area within which the SBAS broadcast can be received (i.e. the union of SBAS satellite footprints).*

Note 3: *SBAS coverage and service areas are discussed in annex 10 Attachment D, 6.2.*

(5) RF characteristics for the SBAS L1 signal

Note: *Detailed RF characteristics are specified in* annex 10 *Appendix B, 3.5.2 for L1.*

(a) L1 carrier frequency.

The L1 carrier frequency shall be 1 575.42 MHz.

(b) L1 signal spectrum.

At least 95 per cent of the L1 broadcast power shall be contained within a ±12 MHz band centred on the L1 frequency. The bandwidth of the L1 signal transmitted by an SBAS satellite shall be at least 2.2 MHz.

Note: *The SBAS L1 RF link needs to provide a higher transmission bandwidth to support the SBAS ranging accuracy figure in annex 10 Appendix B, 3.5.15.4.1, for DFMC SBAS ranging service. A higher transmission bandwidth will improve the performance of the L1 SBAS ranging service.*

(c) L1 satellite signal power level

i. Each SBAS satellite placed in orbit before 1 January 2014 shall broadcast navigation signals on L1 with sufficient power such that, at all unobstructed locations near the ground from which the satellite is observed at an elevation angle of 5 degrees or higher, the level of the received RF signal at the antenna port of a 3 dBi linearly polarized antenna is within the range of – 161 dBW to –153 dBW for all antenna orientations orthogonal to the direction of propagation.

ii. Each SBAS satellite broadcasting an SBAS L1 signal placed in orbit after 31 December 2013 shall comply with the following requirements:

- The satellite shall broadcast navigation signals on L1 with sufficient power such that, at all unobstructed locations near the ground from which the satellite is observed at or above the minimum elevation angle for which a trackable geostationary orbit (GEO) satellite signal needs to be provided, the level of the received RF signal at the antenna port of the antenna specified in Appendix B, Table B-172, is at least –164.0 dBW.
- The minimum elevation angle used to determine GEO coverage shall not be less than 5 degrees for a user near the ground.
- The level of a received SBAS RF signal on L1 at the antenna port of a 0 dBic antenna located near the ground shall not exceed –152.5 dBW.
- The ellipticity of the broadcast L1 signal shall be no worse than 2 dB for the angular range of ±9.1° from boresight.

(d) Polarization.

The broadcast signal on L1 shall be right-hand circularly polarized.

(e) Modulation.

The transmitted sequence on L1 shall be the Modulo-2 addition of the navigation message at a rate of 500 symbols per second and the 1 023-bit pseudo-random noise code. It shall then be BPSK-modulated onto the carrier at a rate of 1.023 megachips per second.

(6) RF characteristics for the SBAS L5 signal

Note: *Detailed RF characteristics are specified in* annex 10 *Appendix B, 3.5.9 for L5.*

(a) L5 carrier frequency.

The L5 carrier frequency shall be 1 176.45 MHz.

(b) L5 signal spectrum.

At least 95 per cent of the L5 broadcast power shall be contained within a bandwidth centred on the L5 frequency and between 20 MHz and 24 MHz.

(c) L5 signal power level.

Each SBAS satellite broadcasting an SBAS L5 signal shall comply with the following Reserved requirements:

i. The satellite shall broadcast navigation signals on L5 with sufficient power such that, at all unobstructed locations near the ground from which the satellite is observed at or above the minimum elevation angle for which a trackable signal needs to be provided, the level of the received RF signal at the output of a 3 dBi linearly polarized antenna shall be at least –158 dBW for all antenna orientations orthogonal to the direction of propagation.
ii. The minimum elevation angle used to determine SBAS satellite coverage shall not be less than 5 degrees for a user near the ground.
iii. The level of a received SBAS RF signal on L5 at the output of a 0 dBic right-hand circularly polarized antenna located near the ground shall not exceed –150.5 dBW**.**
iv. The ellipticity of the broadcast L5 signal shall be no worse than 2 dB for the angular range of ±9.1° from boresight.

Note: *The received signal levels, from a) and c), are measured within a ±10 MHz frequency band centred on the L5 frequency.*

(d) Polarization.

The broadcast signal on L5 shall be right-hand Reserved polarized.

(e) Modulation.

The transmitted sequence on L5 in-phase shall be the result of the 250-bits of the navigation message with forward error correction (FEC) applied for 500 symbols per second that is then bi- binary encoded and finally combined with the 10 230-bit pseudo-random noise code using Modulo- 2 addition. The resulting sequence shall then be BPSK modulated onto the carrier at a rate of 10.23 megachips per second.

(7) SBAS network time (SNT)

(a) SBAS network time (SNT) for L1 SBAS.

The difference between SNT of the SBAS corrections on L1 and GPS Time shall not exceed 50 nanoseconds.

(b) SBAS network time (SNT) for DFMC SBAS.

The difference between SNT of the SBAS corrections broadcast On L5 and the reference time of the core constellation designated as reference constellation (see the time reference identifier Parameter in Annex 10 Appendix B, 3.5.11.4 broadcast by DFMC SBAS) shall not exceed 1 microsecond.

(8) L1 SBAS navigation information.

The navigation data transmitted by an SBAS satellite on L1 shall include the Necessary information to support L1 SBAS services to determine:

(a) SBAS satellite time of transmission;
(b) SBAS satellite position;
(c) Corrected satellite time for all satellites;
(d) Corrected satellite position for all satellites;
(e) Ionospheric propagation delay effects;
(f) User position integrity;
(g) Time transfer to UTC (optional); and
(h) Service level status.

Note: *Structure and contents of data are specified in Annex 10 Appendix B, 3.5.3 and 3.5.4, respectively.*

(9) DFMC SBAS navigation information.

The navigation data transmitted by an SBAS satellite on L5 shall include the necessary information to support DFMC SBAS services to determine:

(a) SBAS satellite time of transmission;
(b) SBAS satellite position;
(c) Corrected satellite time for all monitored satellites;
(d) Corrected satellite position for all monitored satellites;
(e) User position integrity; and
(f) Time transfer to UTC (optional).

Note: *Structure and contents of data are specified in Annex 10 Appendix B, 3.5.10 and 3.5.11, respectively.*

GNSS.060 Ground-based augmentation system (GBAS) and ground-based regional augmentation system (GRAS)

***Note:** Except where specifically annotated, GBAS Standards and Recommended Practices apply to GBAS and GRAS*

(1) Performance.

GBAS combined with one or more of the other GNSS elements and a fault-free GNSS receiver shall meet the requirements for system accuracy, continuity, availability and integrity for the intended operation as stated in Annex 10 in 3.7.2.4 within the service volume for the service used to support the operation as defined in GNSS.060 (3).

***Note:** GBAS is intended to support all types of approach, landing, guided take-off, departure and surface operations and may support en-route and terminal operations. GRAS is intended to support en-route, terminal, non-precision approach, departure, and approach with vertical guidance. The following SARPs are developed to support all categories of precision approach, approach with vertical guidance, and a GBAS positioning service.*

(2) Functions.

GBAS shall perform the following functions:

(a) provide locally relevant pseudo-range corrections;
(b) provide GBAS-related data;
(c) provide final approach segment data when supporting precision approach;
(d) provide predicted ranging source availability data; and
(e) provide integrity monitoring for GNSS ranging sources.

(3) Service volume

(a) General requirement for approach services. The minimum GBAS approach service volume shall be as follows, except where topographical features dictate and operational requirements permit:

i. laterally, beginning at 140 m (450 ft) each side of the landing threshold point/fictitious threshold point (LTP/FTP) and projecting out ±35 degrees either side of the final approach path to 28 km (15 NM) and ±10 degrees either side of the final approach path to 37 km (20 NM); and

ii. vertically, within the lateral region, up to the greater of 7 degrees or 1.75 promulgated glide path angle (GPA) above the horizontal with an origin at the glide path interception point (GPIP) to an upper bound of 3 000 m (10 000 ft) height above threshold (HAT) and 0.45 GPA above the horizontal or to such lower angle, down to 0.30 GPA, as required, to safeguard the promulgated glide path intercept procedure. The lower bound is half the lowest decision height supported or 3.7 m (12 ft), whichever is larger.

***Note 1:** LTP/FTP and GPIP are defined in Annex 10 Appendix B, 3.6.4.5.1.*

***Note.2:** Guidance material concerning the approach service volume is provided in Annex 10 Attachment D, 7.3.*

(b) Approach services supporting Autoland and guided take-off.

The minimum additional GBAS service volume to support approach operations that include automatic landing and roll-out, including during guided take-off, shall be as follows, except where operational requirements permit:

i. Horizontally, within a sector spanning the width of the runway beginning at the stop end of the runway and extending parallel with the runway centre line towards the LTP to join the minimum service volume as described in GNSS.060 (3-a).
ii. Vertically, between two horizontal surfaces one at 3.7 m (12 ft) and the other at 30 m (100 ft) above the runway centre line to join the minimum service volume as described in GNSS.060 (3-a).

Note: *Guidance material concerning the approach service volume is provided in Annex 10 Attachment D, 7.3.*

(c) GBAS positioning service.

The service volume for the GBAS positioning service shall be where the data broadcast can be received and the positioning service meets the requirements of Annex 10 3.7.2.4 and supports the corresponding approved operations.

Note: *Guidance material concerning the positioning service volume is provided in Annex 10 Attachment D, 7.3.*

(4) Data broadcast characteristics

Note: *RF characteristics are specified in 10 Appendix B, 3.6.2.*

(a) Carrier frequency.

The data broadcast radio frequencies used shall be selected from the radio frequencies in the band 108 to 117.975 MHz. The lowest assignable frequency shall be 108.025 MHz and the highest assignable frequency shall be 117.950 MHz. The separation between assignable frequencies (channel spacing) shall be 25 kHz.

Note 1: *Guidance material on VOR/GBAS frequency assignments and geographical separation criteria is given in Annex 10 Attachment D, 7.2.1.*

Note 2: *ILS/GBAS geographical separation criteria and geographical separation criteria for GBAS and VHF communication services operating in the 118 – 137 MHz band are under development. Until these criteria are defined and included in SARPs, it is intended that frequencies in the band 112.050 – 117.900 MHz will be used.*

(b) Access technique.

A time division multiple access (TDMA) technique shall be used with a fixed frame structure. The data broadcast shall be assigned one to eight slots.

Note: *Two slots are the nominal assignment. Some GBAS facilities that use multiple VHF data broadcast (VDB) transmit antennas to improve VDB coverage may require assignment of more than two time slots. Guidance on the use of multiple antennas is given in Annex 10 Attachment D, 7.12.4; some GBAS broadcast stations in a GRAS may use one time slot.*

(c) Modulation.

GBAS data shall be transmitted as 3-bit symbols, modulating the data broadcast carrier by D8PSK, at a rate of 10 500 symbols per second.

(d) Data broadcast RF field strength and polarization

Note 1: *GBAS can provide a VHF data broadcast with either horizontal (GBAS/H) or elliptical (GBAS/E) polarization that employs both horizontal polarization (HPOL) and vertical polarization (VPOL) components. Aircraft using a VPOL component will not be able to conduct operations with GBAS/H equipment. Relevant guidance material is provided in Annex 10 Attachment D, 7.1.*

Note 2: *The minimum and maximum field strengths are consistent with a minimum distance of 80 m (263 ft) from the transmitter antenna for a range of 43 km (23 NM).*

Note 3: *When supporting approach services at airports with challenging VDB transmitter siting constraints, it is acceptable to adjust the service volume when operational requirements permit (as stated in the service volume definition in* GNSS.060 (3-a) *and* GNSS.060 (3-b)*. Such adjustments of the service volume may be operationally acceptable when they have no impaction the GBAS service outside a radius of 80 m (263 ft) from the VDB antenna, assuming a nominal effective isotopically radiated power of 47dBm (Annex 10 Attachment D, Table D-6).*

(e) GBAS/H

i. **A horizontally polarized signal shall be broadcast.**
ii. The effective isotopically radiated power (EIRP) shall provide for a horizontally polarized signal with a minimum field strength of 215 microvolts per meter (–99 dBW/m2) and a maximum field strength of 0.879 volts per meter (–27 dBW/m2) within the GBAS service volume as specified in 5.5.3.1. The field strength shall be measured.

Note: *GNSS elements operating within the frequency bands 1 164 – 1 215 MHz and 1 559 – 1 610 MHz are classified by the ITU as operating in the radionavigation-satellite service (RNSS). Those frequency bands also include global allocations to the and aeronautical radionavigation service (ARNS). Both aeronautical uses of those services are considered "safety services" and are afforded special spectrum protection status in the ITU radio regulations. In order to achieve the performance objectives for precision approach guidance to be supported by the GNSS and its augmentations, RNSS/ARNS is intended to remain the only global allocation in the 1 164 – 1 215 MHz and 1 559 – 1 610 MHz band and emissions from systems in this and adjacent frequency bands are intended to be tightly controlled by national and/or international regulation.*

GNSS.065 Aircraft GNSS Receiver

The aircraft GNSS receiver shall process the signals of those GNSS elements that it intends to use as specified in Annex 10 in Appendix B, 3.1.1 (for GPS), Appendix B, 3.1.2 (for GLONASS), Appendix B, 3.1.3 (for Galileo), Appendix B, 3.1.4 (for BDS), Appendix B 3.3 (for combined core satellite constellations), Appendix B, 3.4 (for ABAS), Appendix B, 3.5 (for SBAS) and Appendix B, 3.6 (for GBAS and GRAS).

Subpart C – signal Performance and Integrity

GNSS.070 Interference Resistance

GNSS shall comply with performance requirements defined in Annex 10 3.7.2.4, Appendix B, 3.7 in the presence of the interference environment defined in Annex 10 Appendix B, 3.7.

Note: *GNSS elements operating within the frequency bands 1 164 – 1 215 MHz and 1 559 – 1 610 MHz are classified by the ITU as operating in the radionavigation-satellite service (RNSS). Those frequency bands also include global allocations to the aeronautical radionavigation service (ARNS). Both aeronautical uses of those services are considered "safety services" and are afforded special spectrum protection status in the ITU radio regulations. In order to achieve the performance objectives for precision approach guidance to be supported by the GNSS and its augmentations, RNSS/ARNS is intended to remain the only global allocation in the 1 164 – 1 215 MHz and 1 559 – 1 610 MHz band and emissions from systems in this and adjacent frequency bands are intended to be tightly controlled by national and/or international regulation.*

GNSS.075 Database Requirements

Note*: SARPs applicable to aeronautical data are provided in Annex 4, Annex 11, Annex 14 and Annex 15.*

Aircraft GNSS equipment that uses a database shall provide a means to:

(a) update the electronic navigation database; and

(b) determine the Aeronautical Information Regulation and Control (AIRAC) effective dates of the aeronautical database.

Note*: Guidance material on the need for a current navigation database in aircraft GNSS equipment is provided in annex 10 Attachment D, 11.*

GNSS.080 Aeronautical Data Integrity

(1) AIRAC Compliance

Navigation databases shall be updated every 28 days in compliance with AIRAC cycles.

(2) Pre-Flight Verification

Operators shall ensure that navigation databases are current and appropriate for the intended flight prior to departure. Aircraft systems should, where capable, provide a means to verify database currency.

Subpart D - Operation Standards

GNSS.085 GNSS Equipment Certification

GNSS equipment shall be certified in accordance with applicable ICAO Standards and Recommended Practices (SARPs) and shall be approved by the State of Registry (LYCAA). Equipment certified by a recognized authority (e.g., EASA, FAA) may be accepted provided it meets the requirements of this regulation.

GNSS.090 Contingency Procedures

Pilots shall immediately revert to conventional navigation aids (e.g., ILS, VOR, DME, NDB) upon detection of GNSS signal degradation or receipt of an alert, in accordance with published procedures. The transition shall be executed in coordination with ATC.

GNSS.095 Air Traffic Control (ATC) Procedures

(1) Real-Time Updates

ATC shall issue navigation instructions and clearances to aircraft in accordance with established procedures, including information on any changes to routes or procedures.

(2) Emergency Management

ATC shall apply documented contingency procedures during GNSS outages, including vectoring aircraft and ensuring safe separation using conventional means.

(3) Joint Training

The Authority shall ensure that the contingency plan is tested through exercises conducted at appropriate intervals. These exercises shall include, as appropriate, the participation of ATC personnel and aircraft operators to validate the effectiveness of GNSS contingency procedures.

GNSS.100 Emergency Protocols

(1) Fallback to Conventional Systems

Pilots shall, upon detection of GNSS signal degradation or receipt of an alert, revert to the use of conventional navigation aids (e.g., ILS, VOR, NDB, DME) in accordance with published instrument approach procedures and the applicable minima.

(2) Emergency Communication

Pilots shall immediately inform ATC of any GNSS failure or degradation affecting navigation capability. ATC shall provide appropriate assistance, including vectoring and reversion to conventional navigation aids, in accordance with established contingency procedures. Pilots shall immediately switch to ILS/VOR if GNSS integrity is compromised, adhering to Minimum Descent Altitude (MDA).

Subpart E - Training and Licensing

GNSS.105 Pilot Training

(1) GNSS approach procedures (LNAV/VNAV, LPV).

Pilots shall be trained on Approach Procedures with Vertical Guidance (APV), including LNAV/VNAV and LPV minima, as defined in ICAO Annex 6, Part I, Chapter 7. Training must emphasize that APV procedures provide vertical guidance but do not meet the more stringent standards of a precision approach (PA) unless specifically classified as SBAS Cat I, in accordance with ICAO Doc 8168 (PANS-OPS), Volume I, Part II, Section 1, Chapter 2.

(2) Emergency protocols for GNSS failure.

Training shall include immediate actions upon GNSS degradation, including monitoring for fault alerts (e.g., "GPS PRIMARY LOST," "NAV GNSS FAULT"), switching to alternate navigation sources (VOR, ILS, INS), and informing ATC using standard ICAO phraseology as specified in ICAO Doc 4444 (PANS-ATM): "UNABLE GNSS POSITION – USING ALTERNATE NAVIGATION". Post-flight reporting of GNSS interference events shall be logged in the aircraft technical log and reported to authorities per ICAO Annex 13 (Aircraft Accident and Incident Investigation) requirements for mandatory occurrence reporting.

GNSS.110 Aircraft Certification

GNSS equipment installation and maintenance shall be approved or accepted by the State of Registry (LYCAA) in accordance with:

(1) ICAO Annex 6, Part I, Chapter 6 (Aeroplan Instruments and Equipment) requirements for navigation equipment;

(2) ICAO Annex 8, Part III (Airworthiness Standards) covering avionics performance and continued airworthiness.

The certification shall ensure compliance with ICAO Standards and Recommended Practices (SARPs) for GNSS as detailed in ICAO Annex 10, Volume I (Radio Navigation Aids). Equipment must meet applicable technical standards (e.g., TSO-C145/146 for SBAS, TSO-C129/196 for GPS/GLONASS) for airborne navigation sensors. All installations and subsequent maintenance shall be documented in the aircraft maintenance log as evidence of continued airworthiness per ICAO Annex 6 requirements.

Subpart F - Aircraft Airworthiness

GNSS.115 Periodic Inspections

All GNSS equipment shall undergo mandatory periodic inspections and scheduled maintenance tasks at intervals specified by the LYCAA, based on the manufacturer's recommendations and the maintenance programmes approved under ICAO Annex 6, Part I, Chapter 6 and Annex 8, Part III. Results shall be documented in the aircraft maintenance log as evidence of continued airworthiness, in accordance with ICAO Annex 6, Part I, Chapter 8.

GNSS.120 Technical Documentation

(1) A maintenance record shall be maintained to demonstrate compliance with:
   - (a) ICAO Annex 10, Volume I (Radio Navigation Aids) for GNSS signal-in-space and avionics performance;
   - (b) ICAO Annex 6, Part I, Chapter 6 for navigation equipment requirements; and
   - (c) ICAO Annex 8, Part III for continued airworthiness standards.

(2) The record shall include details of all software updates, navigation database revisions (including AIRAC cycles), component replacements, and bench test results. Such records shall be kept for a minimum period as defined by LYCAA and be readily available for inspection by the Authority.

GNSS.125 System Integration

GNSS systems shall be designed and installed to ensure safe integration with other onboard navigation systems (e.g., ILS, VOR, DME, INS) in accordance with ICAO Annex 10, Volume I, Chapter 3. The integration shall enable seamless transition during GNSS signal degradation or failure, through either automatic reversion or manual selection using standard operating procedures. System integration must not introduce unacceptable interference or degrade the performance of any other aircraft system, as required by ICAO Annex 6, Part I, Chapter 6 and the airworthiness standards of ICAO Annex 8, Part III.

Subpart G - Risk and Emergency Management

GNSS.130 Radio Frequency Interference Assessment

The Authority shall ensure that periodic radio frequency interference assessments are conducted at critical locations. Results shall be documented and retained.

GNSS.135 GNSS Contingency Arrangements

The Authority shall ensure the existence of regulations, procedures, and instructions for GNSS contingencies. Such arrangements shall include:

(a) coordination with adjacent States, as appropriate;

(b) reversion to conventional navigation aids;

(c) alternative air traffic control procedures; and

(d) periodic exercises to test these arrangements.

Subpart H – Compliance and Review

GNSS.140 Document Revision

This regulation shall be amended, as necessary, to reflect changes to ICAO Standards and Recommended Practices or national requirements.

GNSS.145 GNSS Incident Reporting

The Authority shall establish a mandatory reporting system for GNSS-related incidents, including interference events. Significant interference affecting GNSS signals shall be promptly notified to airspace users via NOTAM and documented for safety analysis.

Appendix A: Signal-in-space Performance (Table A.1)

The combination of GNSS elements and a fault-free GNSS user receiver shall meet the signal-in-space requirements defined in Table A.1.

Note 1: *The concept of a fault-free user receiver is applied only as a means of defining the performance of combinations of different GNSS elements. The fault-free receiver is assumed to be a receiver with nominal accuracy and time-to-alert performance. Such a receiver is assumed to have no failures that affect the integrity, availability and continuity performance.*

Note 2: *For GBAS approach service (as defined in Annex 10 Attachment D, 7.1.2.1) intended to support approach and landing operations using Category III minima, performance requirements are defined that apply in addition to the signal-in-space requirements defined in Table A.1 below.*

Physical operation	Accuracy horizontal 60% (Notes 1 and 3)	Accuracy vertical 95% (Notes 1 and 3)	Integrity (Note 2)	Time to completion (Note 3)	Continuity Note	Availability (Note 5
Ex-route	3.7 km (2.0 NM)	N/A	$1 - 1 \times 10^{-7}$/h	5 min	$1 - 1 \times 10^{-4}$/h to $1 - 1 \times 10^{-8}$/h	0.99 to 0.99999
En-route, Terminal	0.74 km (0.4 NM)	N/A	$1 - 1 \times 10^{-7}$/h	15 s	$1 - 1 \times 10^{-4}$/h to $1 - 1 \times 10^{-8}$/h	0.99 to 0.99999
Initial approach , Intermediate approach , Non-precision approach (NPA) , Departure	220 m (720 ft)	N/A	$1 - 1 \times 10^{-7}$/h	10 s	$1 - 1 \times 10^{-4}$/h to $1 - 1 \times 10^{-8}$/h	0.99 to 0.99999
Approach operations with vertical guidance (APV-I)	16.0 m (52 ft)	20 m (66 ft)	$1 - 2 \times 10^{-7}$ in any approach	10 s	$1 - 8 \times 10^{-6}$ per 15 s	0.99 to 0.99999
Approach operations with vertical guidance (APV-II)	16.0 m (52 ft)	8.0 m (26 ft)	$1 - 2 \times 10^{-7}$ in any approach	6 s	$1 - 8 \times 10^{-6}$ per 15 s	0.99 to 0.99999
Category I precision approach (Note 7)	16.0 m (52 ft)	6.0 m to 4.0 m (20 ft to 13 ft) (Note 6)	$1 - 2 \times 10^{-7}$ in any approach	6 s	$1 - 8 \times 10^{-6}$ per 15 s	0.99 to 0.99999

NOTES:

1. The 95th percentile values for GNSS position errors are those required for the intended operation at the lowest height above threshold (HAT), if applicable. Detailed requirements are specified in Appendix B and guidance material is given in annex 10 Attachment D, 3.2.
2. The definition of the integrity requirement includes an alert limit against which the requirement can be assessed. For Category I precision approach, a vertical alert limit (VAL) greater than 10 m for a specific system design may only be used if a system-specific safety analysis has been completed. Further guidance on the alert limits is provided in annex 10 Attachment D, 3.3.6 to 3.3.10. These alert limits are:

Typical operation	Horizontal alert limit	Vertical alert limit
En-route (oceanic/continental low density)	7.4 km (4 NM)	N/A
En-route (continental)	3.7 km (2 NM)	N/A
En-route, Terminal	1.85 km (1 NM)	N/A
NPA	556 m (0.3 NM)	N/A
APV-I	40 m (130 ft)	50 m (164 ft)
APV-II	40 m (130 ft)	20.0 m (66 ft)
Category I precision approach	40 m (130 ft)	35.0 m to 10.0 m (116ft to 33 ft)

3. The accuracy and time-to-alert requirements include the nominal performance of a fault-free receiver.
4. Ranges of values are given for the continuity requirement for en-route, terminal, initial approach, NPA and departure operations, as this requirement is dependent upon several factors including the intended operation, traffic density, complexity of airspace and availability of alternative navigation aids. The lower value given is the minimum requirement for areas with low traffic density and airspace complexity. The higher value given is appropriate for areas with high traffic density and airspace complexity (see annex 10 Attachment D, 3.4.2). Continuity requirements for APV and Category I operations apply to the average risk (over time) of loss of service, normalized to a 15- second exposure time (see annex 10 Attachment D, 3.4.3).

5. A range of values is given for the availability requirements as these requirements are dependent upon the operational need which is based upon several factors including the frequency of operations, weather environments, the size and duration of the outages, availability of alternate navigation aids, radar coverage, traffic density and reversionary operational procedures. The lower values given are the minimum availabilities for which a system is considered to be practical but are not adequate to replace non-GNSS navigation aids. For en-route navigation, the higher values given are adequate for GNSS to be the only navigation aid provided in an area. For approach and departure, the higher values given are based upon the availability requirements at airports with a large amount of traffic assuming that operations to or from multiple runways are affected but reversionary operational procedures ensure the safety of the operation (see annex 10 Attachment D, 3.5).
6. A range of values is specified for Category I precision approach. The 4.0 m (13 feet) requirement is based upon ILS specifications and represents a conservative derivation from these specifications (see annex 10 Attachment D, 3.2.7).
7. GNSS performance requirements for Category II and III precision approach operations are under review and will be included at a later date.
8. The terms APV-I and APV-II refer to two levels of GNSS approach and landing operations with vertical guidance (APV) and these terms are not necessarily intended to be used operationally.

Appendix B: GBAS Broadcast Characteristics (Table B.2)

Channel	Relative power	Maximum power
1st adjacent	-40 dBc	12 dBm
2nd adjacent	-65 dBc	-13 dBm
4th adjacent	-74 dBc	22 dBm
8th adjacent	-88.5 dBc	-36.5 dBm
16th adjacent	-101.5 dBc	-49.5 dBm
32nd adjacent	-105 dBc	-53 dBm
64th adjacent	-113 dBc	-61 dBm
76th adjacent and beyond	-115 dBc	-63 dBm

NOTES:

1. The maximum power applies if the authorized transmitter power exceeds 150 W.
2. The relationship is linear between single adjacent points designated by the adjacent channels identified above.

Appendix C: GBAS Unwanted Emissions (Table C.3)

Frequency	Relative unwanted emission level (Note 2)	Maximum unwanted emission level (Note 1)
9 kHz to 150 kHz	-93 dBc (Note 3)	-55 dBm/1 kHz (Note 3)
150 kHz to 30 MHz	-103 dBc (Note 3)	-55 dBm/10 kHz (Note 3)
30 MHz to 106.125 MHz	-115 dBc	-57 dBm/100 kHz
106.425 MHz	-113 dBc	-55 dBm/100 kHz
107.225 MHz	-105 dBc	-47 dBm/100 kHz
107.625 MHz	-101.5 dBc	-53.5 dBm/10 kHz
107.825 MHz	-88.5 dBc	-40.5 dBm/10 kHz
107.925 MHz	-74 dBc	-36 dBm/1 kHz
107.9625 MHz	-71 dBc	-33 dBm/1 kHz
107.975 MHz	-65 dBc	-27 dBm/1 kHz
118.000 MHz	-65 dBc	-27 dBm/1 kHz
118.0125 MHz	-71 dBc	-33 dBm/1 kHz
118.050 MHz	-74 dBc	-36 dBm/1 kHz
118.150 MHz	-88.5 dBc	-40.5 dBm/10 kHz
118.350 MHz	-101.5 dBc	-53.5 dBm/10 kHz
118.750 MHz	-105 dBc	-47 dBm/100 kHz
119.550 MH	-113 dBc	-55 dBm/100 kHz
119.850 MHz to 1 GHz	-115 dBc	-57 dBm/100 kHz
1 GHz to 1.7 GHz	-115 dBc	-47 dBm/1 MHz

NOTES:

1. The maximum unwanted emission level (absolute power) applies if the authorized transmitter power exceeds 150 W.
2. The relative unwanted emission level is to be computed using the same bandwidth for desired and unwanted signals. This may require conversion of the measurement for unwanted signals done using the bandwidth indicated in the maximum unwanted emission level column of this table.
3. This value is driven by measurement limitations. Actual performance is expected to be better.
4. The relationship is linear between single adjacent points designated by the adjacent channels identified above.