



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

**MINIMUM AVIATION SYSTEM PERFORMANCE SPECIFICATION
FOR A GLOBAL NAVIGATION SATELLITE SYSTEM
GROUND BASED AUGMENTATION SYSTEM TO SUPPORT
Cat I OPERATIONS**

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ED 95

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FOREWORD

1. This document, prepared by EUROCAE Working Group 28, was accepted by the Council of EUROCAE on October 1999.
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CHAPTER 1

INTRODUCTION1.1 PURPOSE AND SCOPE

This document contains Minimum Aviation System Performance Specification (MASPS) for a Ground Based Augmentation System (GBAS), as part of the Global Navigation Satellite System (GNSS), to support Cat I precision approaches and landing, with a growth capability to support Cat II / III operations.

The purpose of this MASPS is to define the system performance requirements and also to allocate the system performance requirements to the Minimum Operational Performance Specifications (MOPS) of the two major sub-systems.

To ease the introduction of GBAS, the operational concept uses pilot and auto-pilot interfaces, already approved for ILS operation, thereby minimising the impact at the cockpit level. Furthermore, ATC procedures for GBAS will be as close as possible to those of ILS.

Primary performance parameters are accuracy, integrity, availability, and continuity. These parameters are specified at system level and then allocated to the major sub-systems.

Functional specifications are used where possible so that implementers may have flexibility in developing the GBAS equipment.

Chapter 2 of this document provides system information and assumptions needed to understand the rationale for equipment characteristics and requirements stated in the remaining sections. It describes typical equipment applications and operational goals and forms the basis of the specifications in Chapter 3.

Chapter 3 contains the minimum system performance specifications for the complete system and for each sub-system that is a required element of the system. These standards specify the required performance under the standard environmental conditions.

Appendices A to H specify the broadcast message formats, the allocations of accuracy, continuity and integrity, the integrity alert system latency, the VHF and the C-Band implementations of the broadcast system and interference environment.

Appendices A and F to H refer to the signal transmitted by the ground station and are normative. These appendices are consistent with the draft SARPS approved by GNSSP3 and may be superseded by future versions of ICAO documents :

- Appendix A specifies the broadcast message format.
- Appendices F and G describe the VHF and C Band implementations of the broadcast system.
- Appendix H describes the interference environment.

When the GBAS signal in space is specified by ICAO SARPS, these appendices will be superseded by the relevant ICAO documents.

Appendices B through E are informative and contain rationale for the requirements and allocations given in Section 3 on, respectively, accuracy, continuity, integrity and the integrity alert system latency and availability.

1.2 DEFINITIONS, ABBREVIATION AND REFERENCES

1.2.1 Definitions

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.

Altitude: The vertical distance of a level, point or object considered as a point, measured from mean sea level

Cyclic Redundancy Check (CRC): A very powerful form of parity check. The CRC algorithm associates a sequence of CRC code bits with a data block to preserve its integrity during storage and transmission operations.

Decision Altitude/Height (DA/H): A specified altitude or height in the precision approach at which a missed approach must be initiated if the required visual reference to continue the approach has not been established. Decision altitude (DA) is referenced to mean sea level, whereas Decision Height (DH) is referenced to the threshold elevation.

Fault-Free: An operating condition of a given subsystem for which all functions are performed in a normal manner.

Final Approach Path: The prescribed straight three-dimensional path in space to be flown on final approach. For GBAS, this path is defined in the FAS Path Data by the Landing Threshold Point (LTP), the Threshold Crossing Height (TCH), the Flight Path Alignment Point (FPAP), and the Glide Path Angle.

Functional Requirement: A requirement other than those directly addressing one of the system performance parameters of accuracy, integrity, continuity, availability or coverage.

Misleading Information: Any data which is output to other equipment or displayed to the pilot that has a navigation system error larger than the current protection level (LPL/VPL).

Navigation System Error (NSE): Error that results from the residual composite errors from both the ground subsystem and aircraft receiver after correcting the ranging source used to calculate deviations.

Performance Requirement: A requirement directly addressing one of the system performance parameters of accuracy, integrity, continuity, availability or coverage.

Protection Level: The value which bounds the actual error (NSE in particular) with a specified confidence (LPL/VPL).

Reference Receiver: A GNSS receiver incorporated into the GBAS ground subsystem, used to generate pseudorange correction measurements.

Signal-in-Space (SIS): The aggregate of guidance signals arriving at the antennas of an aircraft. The GPS/GBAS SIS is comprised of the satellite signals and all signals emanating from the GBAS ground subsystem, including the data broadcast.

1.2.2 Abbreviations

AC	Advisory Circular
AAD	Aircraft Accuracy Designator
AOR-E	Atlantic Oceanic Region – East (Inmarsat III)
AOR-W	Atlantic Oceanic Region – West (Inmarsat III)
APL	Airport Pseudolite
ATC	Air Traffic Control
Cat	Category (of precision approach operation)

CA	Coarse Acquisition Code
COS	Continuity Of Service
CRC	Cyclic Redundancy Check
CSA	Channel Standard Accuracy (GLONASS)
CW	Continuous Wave
DA	Decision Altitude
DH	Decision Height
D8PSK	Differential 8 Phases Shift Keying
ECEF	Earth Centered Earth Fixed
ERP	Effective Radiated Power
FAS	Final Approach Segment
FASLAL	Final Approach Segment Lateral Alert Limit
FASVAL	Final Approach Segment Vertical Alert Limit
FAA	Federal Aviation Administration (United States)
FAR	Federal Aviation Regulations (United States)
FEC	Forward Error Correction
FPAP	Flight Path Alignment Point
ft	feet
GAD	Ground Accuracy Designation
GBAS	Ground Based Augmentation System
GCID	Ground Continuity And Integrity Designator
GLONASS	Global (Orbiting) Navigation Satellite System
gnd	Ground
GNSS	Global Navigation Satellite System
GP	Glide Path
GPA	Glide Path Angle
GPIP	Glide Path Intercept Point
GPS	Global Positioning System
GS	Geostationary Satellite
HAT	Height Above Threshold
ICAO	International Civil Aviation Organisation
ICD	Interface Control Document
ILS	Instrument Landing System
IOD	Issue of Data
IODC	Issue of Data Clock
IODE	Issue of Data Ephemeris
IODN	Issue of Data Navigation message (SBAS)
IOR	Indian Oceanic Region (Inmarsat III)
JAA	Joint Aviation Authorities.
JAR	Joint Aviation Requirements (JAA)
LAL	Lateral Alert Limit
LOC	Localizer
LPL	Lateral Protection Level
LSB	Least Significant Bit
MASPS	Minimum Aviation System Performance Specification
MASPS (RTCA)	Minimum Aviation System Performance Standard
MBI	Message Block Identifier
MLS	Microwave Landing System
MOPS	Minimum Operational Performance Specification
MOPS (RTCA)	Minimum Operational Performance Standard
MTBO	Mean Time Between Outage
NM	Nautical Mile
NSE	Navigation System Error
PLPL	Predicted LPL
PR	Pseudorange
PRN	Pseudorandom Number
PT	Performance Type
PVPL	Predicted VPL
PVT	Position, Velocity, Time
PZ90	Parameters of Earth (1990)

RF	Radio Frequency
RMS	Root Mean Square
RNAV	Area Navigation
RNP	Required Navigation Performance
RPDS	Reference Path Data Selector
RSS	Root Sum Square
RTCA	Requirements And Technical Concepts for Aviation
SARPS	Standards And Recommended Practices (ICAO)
SBAS	Space Based Augmentation System
SIS	Signal in Space
SPS	Standard Positioning Service
SSID	Station Slot Identifier
TDMA	Time Division Multiple Access
TCH	Threshold Crossing Height
TLM	Telemetry
UTC	Universal Coordinated Time
VAL	Vertical Alarm Limit
VDB	VHF Data Broadcast
VHF	Very High Frequency
VOR	VHF Omnidirectional Range
VPL	Vertical Protection Level
WAAS	Wide Area Augmentation System
WGS-84	World Geodetic System 1984

1.2.3

References

ICAO Standards And Recommended Practices (SARPs) Annex 10 - Aeronautical Telecommunications – Draft document Output of GNSSP 3 April 1999, Montreal.

ICAO, Doc 9674-AN/946 WGS-84 Manual

ICAO RNP for Approach, Landing and Departure Operations Manual(Draft)

JAR Paragraph 23, Paragraph 25, Paragraph 27, Paragraph 29

JAR 25.1309

JAR AWO Subpart 1

JAR OPS 1/3 Subpart E

ACJ-JAR AWO 231

EUROCAE ED-47B, MOPS for Airborne ILS Glide Path Receiving Equipment, September 1995

EUROCAE ED-46 B, MOPS for Airborne ILS Localizer Receiving Equipment, September 1995

EUROCAE ED-72A - MOPS for Airborne GPS Receiving Equipment Used for Supplemental Means of Navigation - April 1997

EUROCAE ED-79 - Certification Consideration for Highly-integrated or Complex Aircraft Systems - November 1996

EUROCAE ED-88 - MOPS for Multimode Receiver Including ILS, MLS and GPS Used for Supplemental Means of Navigation - 1997

RTCA, DO-229 MOPS for GPS/WAAS Airborne Equipment.

EUROCAE ED-53A MOPS for Microwave Landing System (MLS) (Ground Equipment), December 1989

EUROCAE ED-36A MOPS for Microwave Landing System (MLS) Airborne Receiving Equipment, February 1995.

CHAPTER 2

OVERALL SYSTEM

The GNSS is a world-wide satellite based position, velocity and time determination system. It includes one or more satellite constellations, receivers and system integrity monitoring. It also includes augmentation systems to enable, where necessary, the Required Navigation Performance for the desired operation.

The Ground Based Augmentation System (GBAS) is one such augmentation system and is intended primarily to support precision approach operations. It consists of a ground subsystem and an aircraft subsystem. One ground subsystem can support an unlimited number of aircraft subsystems within its service volume. The ground subsystem provides the aircraft with approach path data, corrections and integrity information for each satellite in view. The corrections enable the aircraft to determine its position relative to the approach path more accurately.

The GBAS Signal in Space is defined to be only the data broadcast from the ground to the aircraft subsystem. The Satellite Signals in Space are part of the basic GNSS satellite constellations. The phrase "Signals in Space" alone is used to describe all the transmissions together.

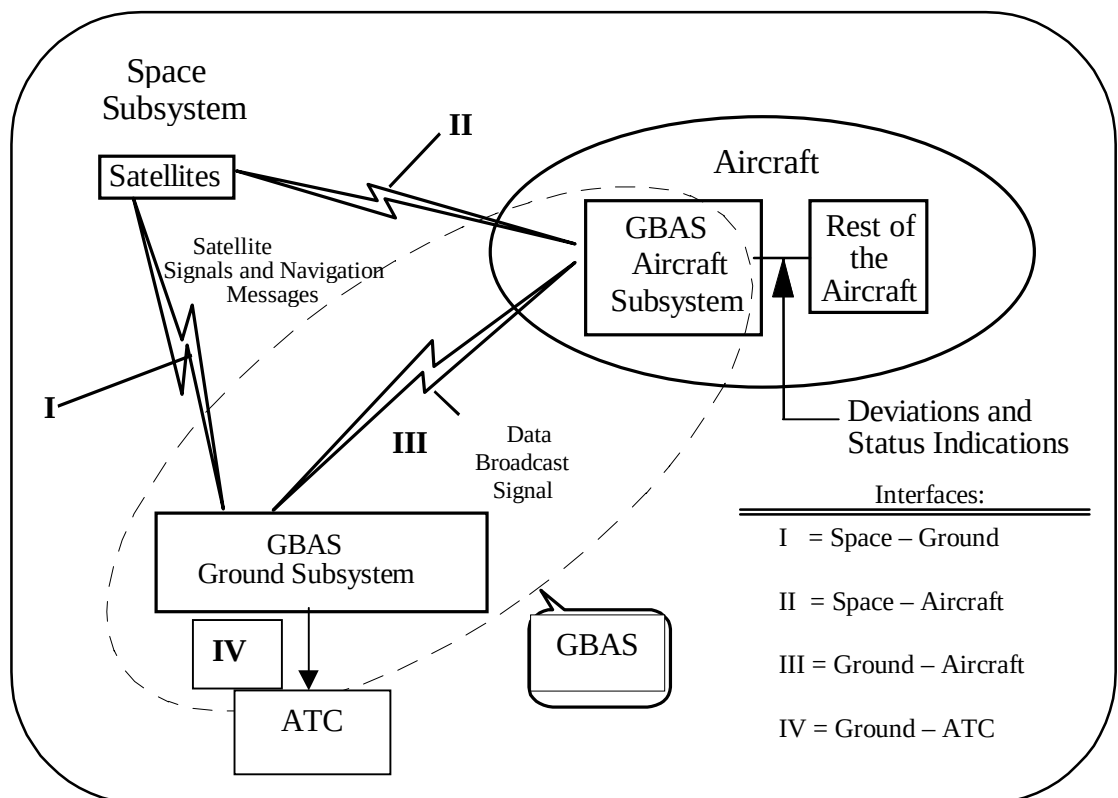


FIGURE 2-1: HIGH LEVEL REPRESENTATION OF GBAS

In the time frame of initial GBAS implementation, it is anticipated that GPS and GLONASS will be the only GNSS constellations declared operational for civil use. Additional ranging signals from geostationary satellites are also anticipated to be available. The use of constellations additional to GPS and GLONASS for GBAS instrument approach operations should be in conformance with both this document and pertinent sections of the EUROCAE and RTCA GBAS subsystems MOPS.

The ground subsystem stores data, related to the serviced runway end(s), in the form of Final Approach Segment (**FAS**) path construction data blocks. It broadcasts this data regularly for reception by approaching aircraft.

The ground subsystem uses at least 2 reference receivers. They calculate pseudoranges for all satellites within view and the ground subsystem broadcasts **differential corrections** for them based on its own surveyed installation position in order that aircraft subsystems use it to correct their own measurement according to the differential principle. This principle requires that ground and aircraft subsystems use exactly the same ephemeris and satellite clock corrections. Moreover, since the differential principle removes all the ranging errors that are common to ground and aircraft subsystems, ionospheric, tropospheric or SBAS corrections are not applied by the two subsystems.

The aircraft subsystem then corrects its own pseudorange measurements for each satellite with the differential correction data received from the ground subsystem. The corrected pseudorange measurements are then used to more accurately determine the aircraft's position relative to the selected FAS.

The **GBAS integrity concept** requires the aircraft subsystem to assess the « protection level integrity risk » which is the integrity risk due to:

- errors corresponding to the normal accuracy of the system,
- not immediately detected erroneous measurement from one of the ground subsystem reference receivers,

taking into account the geometry of the satellites used by the aircraft subsystem. In order to do that, the ground subsystem broadcasts specific integrity data to the aircraft subsystem for each pseudorange corrections (see Appendix D).

The aircraft subsystem uses specific integrity received data to check the « protection level integrity risk ».

The GBAS aircraft subsystem specified in this MASPS is intended to provide ILS look-alike signals to the aircraft.

2.1 GROUND SUBSYSTEM

The ground subsystem consists of two or more reference receivers and their respective geographically separated antennas, a data broadcast transmitter and monitor system and ground processing functions. These processing functions are: signals-in-space receive and decode, carrier smoothed code and differential correction calculation, integrity monitoring, performance categorisation, data broadcast processing and monitoring.

Time-tagged differential correction information is generated for each satellite. Satellite integrity data are also produced. They are obtained by processing the received satellites' signals by reference to the surveyed and stored antenna co-ordinates in the WGS-84 co-ordinate system.

The GBAS ground subsystem stores FAS path construction data and associated Reference Path Data Selector (RPDS) parameter. It consists of Path Points describing approaches for each related runway. They are referenced to the WGS-84 co-ordinate system.

Data are formatted into a standard message format as described in Appendix A.

The data broadcast shall use the VHF band aeronautical radio navigation frequencies. A detailed specification is given in chapter 3. and in appendices A and F. Appendix G is reserved to accommodate the use of C-band data-broadcast if required at a future date.

The ground subsystem includes an integrity monitoring function. Indication of a loss of the required signal in space integrity level (except the « protection level integrity risk ») will result in warnings being issued and if severe, the shutdown of the broadcast.

The ground subsystem provides its operational status to the appropriate air traffic service authorities.

2.2 AIRCRAFT SUBSYSTEM

The primary functions of the aircraft subsystem are to receive and decode the GNSS satellite and GBAS signals, determine the aircraft position and its integrity, and to provide guidance signals.

The aircraft subsystem initially receives the desired channel number selected by the crew or transferred to it by the avionics. It uses the selected channel number to set the data broadcast frequency and the Reference Path Data Selector parameter. The channel number defines the runway end to be used according to the published instrument approach procedure. The aircraft subsystem tunes to the desired data broadcast VHF channel.

From the various FAS path construction data blocks received on the frequency, the aircraft subsystem extracts the one having the matching Reference Path Data Selector and deduces the slot(s) used by the ground subsystem

It extracts the satellite corrections, satellite integrity information and ground subsystem related data from the messages received in these slots.

The aircraft subsystem receives the GNSS satellite signals in space and measures pseudoranges for each GNSS satellite. It applies the corrections received from the ground subsystem to the appropriate satellite measurements. From these it is able to calculate position, velocity and time.

The aircraft subsystem uses the specific integrity data carried in the data broadcast messages to assess the protection level integrity of the position solution derived from the corrected pseudoranges.

The GBAS aircraft subsystem then generates, with respect to the selected FAS, the following guidance signals:

- Lateral Deviation,
- Vertical Deviation,
- Distance to threshold,
- Integrity alert signals if appropriate.

2.3 SYSTEM APPLICATION

The GBAS is intended to be applied to the landing function and to provide an alternative precision approach system to ILS and MLS. While not required to do so by this MASPS, the aircraft subsystem may also output the aircraft's corrected position. This may be used by appropriate avionics to:

- Provide missed approach guidance,
- Offer enhanced RNAV capability,
- Provide surface movement guidance to the crew.

2.4 EXTERNAL INTERFACES

The input interfaces for both ground and aircraft subsystems include the GNSS signals in space.

2.4.1 Aircraft Subsystem Input and Output Signals

The aircraft subsystem has similar external interfaces to those of ILS. It has inputs from the aircraft in the form of the channel number and power supply.

The aircraft subsystem outputs guidance deviations, integrity and annunciation data to the aircraft in a similar fashion to that of an ILS receiver.

2.4.2 Ground Subsystem Input and Output Signals

The ground subsystem is provided with the co-ordinates of its GNSS antennas and the FAS data in secure form by the Air Traffic Services authority.

Ground equipment status shall be output for remote display to the appropriate Air Traffic Services authority. Remote control inputs from the maintenance authority. It obtains a local power supply and has its own emergency power source.

2.5 INTERNAL INTERFACES

The GBAS has an internal interface between the ground and aircraft subsystems in the form of the data broadcast.

2.6 GBAS CLASSIFICATION

GBAS requirements for accuracy, integrity and continuity specified in this document are intended to support Category I approach and landing operations.

It is anticipated that GBAS, in the future, will also support Cat II/III approach, landing and guided takeoff operations. In order to guarantee interoperability and enable efficient spectrum utilisation, the radio frequency and data broadcast characteristics, and frame and message structure, will be the same for GBAS supporting Cat I operations - as described in this document - and future GBAS supporting Cat II/III operations. Some messages may not be required for certain categories.

The GBAS ground subsystem transmits a Ground Continuity and Integrity Designator (GCID) parameter in its message set that will specify the highest level of performances in terms of continuity and integrity that can be supported by the ground subsystem.

A GCID of 1 indicates that the ground subsystem meets the allocated requirements for continuity and integrity associated with Category I operations.

The ability of the ground subsystem to meet the continuity and integrity requirements allocated from the Signal In Space Level performance requirements depends on the redundancy of elements in the ground station as well as the basic reliability of the elements. Hence, GCID is a function of the ground subsystem design and the current state of the ground subsystem.

The GBAS ground subsystem transmits a Ground Accuracy Designator (GAD). The GAD shall indicate the level of signal-in-space accuracy performance provided by the combination of particular GBAS Ground Subsystem and the space segment.

CHAPTER 3

SYSTEM FUNCTIONAL PERFORMANCE

The GBAS shall meet the following functional requirements during normal operation.

These requirements include the concept of a fault-free aircraft subsystem as a means of combining the signals in space broadcast by the space subsystem and the ground subsystem. This aircraft subsystem is defined to have nominal accuracy performance and, because it is assumed to have no failure, it does not contribute to the signal in space integrity and continuity performance.

Thus, concerning the outputs of the aircraft subsystem:

- accuracy is related to the total system (using an onboard receiver with nominal accuracy performances).
- integrity and continuity are only related to the signal in space.

***NOTE:** GBAS accuracy is primarily limited by bias that stems from poor constellation geometry and multipath. This bias is detectable and therefore results in an availability limitation on the system. Failure to detect either this bias or other possible errors constitutes an integrity risk*

This MASPS only applies to a GBAS augmenting GPS or GPS + GLONASS (with or without SBAS ranging sources). A GBAS augmenting GLONASS only (with or without SBAS ranging sources) is not considered.

In these requirements, the space subsystem is assumed to be compliant with ICAO SARPs (Annex 10).

3.1 INPUT AND OUTPUT SIGNALS AND DATA

3.1.1 Input Signals from the GNSS Space Subsystem

The GBAS is dependent on the correct operation of the GNSS space subsystem, initially GPS and GLONASS. These systems are considered to be operating as specified by ICAO Documents. (Annex 10 SARPS) The GBAS must use the GNSS signals correctly both within the ground subsystem and within the aircraft subsystem.

SBAS satellites can be used as supplementary ranging sources by GBAS. In this case the differential corrections transmitted by SBAS shall not be used by GBAS.

GPS sensors shall be designed to operate with a signal in space that meets the requirements of the GPS SARPS. GLONASS sensors shall be designed to operate with a signal in space that meets the GLONASS SARPS.

GPS and GLONASS ionospheric and tropospheric correction models shall not be used by GBAS.

For combined GPS/GLONASS configuration, the reference co-ordinate system shall be WGS-84 and reference time shall be GPS time. GLONASS satellite co-ordinates processed from ephemeris data shall be converted from PZ-90 into WGS-84. See Appendix A

3.1.2 Ground Equipment Input and Output Signals

Input Signals

The following input signals are required:

- a) GNSS satellites signal in space.
- b) Remote control.

Output Signals

The following output signals are required:

- a) VHF data broadcast signal.
- b) Status information for use by the Air Traffic Service provider.

3.1.3 Aircraft Equipment Input and Output Signals

Input Signals

The following input signals are required to enable the aircraft equipment to function correctly:

- a) Channel number.
- b) GNSS satellites signal in space.
- c) VHF Data broadcast signals.
- d) Antenna offset information (if required).

Output Signals

The following output signals are required to provide deviations and warnings for presentation to the pilot or for processing by other aircraft systems:

- a) ILS look-alike and rectilinear lateral and vertical deviations.
- b) Warning indications for a loss of navigation capability, and other failure modes.
- c) An indication of the approach path selected.
- d) Mode indication (where multiple operational modes are supported, e.g. multi-mode receivers).
- e) Position, Velocity and Time (PVT). These are optional outputs to support non-landing applications, e.g. surface movement guidance.
- f) Distance to Threshold

3.2 ACCURACY

GBAS System Accuracy is defined as the degree of conformance between an estimated or measured value at a given time and its true value.

The NSE requirement is based upon ILS specifications to minimise the validation and aircraft certification impact. See Appendix B for rationale on accuracy requirement and measurement methodology

3.2.1 System Lateral Accuracy

The GBAS lateral accuracy is defined in terms of lateral Navigation System Error (NSE).

The lateral NSE is the difference between the measured horizontal displacement from the final approach path and the actual one.

The probability that the lateral NSE value is within the limits shown below shall be at least 95% per approach. See Appendix B.

The lateral accuracy limits are given as a function of the horizontal distance (D) of aircraft position from the Landing Threshold Point / Fictitious Threshold Point (LTP/FTP) as translated along the final approach path. LTP/FTP and the other Final Approach Segment points are defined in Appendix A:

Between 291 m. and 873 m. from LTP/FTP, a constant value of 16 m.

Between 873 m. and 7500 m. from LTP/FTP, a value linearly varying from 16 m. to 27.6 m.

Over 7500 m. from LTP/FTP, within the limit of coverage a constant value of 27.6 m.

NOTE 1: The aim of limiting 95% accuracy is to model the global distribution of positioning errors, whereas the integrity requirement limits the risk of exceeding excessive error values which could lead to a Hazardously Misleading Information (HMI).

NOTE 2: The accuracy requirement must be satisfied for the worst-case geometry under which the system is declared available. See Appendix B-3.

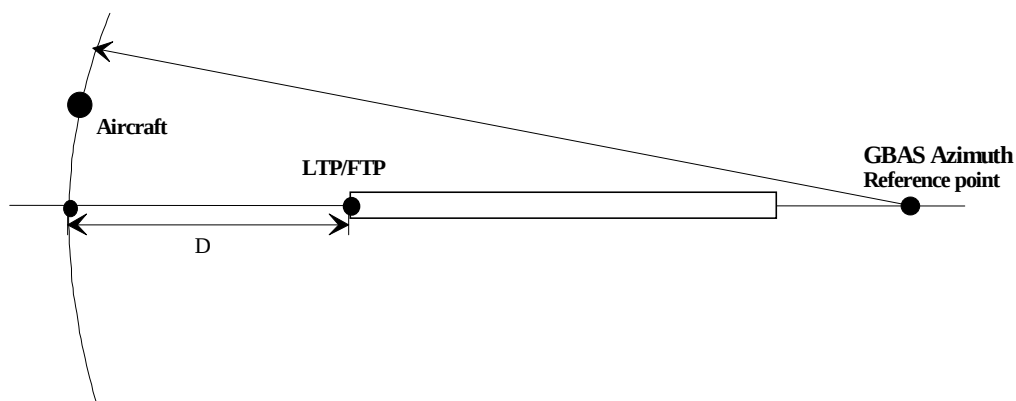


FIGURE 3-1: PRECISION APPROACH - PLAN VIEW

3.2.2

System Vertical Accuracy

The GBAS vertical accuracy is defined in terms of vertical Navigation System Error (NSE).

The vertical NSE is the difference between the measured vertical displacement from the final approach path and the actual one.

The probability that the vertical NSE value is within the limits shown below shall be at least 95% per approach. See Appendix B.

The vertical accuracy limits are given as a function of the height (H) above Landing.

Threshold Point / Fictitious Threshold Point (LTP/FTP) of aircraft position translated onto the final approach path. LTP/FTP and the other Final Approach Segment points are defined in Appendix A:

Between 100 feet HAT and 200 feet HAT a constant value of 4 m.

Between 200 feet and 1340 ft HAT , a value linearly varying from 4 m to 17.3 m.

Above 1340 ft HAT, in the limit of coverage, a constant value of 17.3 m.

NOTE 1: *The aim of limiting 95% accuracy is to model the global distribution of positioning errors, whereas the integrity requirement limits the risk of exceeding excessive error values which could lead to a Hazardously Misleading Information (HMI).*

NOTE 2: *The accuracy requirement must be satisfied for the worst-case geometry under which the system is declared available. See Appendix B.*

NOTE 3: *The accuracy requirements above are given for a system supporting 200ft Decision Height Cat I operations.*

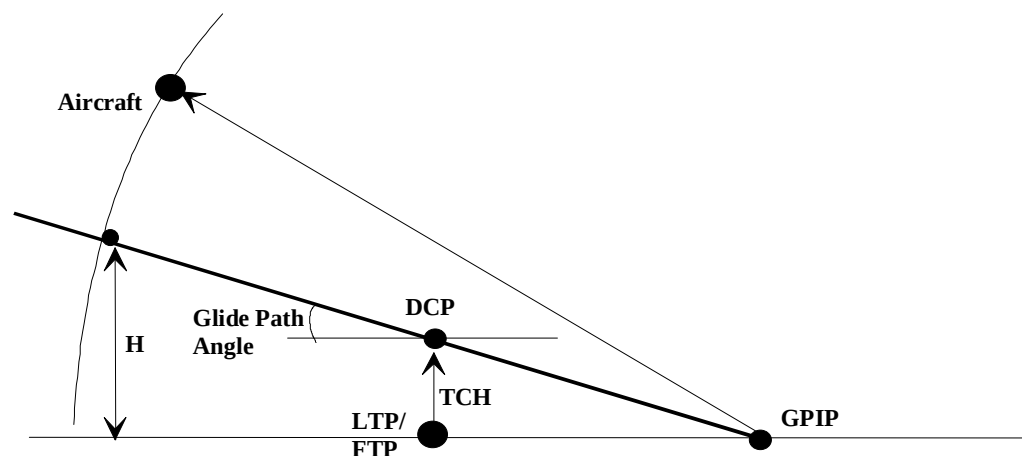


FIGURE 3-2: PRECISION APPROACH - PROFILE VIEW

3.2.3 Ground Subsystem Accuracy

3.2.3.1 Ground Subsystem contribution to Accuracy for Measurements on GPS and GLONASS Satellites

The GBAS ground subsystem accuracy requirement is determined by the Ground Accuracy Designator (GAD) letter and the number of installed reference receivers.

The GAD shall consist of a letter indicating the measurement accuracy (independent of the number of reference receivers) and a number indicating the number of reference receivers included in the ground subsystem.

The RMS of the ground subsystem contribution to the corrected pseudorange accuracy for GPS and GLONASS satellites shall be:

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

Where:

M ≡ number of installed ground reference receivers

$n \equiv n^{th}$ ranging source

$\theta_n \equiv$ elevation angle for the n^{th} ranging source

a_0 , a_1 , a_2 , and θ_0 parameters are defined in the table below for each of the defined Ground Accuracy Designators.

NOTE: The ground subsystem contribution to the corrected pseudorange error for GPS, GLONASS and SBAS satellites doesn't include aircraft noise and aircraft multipath.

Ground Accuracy Designator	θ_n (degrees)	a_0 (meters)	a_1 (meters)	θ_0 (degrees)	a_2 (meters)
A	≥ 5	0.5	1.65	14.3	0.08
B	≥ 5	0.16	1.07	15.5	0.08
C	> 35	0.15	0.84	15.5	0.04
	5 to 35	0.24	0	-	0.04

TABLE 3-1: GBAS - GPS ACCURACY REQUIREMENT PARAMETERS

Ground Accuracy Designator	θ_n (degrees)	a_0 (meters)	a_1 (meters)	θ_0 (degrees)	a_2 (meters)
A	≥ 5	0.51	1.66	14.2	0.06
B	≥ 5	0.16	1.07	14.6	0.06
C	> 35	0.16	1	14.5	0.037
	5 to 35	0.24	0	-	0.037

TABLE 3-2: GBAS - GLONASS ACCURACY REQUIREMENT PARAMETERS

3.2.3.2

Ground Subsystem contribution to Accuracy for Measurements on SBAS Satellites

SBAS employs geostationary (GEO) satellites to relay differential correction messages to users on the L1 frequency. The GEO satellites also transmit C/A-code ranging signals to augment the GPS constellation. These satellites may also be utilised as ranging sources by GBAS.

The RMS of the ground subsystem contribution to the corrected pseudorange accuracy for SBAS satellites shall be:

$$RMS_{pr_gnd} \leq \frac{1.8}{\sqrt{M}}$$

NOTE: GAD classifications for SBAS ranging sources are under development.

3.2.4 Aircraft Subsystem Accuracy

3.2.4.1 Aircraft Subsystem Accuracy for Measurements on GPS and GLONASS Satellites

The RMS of the total aircraft receiver contribution to the error as a function of satellite elevation angle shall be:

$$RMS_{pr_air,GNSS}(\theta_n) \leq a_0 + a_1 e^{-\theta_n/\theta_0}$$

Where:

$n \equiv n^{th}$ ranging source

$\theta_n \equiv$ elevation angle for the n^{th} ranging source

a_0 , a_1 , and θ_0 parameters are defined in the table below for each of the defined Aircraft Accuracy Designators.

Aircraft Accuracy Designator	θ_n (degrees)	a_0 (meters)	a_1 (meters)	θ_0 (degrees)
A	≥ 5	0.16	0.23	19.6
B	≥ 5	0.11	0.13	4

TABLE 3-3: AIRCRAFT- GPS ACCURACY REQUIREMENT PARAMETERS

Aircraft Accuracy Designator	θ_n (degrees)	a_0 (meters)	a_1 (meters)	θ_0 (degrees)
A	≥ 5	0.3	0.53	8.35
B	≥ 5	0.12	0.18	15.2

TABLE 3-4: AIRCRAFT- GLONASS ACCURACY REQUIREMENT PARAMETERS

3.2.4.2 Aircraft Subsystem Accuracy for Measurements of SBAS satellites

For SBAS, the value is independent of the elevation. The RMS of the total airborne error contribution to the error in a corrected pseudorange for an SBAS satellite shall be less than or equal to 1.8 m, excluding multipath effects, tropospheric and ionospheric residual errors. (see ICAO SARPS)

3.3 CONTINUITY OF SERVICE

3.3.1 System level

The GBAS continuity of service risk is defined as the probability, that within any 15 second period, a Cat I approach cannot be continued due to an unscheduled loss of lateral or vertical guidance or warning annunciation onboard the aircraft.

The total GBAS system Continuity of Service shall be such that aircraft complies with Airworthiness and Operational requirements.

NOTE 1: *Airworthiness requirements require that system loss of function occurrence rate is less than a level depending upon the severity of the effects at the aircraft level of the malfunction. It is up to the certification applicant to determine what are the effects with respect to the aircraft and systems definition as well as aircraft operations.*

NOTE 2: *The total continuity of service of GBAS is not quantified, because, in order to ease certification issues, airborne requirements are adopted from existing airworthiness requirements and cannot be easily compared to ILS Signal in Space continuity of service requirements.*

3.3.2 Signal In Space Continuity Of Service

The Signal in Space continuity of service is the probability that a fault-free aircraft subsystem provides valid outputs during any 15s period of an approach, assuming that outputs were valid at the start of the period. Outputs are considered as valid if the NSE is lower than alert limits and if there is no warning. The fault-free receiver's failure to receive differential correction information for longer than 3.5 seconds shall be considered as a loss of Signal in Space continuity.

The Signal In Space Continuity of Service shall be greater than or equal to $1 - 8 \times 10^{-6}$ during any 15s period of an approach.

The GBAS ground sub-system continuity shall be greater than or equal to $1 - 3.3 \times 10^{-6}$ during any 15 seconds.

The ground sub-system continuity is the probability that during any 15 second period:

- the VHF data broadcast transmits data in tolerance;
- and VHF data broadcast field strength is within the specified range;
- and protection levels are lower than the alert limits unless configuration changes occur due to the space segment.

See Appendix C.

NOTE: *When a ground station supports more than one runway in simultaneous use, a lower continuity risk than 3.3×10^{-6} may be required from the ground station. This is an operational consideration specific to each airport.*

3.3.3 Aircraft Subsystem

Taking into account the Signal in Space Continuity of Service achieved by the ground subsystem and the data broadcast, the GBAS aircraft subsystem shall be designed to meet the Airworthiness and Operational requirements.

NOTE: *GBAS aircraft subsystem continuity is only a component in the global system safety of a Cat I operation.*

3.4 AVAILABILITY

GBAS service is defined to be available when all the conditions needed to initiate an approach, i.e. Accuracy, Integrity and Continuity of Service performances better than required, are met. Availability performance is the probability that the service will be available during the time which the system is to be used for navigation. This is discussed in Appendix E of this document.

For GBAS, the Availability performance is given by a combination of the space subsystem availability and ground and aircraft subsystems availability. The ground and aircraft subsystems availability performance result from constraints due to Accuracy, Integrity and Continuity of Service requirements. No additional requirement is made on these subsystems related to availability.

In order to provide the same level of performance as an ILS Cat I, GBAS availability should be 0.9975.

NOTE 1: ICAO specifies a range of values for Cat I Availability ; from 0.99 to 0.9999. The highest value could be needed for a system to support primary and alternate destinations.

NOTE 2: A solution to meet the recommended availability on specific sites could be to restrict the operating times to those periods when the service is predicted to be available.

3.5 INTEGRITY

3.5.1 System Level

The total GBAS system integrity shall be such that the aircraft complies with Airworthiness requirements.

NOTE 1: Airworthiness requirements require that system malfunction occurrence rate is less than a level depending upon the severity of the effects of the malfunction at the aircraft level. It is up to the certification applicant to determine what are the effects with respect to the aircraft and system definition as well as aircraft operations. Generally, for Cat I operations, the effects of landing system malfunctions are considered as Hazardous/Severe-major.

NOTE 2: The total integrity of GBAS is not quantified, because, in order to ease certification issues, aircraft requirements are adopted from existing airworthiness requirements and cannot be easily compared to ILS Signal in Space integrity requirements.

3.5.2 Signal In Space Integrity

The SIS integrity risk is the probability that the NSE, at the deviation output of a fault-free aircraft subsystem, exceeds the alert limits (see Paragraph 3.6) without annunciation for a period longer than the Signal in Space time-to-Alert (see Paragraph 3.7).

The allowable integrity risk value shall be less than 2×10^{-7} per approach. Of this, 0.5×10^{-7} is allocated to protection level integrity risk not assessed by a ground subsystem. The remaining 1.5×10^{-7} is allocated to other failure sources.

These remaining failures can arise from:

Failures in the ground system that cause erroneous data to be broadcast (e.g. failures of the processor computing the broadcast values); or

Undetected failures in the GPS space segment that affect airborne receivers and ground subsystem reference receivers differently;

Undetected failures of measurements from more than one reference receiver;

Undetected VDB failures; and

Other undetected events that produce residual errors in the signal in space that result in misleading information (e.g., incorrect FAS, tropospheric or ionospheric anomalies).

See Appendix D.

3.5.3 Aircraft Subsystem

The aircraft subsystem shall assess signal in space protection level integrity risk. The value allocated to this integrity risk is 0.5×10^{-7} per approach.

Taking into account the guaranteed Signal in Space integrity and the data sent by the ground subsystem, the GBAS aircraft subsystem shall be designed to meet the Airworthiness requirements.

NOTE: *GBAS aircraft subsystem integrity is only a component in the global system safety of a Cat I operations.*

3.6 ALERT LIMITS

The alert limits are defined in the following tables.

NOTE: *The protection level integrity risk is assessed onboard by comparing protection levels against lateral and vertical alert limits. The lateral and vertical alert limits should be set no larger than those given in the following tables.*

Horizontal distance of aircraft position from the LTP/FTP as translated along the final approach path (meters)	Lateral Alert Limit (meters)
$291 < D \leq 873$	FASLAL
$873 < D \leq 7500$	$0.0044D + \text{FASLAL} - 3.85$
$D > 7500$	$\text{FASLAL} + 29.15$

TABLE 3-5: LATERAL ALERT LIMIT

Height above LTP/FTP of aircraft position translated onto the final approach path (ft)	Vertical Alert Limit (meters)
$100 < H \leq 200$	FASVAL
$200 < H \leq 1340$	$0.02925H + \text{FASVAL} - 5.85$
$H > 1340$	$\text{FASVAL} + 33.35$

TABLE 3-6: VERTICAL ALERT LIMIT

NOTE: *The values of the parameters FASLAL and FASVAL are transmitted in message type 4.*

The value FASLAL for each FAS block, as defined in the FAS lateral alert limit field of Message Type 4, shall be no greater than 40 m. The value FASVAL for each FAS block, as defined in the FAS vertical alert limit field of Message Type 4, shall be no greater than 10 m.

3.7 TIME TO ALERT

3.7.1 System Time To Alert

The system Time-to-Alert is the total time between the onset of a condition where the relative position error exceeds the alert limit and the issue of a warning to the aircraft.

This time is a never to be exceeded limit and is intended to protect the aircraft against prolonged periods of guidance outside the lateral or vertical alert limits.

The never to be exceeded total system Time-to-Alert shall be 6 seconds.

3.7.2 Signal-in-Space Time-to-Alert

Signal-in-Space Time-to-Alert refers to the time between the onset of a condition where the relative position error exceeds the alert limit and the time that the last bit in the first Type 1 message containing integrity information reflecting the failure condition is transmitted. The never to be exceeded Signal-in-Space Time-to-Alert shall be 3 seconds.

NOTE: *GBAS ground subsystem shall cease transmission if it cannot indicate a failure by an appropriate message .*

3.7.3 Aircraft Subsystem Time-to-Alert

Aircraft subsystem Time-to-Alert refers to the time between the reception of the last bit in the first message containing integrity information reflecting the failure condition and the issue of a warning to the aircraft. The never to be exceeded aircraft subsystem Time-to-Alert shall be 3 seconds.

3.8 SYSTEM INTEROPERABILITY

Interoperability is required between the aircraft and non-aircraft components of the navigation system. Any aircraft sub-system complying with the relevant certification requirements shall operate within specification when used with any ground station complying with the EUROCAE MOPS. This level of interoperability shall be provided by the MOPS for the ground and aircraft sub-systems. To ensure interoperability both ground and aircraft elements must be tested and approved independently, i.e. it shall not be necessary to carry out system level tests to ensure interoperability.

This Paragraph defines requirements for the processing of satellite navigation data by the ground and aircraft subsystems.

NOTE: *For GPS satellites, ephemeris and clock data should not change without a change in the IODE and IODC parameters.*

For SBAS satellites, ephemeris and clock data should not change without a change in the IODN parameter (type 9 message).

GPS, GLONASS and SBAS navigation data are defined in the SARPS

To avoid undesired changes of navigation parameters due to SIS undetected failures, it is necessary to define rules for navigation parameters acquisition.

3.8.1 Navigation Data Acquisition

Navigation data stands for satellite parameters (clock and ephemeris data) processed from binary words contained in satellite navigation message.

For those satellites whose signals in space is acquired, bits from satellite navigation messages shall be continuously decoded.

These bits shall be packed into binary words whose parity is checked.

Satellite navigation data shall be processed from the words corresponding to the satellite navigation message.

To ensure that satellite navigation data is not corrupted due to Bit Error Rate, the following conditions shall be met:

- Satellite navigation data shall be processed only from words that are decoded when the signal-to-noise ratio estimate of the receiver, C/N_0 , remains over 30 dB-Hz.
- Satellite navigation data shall be processed only from navigation messages for which parity passes for each word.
- Satellite navigation data shall be processed when two successive satellite navigation message are received, which navigation binary words match.
- Navigation Message components consistency shall be checked. For GPS satellites, data shall be processed only from subframes 1, 2 and 3 which IODE (subframes 2 and 3) and IODC 8 LSBs (subframes 1) match. For GLONASS satellite, data shall be processed on four consecutive strings acquired after string #1.

3.8.2 Navigation data Data Modification

For those satellites for which a satellite navigation data set has been processed, the satellite navigation message shall be continuously decoded in order to detect modification of navigation data and to compute a new CRC on binary navigation message.

Once a modification of satellite navigation message, acquired according to the above requirements, is detected, the receiver shall process a new navigation data set.

Detection of modification shall concern following event:

GPS satellite:

- The receiver shall monitor IODE and CRC values.
- In case of a IODE change, the receiver shall update ephemeris and clock data from the newly acquired navigation message.
- In case of CRC modification without IODE change (abnormal change), the considered GPS satellite shall not be used for GBAS operation, until two consecutive navigation messages are acquired with a modified IODE parameter.

GLONASS satellite:

- The receiver shall monitor “ t_b ” and CRC values.
- In case of a “ t_b ” change, the receiver shall update ephemeris and clock data from the newly acquired navigation message.
- In case of CRC modification without “ t_b ” change (abnormal change), the considered GLONASS satellite shall not be used for GBAS operation, until two consecutive navigation messages are acquired with a modified “ t_b ” parameter.

SBAS satellite:

- The receiver shall monitor IODN value (type 9 message) and CRC values.
- In case of a IODN change ,the receiver shall update ephemeris and clock data from the newly acquired navigation message.
- In case of CRC modification without IODN change (abnormal change), the considered SBAS satellite shall not be used for GBAS operation, until two consecutive navigation messages are acquired with a modified IODN parameter.

Following table shows the consequences in case of SIS abnormal operation.

Identifier parameter (IODE, t_b , IODN)v	Navigation data parameter	Consequence on GBAS
No change	No change	Normal operation: navigation data set used is the latest processed valid one.
Change	No change	Abnormal operation for SIS: however the same navigation data as the previous valid one will be processed.
No change	Change	Abnormal operation for SIS: the latest processed valid navigation data are used until the change is detected. When the change is detected, the satellite is immediately rejected.
Change	Change	Normal operation: a new navigation data set is processed.

3.8.3 Satellite Suitability Monitoring

The suitability of each received satellite shall be determined by the monitoring the health status and validity of the data content.

3.8.3.1 « Health status » monitoring

3.8.3.1.1 GPS satellite

A GPS satellite shall not be suitable if:

- The health word in ephemeris indicates that the satellite is unhealthy.
- Parity check has failed on more than 5 consecutive words.
- Navigation data contains alternating ones and zeros.
- Alert bit (bit 18 of HOW) is set to 1
- The preamble in TLM words is other than 8B Hexadecimal
- URA index (N) is 15, which indicates absence of accuracy prediction

3.8.3.1.2 GLONASS satellite

A GLONASS satellite shall not be suitable if:

- The health information parameter B_n in ephemeris indicates a satellite malfunction.
- Parity check has failed on more than 5 consecutive words
- The general unhealthy flag C_n^A relative to the satellite is « 0 » in the almanac message.

3.8.3.1.3 SBAS satellite

A SBAS satellite shall not be suitable if:

- It is indicated as not usable in Type 6 integrity failure message.
- CRC check has failed on more than 5 consecutive words.
- Loss of four consecutive SBAS message.
- URA field in message type 9 indicates that the satellite must not be used.
- Reception of a type 0 message.

3.8.3.2 « Valid navigation data set content » monitoring

Before using new clock or ephemeris satellite parameters, the receiver shall check that:

- The satellite position as determined by a new ephemeris data set differs from the satellite position as determined from the latest almanac by less than 7000 meters.
- The satellite clock bias determined by a new clock data set differs from the satellite clock bias as determined from the latest almanac by less than 10 μ s.
- The satellite position as determined by a new ephemeris data set differs from the satellite position as determined from the previous ephemeris data by less than 250 meters if the satellite was acquired.

3.8.4 GPS Satellite Failures Integrity Risk Management

Due to the nature of possible GPS satellite failures, and the necessity to protect against their effects, it is necessary to constrain the technical implementation of the GPS receiver. These requirements do not apply to SBAS satellites. These constraints are described in terms of correlator spacing and receiver RF bandpass filter characteristics. Allowable combinations will be defined in the aircraft subsystem MOPS.

The satellite failure effects considered in developing these constraints are:

- Distorted satellite signal causing multiple correlation peaks
- Correlator peak asymmetry in transmitted signal due to code coherent spurious signals (such as reflected signals or code transition induced wave forms in the satellite)
- Code coherent spurious signals distorted by RF bandpass filter differences
- Flat correlation peaks causing excessive noise or drift.

The ground station shall protect every possible aircraft implementation within the defined range.

3.9 INTERFERENCE

3.9.1 Interference Susceptibility

GBAS shall meet the performance requirements defined in this MASPS when operating within the interference environment defined in Appendix H. The accuracy requirements in this document assume that this environment bounds the true environment under normal conditions. If there are interference conditions present that are outside the bounds of Appendix H, the probability that GBAS provides misleading information shall be within the appropriate integrity requirement.

3.9.2 Unwanted Emissions

The GBAS ground sub-system shall meet the following unwanted emission requirements:

- a) To ensure that interference is not caused to ILS, VOR and other GBAS installations the power transmitted in the first, second and subsequent 25kHz bands shall be as specified in Appendix F, paragraphs 1.7.1 and 1.7.2.
- b) To ensure that interference is not caused to GBAS installations operating on the same frequency with a different time slot, emissions in unassigned time slots shall be as specified in Appendix F, paragraph 1.7.4.
- c) Spurious emissions shall be as specified in appropriate ITU regulations, see Appendix F, Paragraph 1.7.3.
- d) Spurious emissions in the GNSS L1 band shall be such that the interference environment specified in Appendix H is met for aircraft receivers at the minimum distance from the GBAS transmitter. Additional protection may be necessary to prevent interference to the GBAS reference receivers

In addition to the above requirements the GBAS may need to comply with EEC Directive 89/336/EEC, electromagnetic compatibility.

3.10 GBAS SERVICE VOLUME

The service volume is defined as the region within which the system meets the accuracy, integrity and continuity requirements.

The minimum service volume to support precision approach operations in Category I conditions, depicted in Figure 1, shall be:

Laterally: beginning at 137 m (450 ft) each side of the runway datum point 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

Vertically: within the lateral region, up to the greater of 7° or 1.75 times the promulgated glide path angle (GPA) above the horizontal with an origin at the Glide Path Intercept Point (GPIP) and 0.45 GPA above the horizontal or to such lower angle, down 0.30 GPA, as required to safeguard the promulgated glide path intercept procedure. This coverage applies between 30 m (100 ft) and 3000 m (10 000 ft) height above terrain.

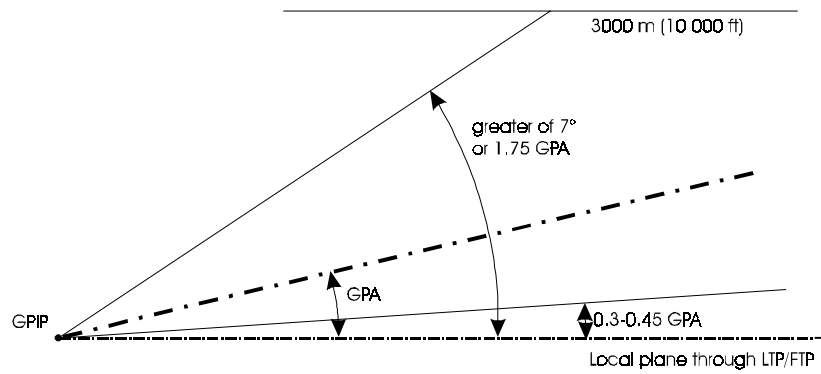


FIGURE 3-3: MINIMUM SERVICE VOLUME - PROFILE VIEW

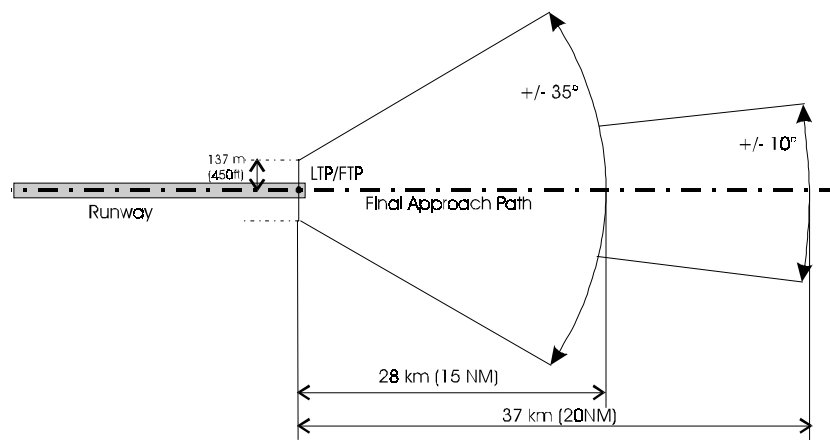


FIGURE 3-4: MINIMUM SERVICE VOLUME - PLAN VIEW

The GBAS coverage shall extend down to 3.7 m (12 ft) above the runway surface.

In the case of multiple runway ends being supported by one ground subsystem, the minimum service volume for each supported runway end shall be as above.

3.11

DATA BROADCAST COVERAGE

The data broadcast coverage shall be sufficient to support the intended operation.

APPENDIX A

GBAS MESSAGE FORMAT AND USEA.1 MESSAGE CONTENTS - APPLICATION LAYER

This paragraph describes data content of the application layer for messages that support GBAS Cat I operations.

A.1.1 Message Blocks

All data broadcast information shall be formatted into message blocks. The message blocks shall consist of a message block header, a message, and a 32-bit cyclic redundancy code (CRC). Figure A-1. displays the general construction of the message block.

All signed parameters shall be 2's complement numbers and all unsigned parameters shall be unsigned fixed-point numbers. The scaling of the data shall be as shown in the message tables. All data fields in the message block shall be transmitted in the order specified in the table in A-1, with LSB of each field transmitted first.

All binary representations reading left to right are MSB to LSB.

Message Block	Length (bits)
Message Block Header	48 bits
Message	up to 1696
Integrity Check (CRC)	32 bits

FIGURE A.-1: FORMAT OF THE GBAS MESSAGE BLOCK

The Message Header is described in Paragraph A.1.2, the Messages in Paragraph A.2. and the CRC in Paragraph A.3.

A.1.2 Message Header

The Message Header contains information relevant to every GBAS data transmission. It shall consist of a Message Block Identifier (MBI), a GBAS identifier (ID), a Message Type Identifier and a Message Length, as shown in Figure A-2.

Parameter	Bits
Message Block Identifier	8
GBAS ID	24
Message Type Identifier	8
Message Length	8

FIGURE A.-2: FORMAT OF THE MESSAGE BLOCK HEADER

Message Block Identifier (MBI): The 8-bit Identifier for the operating mode of the GBAS message block.

Coding:	1010 1010	=	normal GBAS message
	1111 1111	=	test GBAS message

All other values are reserved.

The MBI shall be set to either normal or test according to the coding given above.

GBAS ID: The 4-character GBAS identification included to differentiate between broadcasting stations.

Coding:

Each character is coded using the lower 6 bits of its International Alphabet No. 5 (IA-5) representation. Only upper case letters, numeric digits and IA-5 “blank” are used. The right-most character is transmitted first. For a 3-character GBAS ID, the right-most (first transmitted) character shall be IA-5 “blank”.

NOTE: *The GBAS ID is normally identical to the location indicator at the nearest airport. Assignment of GBAS IDs will be coordinated as appropriate to avoid conflicts.*

Message Type Identifier: Numeric label identifying the content of the message. See Table A-1.

Message Length: The length of the Message in 8-bit bytes including the 6-byte message block header, the message and the 4-byte message CRC code.. Thus messages are restricted to lengths of between 1 and 212 bytes (222 – 10). See Appendix F.

A.1.3 Test mode

When the station is operating in a test mode, the Message Block Identifier shall be set to “1111 1111”.

NOTE: *Individual message transmissions can be set invalid by setting the Message Block identifier to “1111 1111” for that specific message.*

A.2 MESSAGE TYPE DEFINITIONS

The message types that can be transmitted by GBAS shall be as in Table A.-1

Message type identifier	Message name
0	Spare
1	Pseudorange corrections
2	GBAS related data
3	Reserved for Ground Based Ranging Source
4	Final Approach Segment (FAS) data
5	Predicted ranging source availability
6	Reserved for future CATII/III use
7	Reserved for national applications
8	Reserved for test applications
9-255	Spare

TABLE A-1: GBAS VHF DATA BROADCAST MESSAGES

NOTE: *Currently only eight of the 256 available message types have been defined, with the intent that future needs can be addressed in the remaining message types.*

The message types are defined below. It is intended that proposed definitions of these reserved messages be coordinated through ICAO in subsequent years. It is also intended that these messages be assigned for common-use aviation applications only, so that they may be used by any system receiving approval for such operations.

It is an important integrity consideration that all systems shall recognise and reject any current or future messages not intended to be used by the system, e.g., simply checking the least significant bits of the message type for currently defined messages is not sufficient. The same consideration should be given to systems using primary and / or secondary sub-labels.

Message Types 1, 2, and 4 shall be transmitted at the rates shown in table A-2. Refer to Appendix F section F.1.6 for a description of the data broadcast timing structure and definition of frame.

The ground subsystem should broadcast a type 5 message at the rate shown in Table A-2. when the standard 5° mask is not adequate to describe satellite visibility at either the ground subsystem antennas or at an aircraft antenna during a specific approach.

Message type	Minimum broadcast rate	Maximum broadcast rate
1	Once per frame (Note 1)	Once per frame (Note 1)
2	Once per 20 consecutive frames	Once per 5 consecutive frames
4	All FAS blocks once per 20 consecutive frames	All FAS blocks once per 5 consecutive frames
5	All impacted sources once per 20 consecutive frames	All impacted sources once per 5 consecutive frames

TABLE A-2: GBAS VHF DATA BROADCAST RATES

NOTE 1: One Type 1 message or two Type 1 messages that are linked using the additional message flag described in A.2.1.3.

A.2.1 Message Type 1 - GNSS Pseudorange Corrections

A.2.1.1 Scope

Message Type 1 shall provide the differential correction data for individual GNSS ranging sources. The message shall contain three sections:

- message information (time of validity, additional message flag, number of measurements and the measurement type);
- low frequency information (satellite ephemeris CRC and satellite availability duration information);
- the satellite data measurement blocks.

The Additional Message Flag shall be used to indicate that there is a further Message Type 1 being transmitted within the same frame.

Each type 1 message shall include ephemeris CRC and source availability duration parameters for one satellite ranging source. The ephemeris CRC and source availability duration shall apply to the first ranging source in the message.

Message latency: The time between the time indicated by the modified Zcount and the last bit of the broadcast type 1 message shall not exceed 0.5 seconds.

Ephemeris data: Except during an ephemeris change the first ranging source in the message shall sequence so that the ephemeris CRC and source availability duration for each ranging source is transmitted at least once every 10 seconds. When new ephemeris data is received from a GPS or GLONASS ranging source, the ground subsystem shall use the previous ephemeris data from that satellite until it has been continuously received for at least two minutes but before three minutes have passed. When this transition is made to using the new ephemeris data for a given ranging source, the ground subsystem shall broadcast the new ephemeris data for that ranging source in the low frequency information of Message Type 1 in three consecutive frames. For a given ranging source, the ground station shall continue to transmit data corresponding to the previous ephemeris data until the new CRC ephemeris is transmitted in the low frequency data of type 1 message.

NOTE: This enables the aircraft subsystem time to collect new ephemeris data.

If the ephemeris CRC changes and the IOD does not, the ground subsystem shall consider the ranging source invalid (refer to section 3.8).

The first ranging source in the message shall sequence so that the ephemeris CRC and source availability duration for each ranging source is transmitted at least once every 27 seconds.

The ephemeris CRC for each satellite should be broadcast as frequently as possible.

A.2.1.2 Message rate

Message Type 1 shall be transmitted as defined in table A-2.

A.2.1.3 Message content

Data Content	Bits Used	Range of Values	Resolution
Modified Z-count	14	0 to 1199.9 sec	0.1 sec
Additional Message Flag	2	0 to 3	1
Number of Measurements (N)	5	0 to 18	1
Measurement Type	3	0 to 7	1
Spare	8		
Ephemeris CRC	16		
Source availability duration	8	0 to 2540s	10s
For N Measurement Blocks			
Ranging Source ID	8	1 to 255	1
Issue of Data (IOD)	8	0 to 255	1
Pseudorange Correction (PRC)	16	±327.67 m	0.01 m
Range Rate Correction (RRC)	16	± 32.767 m/s	0.001 m/s
σ_{pr_gnd} (unsigned – Note 1)	8	0 to 5.08 m	0.02 m
B ₁ (Note 2)	8	±6.35 m	0.05 m
B ₂ (Note 2)	8	±6.35 m	0.05 m
B ₃ (Note 2)	8	±6.35 m	0.05 m
B ₄ (Note 2)	8	±6.35 m	0.05 m

TABLE A-3: FORMAT OF MESSAGE TYPE 1

NOTE 1: 1111 1111 indicates the ranging source is invalid.

NOTE 2: 1000 0000 indicates that the reference receiver was not used to compute the pseudorange correction.

Modified Z-count: Indication of the time of applicability for all the parameters in the message. The modified Z-count shall define the reference time for all the message parameters in this message (including pseudorange correction and range-rate correction) with a resolution of 0.1 seconds and an acceptable range of 20 minutes. Time shall correlate with GPS time as follows: the clock shall be reset on the hour (xx:00), twenty minutes past the hour (xx:20), and forty minutes past the hour (xx:40).. Higher values are not necessary because the user should already have exact knowledge of the time.

NOTE: GLONASS time (unlike GPS time) is not an independent continuous time scale. It is periodically corrected to integer number of seconds simultaneously with UTC corrections that are performed according to plan of BIH (Bureau International de l'Heure). These corrections are performed at 00 hours 00 minutes 00 seconds at midnight from June 30 to July 1 or from December 31 to January 1 - [GLONASS ICD, 3d edition]. Notification about these planned updates can be got from GPS navigation messages or by other means. There are plans for including such notification data into future GLONASS-M navigation message.

Additional message flag: identifies whether measurement blocks are contained in one or two Type 1 messages in a single frame.

Coding:

- 0 = All measurement blocks are contained in one Type 1 Message
- 1 = This is the first of two Type 1 Messages in a frame containing measurement blocks
- 2 = spare
- 3 = This is the second of two Type 1 Messages in a frame containing measurement blocks

Use of the Type 1 additional message flag. The ground station shall set the additional message flag field to indicate if there is a linked Type 1 Message that contains additional ranging source measurement blocks. The additional message shall have the same Modified Z-count. The minimum number of pseudorange corrections in the additional Type 1 Message is one.

Number of Measurements: This parameter shall identify the number of measurements blocks in the message.

Measurement Type: This parameter shall identify the type of ranging signal from which the corrections have been computed:

Coding: 0 = C/A or CSA code L1
 1 = reserved
 2 = reserved
 3 = reserved
 4 - 7 = spare

Ephemeris CRC: the CRC computed with the ephemeris data used to determine pseudorange and range rate corrections.

The ephemeris CRC shall be calculated in accordance with A.3.
 The length of the CRC shall be $k=16$ bits.

For more information see A.3.3.

The CRC shall be ordered such that r_1 is the first bit transmitted and r_{16} is the last bit transmitted.

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

Coding: 1111 1110 = the duration is greater than or equal to 2540 seconds.
 1111 1111 = prediction of source availability duration is not provided by this ground subsystem.

Ranging Source ID: This parameter shall define the identity of the ranging source to which subsequent message block data are applicable. The range shall be 1-255, where 1 is specified by "0000 0001".

ID's 1-37 shall be reserved for the satellite IDs (PRN) consistent with the Global Positioning System (GPS).
 ID's 38-61 shall be reserved for the satellite IDs (slot) consistent with the Global Navigation Satellite (GLONASS) - slot number plus 37.
 ID's 62-119 SPARE.
 ID's 120-138 shall be reserved for the satellite IDs (PRN) consistent with the SBAS.
 ID's 139-255 / SPARE

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

Coding: for GPS, IOD = GPS IODE parameter (reference GNSSP3 report B.3.1.1.3.2.2)
 for GLONASS, IOD = GLONASS " t_b " parameter (reference GNSSP3 report B.3.2.1.3.1)
 for SBAS, IOD = SBAS IODN parameter (reference GNSSP3 report B.3.5.6)

NOTE: For GLONASS insert 0 in the MSB of the IOD.

The GBAS ground station shall set the IOD field in each ranging source measurement block to be the IOD value received from the ranging source that corresponds to the ephemeris data used to compute the pseudorange correction.

NOTE: Use of the correction data is only recommended if the satellite IOD and the differential correction IOD are identical. The word t_b is time within the current day according to UTC(SU) time + 03 hours 00 minutes. The immediate information transmitted within the frame corresponds to t_b . The discreteness of t_b amount to 15 minutes (see. GLONASS ICD, 3d).

Pseudorange Correction: shall be the correction to the ranging source pseudorange transmitted to the aircraft subsystem.

Broadcast pseudorange correction. Each broadcast pseudorange correction shall be determined by combining the pseudorange correction estimates for the relevant ranging source calculated from each of the reference receivers. For each satellite, the measurements used in this combination shall be obtained from the same ephemeris data.

The corrections shall be based on smoothed code pseudorange measurements for each satellite using the carrier measurement in such a manner that the steady state noise on the pseudorange measurement has a spectral density with a 3 dB bandwidth of 0.01 rad/s.

For GLONASS ranging source:

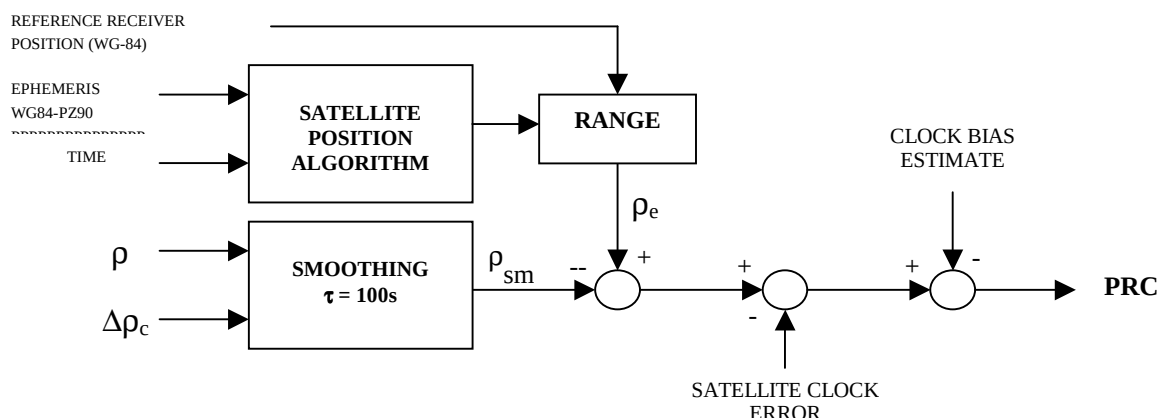
the Ground Station subsystem shall translate satellite coordinates into WGS-84 before it computes correction, the aircraft subsystem shall convert the satellite coordinates into WS-84 to obtain satellite position using the following conversion parameters to obtain position coordinates in WGS-84 from position coordinates in PZ-90:

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_{WGS-84} = \begin{bmatrix} -1.1 \\ -0.3 \\ -0.9 \end{bmatrix} + (1 - 0.12 \times 10^{-6}) \begin{bmatrix} 1 & -0.82 \times 10^{-6} & 0 \\ 0.82 \times 10^{-6} & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_{PZ-90}$$

NOTE: The use of the above conversion parameters results in a conversion error that will not exceed 1.5m (one sigma) along each coordinate axis.

- Pseudorange correction transmission rate. Each measurement block corresponding to a given ranging source shall be transmitted a maximum of once each frame (see A.2.2).
- Ionospheric and tropospheric corrections shall not be applied.
- SBAS corrections received from SBAS shall not be used.

NOTE: The Pseudorange Correction (PRC) is added to the measured pseudorange at the time define in the message



NOTES: ρ_e is the range from the reference receiver antenna to the satellite position determined from current valid ephemeris parameters.

The ionospheric and tropospheric delays are not removed from the pseudorange correction.

FIGURE A-3: PSEUDORANGE CORRECTION COMPUTATION

Range rate correction (RRC): the rate of change of the pseudorange correction.

σ_{pr_and} : the standard deviation of a normal distribution associated with the signal in space contribution of the pseudorange error.

Coding: 1111 1111 = ranging source correction invalid.

B_1 through B_4 : are the integrity parameters associated with the pseudorange corrections provided in the same measurement block. For the i^{th} ranging source these parameters correspond to $B_{i,1}$ through $B_{i,4}$.

Coding: 1000 0000 = reference receiver was not used to compute the pseudorange correction.

Faulted reference receiver measurements or a failed reference receiver should be monitored and identified as invalid in the B parameter according to the coding.

NOTE 1: These σ_{pr_gnd} and B_1 through B_4 parameters shall have values such that the following two conditions are met:

$N(0, \sigma_{pr_gnd})$ overbounds the error distribution for signal-in-space contribution of the pseudorange errors, excluding aircraft receiver and residual tropospheric errors, greater than three times σ_{pr_gnd} in normal measurement conditions (i.e. no fault).

$N(B_{ij}, M_i \times \sigma_{pr_gnd,i} / (M_i - 1))$ overbounds the error distribution for signal-in-space contribution of the pseudorange errors, excluding aircraft receiver and residual tropospheric errors, greater than three times $(M_i \times \sigma_{pr_gnd,i} / (M_i - 1))$ for the case of a fault in the j^{th} reference receiver (under faulted measurement conditions i.e. assuming a latent fault exists in one and only one reference receiver)).

Where:

M_i is the number of valid B_{ij} associated with the pseudorange corrections for the i^{th} ranging source.

$N(m, \sigma)$ defines a normal distribution with average m and a standard deviation σ .

NOTE 2: The errors are the errors in the corrected pseudorange which cause an error in the position relative to the ground subsystem reference point.

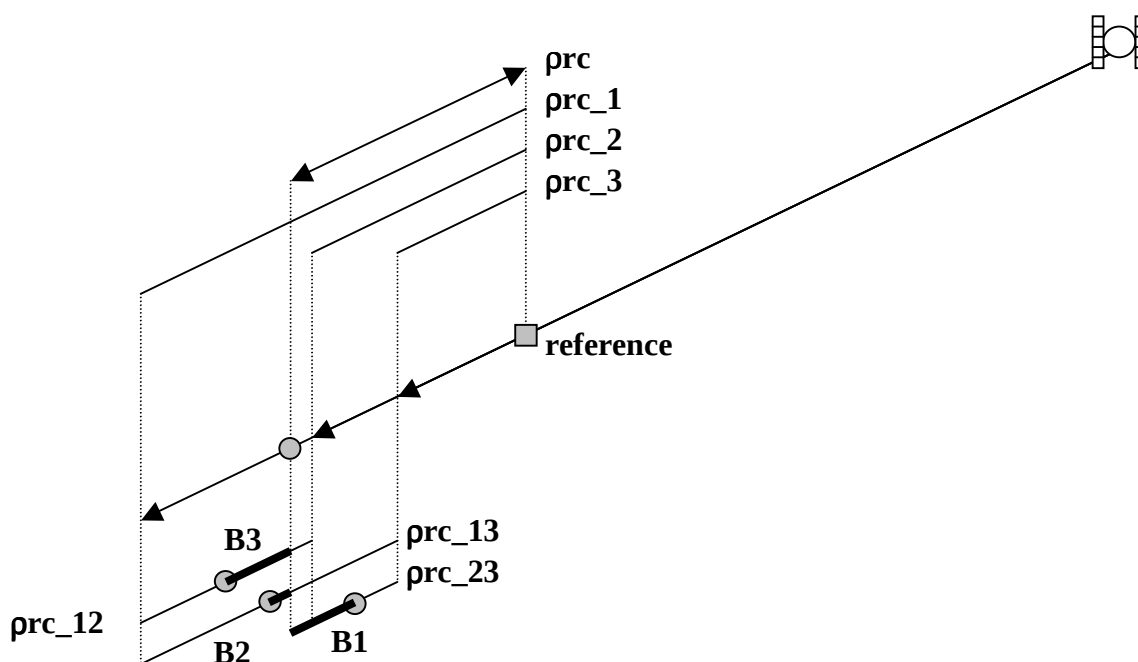


FIGURE A-4: ILLUSTRATION OF ERROR ESTIMATE (B) PARAMETERS

A.2.2 Message Type 2 - GBAS related data

A.2.2.1 Scope

Message Type 2 shall identify the exact location of the point to which the differential corrections provided by the ground based augmentation system are referenced (named the referenced point). The GBAS reference point shall be defined in WGS-84 co-ordinates. The message shall contain other GBAS related data: the number of installed GBAS reference receivers, the GBAS Accuracy Designator, the GBAS Health, the local magnetic variation, the Refractivity Increment, the Scale Height, the Refractivity Uncertainty, the GBAS Latitude, Longitude and Height Above Ellipsoid. The definition is shown in Table A-4.

The ground subsystem shall broadcast a refractivity index, scale height, and refractivity uncertainty in Message Type 2 such that the residual tropospheric error in all corrected pseudoranges obtained within the coverage volume satisfy the following condition:

$N(0, \sigma_{\text{tropo}})$ overbounds the error distribution for residual tropospheric errors greater than three times σ_{tropo}

Where:

$N(m, \sigma)$ defines a normal distribution with average m and a standard deviation σ .

σ_{tropo} is computed as shown in A.5.3.

A.2.2.2 Message rate

The Message Type 2 shall be transmitted at least as defined in table A-2.

A.2.2.3 Message content

Data Content	Bits Used	Range of Values	Resolution
GBAS reference Receivers	2		-
Ground Accuracy Designator letter	2		-
Spare	1	-	-
GBAS Continuity/Integrity Designator	3	0 to 7	1
Local Magnetic Variation	8	$\pm 31.75^\circ$	0.25°
Spare	16	-	-
Refractivity increment	8	± 381	3
Scale Height	8	0 to 25 500 m	100 m
Refractivity Uncertainty	8	0 - 255	1
Latitude (Note 1)	32	$\pm 90.0^\circ$	0.0005 arcsec
Longitude (Note 1)	32	$\pm 180.0^\circ$	0.0005 arcsec
Ellipsoid Height (Note 1)	24	$\pm 83,886.07$ m	0.01 m

TABLE A-4: FORMAT OF MESSAGE TYPE 2

NOTE 1: the accuracy can be greater than the resolution by locating the reference point at the actual point defined in the message.

GBAS related data parameters shall be as follows:

GBAS reference Receivers: shall define the number of GNSS reference receivers installed in this GBAS.

Coding:

- 0 - GBAS ground subsystem installed with 2 reference receivers
- 1 - GBAS ground subsystem installed with 3 reference receivers
- 2 - GBAS ground subsystem installed with 4 reference receivers
- 3 - Spare

Ground Accuracy Designator letter: shall define the letter designator indicating the minimum signal-in-space accuracy performance provided by GBAS.

Coding: 0 - GBAS ground subsystem has accuracy designation A
 1 - GBAS ground subsystem has accuracy designation B
 2- GBAS ground subsystem has accuracy designation C
 3- Spare

Ground Continuity/Integrity Designator: numerical designator, which shall define the operational of the GBAS.

0 - spare
 1 - GDIC 1
 2- GDIC 2
 3- GDIC 3
 4- GDIC 4
 5- spare
 6- spare
 7- GBAS ground subsystem not healthy

If the ground station meets the requirements for Cat I precision approaches the GCID shall be set to 1 otherwise it shall be set to 7.

NOTE: *GCID 2, 3, 4 are specified in order to ensure compatibility of category 1 equipment with future GBAS.*

Local Magnetic Variation: This data parameter shall define the published magnetic variation at the GBAS reference point. The most significant bit shall be the sign bit

where:

Coding: Positive denotes east variation(clockwise from true north),
 Negative denotes west variation (counter-clockwise from true north)

Refraction Increment: is the number is added to 400 to obtain the tropospheric refractivity index at the reference point.

Scale Height: This parameter shall be used for scaling the tropospheric refractivity as a function of differential altitude.

Refraction Uncertainty: the standard deviation of a normal distribution associated with the residual tropospheric uncertainty.

Latitude: the latitude of the reference point defined in WGS-84 and transmitted in arc seconds.

Coding: Positive value denotes north latitude
 Negative value denotes south latitude

Longitude: the longitude of the reference point defined in WGS-84 and transmitted in arc seconds.

Coding: Positive value denotes east longitude
 Negative value denotes west longitude

Ellipsoid Height: The height of the reference point above the WGS-84 ellipsoid..

A.2.3 Message Type 3 - GBRS Data (Reserved)

This message is reserved for use with Ground Based Ranging Sources (pseudolites). It is not required for Category I operations.

NOTE: *The type 3 message is intended to provide the information required to use ground based ranging sources and is reserved for future applications.*

A.2.4 Message Type 4 - Final Approach Segment

A.2.4.1 Scope

Messages Type 4 shall contain the data necessary for the aircraft system to construct a precision approach path.

NOTE: *Message Type 4 can contain a single FAS data block or multiple FAS data blocks. The Type 4 message contains an independent approach capability indication for each FAS data block within the message. Each FAS data block is terminated with a CRC, which wraps around the approach data and each Type 4 message is terminated with a separate CRC (as defined in the message definition) which, wraps the entire message including message header and all the individual FAS data block CRCs.*

A.2.4.2 Message rate

The Message Type 4 shall be transmitted at least as defined in table A-2.

A.2.4.3 Message content

Message Type 4 shall contain one or more sets of FAS data, each defining a single precision approach. The protected FAS data blocks shall be validated individually by the issuing authorities. The data blocks shall include data that allow unambiguous FAS selection against the desired approach charts.

NOTE 1: *The final approach segment CRC should be assigned at the time of procedure design, and kept as an integral part of the FAS data block from that time onward.*

NOTE 2: *The Message Type 4 contains an independent approach capability message for each FAS data block. Each FAS data block contains a CRC, which wraps around the approach data and a separate CRC (as defined in the message definition) which wraps the entire Message Type 4 including message header and all FAS data blocks including the individual FAS data block CRCs.*

The GBAS should allow the capability to set the FASVAL and FASLAL for any FAS data block to “1111 1111” to limit the approach to lateral only or to close the approach respectively.

Data content	Bits used	Range values	of Resolution
For N data sets			
Data set length	8	2 to 212	1 byte
FAS data block	304	-	-
FAS vertical alert limit /approach status	8	0 to 25.4 m	0.1 m
FAS lateral alert limit/approach status	8	0 to 50.8 m	0.2 m

TABLE A-5: FORMAT OF MESSAGE TYPE 4

Each Type 4 message data set shall include the following:

Data set length: the number of bytes in the data set i.e. “Data set length” parameter byte to FASLAL byte.

Final Approach Segment (FAS) data block: sets of parameters to identify a single precision approach and define its associated approach path.

Coding: See Tables A-5 and A-6.

FAS vertical alert limit/approach status: the value of the parameter FASVAL as defined in 3.6.

Coding: 1111 1111 = Do not use vertical deviations.

FAS lateral alert limit/approach status: the value of the parameter FASLAL as defined in 3.6.

Coding: 1111 1111 = Do not use approach.

The GBAS should allow the capability to set the FASVAL and FASLAL for any FAS data block to “1111 1111” to limit the approach to lateral only or to close the approach respectively.

Final Approach Segment (FAS) Data Block:

The Final Approach Segment data block shall contain the parameters which define a single precision approach. The FAS data block is defined in Table A-6.

The FAS data is organised in data blocks for the purpose of computing the CRC. Each data block contains all the information necessary for one single path. Each data block includes an integrity mechanism introduced when the data is determined and validated. This section describes the data block structure only for the computation of the CRC.

The block contains data for a single operation. It is self-contained and includes a means to preserve integrity from the time it is generated and validated to the time that it is used in airborne equipment. All of the information necessary to describe the paths and its designation is contained within it. This primarily includes the following: airport identification, runway designation and position, procedure type (provides flexibility for advanced procedures such as departure or curved approach), procedure name, and runway surveyed points. The data block is generated, protected by a CRC code and validated by the appropriate authorities before distribution. The data block can be transported, reformatted and distributed as long as the original format can be recovered, thereby allowing the verification of the original CRC.

The data block structure consists of a series of fields of different size. The sequence of the fields depends on the operation type the data block supports. Fields common to the different types of operations are placed in the beginning of the data blocks. Fields are coded with the MSB toward the beginning (towards the preceding field) and the LSB towards the end of the block. For the purpose of calculating the CRC, each field is placed in an integral number of 8-bit words (divisible by an integer number of bytes).

Table A-6 indicates the overall structure for straight-in approaches. The data items are defined below. Note that the CRC field always terminates the data block.

FAS path definition:

Lateral orientation: The Final Approach Segment (FAS) is a line in space defined by the Landing/Fictitious Threshold Point (LTP/FTP), the Flight Path Alignment Point (FPAP), the Threshold Crossing Height (TCH) and the Glide Path Angle (GPA). The local level plane for the approach is a plane perpendicular to the local vertical passing through the LTP/FTP (i.e. tangent to the ellipsoid at the LTP/FTP). Local vertical for the approach is normal to the WGS-84 ellipsoid at the LTP/FTP. The Glide Path Intercept Point (GPIP) is where the final approach path intercepts the local level plane.

The Landing Threshold Point/Fictitious Threshold Point (LTP/FTP) is a point over which the FAS path passes at a relative height specified by the threshold crossing height. The LTP is normally located at the intersection of the runway centerline and the threshold. To support rotorcraft approaches the LTP may be offset from the runway centerlines ; in this case it is named the FTP.

The Landing Threshold Point / Fictitious Threshold Point (LTP/FTP) is typically at or near the runway threshold, however, to satisfy operational needs or physical constraints, the LTP/FTP may not be at the threshold. The FPAP is used in conjunction with the LTP/FTP to define the lateral reference plane for the approach. The FPAP is a point at the same height as the LTP/FTP that is used to define the alignment of the approach. For a straight in approach aligned with the runway, the FPAP will be at or beyond the stop end of the runway. The FPAD is not placed before the stop end of the runway.

The absolute position of the LTP/FTP shall be referenced to the geodetic co-ordinate system in accordance with WGS-84. The FPAP position shall be given in Delta latitude and Delta longitude from the LTP/FTP using the same co-ordinate system.

NOTE: *The actual departure end of a runway may be at a different height, but that information is not necessary for these operations.*

NOTE: *The LTP and FPAP may be offset from the runway thresholds to support rotorcraft and offset approaches.*

Vertical orientation: Local vertical for the approach is defined as normal to the WGS-84 ellipsoid at the LTP/FTP. This may differ significantly from the local gravity vector. The local level plane for the approach is defined as a plane perpendicular to the local vertical passing through the LTP/FTP (i.e.; tangent the ellipsoid at the LTP/FTP). The Datum Crossing Point (DCP) is a point at a height defined by the Threshold Crossing Height above the LTP/FTP. The FAS path is defined as a line with an angle (GPA) relative to the local level plane passing through the DCP. The Glide Path Intersection Point (GPIP) is a point where the final approach path intercepts the local level plane through LTP/FTP. The GPIP may actually be above or below the runway surface depending on the curvature of the runway.

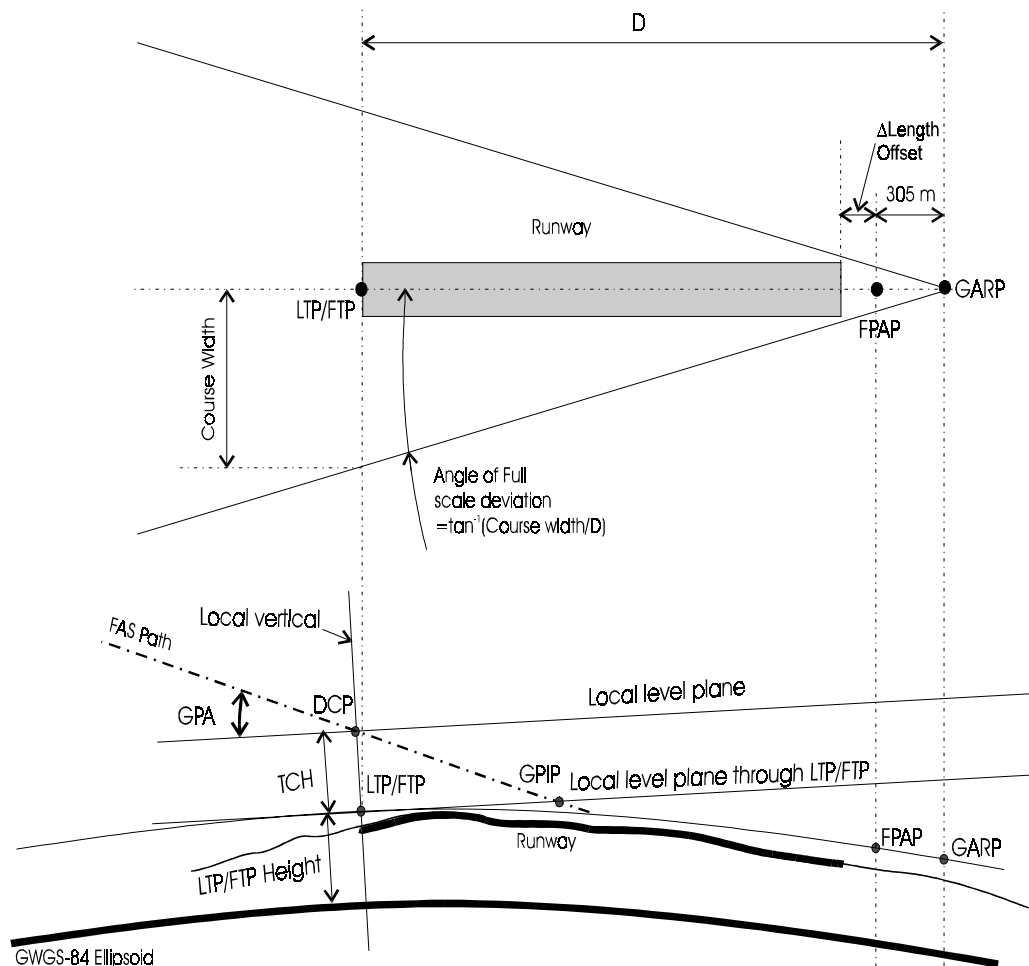


FIGURE A-5: FAS PATH DEFINITION

The Δ Length offset defines the distance from the end of the runway to the FPAP. This parameter is provided to enable the aircraft equipment to compute the distance to the end of the runway. If the Δ Length offset is not set to appropriately indicate the end of the runway relative to the FPAP, the service provider should ensure the parameter is coded as “not provided”.

Some operations may require the definition of a FAS path that is not aligned with the runway centerline. For approaches not aligned with the runway centerline, the LTP/FTP may or may not lie on the extended runway centerline. For this type of approach Δ Length offset is not meaningful and should be set to “not provided”.

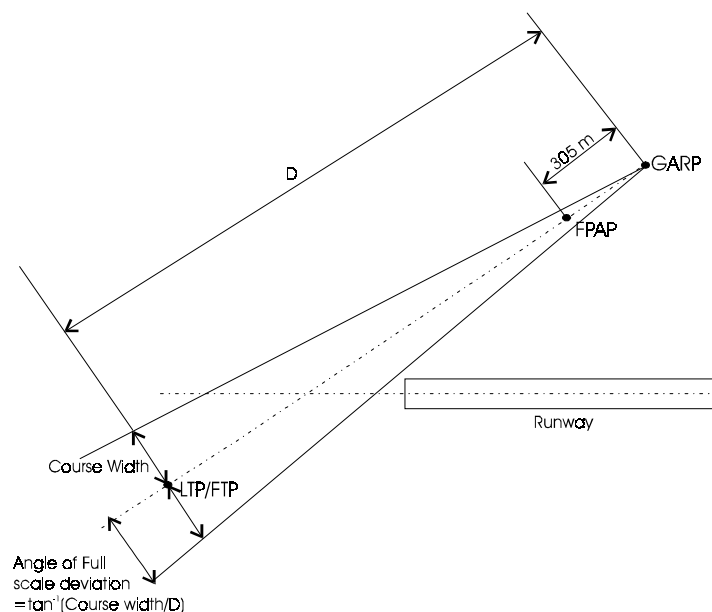


FIGURE A-6: GLIDEPATH DEFINITION FOR NOT ALIGNED APPROACH

To allow ILS Look-Alike computations the course width and FPAP parameters are used to define the origin and sensitivity of the lateral deviations. By adjusting the location of the FPAP and the value of the course width, the course width and sensitivity of a GBAS can be set to the desired values. They may be set to match the course width and sensitivity of an existing ILS. The lateral displacement sensitivity is determined, by the aircraft equipment, from the course width provided in the FAS data block. The angular lateral deviation is a corresponding angular displacement referenced to the GBAS Azimuth Reference Point (GARP). The GARP is defined to be beyond the FPAP along the procedure centerline by a fixed offset value of 305m. Vertical deviations are computed by the aircraft equipment with respect to a GBAS Elevation Reference Point (GERP). The GERP may be at the GPIIP or laterally offset from the GPIIP by a fixed GERP offset value of 150m. The relationship between GPA and the vertical deviation sensitivity is equivalent to the glide path displacement sensitivity provided by ILS.

The FAS path is defined in MT4 by the following parameters:

Landing Threshold Point (LTP) or Fictitious Threshold Point (FTP)
 Flight Path Alignment Point (FPAP)
 LTP/FTP height
 Approach Threshold Crossing Height (TCH)
 Glidepath Angle (GPA)

Structure for Straight-in Approaches Data blocks:

Table A-6 describes in detail the sequence of fields and their contents.. The data fields follow a fixed sequence. The data block size for this type is fixed. The first field (operation type) has a fixed coding corresponding to straight-in approaches

Data Content	Bits Used	Range of Values	Resolution
Operation Type	4	0 to 15	1
SBAS Service Provider ID	4	0 to 15	1
Airport ID	32	-	-
Runway Number	6	0 - 36	1
Runway Letter	2	-	-
Approach performance Designator	3	0 to 7	1
Route Indicator	5	-	-
Reference Path Data Selector	8	0 - 48	1
Reference Path ID	32		
LTP/FTP Latitude	32	$\pm 90.0^\circ$	0.0005 arcsec
LTP/FTP Longitude	32	$\pm 180.0^\circ$	0.0005 arcsec
LTP/FTP Height	16	-512.0 - 6041.5 m	0.1 m
Δ FPAP Latitude	24	$\pm 1.0^\circ$	0.0005 arcsec
Δ FPAP Longitude	24	$\pm 1.0^\circ$	0.0005 arcsec
Approach Threshold Crossing Height (TCH) (Note 1)	15	0 - 1638.35 m (0 - 3276.7 ft)	0.05 m (0.1 ft)
Approach TCH Units Selector	1		
Glidepath Angle (GPA)	16	0 - 90.0 °	0.01°
Course width	8	80.0 to 143.75 m	0.25 m
Δ length offset	8	0 to 2032 m	8m
Final Approach Segment CRC	32		

TABLE A-6: FINAL APPROACH SEGMENT (FAS)

NOTE 1: Information can be provided in either feet or meters as indicated by the approach units selector.

NOTE 2: the maximum values for the TCH in ft and in meters are different to have the best resolution for each unit.

The Final Approach Segment Data Block shall contain the parameters, which define a single precision approach. Each FAS data block shall end with a CRC, which wraps around the approach data. A separate CRC shall be wrapped around the entire FAS Data Message (Type 4).

NOTE: The protected FAS data blocks are validated individually by the civil authorities. The data blocks include data that allow for an unambiguous FAS selection against the desired approach charts.

A.2.4.4 Final approach segment parameter description

Operation Type: shall indicate whether the operation is a straight-in approach procedure or other operation types. The convention for coding shall be as follows:
0 = straight-in approach procedure
1-15 = spare

SBAS service provider ID: indicates which SBAS service provider transmits SBAS corrections that can be used to fly the approach.

Coding:

SBAS Service provider identifiers

Identifier	Service provider
0	WAAS
1	EGNOS
2	MSAS
3 to 13	Spare
14	GBAS only
15	Any SBAS

NOTE: *This parameter is not used for approaches conducted using GBAS pseudorange corrections. It is retained for consistency between GBAS and SBAS FAS data blocks.*

Airport ID: shall be the three or four alphanumeric characters used to designate an airport

Coding: Each character is coded using the lower 6 bits of its International Alphabet No. 5 (IA-5) representation, with the most significant two bits of each 8-bit character set to zero. Only upper case letters, numeric digits and IA-5 "blank" are used. The right-most character is transmitted first. For a 3-character Airport ID, the right most (first transmitted) character shall be IA-5 "blank".

Runway Number: shall represent the approach runway number. The valid range shall be 0-36 where Runway Numbers 1 through 36 designate runway operations and the designation 0 identifies heliport operations.

Coding: 0 = heliport 1 to 36 = runway number

Runway Letter: shall represent the runway letter, where used to differentiate between parallel runways.

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

Approach Performance Designator: shall provide the general information about the approach design.

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

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

Coding: The letter is coded using the lower 5 bits of its International Alphabet No. 5 (IA-5) representation. Only upper case letters, excluding "I" and "O", or a blank are used.

Reference Path Data Selector: is the numerical identifier that is unique in the broadcast region and shall be used to select the FAS data block (desired approach).

NOTE: *A GBAS supported precision approach requires tuning of a data broadcast channel in addition to the precision approach selection that can be accomplished by either unified or systematic type of tuning and approach selection.*

Reference Path Identifier: shall represent the three or four alphanumeric characters used to uniquely designate the reference path.

Coding: Each character is coded using the lower 6 bits of its International Alphabet No. 5 (IA-5) representation, with the most significant two bits of each 8-bit character set to zero. Only upper case letters, numeric digits and IA-5 "blank" are used. The right-most character is transmitted first. For a 3-character reference path identifier, the right-most (first transmitted) character shall be IA-5 "blank".

LTP/FTP latitude: shall represent the latitude of the LTP/FTP point defined in WGS-84 co-ordinates and transmitted in arc seconds.

Coding: Positive value denotes north latitude.
Negative value denotes south latitude.

LTP/FTP Longitude: shall represent the longitude of the LTP/FTP point defined in WGS-84 co-ordinates and transmitted in arc seconds.

Coding: Positive value denotes east longitude.
Negative value denotes west longitude.

LTP/FTP Height: shall represent the height of the LTP/FTP point above the WGS-84 ellipsoid.

Coding: This field shall be coded as an unsigned value with an offset of -512 m. A value of zero in this field shall place the DP 512 m below the earth ellipsoid.

Δ Flight Path Alignment Point (Δ FPAP) – Latitude: shall define the difference of latitude of the runway Flight Path Alignment Point (FPAP) from the LTP/FTP transmitted in arc seconds.

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

Δ Flight Path Alignment Point (Δ FPAP) – Longitude: shall define the difference of longitude of the runway Flight Path Alignment Point from the LTP/FTP transmitted in arc seconds.

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

Approach Threshold Crossing Height (TCH): shall represent the height of the FAS above the LTP/FTP defined in either meters or feet as indicated by the TCH units selector.

Approach TCH Units Selector: shall define the units used to describe the Threshold Crossing Height (TCH). The definition of the bit shall be:

0 = feet
1 = meters

Glide Path Angle (GPA): shall define the angle of the approach path (glide path) with respect to the horizontal plane tangent to the WGS-84 ellipsoid at the LTP/FTP.

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

Coding: This field shall be coded as an unsigned value with an offset of 80 m. A value of zero in this field indicates a course width of 80 m at the LTP/FTP.

Δ Length Offset: distance from the stop end of the runway to the FPAP.

Coding: 1111 1111 = not provided

Final Approach Segment CRC: the 32 bit Cyclic Redundancy Check (CRC) shall be appended to the end of each FAS Data Block in order to ensure approach data integrity.

The Final Approach Segment CRC shall be calculated in accordance with A.3 and A.3.2.

The length of the CRC shall be $k=32$ bits.

The CRC shall be ordered such that r_1 is the least significant bit and r_{32} is the most significant bit.

NOTE: See Paragraphs A.3 and A.3.2 for details.

A.2.5 Message Type 5 - Predicted ranging source availability

A.2.5.1 Scope

Message Type 5 is defined to provide an optional means for the ground subsystem to indicate to the aircraft avionics the future availability of differential corrections for satellites as the aircraft begins its descent into the final approach phase. Type 5 consists of setting/rising information for the currently visible or soon to be visible satellites as shown in table A-7. This message allows the ground subsystem to broadcast predicted changes in the availability of differential corrections at future specific points in time to the aircraft so that the aircraft shall be able to anticipate the satellites that can be used for the duration of the precision approach.

NOTE: *Ranging source availability data is optional for Category I and may be required for possible future operations.*

A.2.5.2 Message rate

When used, the Message Type 5 shall be transmitted as defined in table A-2.

A.2.5.3 Message content

Data content	Bits used	Range of values	Resolution
Modified Z-count	14	0 to 1 199.9 sec	0.1 sec
Spare	2	-	-
Number of impacted sources (N)	8	0 to 31	1
For N impacted sources			
Ranging source ID	8	1 to 255	1
Source availability sense	1	-	-
Source availability duration	7	0 to 1270 sec	10 sec
Number of obstructed approaches (A)	8	0 to 255	1
For A obstructed approaches			
Reference path data selector	8	-	-
Number of impacted sources for this approach (N_A)	8	1 to 31	1
For N_A impacted ranging sources for this approach			
Ranging source ID	8	1 to 255	1
Source availability sense	1	-	-
Source availability duration	7	0 to 1270 sec	10 sec

TABLE A-7: FORMAT OF MESSAGE TYPE 5

Predicted ranging source availability parameters shall be as follows:

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

Coding:
same as modified Z-count field in message type 1

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

Coding:
0=only specified obstructed approaches have limitations
1 to 31= the number of ranging sources impacted

Ranging source ID: as message type 1.