



The European Organisation for Civil Aviation Equipment
L'Organisation Européenne pour l'Équipement de l'Aviation Civile

INTERIM TECHNICAL PERFORMANCE STATEMENT FOR EGNOS / WAAS AIRBORNE EQUIPMENT

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ED-97

January 2000

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FOREWORD

1. Document ED-97 was prepared by EUROCAE Working Group 28 as a Minimum Operational Performance Specification for EGNOS/WAAS airborne receivers. Significant effort has been devoted to have the document complete and it is now in a form considered by the Council of EUROCAE suitable for publication. It is important to recognise that this area of technology is under rapid development and thus the information contained in this document is unlikely to record the latest information on EGNOS/WAAS. In addition, some of the GLONASS data has been difficult to validate. ICAO has recently made changes to the Satellite Based Augmentation System signal in space definition. ED-97, in its current form, does not reflect these changes. Users of this document are recommended to consult the ICAO Standards and Recommended Practices for Satellite Based Augmentation Systems. To reflect these issues the document has been published as an Interim Technical Performance Statement.
2. EUROCAE is an international non-profit making organisation. Membership is open to European users and manufacturers of equipment for aeronautics, trade associations, national civil aviation administrations and, under certain conditions, non-European organisations. Its work programme is principally directed to the preparation of performance specifications and guidance documents for civil aviation equipment, for adoption and use at European and world-wide levels.
3. The findings of EUROCAE are resolved after discussion among its members and in co-operation with RTCA Inc., Washington D.C., USA and/or the Society of Automotive Engineers (SAE), Warrendale PA, USA through their appropriate committees.
4. The main differences between ED-97 and RTCA DO-229 are identified in section 1.4.
5. At the time of publication of this interim document, some uncertainties existed concerning GLONASS parameters. Attention is drawn to these in the appropriate sections, e.g. in Appendix G.
6. EUROCAE performance specifications are recommendations only; EUROCAE is not an official body of the European Governments; its recommendations are valid as statements of official policy only when adopted by a particular government or conference of governments.
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CHAPTER 1

GENERAL1.1 INTRODUCTION

This document has been prepared by EUROCAE Working Group 28 with the expectation that it would be published as a Minimum Operational Performance Specification (MOPS), however the rate of change of the technology in this area and the fact that it has not been possible to validate fully the performance parameters of GLONASS to the standard sufficient to underpin EUROCAE MOPS, the decision has been taken to publish the data as an Interim Technical Performance Statement. The title has been chosen to indicate that prior to use the data needs to be checked. Key discussions on technical performance take place within the ICAO GNSS Panel and it is output from this Panel that should be considered as the most up to date and definitive source of information against which MOPS (using the methods outlined in this document) can be derived.

This document contains the best estimate of operational performance statements for airborne EGNOS/WAAS receiver equipment intended to be used as a primary means of navigation for all phases of flight from En-route down to Non Precision Approach. The terminology EGNOS/WAAS is generically used to refer to Satellite Based Augmentation System (SBAS) providers such as the European Geostationary Navigation Overlay System (EGNOS) and the US Wide Area Augmentation System (WAAS). These Standards are intended to be applicable to other SBAS providers such as Japan's Multifunctional Transport Satellite Augmentation System (MSAS). This document specifies EGNOS/WAAS equipment using the GPS constellation. Equipment combining GPS and GLONASS may be specified in a subsequent publication.

These statements are designed to ensure that airborne EGNOS/WAAS receiving equipment can be designed to be compatible with the technical specification for GPS as defined in the document "GPS Standard Positioning Service - Signal Specifications" and for SBAS signal in space definition as defined in ICAO GNSS Standards and Recommended Practices (SARPs).

This document defines performance, functions and features for a 2D system, which provides only lateral guidance. The performance of specific equipment may be enhanced or superior to this specification depending on the intended application and configuration.

Chapter 1 provides information explaining the need for the equipment characteristics and tests defined in the remaining chapters. It describes typical equipment applications and operational objectives and is the basis for the performance criteria specified in Chapter 2 and Chapter 3. Definitions essential to proper understanding of this document are also provided in Chapter 1.

Chapter 2 contains general design specifications.

Chapter 3 contains the minimum performance specification for the equipment, defining performance under standard operating conditions.

Chapter 4 contains provisions for the minimum performance specification of a EGNOS/WAAS receiving equipment using combined GPS and GLONASS signals; however the reader should note that some of the GLONASS data has not been validated fully.

Chapter 5 prescribes the environmental test conditions which provide a laboratory means of determining the overall performance characteristics of the equipment under conditions representative of those which may be encountered in actual operations.

Chapter 6 describes recommended test procedures for demonstrating compliance with the minimum performance specifications contained in Chapter 3.

Chapter 7 specifies the performance of the installed equipment. Ground and flight tests for the installed equipment are included.

The appendices contain additional information and guidance material regarding the testing and use of an EGNOS/WAAS receiving equipment.

Appendix A contains the EGNOS/WAAS Signal Specification and Appendices B and G describe the standard Interference Environment for GPS and GLONASS respectively.

Appendix C contains GPS, GLONASS, EGNOS and WAAS assumptions.

Appendix D details the algorithms which are used to compute EGNOS/WAAS provided integrity.

Appendix E provides the budget allocated for Integrity calculations.

Appendix F provides information concerning interoperability.

Appendix G provides information on GLONASS characteristics.

Appendix H provides justification for the testing and pass/fail criteria used in Chapter 6.

1.2 SYSTEM OVERVIEW

1.2.1 Background

In 1983 the International Civil Aviation Organisation (ICAO) established a special committee on Future Air Navigation Systems (FANS). This had a mandate to identify and analyse new concepts and technology, and make recommendations for the co-ordinated evolutionary development of air navigation into the 21st century. The recommendations made by the ICAO-FANS committee were endorsed at ICAO's Tenth Air Navigation Conference held in late 1991. It was recognised that Global Navigation Satellite System (GNSS) would form a key element of the European navigation infrastructure in the 21st century.

The initial GNSS envisioned by the ICAO-FANS committee relies on the use of navigation signals from the two existing military systems: the United States' Global Positioning System (GPS) and the Russian Global Navigation Satellite System (GLONASS). In 1992 the United States and Russia offered the civil aviation community the use, free of direct charges, of GPS and GLONASS to the years 2007 and 2002 respectively provided that adequate internal funding remained available. This has been subsequently modified by the formal offers made to ICAO in 1995 and the US Presidential Policy Directive concerning GPS.

Civil aviation has formally expressed its interest and requirements for a global navigation satellite system through the ICAO-FANS committee. ICAO has established a GNSS Panel (GNSS-P) to define the technical standards for satellite-based air navigation, and a Legal and Technical Panel (LTP) to resolve outstanding institutional issues.

1.2.2 EGNOS system and EGNOS signals

The major issue concerning the use of GPS and GLONASS is their ability to satisfy civil aviation requirements, particularly in respect of service integrity and reliability. As GPS and GLONASS can not meet all civil aviation requirements by themselves, augmentation of these systems becomes an operational requirement for certain operations, notably terminal manoeuvring, approach, landing, ground movements, take-off, and departure. EGNOS is such an augmentation to GPS and GLONASS, which includes integrity broadcasts, correction data, and additional ranging signals. It will provide the augmentation necessary to support all phases of flight up to and including Category 1 precision approach.

EGNOS comprises a network of wide-area reference stations that receive and monitor the GPS and GLONASS signals. Data from these reference stations are transmitted to master stations, where the validity of the signals from each satellite is assessed and corrections are computed. The validity and correction messages are transmitted to aircraft via the INMARSAT III Atlantic Ocean Region East (AOR-E) and Indian Ocean Region (IOR) and later to Artemis satellites. These messages also serve as additional ranging signals. They are broadcast on the same frequency, and using the same code division multiplex (CDMA) modulation as the GPS Standard Positioning Service (SPS) signal.

In Europe a Tripartite Group comprising the European Commission, Eurocontrol and the European Space Agency (ESA) initiated a project to develop EGNOS as the implementation of the initial ICAO GNSS (GNSS-1) in Europe.

The EGNOS system will be designed to serve the needs of the aviation, maritime and land transport user communities. An analysis of the multi-modal requirements confirmed those of aviation to be one of the most demanding in terms of required navigation performance. The main objective of EGNOS for aviation, is to provide the required navigation performance from En-Route, Terminal Area, down to Category I Precision Approach applications.

The EGNOS system will be developed in two phases. The first of these will be an Advanced Operational Capability (AOC) using the navigation transponders on-board INMARSAT III , IOR and Artemis communications satellites. This will be followed by a Full Operational Capability (FOC) implementing sole-means civil aviation requirements for all phases of flight down to Category 1 landing, requiring additional geostationary satellites to achieve required redundancy levels. The principles of operation, broadcast frequency, and modulation type are compliant with ICAO SBAS standards.

The architecture of the EGNOS AOC is given in [Figure 1-1](#).

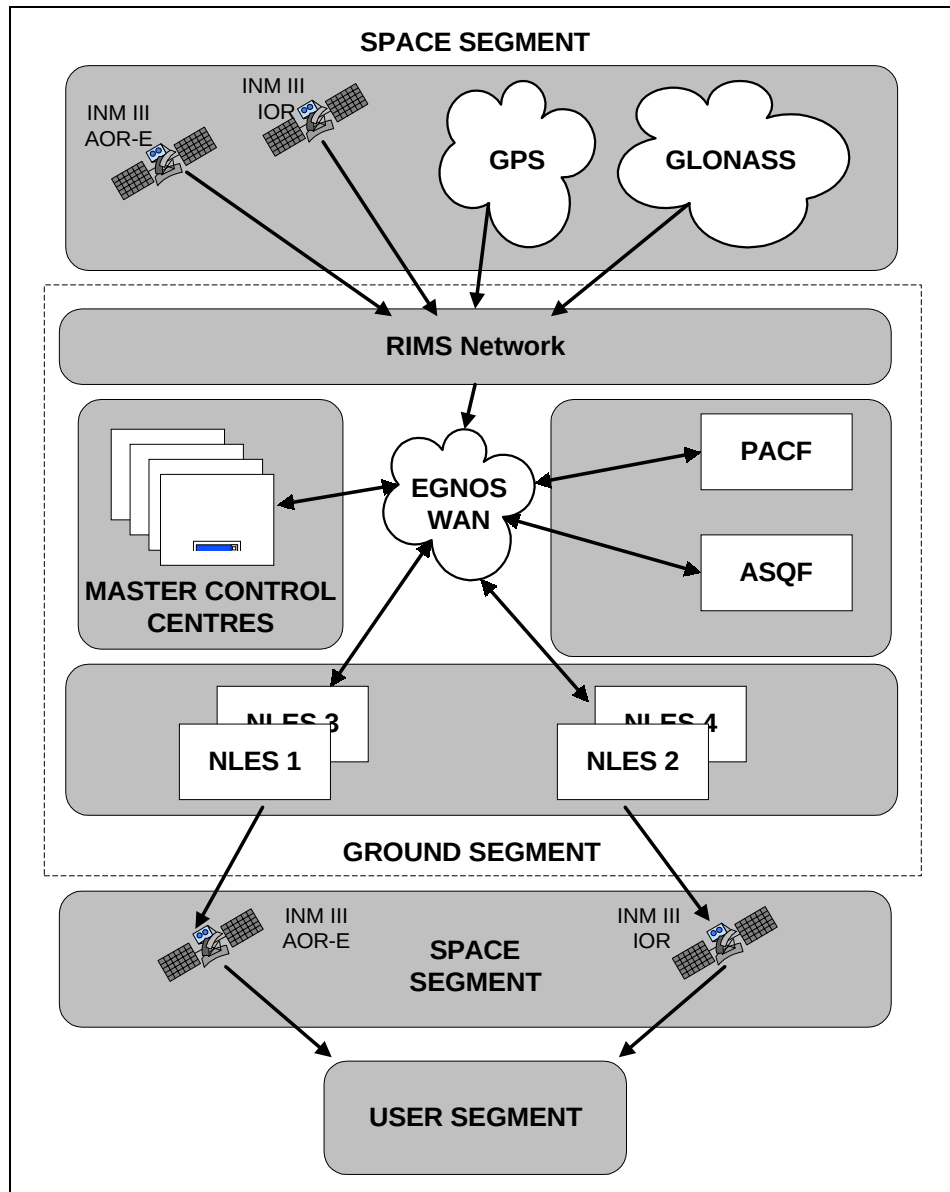


FIGURE 1-1: EGNOS AOC ARCHITECTURE

NOTE: The architecture presented in the figure corresponds to the Advanced Operational Capability (AOC) configuration of EGNOS. The Full Operational Capability (FOC) configuration will be similar with additional geostationary satellites in the space segment.

The key performance characteristics of the EGNOS FOC are given in [Table 1-1](#).

FOC LEVEL	Non Precision Navigation Service	Precision Navigation Service PA 350 feet	Precision Navigation Service CAT 1	Ranging function from GEO
Accuracy 95%	100m	10m (V) 10m (H)	6m (V) 6m (H)	-
NSE 10^{-7} /h	556m	25m (V) 25m (H)	15m (V) 15m (H)	150m
Integrity Risk	10^{-7} /h	10^{-7} /approach	10^{-7} /approach	-
Time to alarm	6s	6s	6s	5.2s
Continuity Risk	10^{-5} /h	10^{-4} /approach	10^{-4} /approach	-
Availability	0.9999	0.999	0.999	-
Service Volume Full	ECAC	ECAC Land Masses	ECAC Land Masses	GBA.IOR U GBA.AORE

TABLE 1-1: EGNOS SIS FOC PERFORMANCE CHARACTERISTICS WITH THE USE OF GPS AND GLONASS SIGNALS

NOTE 1: This table is provisional, and may be subject to change.

NOTE 2: Non precision approach is available with or without the use of GLONASS.

NOTE 3: Precision Navigation Service PA 350 feet includes use of GPS only, whereas CAT 1 makes use of a combination of available signals, e.g. GLONASS, pseudolights, GPS, etc.

1.2.3 WAAS and MSAS

WAAS and MSAS are similar systems to EGNOS, being developed by the USA and Japan respectively. WAAS, MSAS and EGNOS are designed to be interoperable, but only EGNOS offers the use of GLONASS and the enhanced performance that it provides.

1.2.4 GPS system and GPS signals

1.2.4.1 Description of GPS system

NOTE: The following is a brief description of the NAVSTAR GPS and its application to civil aviation. For more detailed information the reader is referred to [ref1] and [ref2].

The GPS is a satellite-based radio positioning, navigation and time-transfer system controlled

by the United States Department of Defence. It operates on two frequencies, 1 575.42 MHz (L1), and 1 227.6 MHz (L2), using spread spectrum modulation.

Two navigation accuracy levels are provided: the Precise Positioning Service (PPS) and the Standard Positioning Service (SPS). The PPS will provide to authorised users the greater degree of accuracy and anti-jam protection. Access to the PPS will be controlled by cryptographic techniques. The civil user will only be given access to the SPS on frequency L1.

The GPS navigation data is referenced to a model of the earth defined by the US Department of Defence World Geodetic System of 1984 (WGS-84).

1.2.4.2 The GPS segments: Space, Control, and User

1.2.4.2.1 Space Segment

The US DoD GPS Space Segment normally consists of a constellation of 24 operational satellites deployed in six orbital planes. Each satellite transmits L1 and L2 frequencies. L1 frequencies are modulated by both a precise and a coarse/acquisition ranging code. L2 frequencies are modulated by the precise ranging code only. Superimposed on these signals are navigation data including satellite ephemeris and satellite clock information.

1.2.4.2.2 Control Segment

The Control Segment includes Monitor Stations and Ground Antennas located throughout the world. The Monitor Stations track all satellites in view and accumulate ranging data from the satellite signals. The information from the Monitor Stations is processed at the Master Control Station to determine satellite orbits and to update the navigation message of each satellite.

1.2.4.2.3 User Segment

The User Segment consists of GPS receiving equipment that uses data transmitted by the satellites to derive navigation and time information. The PPS allows access to full system accuracy. The GPS control segment will apply selective availability (SA) to maintain 100 metres (95%) horizontal accuracy for SPS using the coarse/acquisition code on L1 only.

1.2.4.3 GPS User Equipment

A GPS user equipment calculates a position fix using a ranging technique for selected satellites.

Each satellite signal is modulated with data that define the position of the satellite, the GPS system time, the time of transmission of the signal, the satellite's clock error and the health and accuracy of the transmitted data. The user equipment is able to decode this information to determine where the satellite is located at any given time.

GPS user equipment automatically selects the satellites that provide an adequate navigation solution for a given location and time and, by various means (RAIM, GPS integrity channel, etc.) provide information regarding the integrity of the satellite signals. As the positions of neither the satellites nor the user are fixed these are dynamic processes. The two major limitations to satellite selection are mask angle and the Dilution of Precision factors (HDOP, VDOP, and TDOP).

1.2.4.4 Satellite Signals

Standards and Recommended Practices for GPS signals are detailed in [Ref3].

1.2.4.4.1 Operating Frequencies

The GPS Standard Positioning Service, for general use, operates on a centre frequency of

1 575.42 MHz (L1 carrier). The Main Lobe Bandwidth is 2.046 MHz.

1.2.4.4.2 User Power level

The minimum power level available to the user antenna is -160 dBW (C/A code).

1.2.4.4.3 Maximum Power Level

The maximum power level available at the antenna shall be -153dBW (C/A code).

1.2.4.4.4 Modulation Characteristics

The L1 signal from each satellite consists of two carrier components (P and C/A code) which are in phase-quadrature to within 100 milliradians.

Both carrier components are bi-phase shift key (BPSK) modulated with the Modulo-2 addition of a pseudo-random noise (PRN) ranging code and navigation data message.

1.2.4.5 Ranging Codes

1.2.4.5.1 General

Code-division multiplexing techniques allow differentiation between the satellites even though they all transmit on the same frequency. Three PRN ranging codes may be transmitted:

- the precision P code,
- the Y code, used in place of the P code whenever the anti-spoofing (A-S) mode of operation is being used by the Control Segment,
- the coarse-acquisition C/A code, which may be used for standard accuracy navigation and for acquisition of the P or Y code.

Internal failures detected by a satellite will cause the satellite to transmit warning information in the form of codes which do not correspond to those of any working satellite, and which are designed to protect users from using incorrect information. These codes are termed non-standard C/A (NSC) and non-standard Y (NSY) codes.

1.2.4.5.2 C/A Code

The C/A code is 1 millisecond in length at a chipping rate of 1.023 Mbps. C/A code characteristics are defined in [Ref1] and described in [Ref2]

1.2.4.5.3 Navigation Data

The system navigation data include satellite ephemeris, system time, satellite clock behaviour data, status messages, etc. These 50 bps data are Modulo-2 added to the C/A codes; the resultant bit streams are used to modulate the L1 carrier. The content and characteristics of the navigation data stream are defined in [Ref1].

1.2.4.6 Electrical Characteristics

The electrical characteristics of the signals are defined in [Ref1].

1.2.4.7 System Accuracy

1.2.4.7.1 Positioning Accuracy

Positioning accuracy at any given location and at any given time can be estimated by multiplying two factors: Dilution of Precision (PDOP, HDOP or VDOP, respectively, for 3D

accuracy, horizontal accuracy and vertical accuracy) and User Equivalent Range Error (UERE).

PDOP, HDOP and VDOP depend on the relative geometry of the selected satellites. UERE represents the ranging error in measurement of range between the receiver and the selected satellites.

Worldwide positioning accuracy for a 24-satellite constellation, with the current specification of SA, will be as given in [Table 1-2](#).

	Horizontal	Vertical
95%	100	156
99.99%	300	500

TABLE 1-2: GPS POSITIONING ACCURACY (METRES)

NOTE: *Table 1-2 is derived from the FAA Radionavigation Plan (worldwide consideration over a period of 24 hours with a minimum elevation mask angle of 5 deg.).*

1.2.4.8 Timing Accuracy

SPS timing accuracy with respect to GPS time can be estimated by multiplying the UERE by the Time Dilution of Precision (TDOP) and dividing by the speed of light.

The Control Segment maintains GPS time relative to Co-ordinated Universal Time (UTC[USNO]). Accuracy available to SPS users is within 300 nanoseconds (95%) UTC, 900 ns (99.99%).

1.2.4.9 Velocity Accuracy

There is no specification available for civil users.

1.2.4.10 System Availability

For the purpose of this description, System Availability is defined as the probability that:

- a minimum of 21 satellites will be operational at any time and broadcasting current operational navigation messages, and
- the system will meet the UERE budget for normal operation.

NOTE: *The system availability is a function of the number of satellites in orbit and the fractions of time individual satellites are unhealthy.*

1.2.4.11 General Concepts of GPS Integrity

Signal in Space integrity refers to the ability of the navigation system to provide timely warnings to users when the system should not be used for navigation. The traditional way of assuring integrity in electronic navigation systems has been to monitor transmitted signals and, if the signals are detected to be out of specifications for any reason, a timely warning is provided to the user. The GPS integrity system must at least interpret the information it has about the pseudorange errors in terms of the induced horizontal position error, and then make a decision as to whether the error is outside the allowable radial error specified for the particular phase of flight in progress. The allowable radial error will subsequently be referred to as the alarm limit. If the horizontal error is found to exceed the alarm limit, a timely warning must be issued.

In addition to the safeguards built into the GPS system itself, three rather distinct methods of further assuring GPS signal in space integrity have evolved as the civil use of GPS has progressed. One is the Receiver Autonomous Integrity Monitoring (RAIM) concept, the second is the integrity provided by the aircraft integrated navigation system, and the other is the ground monitoring approach that goes under the name GPS Integrity Channel. These are described briefly in paragraphs 1.2.4.11.1 through 1.2.4.11.3, and the terms RAIM and GPS integrity channel will be used throughout this document.

1.2.4.11.1 Receiver Autonomous Integrity Monitoring

There are many ways of implementing autonomous or self-contained signal in space integrity monitoring, but all the schemes that have been proposed employ a self-consistency check of the measurements. This, of course, requires redundancy. For a self-consistency check to be performed on an instantaneous basis, there must be at least five satellites in view. At least one more satellite is needed to isolate a faulty signal. Also, there are constraints in the satellite geometry that have to be met if the check is to be effective in the presence of noise. Generally speaking, a robust satellite system with many satellites in view makes for a robust RAIM system. Conversely, a sparse satellite configuration with marginal redundancy makes for a RAIM system with limited availability, i.e., there may be short periods when a good consistency check is not possible. The main feature of RAIM is that it is completely self-contained and relatively easy to implement in software.

1.2.4.11.2 GPS Integrity Channel

The concept of a network of ground monitoring stations dedicated especially to GPS integrity is another idea that has evolved. With this concept, ground stations will monitor all satellites in view and then relay on the user either coarse quantitative measures of observed pseudorange errors or simply a go/no-go evaluation for each satellite. The GPS receiver will then make a decision as to whether or not the particular set of satellites being used in the navigation problem will yield a solution that is within the specified alarm limit. This method of assuring integrity has one advantage over RAIM in that the location of the monitoring stations will be known precisely, and satellite redundancy is not needed to detect a satellite failure. Also, identification (isolation) of the errant satellite is easily accomplished with a GPS integrity channel such as EGNOS or WAAS.

A GPS integrity channel system has not been implemented at the time of preparation of this MOPS. However, much is known of the form it will take when it is put into place.

1.2.4.11.3 Integrity Provided by the Aircraft Integrated Navigation System

This is a technique of providing a level of navigation integrity consistent with paragraph 3.2.1 by use of aircraft integrated navigation systems. Typically, the navigation sensor compares GPS position with other precise navigation position sensors (e.g., DME/DME). It is also possible to combine pseudorange measurements directly with inertial data to obtain a good integrity check over both short and long timescales.

1.2.5 GLONASS System and GLONASS signals

1.2.5.1 Description of GLONASS System

GLONASS is the Global Satellite Navigation System developed by the Russian Federation utilising 24 satellites (three in stand-by mode) positioned on three orbital planes. The full GLONASS system is designed so that 8 satellites will be visible anywhere in the world at any one time.

1.2.5.2 Availability

The GLONASS Channels of Standard Precision Navigation Signal (SPNS) signal availability

shall be at least 99.79% Global average.

1.2.5.3 Reliability

The GLONASS Channel of Standard Precision Navigation Signal (SPNS) signal shall conform to the following limit. The operational readiness coefficient of a satellite shall be at least 0.978 during all of its life.

NOTE: During the life of a particular satellite single failures/outages are assumed. The duration of a particular outage may be up to 4 days but the total duration of the outages over the guarantee time of a particular satellite should not exceed 23 days.

b. The satellite replenishment number shall not exceed 6 satellites/year.

1.2.5.4 Coverage

The GLONASS Channel of Standard Precision Navigation Signal (SPNS) signal coverage of the Earth shall be at least 99.9% global average.

1.2.5.5 GLONASS Time

GLONASS time shall be referenced to the UTC (SU)

1.2.5.6 Co-ordinate System

The GLONASS co-ordinate system shall be PZ90.

1.2.5.7 GLONASS Segments

1.2.5.7.1 Space Segment

The Russian GLONASS nominally consists of a constellation of 24 operational satellites positioned on three orbital planes. Each satellite transmits a Navigation Signal at L1 and L2 frequencies. The L1 frequency is available to civil use. L2 signals are encrypted although users can measure ionospheric delays without knowing the encryption code.

1.2.5.7.2 Control Segment

The control Segment consists of a System Control Centre linked to command and measurement stations, equipment for orbital monitoring, measurement stations and quantum optical stations. The GLONASS control segment operates in a largely similar way to that of GPS. The main system differences are the separate monitoring in GLONASS of ephemeris and frequency/time support and the use of two way active measurement techniques for monitoring orbits and synchronising satellite time standards.

1.2.5.7.3 User Segment

The User segment consists of GLONASS receiving equipment that uses data transmitted by satellites to derive navigation and time information. The GLONASS system does not employ special measures to decrease available accuracy to civil users.

1.2.5.8 GLONASS user equipment

GLONASS system user equipment operates in passive mode and performs measurements on four satellite's navigational parameters (pseudo-range and radial pseudo-speed). Navigation messages transmitted from each satellite consisting of information on satellite ephemeris position and corrections relative to GLONASS system time scale as well as information concerning satellite condition are used by GLONASS user system equipment in the calculation of three dimensional position, speed vector and time components.

1.2.5.9 Satellite Signals

1.2.5.9.1 Operating Frequencies

The radio signals of satellites of the GLONASS occupy in the L-band of radio frequencies: the L1 band ranges from 1602.5625 to 1615.5 MHz in steps of 0.5625 MHz, while the L2 band ranges from 1246.4375 to 1256.5 MHz in steps of 0.4375 MHz. The nominal values of the carrier frequencies of the navigational radio signals of the satellites are determined by the following expressions:

$$\begin{aligned} f_1 &= f_{01} + K\Delta f_1 \\ f_2 &= f_{02} + K\Delta f_2 \end{aligned}$$

K-0,1 2,...,24-number of the carrier frequency;

f_{01} - 1602 MHz; f_{02} - 1246 MHz;

$K\Delta f_1$ - 562.5 kHz. $K\Delta f_2$ - 437,5 kHz.

The number K = 0 is not used by users of the GLONASS, and is intended for checking standby satellite in orbit when making up the orbital grouping of the system. Distribution of numbers K = 1, 2, ..., 24 among the satellites of the system n = 1, 2, ..., 24 is contained in the system almanac (non operative information in the navigational data).

L1 and L2 frequencies of each satellite are coherent and generated by common standard of frequency.

The change of frequency band for GLONASS is being carried out by stages.

Stage 1 (up to 1998)

Lettered frequencies (1610,6...1613,8 MHz) with K = 16, 17, 18, 19, 20 are not used.

Lettered frequencies with K = 13, 14, 21 are used with limitation.

GLONASS satellites with K = 0, ..., 12 have the opportunity to emit lettered frequencies with K = (-7, ..., -1).

Satellites launched during this stage are equipped with filters which decrease the level of the out band emission in the frequency band 1660...1670 MHz up to the level which meets Recommendation ITU-R 769.

Stage 2 (1998 - 2005)

Satellites will use unlimited lettered frequencies with K = 0, ..., 12.

Lettered frequency with K = 13 will be used with limitation.

It is supposed that satellites launched at this stage will be equipped with filters which decrease the level of the out band emission in the frequency band 1660...1670 MHz up to the level which meets Recommendation ITU-R 769.

Stage 3 (from 2005)

At this stage the lettered frequencies will be used with $K = (-7, \dots, +6)$ only but lettered frequencies with $K = +5$ and $+6$ will be used with limits during short period of time (for example, during replenishment).

It is supposed that satellites launched at this stage will be equipped with filters which decrease the level of the out band emission in the frequency bands 1610,6...1613,8 MHz and 1660...1670 MHz up to the levels which meet Recommendation ITU-R 769.

Each GLONASS satellite broadcasts its own carrier frequency in the L1 (1.6GHz) frequency band using frequency division multiple access (FDMA). Two GLONASS satellites may have the same carrier frequency but in this case they are located in antipodal slots of orbit plane.

NOTE: A second frequency for civil use is being considered for subsequent GLONASS-M satellites.

1.2.5.9.2 User Power Level

Each GLONASS satellite provides navigation signals with a minimum signal level, so that the level of the received RF signal at the output of 3dB linearly polarised antenna of a user located near the ground whilst observing each satellite at a 5-degree elevation angle shall not be less than -161 dBW.

1.2.5.9.3 Modulation characteristics

Each GLONASS satellite transmits at its carrier frequency, the navigation RF signal, using a BPSK modulated binary train. The phase shift keying of the carrier is performed at π -radians with the maximum error ± 0.2 radian. The binary modulating sequence is the Modulo-2 sum of the ranging code, navigation data, and auxiliary code pulses. The pseudo random code sequence is repeated each millisecond.

The modulating navigation signal is generated by the Modulo-2 summations of the following three binary signals:

- a) ranging code transmitted at 511 kbps;
- b) data sequence transmitted at 50 bps; and
- c) meander oscillation transmitted at a rate of 100 bit/s.

NOTE: The meander sequence is a return to zero code

1.2.5.10 Ranging codes

1.2.5.10.1 Standard Accuracy code structure and timing

The standard accuracy code consists of Modulo 2 sum of the 0.511 Mbps pseudo random ranging code, 50bps navigation data message digital data, and 100 bps auxiliary meander sequence. All these components are built on a basis of common onboard time/frequency standard, and the resultant composite bit train is then used to BPSK modulate the L1 carriers.

1.2.5.10.2 Navigation Data

Navigation message is transmitted as a pattern of digital data which are checked by Hamming code (8 bits are used as parity). Digital data is transformed into relative code. Structurally the code shall be generated as continuously repeating superframes. The superframe consists of the frames, the frames consist of the strings. The boundaries of the strings, frames and superframes consist of navigation messages from different GLONASS satellites which are synchronised with an accuracy which is not worse than 2 milliseconds.

The GLONASS Navigation message includes the following information:

- a) numbering of satellite time marks;
- b) satellite time scale shift relative to GLONASS time;
- c) relative difference between the carrier frequency of the transmitted signal and its nominal value
- d) ephemeris parameters;
- e) the status of all satellites within the GLONASS space segment (status almanac);
- f) coarse shift of each satellite time scale relative to GLONASS time (phase almanac);
- g) orbit parameters of all satellites within GLONASS space segment (orbit almanac);
- h) shift of GLONASS time scale relative to UTC(SU).

1.2.5.11 Electrical Characteristics

The electrical characteristics of the signals are defined in [Ref4]

1.2.5.12 System Accuracy

The GLONASS SPNS signal position errors shall not exceed the following Table 1-3.

	95%	99.99%
Horizontal System Accuracy	25m	140m
Vertical Position Error	48m	585m

TABLE 1-3: LIMITS ON GLONASS POSITION ERRORS

The GLONASS SPNS signal time transfer errors shall not exceed 0.7 microseconds 95% of the time.

1.3 OPERATIONAL GOALS

1.3.1 General

These operational goals establish the airborne EGNOS/WAAS receiver requirements which are reflected in more detail in Section 2 of the EGNOS /WAAS receiver MOPS. Only general operational goals are described.

Table 1-4 details the signal in space requirements which are met by the combination of GNSS elements and a fault-free GNSS receiver. These requirements include the concept of a fault-free receiver only as a means of combining different GNSS elements. The fault-free receiver is defined to be a receiver with nominal accuracy performance and because it is assumed to have no failures it does not contribute to the integrity and continuity performance.

NOTE: *The requirements detailed are under continual review and are not validated yet.*

Typical Operation or Facility Performance	Accuracy Lateral 95% (1)	Accuracy Vertical 95% (1)	Integrity (2)	Time to Alert	Continuity (3)	Availability (4)	Associated RNP Type(s)
En Route	2.0 NM (5)	N/A	$1 \cdot 10^{-7}/h$	5 min.	$1 \cdot 10^{-4}/h$ to $1 \cdot 10^{-8}/h$	0.99 to 0.99999	20 to 10
En Route, Terminal	0.4 NM	N/A	$1 \cdot 10^{-7}/h$	15 s	$1 \cdot 10^{-4}/h$ to $1 \cdot 10^{-8}/h$	0.999 to 0.99999	5 to 1
Initial Approach, NPA, Departure	220 m	N/A	$1 \cdot 10^{-7}/h$	10 s	$1 \cdot 10^{-4}/h$ to $1 \cdot 10^{-8}/h$	0.99 to 0.99999	0.5 to 0.3
Instrument approach with Vertical Guidance (IPV)	220 m	9.1 m	$1 \cdot 2 \cdot 10^{-7}/\text{approach}$	10 s	$1 \cdot 8 \cdot 10^{-6}$ in any 15 s	0.99 to 0.99999	0.3/125
Category 1	16.0 m	7.7 m to 4.0 m (6)	$1 \cdot 2 \cdot 10^{-7}/\text{approach}$	6 s	$1 \cdot 8 \cdot 10^{-6}$ in any 15 s	0.99 to 0.99999	0.03/50 to 0.02/40

TABLE 1-4: GNSS SIGNAL-IN-SPACE REQUIREMENTS

NOTE 1: The 95 percentile NSE values are those required for the intended operation at the lowest HAT, if applicable
A range of NSE performance is specified for Performance Category 1. The 4.0 metre requirement is based upon ILS specifications to minimise the validation and aircraft certification impact. For performance which is not consistent with ILS specifications, operational procedures or restrictions may apply.

NOTE 2: The definition of the integrity requirement includes an alert limit against which the requirement can be assessed. These alert limits are:

NOTE 3: A range of values is given for the continuity requirement for en route operations, initial approach, non-precision approach, 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.

NOTE 4: A range of values is given for the availability requirements as these requirements are dependent upon the size and duration of the outages, availability of alternate navigation aids, radar coverage, traffic density, reversionary operational procedures. The lower values given are the minimum availability 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.

NOTE 5: This requirement is stringent with regard to the associated RNP types, but is well within the accuracy performance achievable by GNSS.

Typical Operation or Facility Performance	HAL	VAL	Associated RNP Type
En Route	4 NM	N/A	20 to 10
En Route	2 NM	N/A	2 to 5
En Route	1 NM	N/A	1
NPA	0.3 NM	N/A	0.5 to 0.3
IPV	0.3 NM	22.8 m	0.3/125
Category 1	40.0 m	20.0 m to 10.0 m (1)	0.03/50 to 0.02/40

TABLE 1-5: ALERT LIMITS

1.3.2 Typical Applications

1.3.2.1 General

The EGNOS/WAAS system shall provide civil aviation with primary means navigation for all phases of flight from En-Route to Non-Precision approach (NPA) with the capability for Precision approach down to Category 1 Landing requirements.

Typical applications are described in the following sections. However it should be noted that these examples are primarily presented to indicate the range of possible applications of EGNOS including the ground, space, and airborne elements.

For each Phase of flight the associated RNP type is given as referenced from [Table 1-5](#).

1.3.2.2 Oceanic Navigation

It is expected that the EGNOS service will be used by aircraft operating across oceanic routes into European Controlled Airspace. Oceanic Navigation is characterised by an RNP type of 5 and above.

1.3.2.3 Area Navigation - B-RNAV

The EGNOS/WAAS SIS shall be used by aircraft using B-RNAV equipment as a method of direct navigation. The EGNOS/WAAS SIS shall be used as an input to B-RNAV airborne equipment as a method of supporting area navigation in the ECAC controlled airspace.

1.3.2.4 En-Route Navigation

It is expected that the EGNOS service is most likely to be used for continental En-Route navigation across the ECAC region. Likely users of the EGNOS signals across European Air space are to be all aircraft types flying IFR.

The associated RNP type for Continental En-Route Navigation is RNP 1.

1.3.2.5 Terminal Area Navigation

EGNOS/WAAS SIS combined with GPS and/or GLONASS signals shall be used to support the transition from en-route to the terminal phases of flight. Data will be fed from the EGNOS/WAAS receiver to the airborne AFCS/FMS to allow for descent to the initial approach fix altitude. From this point the flight can conduct either a non precision-precision or precision approach.

Terminal Area Navigation requirements shall conform to RNP 1.

1.3.2.6 Non Precision Approach

The EGNOS/WAAS SIS when combined with GPS and/or GLONASS signals shall be capable of supporting Non Precision approaches to the airfield. In this mode of approach the EGNOS/WAAS signals must be capable of providing lateral guidance to the runway.

NPA requirements shall be met by RNP 0.3.

1.3.2.7 Precision Approach

EGNOS/WAAS signals when combined with GPS and/or GLONASS signals shall be capable of providing lateral and vertical guidance for Category 1 precision approaches.

The use of EGNOS and GPS signals shall meet RNP 0.03/50 and the combined use of EGNOS, GPS and GLONASS shall meet RNP 0.02/40.

1.4 LIST OF ED-97 AND DO-229 DIFFERENCES;

Although both documents have the same objective, which is to define the Minimum Operational Performance Specification for a GPS receiver when used with a Satellite Based Augmentation System, some differences exist between the documents. These differences are listed below.

The DO-229:

- Addresses the MOPS for a GPS receiver when used with the WAAS SBAS system It does not explicitly state interoperability requirements for WAAS/EGNOS receivers
- Specifies the MOPS for all phases of flight, including precision approach (DO-229A)
- Does not specify any requirements for the use of GLONASS constellation.

The ED-97

- Specifies the MOPS for an EGNOS receiver which can also be used with the WAAS SBAS system.
- Provides some provisions for receivers that are capable of using the constellations of GPS and GLONASS with EGNOS.
- Makes some outlineprovisions for precision approach operations.
- Discusses Interoperability issues between different SBAS services.

Where possible, requirements have been defined in ED-97 for maximum compatibility between the EGNOS/WAAS and WAAS receiver. Therefore similar requirements for the Signal in Space and associated message processing, Interference environment, signal processing and test procedures recommendations can be found in both documents. Furthermore a specific Appendix discusses interoperability issues raised by the use of multiple SBAS services in a given airspace.

When used in phases of flight up to and including Non-Precision Approach, the two documents have where possible been harmonised. Only slight differences have been raised as issues. These are specifically as follows.

- The EGNOS System Overview and specification is introduced instead of WAAS.
- The Test Procedures chapter utilises a test cross reference matrix which focuses on high level requirements and specific message processing requirements.

The use of the EGNOS/WAAS receiver for PA operations provides some recommendations which may be different than specified in DO-229. Wherever possible the two documentations have been harmonised, however the RNP performance achievable with the two systems may be different. This identifies the main difference between ED-97 and DO-229. Preliminary work has been completed to identify the main issues with the use of GLONASS and the exchange of information for inclusion of recommendations has been initiated.

ACRONYMS

The following acronyms are used in the document:

AC	Alternating Current
AFCS	Automatic Flight Control System
AOC	Advanced Operational Capability
AOR-E	Atlantic Ocean Region – East
AOR-W	Atlantic Ocean Region West
A-S	Anti-Spoofing
BPSK	Bi-Phase Shift Keying
B-RNAV	Basic Area Navigation
C/A	GPS Coarse-Acquisition code
CDM	Code Division Multiple Access
CRC	Cyclic Redundancy Check
CW	Continuous Wave
DME	Distance Measuring Equipment
DOP	Dilution of Precision
ECAC	European Civil Aviation Conference
ECEF	Earth Centred Earth Fixed
EGNOS	European Geostationary Navigation Overlay Service
ESA	European Space Administration
EUROCAE	European Organisation for Civil Aviation Equipment
FAA	Federal Aviation Agency
FANS	Future Air Navigation Systems
FC	Fast Correction
FDE	Fault Detection and Exclusion
FDMA	Frequency Division Multiple Access
FMS	Flight Management System
FOC	Full Operational Capability
GIVE	Grid Ionospheric Vertical Error
GLONASS	Global Navigation Satellite System
GNSS	Global Navigation Satellite System
GNSS-P	ICAO GNSS Panel
GPS	Global Positioning System
HAL	Horizontal Alert Limit
HDOP	Horizontal Dilution of Precision
HEL	Horizontal Exclusion Level
HPL	Horizontal Protection Level
ICAO	International Civil Aviation Organisation
IFR	Instrument Flight Rules
IGP	Ionospheric Grid Point
ILS	Instrument Landing System
IOD	Issue Of Data
IODC	Issue Of Data-Clock
IODE	Issue Of Data-Ephemeris
IODF	Issue of Data - Fast Correction
IODG	Issue of Data - GEO
IODI	Issue Of Data-Ionospheric
IODP	Issue of Data - PRN
IODS	Issue of Data - Service
IOR	Indian Ocean Region
IPP	Ionospheric Pierce Point
IPV	Instrument Approach with Vertical Guidance
LSB	Least Significant Bit
LTP	ICAO Legal and Technical Panel
MOPS	Minimum Operational Performance Specification
(MTSAT)	Multifunction Tra Multifunction Transport Satellite
MSAS	MTSAT Satellite Based Augmentation System
MSB	Most Significant Bit
MSL	Mean Sea Level

NPA	Non-Precision Approach
NSC	Non-Standard C/A
NSE	Navigation System Error
NSY	Non-Standard Y
P	GPS Precision code
PA	Precision Approach
Pfa	Probability of False Alert
Pmd	Probability of Missed Detection
PPS	Precise Positioning Service
PR	Pseudorange
PRN	Pseudo-Random Noise
PZ90	PZ90 GLONASS Geodetic Datum
RAIM	Receiver Autonomous Integrity Monitoring
RNAV	Area Navigation
RNP	Required Navigation Performance
RRC	Range-rate Correction
Rx	Receiver
SA	Selective Availability
SARPs	Standards and Recommended Practices (ICAO)
SATCOM	Satellite Communications
SBAS	Satellite Based Augmentation System`
SIS	Signal in Space
SPNS	Standard Precision Navigation Signal
SPS	Standard Positioning Service
TCAS	Traffic Alert and Collision Avoidance System
TDOP	Time Dilution of Precision
TMA	Terminal Area
TTFF	Time to First Fix
UDRE	User Differential Range Error
UDREi	User Differential Range Error Indicator
UERE	User Equivalent Range Error
UIRE	User Ionospheric Range Error
URA	User Range Accuracy
UTC	Co-ordinated Universal Time
VAL	Vertical Alert Limit
VDOP	Vertical Dilution of Precision
VHF	Very High Frequency
VOR	VHF Omnidirectional Range
VPL	Vertical Protection Level
WAAS	Wide Area Augmentation System
WER	Word Error Rate
WGS-84	World Geodetic System of 1984
Y	GPS Precision code with anti-spoofing

1.6 DEFINITION OF KEY TERMS

1.6.1 General terms

Accuracy

In theory, system level accuracy is defined as a figure in metres associated to a percentile, 95 %. SBAS position error is the difference between the estimated position, and the actual position. For any estimated position at a specific location, accuracy is met when the probability that position error is within the accuracy figure is at least 95 %.

System level accuracy is based on SBAS SIS and receiver performances. Thus receiver accuracy is quantified using standardized SIS message formats contents and stable DOP values. In such a configuration, ensuring that a tropospheric model is installed in the receiver, the receiver resistance to interference, multipath, effects is tested, and receiver accuracy is assessed.

In the particular case of precision approach, receiver accuracy is not defined in the position domain, but in the pseudorange domain. Using standard SIS message format contents and stable DOP values, receiver horizontal and vertical accuracy is met when the impact of multipath and receiver noise is less than requirements figures, in the presence of tropospheric model.

NOTE: Definition of accuracy at system and receiver level as provided in the latter paragraphs are preliminary ones, and may need revision, when GNSS-P and RTCA definitions are mature enough.

Aircraft Based Augmentation System (ABAS)

An augmentation system which augments and/or integrates the information obtained from the other GNSS elements with information available onboard 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.

Availability

The availability of a navigation system is the ability of the system to provide the required function and performance at the initiation of the intended operation. Availability is an indication of the ability of the system to provide usable service within the specified coverage area. Signal availability is the percentage of time that navigational signals transmitted from external sources are available for use. Availability is a function of both the physical characteristics of the environment and the technical capabilities of the transmitter facilities.

Chip

A single digital bit of the output of a pseudo-random bit sequence.

Continuity

The continuity of a system is the ability of the total system (comprising all elements necessary to maintain aircraft position within the defined airspace) to perform its function without interruption during the intended operation. More specifically, continuity is the probability that the specified system performance will be maintained for the duration of a phase of operation, presuming that the system was available at the beginning of that phase of operation.

Gold Code

A class of unique codes presently used by GPS, which exhibit bounded cross-correlation and off peak auto-correlation values.

Global Navigation Satellite System (GNSS)

A world-wide 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 actual phase of operation.

Ground Based Augmentation System (GBAS)

A augmentation system in which the user receives augmentation information directly from a ground-based transmitter.

Integrity

A measure of the trust which 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) when the system must not be used for the intended operation (or phase of flight).

Misleading Information

Within this standard, misleading information is defined to be any data which is output to other equipment or displayed to the pilot that has an error larger than the alert limit (HAL/PAL) or current protection level (HPL/VPL), without any indication of the error (e.g., flag). For equipment which is aware of the navigation mode, and therefore the alert limit, misleading information is defined relative to the alert limit. If the equipment is not aware of the mode, then misleading information is defined relative to the protection level, since the alert limit is not known. This includes all output data, such as position, non-numeric cross-track, numeric cross-track, and distance-to-waypoint as applicable.

Navigation Mode

The navigation mode refers to the equipment operating to meet the requirements for a specific phase of flight. The navigation modes are: oceanic/remote, en route, terminal, non-precision approach, and precision approach. The oceanic/remote mode is optional; if it is not provided, the en route mode can be substituted for the oceanic mode. In addition, departure guidance is provided by Class 2 and 3 equipment in the terminal mode.

Navigation System

A combination of a navigation aid with an associated aircraft navigation receiver.

Navigation System Error

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

Planned Primary Means of Navigation

Planned primary means of navigation refers to the capability of planning an operation around scheduled outages so that the system is available for a particular flight and the operational continuity, integrity and accuracy requirements are met

Primary Means of Navigation

The airborne navigation equipment that meets the requirements of radionavigation for the intended phase of flight (route to be flown). These requirements include satisfying the necessary level of accuracy, integrity, continuity, and availability for a particular area, route, procedure, or operation. Examples of systems which provide a primary means of navigation include:

- VOR for continental en route, terminal, and nonprecision approach where it is available
- VOR/DME for domestic en route above flight level 240, terminal, and nonprecision approach where it is available
- INS for oceanic operation

Pseudorange

The distance from the user to a satellite plus an unknown user clock offset distance.

Required Navigation Performance (RNP)

A statement of the navigation performance accuracy necessary for operation within a defined airspace. Note that there are additional requirements, beyond accuracy, applied to a particular RNP type.

Satellite Based Augmentation System (SBAS)

A wide coverage augmentation system in which the user receives augmentation information directly from a satellite-based transmitter.

Selective Availability

A set of techniques for denying the full accuracy and selecting the level of positioning, velocity and time accuracy of GPS available to users of the Standard Positioning Service signal.

Standard Positioning Service

The specified level of positioning, velocity and timing accuracy that is available to any Global Positioning System (GPS) user on a continuous world-wide basis.

1.6.2

Alert Limits and Protection Levels

Horizontal Alert Limit

The Horizontal Alert Limit (HAL) is the radius of a circle in the horizontal plane (the local plane tangent to the WGS-84 ellipsoid) which describes the region which is required to contain the indicated position, and not to be exceeded without issuing an alert.

Vertical Alert Limit

The Vertical Alert Limit is half the length of a segment on the vertical axis (perpendicular to the horizontal plane of WGS-84 ellipsoid), with its centre being at the true position, which describes the region which is required to contain the indicated position, and not to be exceeded without issuing an alert.

Horizontal Protection Limit Fault Detection

The Horizontal Protection Level Fault Detection (HPLFD) is the radius of a circle in the horizontal plane (the local plane tangent to the WGS-84 ellipsoid), with its centre being at the true position, which describes the region which is assured to contain the indicated position with a given probability. It is a horizontal region for which the missed alert and false alert requirements are met for the chosen set of satellites when autonomous fault detection is used. It is only a function of the satellite and user geometry and the expected error characteristics: it is not affected by actual measurements. Therefore, this value is predictable.

Vertical Protection Limit Fault Detection

The Vertical Protection Level Fault Detection (VPLFD) is half the length of a segment on the

vertical axis (perpendicular to the horizontal plane of WGS-84 ellipsoid), with its centre being at the true position, which describes the region which is assured to contain the indicated position with a given probability when autonomous fault detection is used. It defines the vertical region for which the missed alert and false alert requirements are met for the chosen set of satellites when autonomous fault detection is used. It is only a function of the satellite and user geometry and the expected error characteristics: it is not affected by actual measurements. Therefore, this value is predictable.

Horizontal Protection Limit EGNOS

The Horizontal Protection Limit EGNOS (HPLEGNOS) is the radius of a circle in the horizontal plane (the plane tangent to the WGS-84 ellipsoid), with its centre being at the true position with a given probability, which describes the region which is assured to contain the indicated position. It is based upon the error estimates provided by EGNOS.

Vertical Protection Limit EGNOS

The Vertical Protection Limit EGNOS (VPLEGNOS) is half the length of a segment on the vertical axis (perpendicular to the horizontal plane of WGS-84 ellipsoid), with its centre being at the true position with a given probability, which describes the region which is assured to contain the indicated position. It is based upon the error estimates provided by EGNOS.

Horizontal Exclusion Limit Fault Detection

The Horizontal Exclusion Limit Fault Detection (HELFD) is the radius of a circle in the horizontal plane, for which the missed alert and failed exclusion requirements can be met when autonomous Fault Detection and Exclusion is used (i.e., exclusion is available). It is only a function of the satellite and user geometry and the expected error characteristics: it is not affected by actual measurements. Therefore, this value is predictable.

1.6.3 Fault Detection and Exclusion (FDE) Terms

Fault Detection and Exclusion (FDE)

Fault detection and exclusion is a receiver processing scheme that autonomously provides integrity monitoring for the position solution, using redundant range measurements. The FDE consists of two distinct parts: fault detection and fault exclusion. The fault detection part detects the presence of an unacceptably large position error for a given mode of flight. Upon the detection, fault exclusion follows and excludes the source of the unacceptably large position error, thereby allowing navigation to return to normal performance without an interruption in service.

Alert

For the definitions of missed alert, false alert, and time-to-alert, an alert is defined to be an indication that is provided by the GNSS/SBAS equipment when the positioning performance achieved by the equipment does not meet the integrity requirements. This alert is one of the conditions that would cause a navigation alert.

Missed Detection

A missed detection is defined to occur when a positioning failure is not detected within Time to Alert.

NOTE: *The term, missed detection, refers to internal processing of the FDE algorithm. It does not refer to an alert that is issued by the GNSS/SBAS equipment.*

Time-To-Alert

Time-to-Alert is the maximum allowable elapsed time from the onset of a positioning failure until the equipment annunciates the alert.

Failed Exclusion (exclusion not possible)

A failed exclusion is defined to occur when a true positioning failure is detected and the detection condition is not eliminated within the time-to-alert (from the onset of the positioning failure). A failed exclusion would cause a navigation alert.

Wrong Exclusion: A wrong exclusion is defined to occur when a positioning failure is detected and the positioning failure still exists, but is undetected after exclusion, resulting in a missed alert.

Position failure: A position failure is defined to exist when the horizontal (resp. vertical) NSE is outside the specified horizontal (resp. vertical) alarm limit for the phase of flight in progress.

Non integrity event

A non integrity event is defined to exist when a position failure occurs and is not announced within the specified time to alarm for the phase of flight in progress.

Time to alert: Time to alert is defined to be the maximum allowable elapsed time from the onset of a position failure, as defined above, until the time the integrity alarm is annunciated.

False Alert

A false alert is defined as the indication of a positioning failure when a positioning failure has not occurred (a result of false detection). A false alert would cause a navigation alert.

NOTE: *The exclusion function may exclude a false detection internal to the GNSS/SBAS equipment, which does not contribute to the false alert rate (if an alert is not issued by the GNSS/SBAS equipment).*

Availability of Exclusion

The exclusion function is defined to be available when the constellation of satellites provides a geometry for which the FDE algorithm can meet the failed exclusion requirement, and prevent the indication of a positioning failure or a loss of integrity monitoring function. Therefore, exclusion must occur before the duration of a positioning failure exceeds the time-to-alert, and the detection function as defined above must be available after exclusion.

Note that for a given geometry and navigation mode, the exclusion function is either available or unavailable.

NOTE: *The fact that the definition of exclusion availability states that detection is required to be available after exclusion occurs is only intended to be used as a comparison of algorithmic availability. There may be significant operational benefit gained by an algorithm that is designed such that it is capable of excluding even when detection is not available after exclusion. However, such an algorithm must still meet the missed alert (including wrong exclusion) requirement. There must be a means of demonstrating that, when exclusion is attempted without later detection, the equipment still satisfies a 0.001 probability of missed alert.*

1.7

REFERENCE DOCUMENTS

- Ref1: "GPS Standard Positioning Service - Signal Specifications dated 2 June 1995"
- Ref2: "TECHNICAL CHARACTERISTICS OF THE NAVSTAR GPS"
- Ref3: ICAO Aeronautical Communications Annex 10 Volume I
- Ref4: GLOBAL NAVIGATION SATELLITE SYSTEM (GLONASS) Interface Control Document, Moscow, 1995 (Ministry of Defence)
- Ref5: "Change 3 to RTCA/DO229 MOPS GPS/WAAS SYSTEM " RTCA Paper n°061-98/SC 159-781, March 31,1998.

CHAPTER 2

GENERAL DESIGN SPECIFICATION2.1 GENERAL REQUIREMENTS2.1.1 Airborne Receiver general requirements2.1.1.1 Accuracy

The accuracy of EGNOS/WAAS receiver when combined with GPS and/or GLONASS signals should allow an aircraft to fly safe, accurate paths during the phases of flight up to and including precision approach phases of flight described in section 1.3.3 depending on the class of equipment.

2.1.1.2 Integrity

All classes of receivers shall ensure integrity of navigation information to the pilot and where applicable to the Automatic Flight Control System (AFCS) or Flight Management System (FMS).

Integrity checks must be provided to ensure correctness of data contained in the equipment memory. Displays are to be provided to enable the pilot to check the aircraft position against published charts.

2.1.1.3 Controls

Any controls provided by the EGNOS/WAAS receiver equipment shall be simple to operate and not impose excessive cockpit workload. If automatic data selection feature is to be provided, positive aircrew action shall be required to initiate and/or complete the sequence.

2.1.1.4 Outputs

The output requirements for the EGNOS/WAAS receiver shall be visual and/or electrical outputs to the airborne AFCS/FMS to permit phases of flight described in section 1.3.3.

2.1.1.5 Warnings

A warning system will be incorporated into the equipment to activate a warning display such as instrument flags and to activate the appropriate circuits in associated systems when any unsafe or unreliable condition exists.

2.1.1.6 Data Display

The equipment shall provide unambiguous displays to the flight crew. Dedicated displays may be used, or the EGNOS/WAAS information may be incorporated into other multipurpose cockpit displays.

2.1.1.7 Interface with other Aircraft systems

The EGNOS/WAAS receiver equipment may provide inputs to other airborne systems. It will provide signals that are adaptable for use by other aircraft instruments, navigation equipment and automatic flight controls.

EGNOS/WAAS signal interface with other airborne equipment intended for use during flight should not result in a condition whose presence or continuation would be detrimental to the safe conduct of flight.

2.2 EQUIPMENT CLASSES

Equipment developed to these MOPS should be identified with the applicable functional and operational class which describes the equipment capabilities. These classes are defined below.

2.2.1 Functional classes

Class beta

Equipment consisting of a GPS/EGNOS/WAAS sensor that determines position (with integrity) and provides position and integrity data to an integrated navigation system. This equipment also provides integrity in the absence of the EGNOS/WAAS signal through the use of FDE.

Class gamma

Equipment consisting of both the GPS/EGNOS/WAAS sensor (defined by class beta) and a navigation function, so that the equipment provides path deviations relative to a selected path. The equipment provides the navigation function required of a stand alone navigation system including the display. It also includes the database required for navigation and for precision approach. This equipment also provide integrity in the absence of WAAS/EGNOS subsystem through the use of FDE.

Class delta

Equipment providing class gamma functions with the exception of database being external.

2.2.2 Operational Classes

Class 1

Equipment which supports oceanic and domestic en-route and terminal operation. This class of equipment must check the EGNOS reported integrity status of GPS and/or GLONASS satellites and applies the long term and fast EGNOS differential corrections when they are available.

Class 2

Equipment which supports oceanic and domestic en-route, terminal, non precision approach, and departure operation. When in non precision approach mode, this class of equipment applies the long term and fast EGNOS differential corrections when they are available. Class two differs from class one on time to alert and FDE availability requirements for NPA.

Class 3

Equipment which supports oceanic and domestic en route, terminal, non precision approach, down to RNP 0.03/50/Cat 1 precision approach and departure operation. When in precision approach mode, this class of equipment applies the long term, fast and ionospheric corrections received from the EGNOS SIS.

Class 4

Equipment which supports precision approach operations. This class of equipment is intended to serve as a replacement to existing precision approach equipment such as ILS. Class 4 equipment is only applicable to functional Class delta, and equipment which meets Class Delta-4 is also likely to meet the requirements for Class Beta-1, -2, or -3.

GLONASS equipment

GPS/GLONASS/WAAS/EGNOS receiver should be referred to by the use of existing Operational classes with the addition of a G extension for identifying GLONASS capability. e.g. Class Delta 4-G identifies a receiver capable of precision approach using GPS and GLONASS signals when augmented by EGNOS or WAAS.

CHAPTER 3

MINIMUM PERFORMANCE UNDER STANDARD TEST CONDITIONS3.1 GENERAL REQUIREMENTS3.1.1 GPS Signal processing requirements

EGNOS equipment shall be designed to process the GPS signals and necessary data described in [Ref.1] , under interference conditions described in Appendix B and with GPS signals specified in Section 1.2.4. If the ionospheric corrections provided by the EGNOS/WAAS are not applied to the GPS pseudoranges, the equipment shall decode the ionospheric coefficients in the GPS navigation message and apply the ionospheric corrections described in the GPS/SPS Signal Specification. If the ionospheric corrections provided by EGNOS/WAAS are applied, the GPS ionospheric model shall not be used.

3.1.2 EGNOS/WAAS Signal Processing Requirements3.1.2.1 Acquisition and track

The GPS/EGNOS/WAAS equipment shall be designed to acquire and track the PRN codes of the EGNOS/WAAS satellites as described in Appendix A, and under interference conditions described in Appendix B.

3.1.2.2 Demodulation and Forward Error Correction (FEC) Decoding

The GPS/EGNOS/WAAS equipment shall be designed to demodulate the signals described in Appendix A. The embedded forward error correction shall be applied in order to minimise data errors in the decoded messages.

The equipment shall not utilise any message for which the Cyclic Redundancy Check described in Appendix A fails.

The EGNOS/WAAS message loss rate (Word Error Rate) (WER) rate shall be less than 1 message in 10^3 under interference conditions described in Appendix B and under the minimal conditions defined in section 1.2.4

3.1.2.3 EGNOS/WAAS Satellite pseudorange Determination

The GPS/EGNOS/WAAS receiver shall determine the pseudorange to each EGNOS/WAAS satellite that is currently tracked.

These pseudoranges shall be referenced to the same time base as that of the GPS satellites.

If the ionospheric corrections provided by WAAS/EGNOS are not applied, the equipment shall use ionospheric corrections based on the GPS navigation message as defined in the GPS/SPS signal specification.

3.1.3 Sensitivity and dynamic range

Two different antenna configurations are specified in this document: an antenna without a preamplifier (passive antenna) and antenna with a preamplifier (active antenna).

The active antenna defined in [Figure 3-2](#) includes a passive antenna as defined in [Figure 3-1](#) and in [Table 3-1](#) and a preamplifier meeting the requirements of Section 3.1.3.2

Elevation angle	Minimum gain	Maximum gain
> 15 deg	-2.0 dBic	+7 dB
10 deg	-3.0 dBic	+ 7 dB
5 deg	-4.5 dBic	+ 7 dB
0 deg	-5.0 dBic	-2 dB

TABLE 3-1: ANTENNA CHARACTERISTICS

3.1.3.1 Passive antenna configuration

When using the passive antenna configuration the receiver shall be capable of tracking GPS and EGNOS/WAAS satellites in the presence of background thermal noise of density - 176.6 dBm/Hz and with minimum/maximum signal power at receiver port (see [Figure 3-1](#)) as defined below :

GPS satellites	min signal: -136 dBm	max signal: -116 dBm
EGNOS/WAAS satellites	min signal: -137 dBm	max signal: -116 dBm

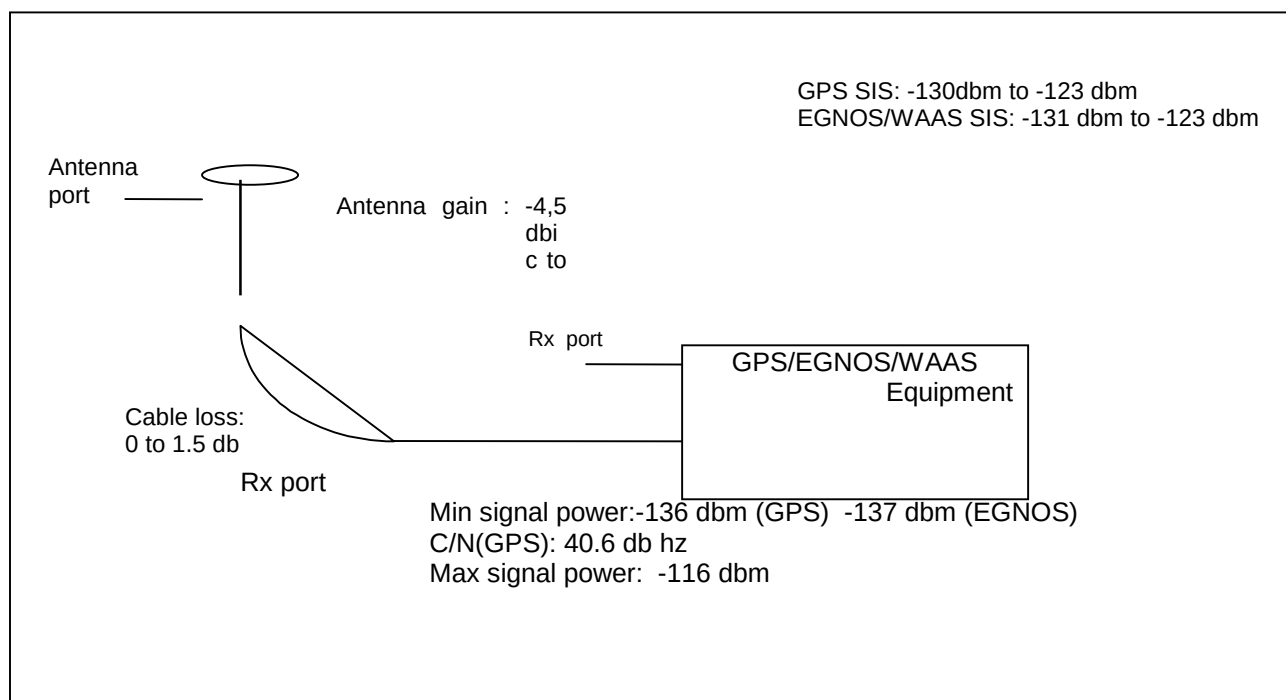


FIGURE 3-1: PASSIVE ANTENNA (ANTENNA WITHOUT PREAMPLIFIER)

NOTE 1: The minimum signal at the Rx port is defined with a minimum antenna gain and maximum cable loss.

NOTE 2: The maximum signal at the Rx port is defined with a maximum antenna gain and 0 dB cable loss.

3.1.3.2 Active antenna configuration

When using the active antenna configuration the receiver sensitivity and dynamic range depends on the RF preamplifier design. The preamplifier shall accommodate GPS signals and EGNOS/WAAS signals with a minimum power of -134.5 dBm and -135.5 dBm respectively and a maximum power of -116 dBm in the presence of a background noise density of -178.6 dBm/Hz.

In addition the minimum and maximum cable loss of the installation shall be determined and used to define the minimum / maximum signal input at the receiver test port.

Figure 3-2 corresponds to one typical configuration.

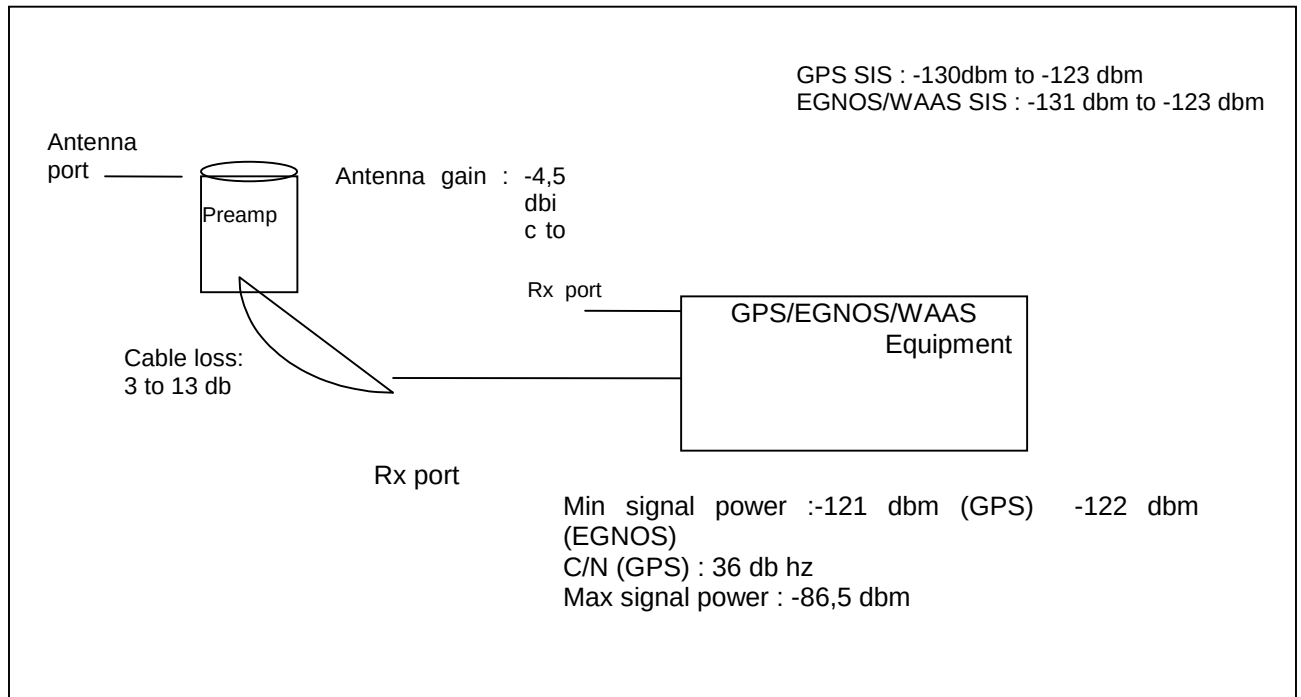


FIGURE 3-2: ACTIVE ANTENNA (ANTENNA WITH PREAMPLIFIER) TYPICAL CONFIGURATION

3.1.4 Initial Acquisition time

The equipment shall be capable of acquiring satellites and determining a position without any initialisation information, including time, position and GPS and WAAS/EGNOS almanac data.

The time to from application of power to the first valid position fix shall be less than 5 minutes under the following conditions.

The receiver

- shall be initialised to a latitude and longitude position within 60 nautical miles
- shall be initialised to within one minute of UTC time
- shall have valid almanac data and unobstructed satellite visibility
- will be subjected to the interference conditions of Appendix B

In this context, valid means all of the following conditions are met:

- if available, signals from at least one EGNOS/WAAS satellite are received and processed within the 5-minute period,
- the determined position meets the accuracy requirements and at least one minute of performance meeting conditions follows the first position fix.

3.1.5 Satellite acquisition time

3.1.5.1 GPS satellite acquisition time

After steady state accuracy has been established (i.e. at least one minute of accurate navigation) the equipment shall be capable of incorporating a new GPS satellite signal into the position within 110 seconds (96 seconds to be sure that the satellite ephemeris has been received twice plus 14 s for Doppler and range bin search). This requirement applies to a satellite with the minimum signal power in the presence of interfering signals described in Appendix B, and assumes that valid almanac data is available.

3.1.5.2 EGNOS/WAAS satellite acquisition time

After steady state accuracy has been established (i.e. at least one minute of accurate navigation), the equipment shall be capable of acquiring a new EGNOS/WAAS satellite signal, apply the EGNOS/WAAS integrity information and incorporate that satellite signal into the position solution within 134 seconds. This requirement applies to a satellite with the minimum signal power in the presence of interfering signals described in Appendix B, and assumes valid almanac data is available.

3.1.6 Satellite re-acquisition time

Given that steady state accuracy has been established, the equipment must be capable of reincorporating into the position solution a GPS or EGNOS/WAAS satellite signal that has been temporarily lost. The satellite signal shall be re-incorporated within 10 seconds of the signal being available again (for outages up to and including 30 seconds). This requirement applies to a satellite with the minimum signal power in the presence of interfering signals as described in Appendix B.

3.1.7 EGNOS / WAAS Message Processing Requirements

Message Types 0,1,2,3,4,5,6,7,9,17,24,25 and 27 shall be decoded in all navigation modes.

Message Types 10,18,26 in Precision Approach mode (See Section 3.4.4).

Any such messages may be optionally used in modes for which they are not specifically required, but shall conform to the relevant requirements. If an optional message is used, the loss of those messages shall not cause loss of function. For example, if the ionospheric corrections are used during a Non Precision Approach , the time-out of those corrections should result in reversion to the GPS ionospheric model as described in Section 3.1.1.

All Messages Types that the equipment is not specifically designed to decode shall be ignored.

3.1.7.1 Message Type 0 : Don't use EGNOS / WAAS satellite

The receipt of a message type 0 shall result in the cessation of the use of data from that EGNOS/WAAS satellite, and all data obtained from that EGNOS/WAAS satellite shall be deselected for at least one minute. ([Table A-10](#))

NOTE: *Message Type 0 's will be used during testing of a new EGNOS / WAAS satellite, and could be used if the EGNOS/WAAS ground segment determined that there was a problem in the signals or data already transmitted .*

3.1.7.2 Message Type 1 : PRN Mask Assignments

Masks are used to designate which PRN belongs to which correction slot. For example, GPS satellites are assigned the first slots (1 - 37). The receipt of a message Type 0 shall result in the cessation of the use of data from that EGNOS/WAAS satellite, and all data obtained from that EGNOS/WAAS satellite shall be deselected for at least one minute (See [Table A-11](#)).

The EGNOS/WAAS equipment shall be able to store and use two PRN MASKS. During the transition period between Masks, the EGNOS/WAAS equipment shall be able to use the old Mask to decode messages and store the new Mask so that there are no interruptions to service when the new Mask becomes effective.

NOTE: *The IODP associates the correction data with a PRN MASK (applicable Message Type 1-5 , 7, 24, 25).*

The new PRN MASK received in a message Type 1 is different from the last received only if the IODP is different.

3.1.7.3 Message Type 2-5 and 24: Fast Clock Corrections

Fast Clock correction and $\sigma_{i,UDRE}$ are broadcast in message type 2-5 and 24. The Fast Correction for a satellite i (Fc_i) is the correction for rapidly varying errors applicable to the pseudorange. The $\sigma_{i,UDRE}$ defines the variance of this error at 99.9%.

All classes of equipment shall decode message Types 2,3,4,5,24 , applying fast corrections for all EGNOS/WAAS HEALTHY satellites being used in the position solution and use $\sigma_{i,UDRE}$ information for integrity purpose.

Neither integrity nor correction data shall be utilised for any satellite unless it matches the IODP obtained from the last Type1 message received ([Table A-12](#)).

3.1.7.4 Message Type 6: Integrity information

Parameters broadcast in the message type 6 are $\sigma_{i,UDRE}$ and IODF. Message type 6 allows the fast corrections of message type 2-5 and 24 to be updated infrequently, proportionally with the dynamics of the satellite clock errors (See [Table A-13](#)).

All classes of equipment shall decode message Type 6. The EGNOS/WAAS equipment shall use the $\sigma_{i,UDRE}$ to determinate the integrity of the satellite and the corrected position.

If an $IODF_j = 3$, The equipment shall utilise the $\sigma_{i,UDRE}$ and apply them to all active data previously received in the corresponding message type ($j = 2-5$).

If an $IODF_j < 3$, The equipment shall only utilise the $\sigma_{i,UDRE}$ if the $IODF_j$ matches the IODF in the associated corrections message.

NOTE: *- This message is optional at SBAS level and mandatory at receiver level.*

3.1.7.5 Message Type 7 : $\sigma_{i,UDRE}$ Degradation

Parameter broadcast in the message type 7 is the $\sigma_{i,UDRE}$ degradation factor indicator (a_i). Time-out intervals for Fast Corrections are defined with this factor (See [Table A-14](#) and [Table A-4](#)).

The EGNOS/WAAS equipment shall decode Message Type 7 and determine the Time-out interval for fast corrections.

The message Type 7 shall not be utilised, if the IODP does not match the IODP obtained from the last Type 1 message received.

3.1.7.6 Message Type 9 : EGNOS / WAAS Satellite Navigation Message

The EGNOS/WAAS equipment shall utilize the navigation information contained in message Type 9, which contains EGNOS/WAAS satellite orbit information, to determine the location of each EGNOS/WAAS satellite being tracked (See [Table A-15](#)).

The position of the EGNOS/WAAS satellite in the WGS-84 earth-centred earth-fixed co-ordinates, at time_of_day t_k is defined as:

$$\begin{bmatrix} X_{GK} \\ Y_{GK} \\ Z_{GK} \end{bmatrix} = \begin{bmatrix} X_G \\ Y_G \\ Z_G \end{bmatrix} + \begin{bmatrix} \dot{X}_G \\ \dot{Y}_G \\ \dot{Z}_G \end{bmatrix} (t_k - t_{GEO}) + \frac{1}{2} \begin{bmatrix} \ddot{X}_G \\ \ddot{Y}_G \\ \ddot{Z}_G \end{bmatrix} (t_k - t_{GEO})^2$$

and the GEO time (t_G), is defined as:

$$t_G(t_k) = t_k + a_{Gf0} + a_{Gf1}(t_k - t_{GEO})$$

The equipment shall always use the most recent Message Type 9.

3.1.7.7 Message Type 17: EGNOS / WAAS Satellite Almanac

All Almanac data broadcast in the message type 17 shall be stored in order to support rapid acquisition of a new EGNOS/WAAS satellite (See [Table A-18](#)).

The position of the EGNOS/WAAS satellite in the WGS-84 earth-centred earth-fixed co-ordinates, at time-of-day t_k is defined as:

$$\begin{bmatrix} X_{GK} \\ Y_{GK} \\ Z_{GK} \end{bmatrix} = \begin{bmatrix} X_G \\ Y_G \\ Z_G \end{bmatrix} + \begin{bmatrix} \dot{X}_G \\ \dot{Y}_G \\ \dot{Z}_G \end{bmatrix} (t_k - t_{almanac})$$

3.1.7.8 Messages Types 24 and 25 Long-Term Corrections

Message Types 24 and 25 are broadcast to provide error estimates for slow varying satellite ephemeris and clock errors with respect to WGS-84 ECEF co-ordinates (See [Table A-20](#) and [Table A-21](#)).

The GPS/EGNOS/WAAS equipment shall decode Message Type 24 and 25 and determine and apply the long-term clock corrections for all satellites being used in the position solution or FDE algorithm. The equipment shall compare the Issue of Data (IOD) in the EGNOS/WAAS Type 24 or 25 for each GPS satellite with the IODE and IODC of that GPS satellite being utilised by the equipment. There are three possible outcomes:

- a) The EGNOS/WAAS IOD and GPS IODE and IODC match (The normal condition), in which case the EGNOS/WAAS corrections shall be applied using the current GPS IODE to compute satellite position.

- b) The EGNOS/WAAS IOD and GPS IODE and IODC do not match, but the EGNOS/WAAS IOD matches the previous GPS IODE (a condition which will happen for a few minutes each hour), in which case the EGNOS/WAAS corrections shall be applied using previous GPS IODE to compute satellite position.
- c) They do not match, nor does the EGNOS/WAAS IOD match the previous GPS IODE and IODC (a rare condition), then the equipment shall not apply the fast or long-term corrections. Satellite integrity information from messages Types 2,3,4,5,6,7,24 can still be used.

The equipment shall retain old ephemeris information until a match between EGNOS/WAAS IOD and GPS IODC and IODE is obtained (Within the ephemeris Time-out duration).

Long-term corrections shall not be applied without active fast corrections.

NOTE: *The EGNOS/WAAS system will generate each satellite correction based on the old ephemeris for approximately two minutes after the GPS broadcast ephemeris has changed, in order to ensure that the user equipment has decoded the new ephemeris. During this period, The EGNOS/WAAS equipment needs to retain the old ephemeris in order to ensure that the pseudorange measurement and long-term correction for that satellite are based on the same ephemerides.*

3.1.7.9 Message Type 27: EGNOS/WAAS Service Message

This message may be transmitted because the integrity of EGNOS/WAAS information can not be verified in a particular region (See Table A-24 and Table A-8).

The EGNOS/WAAS equipment shall examine the information contained in Message Type 27 to determine whether the user is within the region of applicability.

The equipment shall apply the $\sigma_{i,UDRE}$ degradation transmitted in message Type 27 when computing the HPL/VPL if the user is in the degradation zone coded in message type 27.

In this region if a message Type 27 indicates that the navigation mode is not supported by the EGNOS/WAAS service, the equipment shall not use the EGNOS/WAAS corrections and integrity information provided.

A message Type 27 shall continue to be applied until a subsequent Message Type 27 is received.

3.1.7.10 Message Time-out Periods

EGNOS/WAAS equipment shall not use timed out data. The time-out intervals are defined as being from the end of reception of a message until the end of reception of a message which contains replacement information. The Time-out intervals are a function of the navigation mode. The time-out intervals are given in Table 3-2. The time-out interval for fast corrections is a function of the $\sigma_{i,UDRE}$ degradation factor broadcast in a Type 7 message and the navigation mode of the equipment, as shown in Table 3-3. The data items which have not timed-out shall continue to be used until replaced.

Data	Associated Message Type	En Route, Terminal, NPA Time-out (seconds)	Precision Approach Time-out (seconds)
EGNOS/WAAS in Test Mode	0	N/A	N/A
PRN Mask	1	600	600
UDREI	6	18	12
Fast Corrections	2-5,24	Variable (see table 3.4)	Variable (see Table 3.4)
Long Term Corrections	24,25	360	240
GEO Ephemeris	9	360	240
UDRE Degradation	7	360	240
Degradation Parameters	10	360	240
Ionospheric Mask	18	1200	1200
Ionospheric Corrections	26	600	600
Service Message	27	None	None
Timing Data	12	None	None
Almanac Data	17	None	None

TABLE 3-2: TIME-OUT INTERVALS

UDRE Degradation Factor Indicator (aij)	En Route through NPA User Time-out Interval for Corrections (seconds)	PA User Time-out Interval for corrections (seconds)
0	180	120
1	180	120
2	153	102
3	135	90
4	135	90
5	117	78
6	99	66
7	81	54
8	63	42
9	45	30
10	45	30
11	27	18
12	27	18
13	27	18
14	18	12
15	18	12

TABLE 3-3: TIME-OUT INTERVAL FOR FAST CORRECTIONS

3.1.8 Satellite selection

3.1.8.1 Satellite Integrity Status

The EGNOS/WAAS equipment shall designate each GPS and WAAS satellite as:

- EGNOS/WAAS UNHEALTHY
- or, EGNOS/WAAS UNMONITORED
- or, EGNOS/WAAS HEALTHY

as defined in Sections 3.1.8.1.2 through 3.1.8.1.4.

The EGNOS/WAAS equipment shall also designate each GPS satellite as:

- GPS HEALTHY
- or, GPS UNHEALTHY

as defined in Sections 3.1.8.1.5 and 3.1.8.1.6.

The latency of this designation must be consistent with the requirements of Sections 3.1.8 and 3.4.8.

3.1.8.1.1 Step Detector

The EGNOS/WAAS equipment shall detect a pseudorange step greater than 700 metres on any satellite used in the position solution, including steps which cause loss of lock for less than 10 seconds. A pseudorange step can be caused by :

- a change in navigation data, or
- a sudden change in the code phase.

Erroneous declarations of pseudorange steps shall not exceed 10^{-5} /flight hour. If the equipment is capable of recovering a satellite after a step error has been declared, the declaration of a pseudorange step shall only be cleared, if it is verified through autonomous fault detection.

3.1.8.1.2 EGNOS/WAAS UNHEALTHY Designation

The EGNOS/WAAS equipment shall designate any GPS or EGNOS/WAAS satellite as EGNOS/WAAS UNHEALTHY upon the occurrence of any of the following conditions:

- The equipment has successfully decoded a UDREI of 15, indicating that the EGNOS/WAAS has assessed the satellite signal as unusable
- The step detection function has declared a step error
- For EGNOS/WAAS satellites, failure of parity on 4 successive messages.

The EGNOS/WAAS UNHEALTHY status for that satellite shall be changed after the condition has been cleared and none of the above conditions exist. When a EGNOS/WAAS satellite is designated as UNHEALTHY due to any one of the above conditions , the integrity and correction data can continue to be applied until the normal timeout interval expires.

3.1.8.1.3 EGNOS/WAAS UNMONITORED Designation

The EGNOS/WAAS equipment shall designate any GPS or EGNOS/WAAS satellite as EGNOS/WAAS UNMONITORED upon the occurrence of any of the following conditions (if not designated as EGNOS/WAAS UNHEALTHY):

- The equipment has successfully decoded a UDREI of 14 ("Not Monitored")
- EGNOS/WAAS data is not provided (satellite not in mask)
- EGNOS/WAAS signals are not being received (affects all satellites)

- EGNOS/WAAS data has timed-out
- If using long-term corrections, EGNOS/WAAS IOD and GPS IODE cannot be reconciled, as described in 3.1.7.8.

The EGNOS/WAAS UNMONITORED status for that satellite shall be changed only after the condition has cleared and none of the above conditions exist.

3.1.8.1.4 EGNOS/WAAS HEALTHY Designation

The EGNOS/WAAS equipment shall designate any GPS or EGNOS/WAAS satellite as EGNOS/WAAS UNHEALTHY, if it does not satisfy any of the criteria listed under Sections 3.1.8.2 and 3.1.8.3 (if not designated as EGNOS/WAAS UNHEALTHY or EGNOS/WAAS UNMONITORED).

NOTE: *The EGNOS/WAAS may declare a satellite as usable under some conditions when the GPS navigation message indicates that the satellite is unhealthy. For example, the GPS satellite may be declared unhealthy for P(Y)-code reasons while the C/A-code is operating normally. In such a case the user will utilize the satellite in any mode of navigation.*

3.1.8.1.5 GPS UNHEALTHY Designation

The EGNOS/WAAS equipment shall designate any GPS satellite as GPS UNHEALTHY if the GPS satellite navigation message meets any of the following conditions:

- 6 bit health word in the subframe 1 : all cases where MSB="1" except when other bits are "11101", indicates that the satellite will be out of service but is not at this time (ref 2.4.5.3 of GPS SPS Signal Specification)
- Failure of parity on 10 successive words (6 seconds)
- Broadcast IODE does not match 8 least-significant bits of broadcast IODC
- URA of 128 metres or more
- Bit 18 of the HOW set to 1 (GPS SPS Signal Specification).
- All data bits in subframe 1,2 or 3 are 0's

The GPS UNHEALTHY status for that satellite shall be changed only after the condition has cleared .

NOTE: *The condition of parity on 10 successive words is intended to avoid processing an interfering signal by mistake.*

3.1.8.1.6 GPS HEALTHY Designation

The EGNOS/WAAS equipment shall designate any GPS satellite as GPS HEALTHY, if it does not satisfy any of the criteria listed under Section 3.1.8.1.5.

3.1.8.2 Satellite selection strategy

Satellite selection is accomplished as shown Figure 3-3. The EGNOS/WAAS equipment shall operate to the highest available set shown on the figure that can satisfy the performance requirements of the navigation mode.

The equipment shall not utilise any satellite designated EGNOS UNHEALTHY.

EGNOS / WAAS equipment shall continuously select and track available satellites for the EGNOS/WAAS satellite with the highest elevation angle which is providing valid integrity information. Remaining satellites shall be selected to ensure continued integrity in the event of a loss of the EGNOS/WAAS satellite (Including the loss of the signal-in-space or the situation where valid integrity information is no longer being received). This shall be done by selection of another EGNOS/WAAS satellite or by selecting GPS/EGNOS/WAAS satellites to minimise the HPL_{FD} .

If manual deselection is implemented, consideration should be given to annunciations to remind the pilot that the satellites have been deselected, the capability to readily reselect satellites, and the appropriate training to ensure proper equipment operation.

NOTE: *There might be a need for an SBAS service provider selection/deselection capability in the equipment. If such a need is identified for institutional purposes, a specific requirement will be added to this document.*

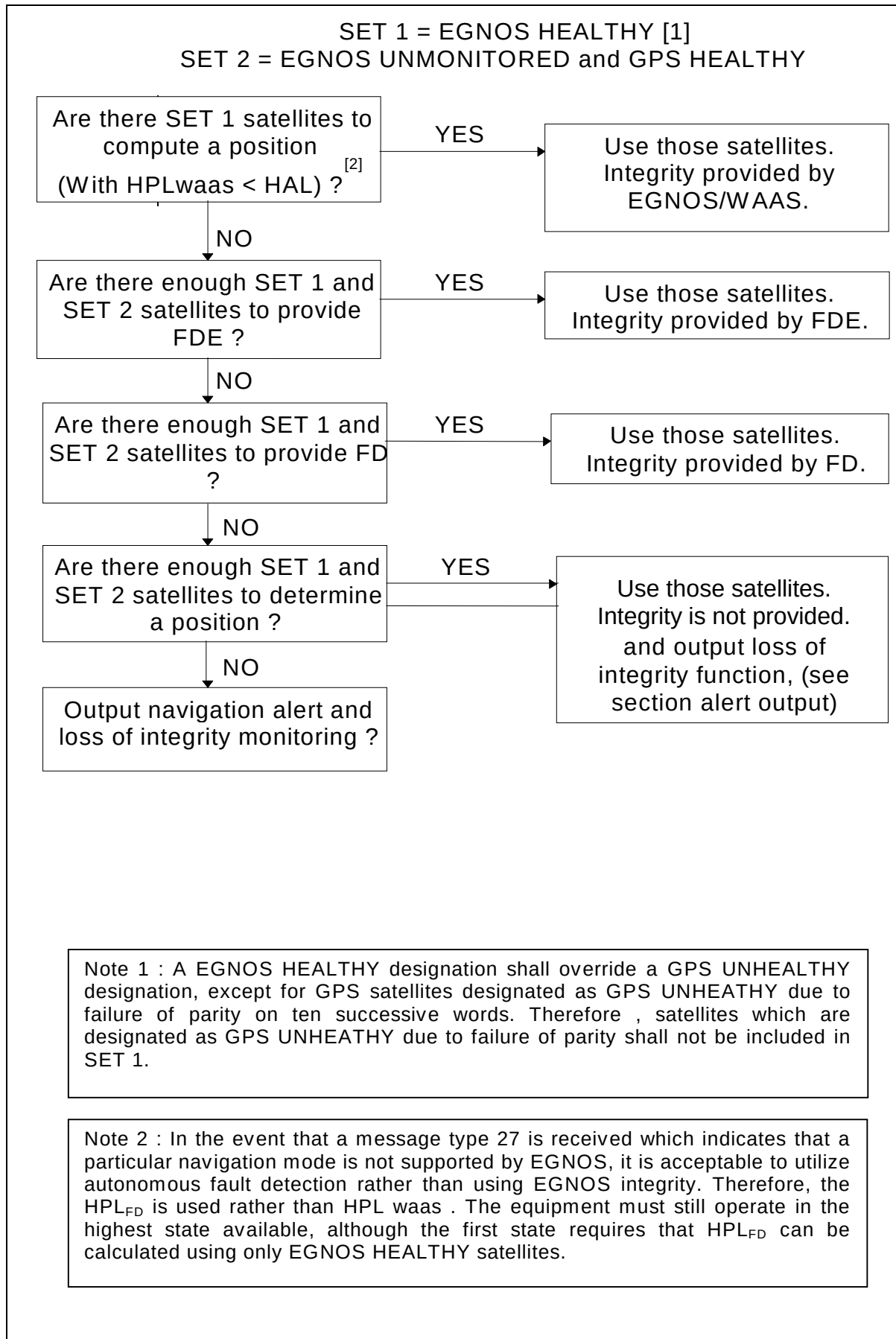


FIGURE 3-3: SATELLITE SELECTION HIERARCHY