UNITED STATES DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

NON-FED SPECIFICATION
FAA-E-AJW44-2937A

CATEGORY I
LOCAL AREA AUGMENTATION SYSTEM
GROUND FACILITY

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1 SCOPE

1.1 IDENTIFICATION

This specification establishes the minimum performance requirements for the non-Federal Category I (CAT I) Local Area Augmentation System (LAAS) Ground Facility (LGF). Requirements contained within this specification are based on FAA-E-2937A and are the basis to augment the Global Positioning System (GPS) to provide precision approach capability down to Category I minimums and area navigation (RNAV). In addition, this specification contains optional requirements to support Terminal Area Procedures (TAP) in accordance with LAAS ICD (RTCA/DO-246C). The performance requirements are suitable for use with a Minimum Operational Performance Standards (MOPS) airborne user that conforms to LAAS MOPS (RTCA/DO-253A) and the International Civil Aviation Organization (ICAO) Annex 10 including amendment 76 and 77.

1.2 SYSTEM OVERVIEW

The LGF is a safety-critical system consisting of the hardware and software that augments the GPS Standard Positioning Service (SPS) providing RNAV in the terminal area and a precision approach and landing capability. The current GPS positioning service provided is insufficient to meet the integrity, continuity, accuracy, and availability demands of precision approach and landing navigation. The LGF, using differential GPS concepts, augments the GPS SPS in order to meet these requirements.

The GPS/LAAS is maintained in three separate segments; the LGF, the Space Segment, and the Airborne Subsystem as illustrated in Figure 1-1. The LGF provides differential corrections, integrity parameters, and precision approach pathpoint data that are broadcast via a Very High Frequency (VHF) Data Broadcast (VDB) to the Airborne Subsystem for processing. The Space Segment provides the LGF and Airborne Subsystem with GPS ranging signals and orbital parameters. The Space Segment also provides the LGF and Airborne Subsystem with optional Satellite-Based Augmentation System (SBAS) ranging signals and orbital parameters. The Airborne Subsystem applies the LGF corrections to the GPS and SBAS ranging signals to obtain position with the required accuracy, integrity, continuity, and availability. The differentially corrected position is used, along with pathpoint data, to supply deviation signals to drive appropriate aircraft systems supporting terminal area and precision approach operations. Furthermore, using the position output from the airborne receiver, LAAS augments the availability of terminal area operations for aircraft equipped with RNAV capability.

The LGF provides detailed status information to support maintenance and air traffic requirements. Status and control capabilities are executed through a Maintenance Data Terminal (MDT). Additionally, the LGF sends status information to FAA Air Traffic Control (ATC) via an Air Traffic Status Unit (ATSU). For maintenance purposes, LGF status information is available on the Local Status Panel (LSP).

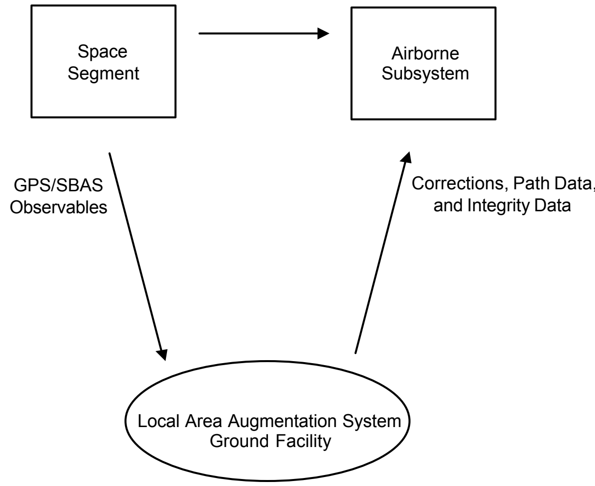

Figure 1-1. Local Area Augmentation System

1.3 DOCUMENT OVERVIEW

The format of this document complies with FAA-STD-005E, MIL-STD-961D, and MIL-STD-962C. Section 1 provides a general overview of the LGF and a high-level introduction to the requirements for implementing operational satellite-based precision approach. Section 2 lists the documents from which requirements are referenced or derived. Section 3 contains the performance, functional, operational, and maintenance requirements for the LGF. Section 4 contains verification requirements for both hardware and software. Appendix A and Appendix B are reserved. Appendix C provides a Verification Requirements Traceability Matrix. Appendix D supplies a listing and expansion of acronyms. Appendix E provides information on the Ranging Source Failure Threat Models. Appendix F supplies information on the usage of LGF Test and Alarm Indicators. Appendix G provides the Integrity Risk and Continuity Risk Allocation trees. Appendix H contains the definitions for the Final Approach Segment.

2 APPLICABLE DOCUMENTS

The following documents form a part of this specification and are applicable to the extent specified herein. In the event of a conflict between referenced documents and the contents of this specification, the contents of this specification shall take precedence

2.1 GOVERNMENT DOCUMENTS

2.1.1 SPECIFICATIONS

2.1.1.1 Federal Aviation Administration

Federal Aviation Administration. (2002). *Category I Local Area Augmentation System Ground Facility.* (FAA-E-2937A) Washington, DC: U.S. Government Printing Office.

Federal Aviation Administration. (2001). *Electronic equipment, general requirements* (FAA-G-2100G). Washington, DC: U.S. Government Printing Office.

Federal Aviation Administration. (2000). Code of Federal Regulations, Part 139-*Certification and Operation: Land Airports Serving Certain Air Carriers*. Washington, DC: U.S. Government Printing Office.

Federal Aviation Administration. (1997). *Wide area augmentation system (WAAS) specification* (FAA-E-2892B). Washington, DC: U.S. Government Printing Office.

2.1.2 STANDARDS

2.1.2.1 Federal Aviation Administration

Federal Aviation Administration. (1996). *Standard practice preparation of specifications, standards and handbooks* (FAA-STD-005E). Washington, DC: U.S. Government Printing Office.

DOT/FAA/CT-03/05. (2003). *Human Factors Design Standard for Acquisition of Commercial-Off-the-Shelf Subsystem, Non-Developmental Items, and Developmental Systems*. William J. Hughes Technical Center, Research Development and Human Factors Laboratory, Building 28, Atlantic City International Airport, NJ.

Federal Aviation Administration. (1992). *Transient protection, grounding, bonding and shielding requirements for electronic equipment* (FAA-STD-020B). Washington, DC: U.S. Government Printing Office.

2.1.2.2 Military

Department of Defense. (1960). *Thread Compound; Antiseize, Zinc Dust-Petrolatum*. MIL-T-22361(1). Washington, DC: U.S. Government Printing Office.

Department of Defense. (1966). *Insulating Compound, Electrical, Ceramic, Class L*. (MIL-I-10B). Washington, DC: U.S. Government Printing Office.

Department of Defense. (1983). *Sealing, Locking, and Retaining Compounds: (Single - Component)*. (MIL-S-22473E). Washington, DC: U.S. Government Printing Office.

Department of Defense. (1989). *Sealing, Lubricating, and Wicking Compounds: Thread-Locking, Anaerobic, Single-Component*. (MIL-S-46163A(2)). Washington, DC: U.S. Government Printing Office.

Department of Defense. (1995). *Department of defense standard practice for defense specifications* (MIL-STD-961D). Washington, DC: U.S. Government Printing Office.

Department of Defense. (1995). *Department of defense standard practice defense standards and handbooks* (MIL-STD-962C). Washington, DC: U.S. Government Printing Office.

Department of Defense. (1996). *Reliability testing for engineering development, qualification, and production*. (MIL-HDBK-781A). Washington, DC: U.S. Government Printing Office.

Department of Defense. (2000). *Navstar GPS Space Segment/Navigation User Interfaces* (ICD-GPS-200C with IRN-200C-004, 12 April 2000). Washington, DC: U.S. Government Printing Office.

Department of Defense. (2001). *GPS Standard Positioning Service Performance Standard*. Washington, DC: U.S. Government Printing Office.

Department of Defense. (2000). *Environmental Engineering Considerations and Laboratory Tests*. (MIL-STD-810F). Washington, DC: U.S. Government Printing Office.

Department of Defense. (1968). Military Specification Sheet(s) (MIL-I-23264). Washington, DC: U.S. Government Printing Office.

2.1.3 FAA ORDERS

Federal Aviation Administration. (2000). *General Maintenance Handbook for Airway Facilities*. FAA Order 6000.15C. Washington, DC: U.S. Government Printing Office.

2.1.4 OTHER GOVERNMENT DOCUMENTS

Federal Specification. (1967). *Plastic Sheet and Plastic Rod, Thermosetting, Cast* (L-P-516a). Washington, DC: U.S. Government Printing Office.

Federal Specification. (1971). *Sealing Compound, Pipe Joint and Thread, Lead Free General Purpose* (TT-S-1732). Washington, DC: U.S. Government Printing Office.

Federal Aviation Administration. (1989). Advisory Circular, *Airport Design*. (AC-150/5300-13) Washington, DC: U.S. Government Printing Office.

2.2 NON-GOVERNMENT DOCUMENTS

RTCA, Incorporated. (2001). *GNSS based precision approach local area augmentation system (LAAS) signal-in-space interface control document* (RTCA/DO-246C). Washington, DC: RTCA, Incorporated.

RTCA, Incorporated. (2001). *Minimum Aviation System Performance Standards for the local area augmentation system (LAAS)* (RTCA/DO-245A). Washington, DC: RTCA, Incorporated.

National Fire Protection Association. (1996). *NFPA 70, national electrical code* (1996 ed.). Quincy, MA: National Fire Protection Association.

RTCA, Incorporated. (2001). *Minimum operational performance standards for global positioning system/local area augmentation system airborne equipment* (RTCA/DO-253A). Washington, DC: RTCA, Incorporated.

RTCA, Incorporated. (2001). *Minimum operational performance standards for global positioning system/wide area augmentation system airborne equipment* (RTCA/DO-229C). Washington, DC: RTCA, Incorporated.

RTCA, Incorporated. (2002). *Guidelines for Communication Navigation Surveillance, and Air Traffic Management (CNS/ATM) Systems Software Integrity Assurance* (RTCA/DO-278). Washington, DC: RTCA, Incorporated.

RTCA, Incorporated. (2000). *Design Assurance Guidelines for Airborne Electronic Hardware* (RTCA/DO-254). Washington, DC: RTCA, Incorporated.

UL Standards. (2000). *Safety of information Technology Equipment* (UL 60950).

3 REQUIREMENTS

This section prescribes functional and performance requirements. When required to establish interoperability, specific design and/or algorithms are specified. Certain other design-specific requirements are given, as necessary, to ensure the accuracy, continuity, availability, and integrity needed to support minimum performance levels required to operate within the U.S. National Airspace System (NAS).

3.1 LGF GENERAL REQUIREMENTS

3.1.1 COVERAGE VOLUME

The approach coverage volume for a system is defined as the volume of airspace within which the system meets the VDB field strength requirements. By meeting all of the requirements in this specification, the LGF provides the accuracy, integrity, continuity, and availability necessary to support CAT I precision approach operations and RNAV operations within the coverage volume. LAAS Approach coverage shall comply with Section 2.3.2 of RTCA/DO-245A for CAT I and Missed Approach.

The LGF provides the level of service necessary to support CAT I and meets the integrity to support terminal area operations. The VDB, an omni-directional signal, accommodates terminal and surface navigation, surveillance, and other users requiring Differentially Corrected Positioning Service information. However, the use of VDB may be impacted by the existence of terrain or obstacles on or around the airport.

3.1.1.1 VDB Coverage Volume

3.1.1.1.1 Minimum Field Strength

The LGF shall meet the minimum field-strength requirements, as defined in Section 2.1.3 of RTCA/DO-246C, using a single VDB antenna with a phase center height no higher than 25 ft. above the ground plane. The LGF shall meet these minimum field-strength requirements (1) when there is no blockage of line-of-sight due to local terrain or obstacles, and (2) within the following minimum coverage volume:

a. Laterally:
   1. Encompassing 360° around the VDB antenna,
   2. Beginning at 100 m, and
   3. Extending to 23 nm,
b. Vertically, within the lateral region:
   1. Within 1.5 nm of the VDB antenna, between the horizontal plane 8 ft above the ground at the antenna and a conical surface inclined at not less than 85° above the horizontal plane, up to a height of 10,000 ft, and
   2. From 1.5 nm to 23 nm, between 10,000 ft AGL and a conical surface that is inclined at 0.9° above the horizontal plane with an origin 137 ft below the ground at the antenna.

3.1.1.1.2 Maximum Field Strength

The LGF shall not exceed the maximum field strength requirements, as defined in Section 2.1.3 of RTCA/DO-246C, in any direction, beginning at 200 m from the VDB antenna within the coverage volume specified in Section 3.1.1.1.1. The LGF shall meet these maximum field strength requirements when (1) there is no blockage of line-of-sight due to local terrain or obstacles, and (2) the on-channel power is set to the upper alarm limit.

Figure 3-1 depicts a representation of the VDB coverage volume.

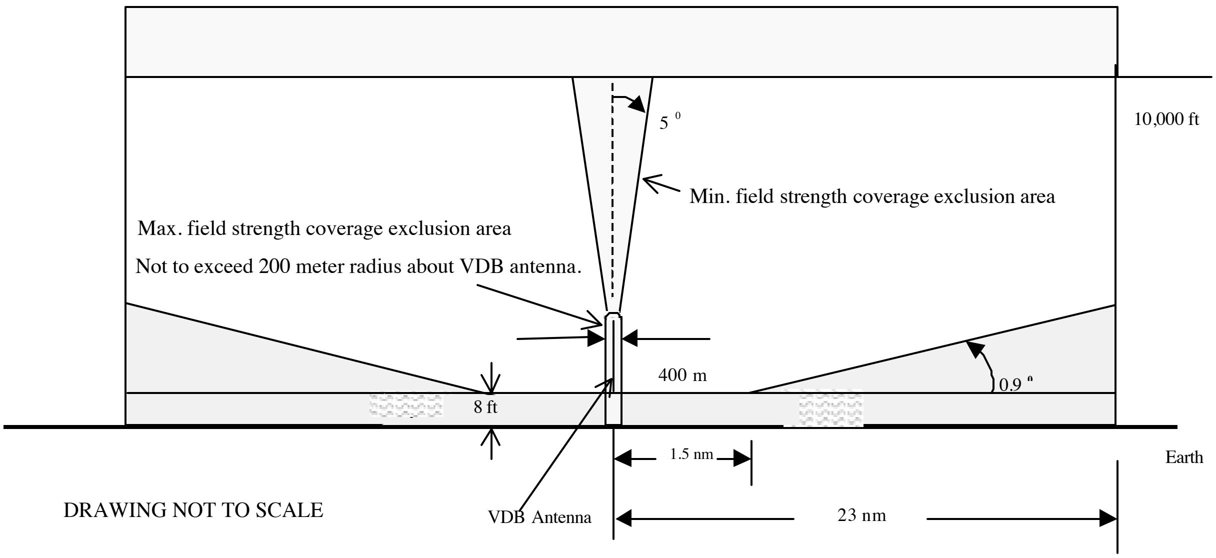

Figure 3-1. VDB Coverage Volume

3.1.2 INTEGRITY

The LGF is required to meet the integrity to support Category I precision approach, area navigation, and other operations that use differentially corrected positioning service. Some of the integrity allocations have different requirements for the operations and are specified separately in the subsections below.

3.1.2.1 LGF Integrity Risk

3.1.2.1.1 Category I Precision Approach

The probability that the LGF transmits out-of-tolerance precision approach information for 3 seconds or longer due to a ranging source failure, LGF failure, anomalous environmental or atmospheric effects, when operating within the Radio Frequency Interference (RFI) environment defined in appendix D of RTCA/DO-253A, shall not exceed 1.5×10^{-7} during any 150-second approach interval. Out-of-tolerance precision approach information is defined as broadcast data that results in a position error exceeding the Category I precision approach protection level and ephemeris error bound for any user that complies with RTCA/DO-253A and is located anywhere within D_{max}. Ranging source failures, as described in Appendix E, shall include:

a. Signal deformation, with a failure rate of 1.0×10^{-4} per hour per satellite during initial acquisition, and a prior probability of 4.2×10^{-6} per approach per satellite after acquisition;

b. Signal levels below those specified in Sections 3.3.1.6 and 6.3.1 of ICD-GPS-200C, for C/A code on L1 only, with a failure rate of 1.0 x 10^{-4} per hour per satellite during initial acquisition, and a prior probability of 4.2 x 10^{-6} per approach per satellite after acquisition;
c. Code/carrier divergence, with a failure rate of 1.0 x 10^{-4} per hour per satellite during initial acquisition, and a prior probability 4.2 x 10^{-6} per approach per satellite after acquisition;
d. Excessive pseudorange acceleration, such as step or other rapid change, with a failure rate of 1.0 x 10^{-4} per hour per satellite during initial acquisition, and a prior probability of 4.2 x 10^{-6} per approach per satellite after acquisition; or
e. Erroneous broadcast of GPS ephemeris data, with a failure rate of 1.0 x 10^{-4} per hour per satellite during initial acquisition, and a prior probability of 4.2 x 10^{-6} per approach per satellite after acquisition.

The LGF failures shall include the broadcast of erroneous data, or that one or more failures exist that affect the smoothed pseudorange corrections (PR_{sca}) from more than one Reference Receiver (RR). Erroneous data is defined to be any broadcast parameter that is not computed and broadcast in accordance with Section 3.2.1.

3.1.2.1.2 Differentially Corrected Positioning Service

The probability that the LGF transmits out-of-tolerance differentially corrected positioning information for 3 seconds or longer due to a ranging source failure, LGF failure, anomalous environmental or atmospheric effects, when operating within the Radio Frequency Interference (RFI) environment defined in appendix D of RTCA/DO-253A, shall not exceed 9.9x10^{-8} during any 1 hour period. Out-of-tolerance differentially corrected positioning information is defined as broadcast data that results in a position error exceeding the horizontal protection level and horizontal ephemeris error bound for any user that complies with RTCA/DO-253A and is located anywhere within D_{max}. Ranging source failures, as described in Appendix E, shall include:

a. Signal deformation, with a failure rate of 1 x 10^{-4} per hour per satellite;
b. Signal levels below those specified in Sections 3.3.1.6 and 6.3.1 of ICD-GPS-200C, for C/A code on L1 only, with a failure rate of 1 x 10^{-4} per hour per satellite;
c. Code/carrier divergence, with a failure rate of 1 x 10^{-4} per hour per satellite;
d. Excessive pseudorange acceleration, such as a step or other rapid change, with a failure rate of 1 x 10^{-4} per hour per satellite; or
e. Erroneous broadcast of GPS ephemeris data, with a failure rate of 1 x 10^{-4} per hour per satellite.

The LGF failures shall include the broadcast of erroneous data, or that one or more failures exist that affect the smoothed pseudorange corrections (PR_{sca}) from more than one Reference Receiver (RR). Erroneous data is defined to be any broadcast parameter that is not computed and broadcast in accordance with Section 3.2.1.

3.1.2.2 Protection Level Integrity Risk

In conforming to the integrity risk assigned to the LGF, the broadcast integrity parameters (B-values Section 3.2.1.2.8.8, σ_{pr_gnd} Section 3.2.1.2.8.7, $\sigma_{vert\_iono\_gradient}$ Section 3.2.1.3.5, P-value

Section 3.2.1.2.7, K-values Section 3.2.1.3.12, Refractivity Index Section 3.2.1.3.6, Scale Height Section 3.2.1.3.7, and Refractivity Uncertainty Section 3.2.1.3.8) shall be defined to ensure proper operation under fault-free conditions (both system and local environment).

3.1.2.2.1 Category I Precision Approach

When the LGF is not broadcasting erroneous data and no failures exist that would affect the smoothed pseudorange corrections (PR_{sca}) from more than one RR, the probability that the LGF transmits out-of-tolerance precision approach information for 3 seconds or longer when operating within the Radio Frequency Interference (RFI) environment defined in appendix D of RTCA/DO-253A, shall not exceed $5x10^{-8}$ during any 150-second approach interval.

3.1.2.2.2 Differentially Corrected Positioning Service

When the LGF is not broadcasting erroneous data and no failures exist that would affect the smoothed pseudorange corrections (PR_{sca}) from more than one RR, the probability that the LGF transmits out-of-tolerance differentially corrected positioning information for 3 seconds or longer when operating within the Radio Frequency Interference (RFI) environment defined in appendix D of RTCA/DO-253A, shall not exceed $1x10^{-9}$ in any 1 hour interval.

3.1.2.3 Integrity in the Presence of Excessive Radio Frequency Interference (RFI)

The probability that the LGF, in the presence of RFI that exceeds the levels in appendix D of RTCA/DO-253A, broadcasts data that result in a position error exceeding the H_0 protection level for 3 seconds or longer (assuming use of all satellites for which the LGF provides corrections), for any user that complies with RTCA/DO-253A, shall not exceed 1×10^{-3} for any 150 sec approach interval.

3.1.3 CONTINUITY

3.1.3.1 VDB Transmission Continuity

The probability of an unscheduled interruption of the VDB transmission, where messages are not transmitted in accordance with Section 3.2.2 for a period equal to or greater than 3 seconds, shall not exceed $1x10^{-6}$ in any 15-second interval.

3.1.3.2 Reference Receiver and Ground Integrity Monitoring Continuity

The probability that the number of valid B-values is reduced below three (3) for any valid ranging source within the reception mask (Section 3.2.1.2.6.1) shall not exceed $2.3x10^{-6}$ in any 15-second interval.

3.1.4 STATES AND MODES

3.1.4.1 States

The LGF shall have the following two states:

a. LGF On: Main or supplemental power is applied to the LGF equipment, and
b. LGF Off: No power is applied to the LGF equipment.

Only one state shall exist at a time.

3.1.4.2 Modes

The LGF shall have the following modes while in the On State:

a. Normal,
b. Not Available, and
c. Test.

There are no modes when the LGF is in the Off State.

Only one mode shall exist at a time. The LGF shall automatically transition from Normal to Not Available when there is an alarm condition.

3.1.5 EXECUTIVE MONITORING

3.1.5.1 Fault Monitoring

The LGF shall take the identified action for each fault condition identified in Table 3-1 and Table 3-2.

Table 3-1. Fault Conditions and Actions

Section	Fault	Action
	Ranging Source	
3.1.2.1.1(a)/ 3.1.2.1.2 (a)	Signal Deformation	Exclude Ranging Source Measurement Block from Type 1 Message Broadcast and the clock correction (S_c).
3.1.2.1.1(b)/ 3.1.2.1.2 (b)	Low Signal Power	Exclude Ranging Source Measurement Block from Type 1 Message Broadcast and the clock correction (S_c).
3.1.2.1.1(c)/ 3.1.2.1.2 (c)	Code/Carrier Divergence	Exclude Ranging Source Measurement Block from Type 1 Message Broadcast and the clock correction (S_c).
3.1.2.1.1(d)/ 3.1.2.1.2 (d)	Excessive Acceleration	Exclude Ranging Source Measurement Block from Type 1 Message Broadcast and the clock correction (S_c).
3.1.2.1.1(e)/ 3.1.2.1.2 (e)	Erroneous Ephemeris	Exclude Ranging Source Measurement Block from Type 1 Message Broadcast and the clock correction (S_c).
3.2.1.2.8.3.3	Invalid GPS C/A Code	Exclude Ranging Source Measurement Block from Type 1 Message Broadcast and the clock correction (S_c).
	Corrections	
3.2.1.2.8.7	Filters not converged	Exclude PR_{mn}[1] from PRC and B-value calculation, exclude ranging source from Type 1 Message broadcast.
3.2.1.2.8.8.1	B-value exceeds limit	Exclude PR_{mn}[1] from PRC and B-value calculation.
3.2.1.2.8.5.6.1	Pseudorange correction exceeds limit	Exclude ranging source from Type 1 Message broadcast.
3.2.1.2.8.5.6.1	Navigation data inconsistent between RRs	Exclude ranging source from Type 1 Message broadcast.
3.2.1.2.8.6.1	Range Rate Correction (RRC) exceeds limit	Exclude ranging source from Type 1 Message broadcast.
3.2.1.2.8.7.3	Faulted σ_{pr_gnd}	Exclude PR_{mn}[1] from PRC and B-value calculation, exclude ranging source from Type 1 Message broadcast, or exclude all RR measurements from PRC and B-value calculation.
3.2.1.3.5.1	Faulted $\sigma_{vert\_iono\_gradient}$	Exclude ranging source from Type 1 Message broadcast, or exclude all RR measurements from PRC and B-value calculation.
	RFI	
3.1.2.3	Excessive RFI	Exclude affected measurements from calculations and/or Type 1 Message Broadcast, as appropriate.
	Data Broadcast	
3.2.3 (a)	Disagreement between transmitted data	Terminate VDB output.
3.2.3 (b)	On-channel assigned power exceeds limits	Terminate VDB output.
3.2.3 (c)	No transmission for 3 seconds	Terminate VDB output.
3.2.3 (d)	Transmitted data outside of assigned Time Division Multiple Access (TDMA) time slots	Terminate VDB output.

[1] *Pseudorange (PR), where m indicates an individual RR and n indicates an individual ranging source.*

Table 3-2. Valid GPS and SBAS Navigation Data

Section	Fault	Action
3.2.1.2.8.3.1:		
(a)	Failed parity	Exclude GPS ranging source from Type 1 Message broadcast
(b)	Bad IODC	Exclude GPS ranging source from Type 1 Message broadcast
(c)	HOW bit 18 set to “1”	Exclude GPS ranging source from Type 1 Message broadcast
(d)	Data bits in subframes 1, 2, or 3 set to “0”	Exclude GPS ranging source from Type 1 Message broadcast
(e)	Subframes 1, 2, or 3 set to default	Exclude GPS ranging source from Type 1 Message broadcast
(f)	Preamble incorrect	Exclude GPS ranging source from Type 1 Message broadcast
(g)	Almanac differs from ephemeris by more than 7000 m at any point	Exclude GPS ranging source from Type 1 Message broadcast
(h)	Ephemeris CRC changes and IODE does not	Exclude GPS ranging source from Type 1 Message broadcast
(i)	GPS PRN = 33 - 37	Exclude GPS ranging source from Type 1 Message broadcast
(j)	Satellite declared unhealthy	Exclude GPS ranging source from Type 1 Message broadcast
3.2.1.2.8.3.1	Ephemeris not consistent to within 250 m	Exclude GPS ranging source from Type 1 Message broadcast
3.2.1.2.8.3.2:		
(a)	Failed parity	Exclude SBAS ranging source from Type 1 Message broadcast
(b)	Almanac differs from ephemeris by more than 200 km at any point	Exclude SBAS ranging source from Type 1 Message broadcast
(c)	No SBAS navigation message for 4 minutes	Exclude SBAS ranging source from Type 1 Message broadcast
(d)	Receive ‘Do Not Use” SBAS message	Exclude SBAS ranging source from Type 1 Message broadcast

3.1.5.1.1 Fault Recovery

Upon exclusion of a single measurement, ranging source, or RR, the LGF shall continue to monitor the excluded single measurement, ranging source, or RR. For ranging source faults and correction faults in Table 3-1, except as noted in Section 3.2.1.2.8.7.3, the LGF shall re-introduce the excluded single measurement, ranging source, or RR when the fault no longer exists. The LGF shall use a probability of missed detection consistent with an apriori failure probability of one for excluded single measurement on a ranging source to meet LGF integrity risks in Section 3.1.2.

3.1.5.1.2 Generation of Alerts

The LGF shall generate an alert upon detecting a fault that does not affect the ability of the system to meet the integrity requirements of Section 3.1.2. Faults shall include the ranging source and correction faults identified in Table 3-1, navigation data in Table 3-2, environmental sensor conditions exceeding the limits defined in Sections 3.3.1.4.

3.1.5.1.3 Generation of Service Alerts

A service alert shall be defined as a fault that requires corrective maintenance.

3.1.5.1.3.1 Continuity Faults

A service alert shall be generated when the LGF is unable to ensure that the continuity requirements of Section 3.1.3 can be met due to a fault in either of the following items:

a. Main and standby Line Replaceable Units (LRUs), or
b. Uninterruptible power supply.

3.1.5.1.3.2 Environmental Faults

A service alert shall be generated when the thresholds for the following environmental sensors are exceeded:

a. Intrusion detector (Section 3.3.1.4.1),
b. Smoke detector (Section 3.3.1.4.2),
c. Alternating Current (AC) power (Section 3.3.1.4.3), and
d. Inside temperature (Section 3.3.1.4.4).

3.1.5.1.4 Generation of Constellation Alerts

A constellation alert shall be generated when the constellation no longer supports CAT I service, or the service is predicted to be unavailable in the next 30 minutes. The duration of the predicted outage shall be at least 15 minutes long. The predictive constellation alert shall be generated prior to the loss of service availability in accordance with the following:

a. Constellation alerts shall be based on aircraft equipage with the Aircraft Accuracy Designator stored in NVM (Section 3.3.2.2.23), the σ_{pr_gnd} achieved by the installed and operating LGF (including the number of operating RRs), and assuming the standard interference environment defined in Appendix D of RTCA/DO-253A.
b. The constellation alert shall be generated by comparing the Precision approach Protection Level equations for Hypothesis H_0 (VPL H_0 and LPL H_0) for all in view GPS and SBAS satellites, to their tightest alert limits as indicated by FASVAL and FASLAL in Section 3.3.2.2.6. Numerical values of VPL H_0 and LPL H_0 shall be generated in accordance with RTCA/DO-253A. In the numerical evaluation of VPL H_0 and LPL H_0, the LGF shall not use information or measurements from satellites that are:
    1. Flagged unhealthy in its transmitted message.
    2. Currently excluded by the LGF.
c. The constellation alert shall be generated with respect to the centroid of the reference receiver locations.
d. Constellation alert generation shall include effect of reception masking, as defined in section 3.2.1.2.6.1.

e. Constellation alert generation shall use current ephemeris for all visible satellites within the reception mask. For all satellites entering the reception mask, the most recent almanac shall be used.

3.1.5.1.5 Generation of Alarms

The LGF shall generate an alarm when the integrity requirements of Section 3.1.2 cannot be met. The LGF shall generate an alarm when the VDB monitor has detected any fault identified in Section 3.2.3. When an alarm is generated, one of the following actions is taken:

a. The LGF shall broadcast the Type 1 Message with no measurement blocks when the integrity requirements of Section 3.1.2 cannot be met.

b. When there is a fault detected in accordance with the requirements of Section 3.2.3, the LGF shall terminate the VDB output.

Alarm thresholds shall be stored in NVM, and the default thresholds shall be defined during the design process.

3.1.6 SOFTWARE DESIGN ASSURANCE

All LGF software functions shall be compliant with the guidelines and objectives of the applicable software level specified in RTCA/DO-278.

3.1.7 COMPLEX ELECTRONIC HARDWARE DESIGN ASSURANCE

Electronic hardware is complex when its normal operation has a multiplicity of states, and its design must be constrained to ensure that failures or errors in a normal operational state have a one-to-one mapping to failure conditions or failure modes. The design of complex electronic hardware devices, including Application Specific Integrated Circuits (ASIC) and Programmable Logic Devices (PLD), shall be in accordance with RTCA/DO-254. The level of design assurance required shall be based on the complexity of the device and its contribution to potential failure conditions that adversely affect the safety of the system.

The level of production process rigor associated with complex electronic hardware shall be based on the contribution of the hardware to potential failure conditions as determined by the System Safety Assessment (SSA) process.

3.2 DATA BROADCAST

3.2.1 BROADCAST DATA REQUIREMENTS

All message types shall be in accordance with Section 2.4 of RTCA/DO-246C. All static parameters to be broadcast and default values shall be stored in the LGF Non-Volatile Memory (NVM).

3.2.1.1 LAAS Message Block

The LGF shall transmit the LAAS message block. The LAAS message block consists of the Message Block Header, the Message, and the Cyclic Redundancy Check (CRC).

3.2.1.1.1 Message Block Header

3.2.1.1.1.1 Message Block Identifier

The LGF shall set the Message Block Identifier Field to 1010 1010 when the LGF is not in the Test Mode.

The LGF shall set the Message Block Identifier Field to 1111 1111 when the LGF is in the Test Mode.

3.2.1.1.1.2 Ground Station Identification

The GBAS ID Field shall denote the LGF station Identification (ID) stored in LGF NVM.

3.2.1.1.1.3 Message Type Identifier

The Message Type Identifier Field shall denote the Message Type.

3.2.1.1.1.4 Message Length

The Message Length Field shall denote the number of 8-bit words in the message block. The message length includes the header, the message, and the CRC field.

3.2.1.1.2 Cyclic Redundancy Check (CRC)

The CRC Field shall denote the CRC calculated on the message header and the message.

3.2.1.2 Type 1 Message – Differential Corrections

The LGF shall broadcast the Type 1 Message once per frame.

The LGF shall generate a ranging source measurement block for all ranging sources when available within the reception mask. The LGF shall accommodate up to 18 ranging sources.

Note: If a linked pair of the Type 1 Message is needed, guidance can be found in the SARPS Appendix B section 3.6.7.2.2.6 and 3.6.7.2.2.9.

3.2.1.2.1 Modified Z-Count

The Modified Z-count shall indicate the time of the pseudorange measurements (PR_r in Section 3.2.1.2.8.5.1) and phase measurement (ϕ in Section 3.2.1.2.8.5.1) to within 0.05 seconds. The broadcast corrections shall be broadcast within 0.5 seconds after the time indicated by the Modified Z-count corresponding to the broadcast corrections.

Note: In accordance with Section 2.4.3.2 of RTCA/DO-246C, the Modified Z-count of Type 1 Messages of a given Measurement Type shall advance every frame.

3.2.1.2.2 Additional Message Flag

The Additional Message Flag Field shall denote that additional messages are not provided.

3.2.1.2.3 Number of Measurements

The Number of Measurements Field shall denote the number of ranging source measurement blocks broadcast in the Type 1 Message.

3.2.1.2.4 Measurement Type

The Measurement Type Field shall denote the measurement type is C/A code.

3.2.1.2.5 Ephemeris CRC

The Ephemeris CRC Field shall denote the CRC for the ranging source associated with the first ranging source measurement block in the Type 1 Message.

3.2.1.2.6 Source Availability Duration

The Source Availability Duration Field shall denote the period that the ranging source is predicted to remain within the reception mask associated with the first ranging source measurement block relative to the Modified Z-count. The accuracy of the calculated Source Availability Duration shall be better than +/- 60 seconds for all source availability duration less than the maximum range of the Source Availability Duration Field.

3.2.1.2.6.1 Reception Mask

The reception mask for each RR shall define the region in which the RR can provide sufficient data to the LGF such that measurement blocks can be calculated. The reception mask shall include all elevations from 5^o to 90^o and all azimuths from 0^o to 360^o, excluding blockage of line-of-site due to any permanent obstacle. The RR antenna shall have at least 0 dBi gain at 5^o elevation and no more than –10 dBi gain at 0.5^o elevation. The antenna gain shall monotonically decrease from 5^o elevation to 0^o elevation at a rate of not less than 2dB per degree.

3.2.1.2.6.2 Azimuth/Elevation Sector Masking

The LGF shall have the capability to exclude measurements from the pseudorange correction calculation within azimuth/elevation sector(s) on a per RR basis. The resolution of the azimuth and elevation limits shall be less than 0.5 degrees.

3.2.1.2.7 Ephemeris Decorrelation Parameter (P)

The Ephemeris Decorrelation Parameter field shall characterize the impact of residual ephemeris errors due to spatial decorrelation for the ranging source, associated with the first ranging source measurement block, in the Type 1 message. For every valid GPS ranging source, the LGF shall broadcast a *P*-value to represent the impact of undetected ephemeris errors on user range error. The maximum value for *P* shall be $1.5x10^{-4}$ m/m. The LGF shall exclude any ranging source for which the *P*-value cannot be validated. The broadcast ephemeris *P*-value for a given satellite shall account for the condition where the broadcast reference point (Section 3.2.1.3.9) does not match the reference receiver centroid location.

3.2.1.2.8 Ranging Source Measurement Block

The first ranging source in the message shall sequence so that the ephemeris decorrelation parameter, the ephemeris CRC, and source availability duration for each ranging source is transmitted at least once every 10 seconds from each VDB antenna, except when new ephemeris data are received from a ranging source. When new ephemeris data are received from a ranging source, the LGF shall broadcast the new ephemeris data for that ranging source in three consecutive Type 1 Messages from each VDB antenna. When new ephemeris data are received from more than one ranging source, the first ranging source in the Type 1 Message shall sequence so that the ephemeris decorrelation parameter, the ephemeris CRC, and source availability duration for each ranging source are transmitted at least once every 27 seconds from each VDB antenna.

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

3.2.1.2.8.1 Ranging Source Identification

The Ranging Source ID Field shall denote the satellite pseudorandom number assigned to the ranging source associated with the ranging source measurement block.

3.2.1.2.8.2 Ranging Signal Sources

The LGF shall be capable of processing:

a. GPS SPS signals, as defined in the ICD-GPS-200C and the SPS Performance Standard, and

b. And optionally, SBAS signals, as defined in the Wide Area Augmentation System (WAAS) Specification (FAA-E-2892B).

3.2.1.2.8.3 Conditions for Transmitting the Ranging Source Measurement Block

The LGF shall cease broadcast of a failed ranging source measurement block within 3 seconds of the onset of the associated ranging source failures, as specified in Sections 3.1.2.1.1 and 3.1.2.1.2.

3.2.1.2.8.3.1 Valid GPS Navigation Data

The LGF shall cease broadcast of the ranging source measurement block associated with a given ranging source if:

a. Three or more parity errors have been detected from multiple receivers in the previous 6 seconds, in accordance with the parity algorithm equations defined in Section 20.3.5, 20.3.5.1, and 20.3.5.2 of ICD-GPS-200C,

b. Broadcast Issue of Data (IOD) Ephemeris (IODE) does not match eight least-significant bits of broadcast IOD Clock (IODC),

c. Bit 18 of the Hand-over-Word (HOW) is set to 1 (Section 20.3.3.2 of ICD-GPS-200C),

d. All data bits are zeros in sub-frames 1, 2, or 3,

e. Default navigation data are being transmitted in sub-frames 1, 2, or 3 (Section 20.3.2 of ICD-GPS-200C, for C/A code on L1 only),

f. The preamble does not equal 8B (hexadecimal),

g. At any time in the next 12 hours, any point on the orbit defined by the broadcast ephemeris is more than 7000 m from the orbit defined by the broadcast almanac,

h. The ephemeris CRC changes and the IODE does not,

i. The PRN is 33, 34, 35, 36, or 37, or

j. The health bits in sub-frame 1 word 3 indicate that the satellite is unhealthy.

A new ephemeris shall be compared to the previously broadcast ephemeris, if available, and is validated if the difference in satellite position is less than 250 m and none of the conditions in (a) through (j) exists. Ephemeredes shall be validated and applied within 3 minutes of receiving a new set, but not before they have been continuously present for 2 minutes.

3.2.1.2.8.3.2 Valid SBAS Navigation Data

When SBAS is available and the LGF is capable of receiving and decoding applicable signals, the LGF shall cease broadcast of the ranging source measurement block associated with a given SBAS ranging source if:

a. Three or more parity errors have been detected from multiple receivers in the previous 6 seconds, in accordance with the parity algorithm equations defined in Appendix 2, Section 4.3.3 of FAA-E-2892B,
b. The satellite position defined by the broadcast ephemeris is more than 200 km from the satellite position defined by the broadcast almanac,
c. More than 4 minutes have elapsed since reception of the SBAS Type 9 navigation message, or
d. The SBAS satellite, for which the ranging source measurement block provides a correction, broadcasts a Message Type 0 indicating “Do Not Use This SBAS Signal” within the last 60 seconds, a Message Type 2, 3, 4, 5, 6, or 24 indicating “Do Not Use This SBAS Satellite” within the last 6 seconds, or if its User Range Accuracy (URA) in Message 10 indicate "Unbounded Ranging", as defined in Section 2.1.1.4 of RTCA/DO-229C.

After confirming that none of the conditions in (a) through (d) exists, new SBAS navigation data shall be used for subsequent measurements.

Note: GPS health status is available in SBAS Message Type 2, 3, 4, 5, 6 and 24. See RTCA/DO-229C for its use and application.

3.2.1.2.8.3.3 Invalid GPS C/A Code

The LGF shall cease broadcast of the ranging source measurement block if non-standard C/A code (NSC) is transmitted for that satellite, as described in Section 3.2.1 of ICD-GPS-200C.

3.2.1.2.8.4 Issue of Data

The IOD Field shall denote the IODE for GPS associated with the ephemeris data used to determine the broadcast correction or 1111 1111 for SBAS.

3.2.1.2.8.5 Pseudorange Corrections

The Pseudorange Correction Field shall denote the broadcast pseudorange correction.

3.2.1.2.8.5.1 Smoothed Pseudorange

In steady state, each pseudorange measurement from each RR shall be smoothed using the filter

$$PR_s(k) = \left(\frac{1}{N}\right) PR_r(k) + \left(\frac{N-1}{N}\right)\left[PR_s(k-1) + \phi(k) - \phi(k-1)\right] \tag{1}$$

$$N = S / T$$

where PR_r is the raw pseudorange,
PR_s is the smoothed pseudorange,
N is the number of samples,
S is the time filter constant, equal to 100 seconds,
T is the filter sample interval, nominally equal to 0.5 seconds,
ϕ is the accumulated phase measurement,
k is the current measurement, and
$k-1$ is the previous measurement.

The raw pseudorange shall be determined under the following conditions:

a. The code loop is carrier driven and of first order, or higher, and has a one-sided noise bandwidth ≥ 0.125 Hz.
b. The strongest correlation peak is acquired.
c. The correlator spacing is 0.11 or less.

The measurements for each satellite shall be obtained from the same ephemeris data.

3.2.1.2.8.5.2 GPS Predicted Range

The predicted range to each GPS ranging source shall be computed from the corresponding RR antenna-phase center location and the validated ephemeris. The ephemeris shall be determined in accordance with Section 20.3.3.4.3 of ICD-GPS-200C.

3.2.1.2.8.5.3 SBAS Predicted Range

When LGF capability is provided for tracking SBAS signal, the predicted range to each SBAS ranging source shall be computed from the corresponding RR antenna-phase center location and the validated ephemeris. The position of the ranging source shall be determined in accordance with Section 2.1.1.4.6 of RTCA/DO-229C.

3.2.1.2.8.5.4 GPS Smoothed Pseudorange Correction

The smoothed pseudorange correction (PR_{sc}) for a GPS ranging source shall be calculated using the equation:

$$PR_{sc}(n,m) = R(n,m) - PR_s(n,m) - t_{sv\_gps}(n) \qquad (2)$$

where R is the predicted range;
n is the satellite index;
m is the RR index;
$t_{sv\_gps}(n)$ is the correction due to the satellite clock from the decoded GPS Navigation Data in accordance with Sections 3.3.1.7 and 20.3.3.3.1.9, and algorithms given in Section 20.3.3.3.3 of ICD-GPS-200C, for C/A code on L1 only.

Ionospheric and tropospheric corrections shall not be applied to the smoothed pseudorange correction.

3.2.1.2.8.5.5 SBAS Smoothed Pseudorange Correction

When LGF capability is provided for tracking SBAS signal, the smoothed pseudorange correction (PR_{sc}) for an SBAS ranging source shall be calculated using the equation:

$$PR_{sc}(n,m) = R(n,m) - PR_s(n,m) - t_{sv\_sbas}(n) \quad (3)$$

where $t_{sv\_sbas}(n)$ is the correction due to the satellite clock from the decoded WAAS Navigation Data Message Type 9 in accordance with the algorithm given in Section 2.1.1.4.6 of RTCA/DO-229C.

3.2.1.2.8.5.6 Broadcast Correction

The broadcast correction shall be calculated using the equations:

$$PR_{corr}(n) \equiv \frac{1}{M(n)} \sum_{m \in S_n} PR_{sca}(n,m) \quad \text{and} \quad (4)$$

$$PR_{sca}(n,m) \equiv PR_{sc}(n,m) - \frac{1}{N_c} \sum_{n \in S_c} PR_{sc}(n,m) \quad (5)$$

where: PR_{corr} is the broadcast correction,

$M(n)$ is the number of elements in set S_n,

PR_{sca} is the carrier smoothed and receiver clock adjusted pseudorange correction,

S_n is the set of RRs with valid measurements for satellite n,

S_c is the set of valid ranging sources tracked by all RRs, and

N_c is the number of elements in set S_c;

given the following conditions:

a. If N_c is less than four, a constellation alert shall be generated in accordance with 3.1.5.1.4. If N_c is predicted to be greater than four and more than two ranging sources are determined to be faulted by the LGF, resulting in N_c less than four, an alarm shall be generated in accordance with 3.1.5.1.5.

b. Each RR measurement (n, m) used to determine the broadcast corrections shall be updated at no less than a 2 Hz rate.

3.2.1.2.8.5.6.1 Conditions for Broadcast Corrections

The LGF shall cease broadcast of the ranging source measurement block if the magnitude of the pseudorange correction exceeds a threshold. The default value of this threshold shall be field selectable. The LGF shall cease broadcast of the ranging source measurement block unless the pseudorange correction is computed using identical valid navigation data (Sections 3.2.1.2.8.3.1 and 3.2.1.2.8.3.2) decoded from the reference receivers.

3.2.1.2.8.6 Range Rate Correction (RRC)

The Range Rate Correction Field shall indicate the rate of change of the pseudorange correction, defined to be RRC_{corr}, based on the difference between the current and immediately prior averaged corrections as defined in Section 3.2.1.2.8.5.6, but replacing S_c (and related terms) using the set of valid ranging sources tracked by all RRs for both epochs.

3.2.1.2.8.6.1 Condition for Valid RRC

The LGF shall cease broadcast of the ranging source measurement block if the RRC exceeds +/- 3.4 meters per second.

3.2.1.2.8.7 Sigma Pseudorange Ground

The broadcast σ_{pr_gnd} for each ranging source shall account for all equipment and environmental effects, including the received signal power, the local interference environment, and any transient error in smoothing filter output, relative to steady-state, caused by ionospheric divergence. The code-carrier divergence rate can be assumed to be represented by a Normal distribution with zero mean and a standard deviation of 0.018 m/s. The broadcast σ_{pr_gnd} shall be such that the LAAS service availability, as defined in Section 2.3.3.2 of RTCA/DO-245A, for a nominal 24 satellite constellation described in the GPS Standard Positioning Service Performance Standards, must be at least 0.99.

3.2.1.2.8.7.1 GPS Sigma Pseudorange Accuracy

In the standard interference environment defined in Appendix D of RTCA/DO-253A, the ground subsystem contribution to the corrected pseudorange accuracy of the LGF shall be such that the root-mean-square (RMS) (1 sigma) satisfies the following inequality:

$$RMS_{pr\_error}(\theta_n) \le \sqrt{\left(\frac{a_0 + a_1 e^{-\theta_n/\theta_0}}{M(n)}\right)^2 + (a_2)^2} \qquad (6)$$

where θ_n is the n[th] ranging source elevation angle, a_0, a_1, a_2, and θ_0 are the coefficients for the applicable Accuracy Designator defined in Table 3-3.

Table 3-3. GPS Accuracy Designator C Coefficients

Accuracy Designator C	a_0 meters	a_1 meters	a_2 meters	θ_0 degrees
$\theta_n \geq 35°$	0.15	0.84	0.04	15.5
$\theta_n < 35°$	0.24	0	0.04	-

The accuracy requirement shall be met for a satellite at any azimuth or elevation in the reception mask given in Section 3.2.1.2.6.1. The accuracy requirement shall be met at the Reference Receiver Centroid.

3.2.1.2.8.7.2 SBAS Sigma Pseudorange Accuracy

When LGF capability is provided for tracking SBAS signal, the ground subsystem contribution to the corrected pseudorange accuracy of the LGF shall be such that:

$$RMS_{pr\_error} \leq \frac{1.8}{\sqrt{M(n)}} \qquad (7)$$

The accuracy requirement shall be met for a satellite at any azimuth or elevation in the reception mask given in Section 3.2.1.2.6.1. The accuracy requirement shall be met at the Reference Receiver Centroid and at the minimum SBAS signal strength defined in Appendix 2, Section 2.6.5 of FAA-E-2892B and the standard interference environment defined in appendix D of RTCA/DO-253A.

Note: In cases of dual antennas, the phase-center height of the higher element shall be used.

3.2.1.2.8.7.3 Condition for Valid Sigma Pseudorange Ground

The LGF shall detect conditions relating to the broadcast Sigma Pseudorange Ground that result in noncompliance with the results in Sections 3.1.2.1 and 3.1.2.2. When the increase in system risk associated with degraded performance is minimal (is no greater than one order of magnitude), but exceeds design tolerances, the LGF shall initiate a service alert. The threshold shall be adjustable, with a default value set to achieve a nominal false alert rate of 1x 10^{-6} per 15-second interval. When the increase in system risk is not minimal, the LGF shall exclude the offending RR or generate an alarm, as appropriate, and the alarm threshold shall be adjustable. A service alert shall be issued when a RR is excluded except when a single RR remains, at which time an alarm shall be issued. Self-recovery shall not be applied in either case. Automatic restart shall not be attempted when an alarm condition exists when system risk is not minimal. The rate of false RR exclusion or alarm shall be less than 1 x 10^{-7} per 15-second interval.

3.2.1.2.8.8 B-Values

The B-Value Field shall denote the B-value calculated using the equation:

$$B_{PR}(n,m) \equiv PR_{corr}(n) - \frac{1}{M(n)-1}\sum_{\substack{i \in S_n \\ i \neq m}} PR_{sca}(n,i) \qquad (8)$$

where $B_{PR}(n,m)$ is the estimate of the error contribution from RR m.

3.2.1.2.8.8.1 Conditions for Broadcast

The LGF shall indicate the reference receiver measurement is invalid in the B_{PR} field for any measurement whose $B_{PR}(n,m)$ exceeds:

$$\frac{K_{B\_PR}\sigma_{pr\_gnd}(\theta_n)}{\sqrt{M(n)-1}} \qquad (9)$$

for GPS and SBAS ranging sources.

Where K_{B_PR} is the PR B-value threshold, K_{B_PR} shall:

a. Be configurable, and

b. Have a minimum configurable value of 5 and a maximum configurable value of 6.

3.2.1.3 Type 2 Message – Differential Reference Point

The LGF shall broadcast the Type 2 Message at least once every 20 consecutive frames. The LGF shall broadcast the Type 2 Message a maximum of once per frame.

3.2.1.3.1 Ground Station Installed Receivers

The Ground Station Installed Receivers Field shall denote the number of installed reference receivers stored in LGF NVM.

3.2.1.3.2 Ground Station Accuracy Designator

The Ground Station Accuracy Designator Field shall denote the accuracy designator stored in LGF NVM.

Note: This designator is determined at the time of installation depending on siting conditions.

3.2.1.3.3 Continuity and Integrity Designator

The LGF Ground Continuity and Integrity Designator (GCID) Field shall denote the LGF GCID. The LGF GCID value shall be 1 when no alarm exists. The LGF GCID value shall be seven (7) when an alarm exists.

3.2.1.3.4 Local Magnetic Variation

The Local Magnetic Variation Field shall denote the local magnetic variation stored in LGF NVM.

3.2.1.3.5 Sigma Ionosphere

The Sigma Vertical Ionosphere Gradient Field shall denote the value stored in LGF NVM.

3.2.1.3.5.1 Condition for Valid Sigma Ionosphere

The LGF shall detect Ionospheric conditions that result in noncompliance with the requirements in Sections 3.1.2.1 and 3.1.2.2. When the increase in system risk associated with increased ionosphere gradients exceeds design tolerances, the LGF shall exclude the offending ranging source(s) and generate alerts as appropriate. When ionospheric disturbances cannot be isolated to specific ranging sources, and system risk is not minimal (increases by more than one order of magnitude) as a result, the LGF shall generate an alarm. Self-recovery shall be accomplished after ranging source exclusions or alarms are generated once the integrity requirements in Sections 3.1.2.1 and 3.1.2.2 are again met. The probability of a false alarm shall be less than 5×10^{-8} per 15-second interval.

Note: The sigma ionosphere vertical gradient term must be valid for all users within D_{max} from the LGF reference point, as identified in Section 3.1.2.

3.2.1.3.6 Refractivity Index

The Refractivity Index Field shall denote the refractivity index stored in LGF NVM.

3.2.1.3.7 Scale Height

The Scale Height Field shall denote the scale height stored in LGF NVM.

3.2.1.3.8 Refractivity Uncertainty

The Refractivity Uncertainty Field shall denote the refractivity uncertainty stored in LGF NVM.

3.2.1.3.9 Reference Point

3.2.1.3.9.1 Latitude

The Latitude Field shall denote the LGF reference point latitude stored in LGF NVM.

3.2.1.3.9.2 Longitude

The Longitude Field shall denote the LGF reference point longitude stored in LGF NVM.

3.2.1.3.9.3 Reference Point Height

The Reference Point Height Field shall denote the LGF reference point height above the WGS-84 ellipsoid stored in LGF NVM.

3.2.1.3.10 Reference Station Data Selector (RSDS)

The Reference Station Data Selector field shall denote the LGF RSDS stored in LGF NVM.

3.2.1.3.11 Maximum Use Distance (D_{max})

The Maximum Use Distance field shall denote the LGF Maximum Use Distance stored in LGF NVM. The Maximum Use Distance shall be a minimum of 23 nmi measured from the centroid of the reference receivers.

Note: The value of D_{max} is determined depending on the operational needs and supporting analysis that ensures integrity is met.

3.2.1.3.12 Ephemeris Fault-Free Missed Detection Parameters

3.2.1.3.12.1 $K_{md\_e\_POS,\ GPS}$

The $K_{md\_e\_POS,\ GPS}$ field shall denote the ephemeris fault-free missed detection parameter for the GPS Differential Positioning Service stored in LGF NVM.

3.2.1.3.12.2 $K_{md\_e\_CAT\ I,\ GPS}$

The $K_{md\_e\_CAT\ I,\ GPS}$ field shall denote the ephemeris fault-free missed detection parameter for the GPS Category I Precision Approach stored in LGF NVM.

3.2.1.3.12.3 $K_{md\_e\_POS,\ GLONASS}$

The $K_{md\_e\_POS,\ GLONASS}$ field shall denote that this parameter is not used.

3.2.1.3.12.4 $K_{md\_e\_CAT\ I,\ GLONASS}$

The $K_{md\_e\_CAT\ I,\ GLONASS}$ field shall denote that this parameter is not used.

3.2.1.4 Type 4 Message – Final Approach Segment Data

The LGF shall broadcast each FAS data block at least once every 20 consecutive frames from each VDB antenna. The LGF shall broadcast each FAS data block a maximum of once per frame including transmissions from all VDB antennas.

3.2.1.4.1 Data Set Length

The Data Set Length Field shall denote the Type 4 Message data set length, which indicates the number of bytes in the data set.

3.2.1.4.2 FAS Data Block

The Type 4 Message shall denote the FAS data block for each runway approach served by the LGF as stored in NVM. The FAS data block shall conform to section 2.4.6.3 of RTCA/DO-246C.

When the LGF capability exists to support TAP, all broadcast data shall conform to section 2.4.6.3 of RTCA/DO-246C.

Note: Additional conditions for TAP can be found in Section 3.2.5.4.3 and 3.3.2.5.3 of RTCA/DO-245A.

3.2.1.4.3 FAS VAL/Approach Status

The FAS VAL/Approach Status Field shall denote the FAS VAL or “Do Not Use Vertical” coding as stored in the LGF NVM. The maximum value in the FAS VAL field shall be 10 meters.

3.2.1.4.3.1 TAP VAL

The TAP VAL field shall denote the TAP VAL or “Do Not Use Vertical” coding as stored in the LGF NVM.

3.2.1.4.4 FAS LAL/Approach Status

The FAS LAL/Approach Status Field shall denote the FAS LAL or “Do Not Use Approach” coding as stored in the LGF NVM. The maximum value in the FAS LAL field shall be 40 meters.

3.2.1.4.4.1 TAP LAL

The TAP LAL field shall denote the TAP LAL or “Do Not Use Vertical” coding as stored in the LGF NVM.

3.2.2 RADIO FREQUENCY TRANSMISSION CHARACTERISTICS

The LGF VDB shall be designed in conformance with section 2.1, 2.2, and 2.3 of RTCA/DO-246C.

3.2.2.1 Signal Polarization

The LGF shall be able to broadcast either an elliptically polarized (EPOL) signal or a horizontally polarized (HPOL) signal. The option to transmit either an EPOL or HPOL signal shall be selected by changing only the antenna and power setting.

Note: An elliptically polarized signal should be broadcast whenever possible.

3.2.3 RADIO FREQUENCY BROADCAST MONITORING

The data broadcast transmissions from each VDB antenna shall be monitored. The transmission of the data from a single VDB antenna shall cease within 0.5 seconds when any of the following conditions exist:

a. Continuous disagreement for any 3 second period between the transmitted application data and the application data derived or stored by the monitoring system prior to transmission,
b. A transmitted power increase of more than 3 dB from the on-channel assigned power for 1 second. The probability that the transmitted power is increased more than 3 dB for 1 second shall be less than 2.0 x 10^{-7} in any 30-second period,
c. No transmission for 3 seconds, or
d. Any transmitted data outside of the assigned TDMA time slots for 1 second in excess of the limit defined in 3.2.2.6.1. The risk that the LGF transmits a signal in an unassigned slot and fails to detect an out-of-slot transmission, within 1 second, shall be less than 1.0 x 10^{-7} in any 30-second period.

Conditions (a) through (d) include the time to switch to redundant equipment, if available.

3.3 OPERATION AND MAINTENANCE

Operations and maintenance functions are provided via internal and external LGF components. These components include:

a. LSP (internal),
b. MDT (internal),
c. ATSU (external),
d. LGF Built-in-Test (BIT) (internal),
e. Recording (internal, Sections 3.3.3.1), and
f. Recording (external, Sections 3.3.3.3).
g. RIMS (external)

Figure 3-2 provides a high-level diagram depicting the functional relationship between the LGF and Operations and Maintenance.

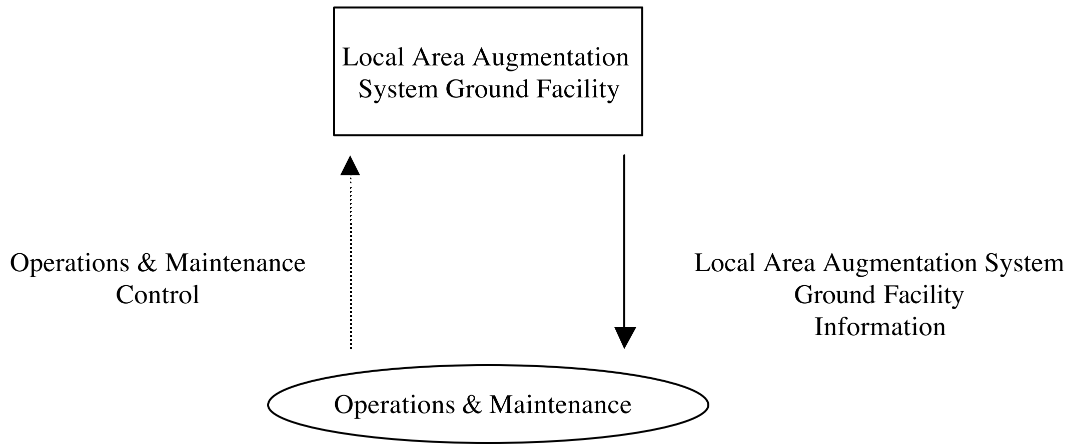

Figure 3-2. Operations and Maintenance

Figure 3-3 depicts the internal and external interfaces of the LGF.

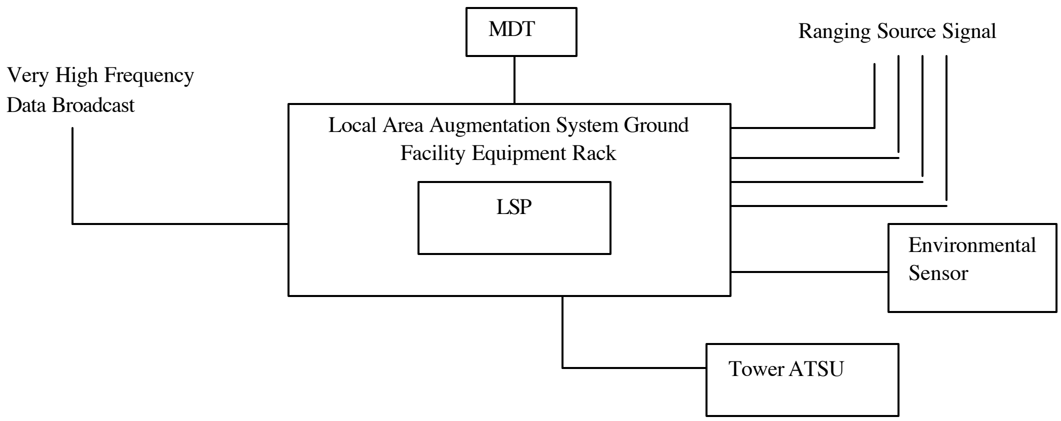

Figure 3-3. Local Area Augmentation System Ground Facility Interfaces

3.3.1 SYSTEM REQUIREMENTS

When establishing general and detailed design criteria, elements affecting safety shall be engineered with consideration given to human factors. All system components shall be designed in accordance with Human Factors guidelines, defined in Section 3.3.6 of FAA-G-2100G and Sections 4, 6, 7, 8, and 12 of the Human Factors Design Standard. In the event of a conflict within these documents, the Human Factors Design Standard shall take precedence.

3.3.1.1 LGF Configuration

3.3.1.1.1 Standard LGF Equipment Configuration

The LGF shall be configured such that:

a. There are four (4) RR/RR-antenna pairs.

b. The LGF correction processors, integrity monitor processors, power supplies, back-up power source, LSP, and all other equipment are housed in the primary equipment shelter.

c. Equipment listed in (c) fits in standard 19 in. racks.

d. There is one Air Traffic Status Unit (ATSU) that indicates constellation alert or LGF mode.

e. There is one (1) MDT.

3.3.1.1.2 Additional VDB Subsystems

Note: If Additional VDB Subsystems are needed, guidance can be found in the SARPS 3.7.3.5.4 or 3.7.3.5.4.2

3.3.1.2 Primary Power

The LGF shall operate from a nominal 120 volt, 60 Hz, three wire, single-phase AC power source.

3.3.1.3 Supplementary Power

The LGF shall include an uninterruptible supplementary power source. The supplementary power source shall continuously power the LGF for a period of not less than four hours after a loss of primary power under nominal conditions. Nominal conditions are defined to be a room temperature of 30° C and a Voltage Standing Wave Ratio (VSWR) of 1.5:1. The LGF shall provide status and health data for the supplementary power.

3.3.1.3.1 Power Supply

The LGF shall automatically sense when the supplementary power discharge point is reached. When operating on supplementary power, the LGF shall initiate facility shutdown if a critical discharge point is met. Upon restoration of primary power, the LGF shall self-restore to operate on primary power. To maintain the supplementary power in operational readiness, a trickle charge shall be supplied to recharge the supplementary power during the period of available primary power. Upon loss and subsequent restoration of primary power, the LGF supplementary power shall restore to a full charge condition from a 50% discharge condition within 8 hours. The LGF shall continue at the same level of service upon restoration of primary power.

3.3.1.4 Environmental Sensors

The LGF design shall include an:

a. Intrusion detector sensor,
b. Smoke detector sensor,
c. AC power sensor,
d. Inside temperature sensor, and

The environmental sensor output shall be processed by the LGF and retrievable by the MDT. The LGF shall be capable of bypassing any sensor that is not used.

3.3.1.4.1 Intrusion Detector

The intrusion detector shall detect when the LGF shelter door has been open for any period greater than 0.50 seconds. The LGF shall generate a service alert message if valid log-on ID and password entries are not received within 5 minutes of detecting an open shelter door. Upon command, the LGF shall arm and bypass the intrusion detector through the MDT.

3.3.1.4.2 Smoke Detector

The smoke detector shall be an ionization-type smoke detector. The smoke detector shall meet the requirements of Underwriters Laboratories (UL), Inc. Standard 268. The smoke detector shall bear the UL, Inc. label. The LGF shall generate a service alert upon detection of combustion products.

3.3.1.4.3 AC Power

The AC power sensor shall detect the presence of primary AC power. The LGF shall generate a service alert when a loss of AC power is detected. The LGF shall generate a service alert when the AC power sensor detects the absence of acceptable primary AC power.

3.3.1.4.4 Inside Temperature

The inside temperature sensor shall provide the temperature inside the LGF equipment shelter to the LGF, with a minimum resolution of one-degree centigrade. The accuracy over the range of -10° to +50° centigrade shall be ± 5° centigrade without calibration. The LGF shall generate an alert when the temperature has exceeded the alert thresholds. The LGF shall generate a service alert message when the upper and lower temperature design thresholds are exceeded.

3.3.1.5 Fault Diagnostics, Built-in-Test, and Isolation Procedures

The LGF shall perform fault diagnosis to the LRU level. The resulting data shall be stored in memory until manually cleared via the MDT. Stored data shall be accessible via the MDT. Manually initiated diagnostics shall be available from the MDT.

3.3.1.6 Reliability, Maintainability, and Availability of LGF Equipment

3.3.1.6.1 Reliability

The Mean Time Between Failures (MTBF) for the LGF shall be at least 2190 hours. A failure resulting in a service alert as defined in Section 3.1.5.1.3.1, or an alarm as defined in Section 3.1.5.1.5, shall contribute to the MTBF.

3.3.1.6.2 Maintainability

3.3.1.6.2.1 Mean Time To Repair (MTTR)

The Mean-Time-to-Repair (MTTR) shall be less than 30 minutes.

a. Diagnostic time,
b. Removal of the failed LRU,
c. Installation of the new LRU,
d. Initialization of the new LRU, and
e. All adjustments required to return the LGF to the Normal Mode.

3.3.1.7 Security

The LGF shall provide secure user access (remote and MDT) and shall be in accordance with current National Institute of Standards and Technology (NIST) standards or equivalent standard.

3.3.1.7.1 Access Control

3.3.1.7.1.1 Access Levels

Logical user access levels shall consist of the following:

a. Access Level 1: General Use/System Monitoring (RIMS) – Read Only,
b. Access Level 2: Air traffic Specialist – Modify runway operational parameters,
c. Access Level 3: Remote Certified Maintenance Specialist – Modify configuration parameters,

d. Access Level 4: Local Certified Maintenance Specialist – Modify operational states and modes, modify runway operational parameters, and

e. Access Level 5: System Administrator – Add, Change, Delete User ID, Password, and Access Level; Audit Log File Processes.

3.3.1.7.2 Security Management

3.3.1.7.2.1 System Identification

The LGF shall display a warning banner to each user before logon. The warning banner shall be stored in NVM and shall only be accessible to the Systems Administrator for maintenance purposes.

3.3.1.7.3 Accountability and Traceability

3.3.1.7.3.1 Audit Log File Recording

The system shall have an audit log file as part of the system events recording function (Section 3.3.3.1). The log file shall only be written to by the secure portion of the operating system and shall be protected against deletion and modification. All system administration functions and security-relevant activities, including logon and logoff, and user identifier and authentication maintenance, performed by any user, both successful and unsuccessful, shall be logged in the audit log file. The logged data shall include user identifier, timestamp and other data as necessary to support individual accountability and detection and response to insecurity.

3.3.1.7.3.2 Audit Log File Maintenance

The audit log file shall be developed in such a way that data analysis and reduction may be performed by the System Administrator through a commercially available software tool. The System Administrator shall only be able to delete the log file after a successful archival procedure.

3.3.1.7.3.3 Audit Log File Archive

The system shall allow for the System Administrator to specify the period of time between audit log file archiving. The audit log file archiving process shall provide for unattended logging for a period of up to 90 days. The system shall maintain audit log files for a period of 90 days.

3.3.1.8 Physical Design for Certification

The LGF and the status and control subsystem-component equipment shall facilitate the accomplishment of all maintenance and certification procedures through the physical design of the equipment.

3.3.1.8.1 System Verification Requirements

The LGF shall be designed in such a manner so that the system performance can be checked and verified for proper operation.

3.3.1.9 Electronic Equipment, General Requirements

The LGF shall meet the Electronic Equipment, General Requirements tailored from FAA-G-2100G. as defined in Table 3-4.

Table 3-4. General Navigational Aid Electronic Equipment Requirements

Requirement	FAA-G-2100G Section	Applicability Notes
REQUIREMENTS	3	
General	3.1	
Electrical Power	3.1.1	Applies in total
Mechanical	3.1.2	Applies in total
Characteristics	3.2	
Environmental Conditions	3.2.1	
Physical Characteristics	3.2.2	Applies in total
[Failsafe] External Equipment Interfaces	3.2.5	Applies in total
Electrostatic Discharge	3.2.6	Applies in total
Equipment Design and Construction	3.3	
Materials, Processes and Parts	3.3.1	Applies in total.
Electromagnetic Compatibility (EMI/EMC) and FCC Type Certification	3.3.2	Applies in total. Additional requirements for FCC Type Certification of Radio navigational aid transmitters in accordance with Part 87 (47 CFR 87)
Personal Safety and Health	3.3.5	Applies in total.
Documentation, Personnel and Training	3.4 & 3.5	Applies in total
FCC Type Acceptance and Registration	4.2.2.4	FCC Type Certification and Registration is required.

3.3.1.9.1 VDB and Reference Receiver Antenna Masts

Antenna masts located within the airport safety areas (Runway Safety Area, Object Free Area, and Obstacle Free Zone) shall be frangible in accordance with FAR part 139, Certification and Operation: Land Airports Serving Certain Air Carriers; and AC 150/5300.13, Airport Design.

3.3.1.9.2 Grounding, Bonding, Shielding, and Transient Protection

Grounding, bonding, shielding, and transient protection for the LGF shall be in accordance with FAA-STD-020 for Non-Developmental Items (NDI) and developmental items. At the facility interface, the requirements for grounding, bonding, shielding, and transient protection shall be in accordance with NFPA 70 and shall not violate the requirements of FAA-STD-020. If the item is to be UL-recognized, protective measure shall be in accordance with UL 60950.

Shielding on wire and cable shall be grounded in accordance with Section 3.3.6.1.3 of FAA-G-2100G.

3.3.2 CONTROL AND DISPLAY

3.3.2.1 Local Status Panel

3.3.2.1.1 LSP – Modes and Service Alerts

The LSP shall annunciate LGF operating status as follows:

a. Green for Normal,
b. Red for Not Available,
c. White for Test, or
d. Orange for Service Alert.

The LSP shall display a change in mode and service alerts within 2 seconds of detection by the LGF.

3.3.2.1.1.1 LSP – Initialization

The LSP shall simultaneously annunciate green, red, white, and orange during a power-up, manual reset, or automatic restart, as a test to ensure all indicators are displaying properly. The LSP shall have a legible label to denote panel indicator functions.

3.3.2.1.2 LSP – Aural Signal

The LSP shall initiate a steady tone aural signal when the LGF is Not Available. The LSP shall initiate an intermittent beep aural signal when there is a service alert. Annunciating “Not Available” shall take precedence over a service alert.

3.3.2.1.3 LSP – Silence Switch

Upon command, the LSP shall manually silence an aural signal. The LSP shall automatically reset the signal, once it has been silenced, until another alarm, or service alert.

3.3.2.2 Maintenance Data Terminal

The MDT shall command and monitor all test and maintenance actions available through a maintenance interface, in accordance with current industry standards.

3.3.2.2.1 Restart

Upon command, the MDT shall restart the LGF. Commanding restart shall cause all program variables and all software and firmware-controlled hardware to be initialized to a pre-defined condition upon entering the Normal Mode.

3.3.2.2.2 States and Modes Display

The MDT shall display the current LGF state and mode, defined in Section 3.1.4.

3.3.2.2.3 Alerts and Alarm Display

The MDT shall display, within 2 seconds, all alert and alarm messages generated by the LGF.

3.3.2.2.4 VDB Display

The MDT shall display the status of VDB(s) as either transmitting or not transmitting. The MDT shall display the VDB message type and data fields. The MDT shall provide an indication when the VDB coverage is not met due to a low power condition.

3.3.2.2.5 VDB Control

Upon command, the MDT shall activate and deactivate the VDB transmission to any VDB antenna. VDB deactivate shall by-pass the VDB antenna and terminate into a dummy load.

3.3.2.2.6 VDB Message Data

Upon command, the MDT shall allow adjustment of the following VDB message data for each message type and parameter:

a. Message Header
   1. Reference Station ID

b. Type 1 Message
   1. Measurement Type
   2. Sigma Pseudorange Ground (Section 3.2.1.2.8.7)
   3. Ephemeris Decorrelation Parameter

c. Type 2 Message
   1. LGF Installed RRs
   2. LGF Accuracy Designator
   3. Local Magnetic Variation
   4. Refractivity Index
   5. Scale Height
   6. Refractivity Uncertainty
   7. Latitude
   8. Longitude
   9. Reference Point Height
   10. Sigma Ionosphere
   11. Reference Station Data Selector
   12. Maximum Use Distance
   13. Ephemeris Fault-Free Missed Detection Parameters

d. Type 4 Message
   1. Data Set Length
   2. FAS Data Block - manually entered as a block in its entirety:

3. FAS VAL
4. FAS LAL

3.3.2.2.7 System Power Display

The MDT shall display the LGF power source.

3.3.2.2.8 Alerts and Alarm Status Display

The MDT shall display the status of all existing alerts and alarms.

3.3.2.2.9 Alerts and Alarm Threshold Display

Upon command, the MDT shall display the thresholds and tolerances for alert, service alert, constellation alert, and alarm parameters used in the generation of alerts and alarms in Sections 3.1.5.1.2, 3.1.5.1.3, 3.1.5.1.4, 3.1.5.1.5, 3.2.1.2.8.5.6.1, 3.2.1.2.8.6.1, and 3.2.1.2.8.8.1.

3.3.2.2.10 Alerts and Alarm Threshold Control

Upon command, the MDT shall enable the modification of the thresholds for alert, service alert, constellation alert, and alarm parameters, used in the generation of conditions identified in Sections 3.1.5.1.2, 3.1.5.1.3, 3.1.5.1.4, 3.1.5.1.5, 3.2.1.2.8.5.6.1, 3.2.1.2.8.6.1, and 3.2.1.2.8.8.1. Upon command, the MDT shall enable the modification of the defined thresholds, in minimum steps, within design tolerances. The MDT shall enable the manual input of all pre-defined thresholds within the design tolerances.

3.3.2.2.11 Monitor By-Pass

3.3.2.2.11.1 By-Pass Annunciation

Upon command, the MDT shall by-pass the aural annunciation of all alerts and alarms to the LSP or ATSU, or all simultaneously while the LGF is in the Test Mode. The MDT by-pass annunciation function shall have a configurable default setting.

3.3.2.2.12 Static Site Data Display

Upon command, the MDT shall display the following site-specific parameters:

a. Transmitter Frequency,
b. Measured power of each VDB,
c. TDMA Time Slot(s) of each VDB,
d. RR Geodetic Coordinates, and
e. Reception Mask.

3.3.2.2.13 Static Site Data Control

Upon command, the MDT shall enable the input of the following site-specific parameters:

a. VDB Frequency of each transmitter, 108.025 MHz to 117.950 MHz in 25 kHz channels,
b. VDB Power Adjustment of each VDB,
c. TDMA Time Slot(s) of each VDB,

d. RR Geodetic Coordinates (WGS-84), and
e. Reception Mask.

3.3.2.2.14 Approach Status Display

The MDT shall simultaneously display the approach status for the LGF. The MDT shall display the enable, disable, and Lateral Navigation (LNAV) status of each FAS supported by the LGF.

3.3.2.2.15 Approach Control

Upon command, the MDT shall enable any FAS provided by the LGF. Upon command, the MDT shall disable any FAS provided by the LGF.

3.3.2.2.15.1 LNAV Only Approach

Upon command, the MDT shall enable LNAV only for any FAS provided by the LGF. Upon command, the MDT shall disable LNAV only for any FAS provided by the LGF.

3.3.2.2.16 Diagnostics Display

The MDT shall display diagnostic results following a failure or a manual initiation. The MDT shall have on-screen-help in order to perform diagnostics and other maintenance related actions.

3.3.2.2.17 Diagnostics Control

The MDT shall enable manually initiated diagnostics. This shall include both Non-intrusive and Intrusive maintenance actions, as follows:

a. Non-intrusive diagnostics do not affect the current LGF operation.
b. Intrusive diagnostics may affect the LGF operation or require a re-certification Flight Check.

3.3.2.2.18 Temperature Display

The MDT shall display the temperature inside of the LGF equipment facility.

3.3.2.2.19 Adjustment Storage

Before log-off, MDT-entered settings and adjustment shall be confirmed and the values stored in LGF NVM.

3.3.2.2.20 Processing and Memory Load Display

The MDT shall display the processor and memory loading factors, and error sensing and reporting.

3.3.2.2.21 Logons Display List

Upon logon, the MDT shall display all active LGF maintenance users.

3.3.2.2.22 Azimuth/Elevation Sector

Upon command, the MDT shall enable inputs of the Azimuth/Elevation sector masks. Upon command, the MDT shall display the Azimuth/Elevation sector masks stored in the NVM.

3.3.2.2.23 Airborne Accuracy Designator

Upon command, the MDT shall enable input of the Aircraft Accuracy Designator. Upon command, the MDT shall display the Aircraft Accuracy Designator stored in the NVM.

3.3.2.3 Air Traffic Status Unit (ATSU)

The LGF configuration shall include an ATSU. The ATSU shall be designed as an external interface.

3.3.2.3.1 ATSU – Operational Status Display

The ATSU shall display the alarm status of the LGF mode as defined in 3.1.4.2 and constellation alert as defined in Section 3.1.5.1.4.

3.3.2.4 Remote Interface Management System (RIMS)

The LGF-to-RIMS interface shall be configurable for monitoring only and/or maintenance control capability exclusively at the LGF via an MDT. The interface shall be developed to initially limit RIMS functions to monitoring-only capability.

3.3.3 RECORDING

Filtering of repetitive events shall be permitted, with the most recent event logged with an indication of the start of the event. Commands to write over or delete any of the data sets in Sections 3.3.3.1, 3.3.3.3, and 3.3.3.4 shall not be permitted. The LGF NVM used to store data shall be secure at all times from tampering and manipulation.

3.3.3.1 System Events

The LGF shall maintain a chronological record in NVM of the previous 90 days of date, time, inside temperature, log-on, log-off, alert, service alert, and alarm events. The MDT shall display system event records.

3.3.3.2 VDB Recording

The LGF shall automatically record all data broadcast parameters for a period not less than 14 days. This data shall be exportable via a standard, commercially available electronic media.

3.3.3.3 Reference Receiver Data

The LGF shall automatically record RR data for all RRs for a period not less than 14 days. This data shall be exportable via a standard, commercially available electronic media.

Note: Refer to ICAO SARPS Attachment D for minimum list of parameters to be recorded.

3.3.4 INTERFACE REQUIREMENTS

3.3.4.1 LSP Interface

The vendor shall define all LSP data interface requirements. The interface characteristics shall be commercially available and in accordance with ISO standards and recommendations.

4 VERIFICATION

The applicant is responsible for showing compliance (i.e., validating, verifying, and providing requisite substantiation data) with all specification requirements. This includes a demonstration of compliance with the LAAS Verification Methodologies and Cases. The FAA may also perform independent verification of the applicant's equipment and substantiation data as a part of the Regulatory Approval Process.

The primary objective of the system design approval is to:

- Verify compliance with the LGF specification requirements,
- Document the design data that substantiates compliance,
- Document the accepted equipment configuration (hardware and software), and
- Recommend Regulatory Approval of the accepted design.

Compliance findings are generally established by reviewing data submitted by the applicant; performing in-process reviews; and conducting laboratory inspection, demonstration, and tests at an FAA facility. The System Design Approval Process provides a basis for recommending Regulatory Approval.

The Regulatory Approval does not provide an operational approval or otherwise certify the LAAS service. An applicant or sponsor must show compliance with other requirements relating to the approval of a Facility and the Service approval. These other requirements address installation, maintenance, training, operations, etc., and are beyond the scope of system design approval and this specification.

4.1 GENERAL TESTING REQUIREMENTS

4.1.1 VERIFICATION METHODS

The LGF Test Program shall use the verification methods of Inspection (I), Analysis (A), Test (T) and Demonstration (D). These methods are defined as follows:

a. I – Inspection is a method of verification to determine compliance with specification requirements and consist primarily of visual observations, mechanical measurements of the equipment, physical locations, and technical examination of engineering-supported documentation.
b. A – Analysis is a method of verification that consists of comparing hardware or software design with known scientific and technical principles, technical data, or procedures and practices to validate that the proposed design will meet the specified functional and performance requirements. Analysis also includes the use of modeling and simulation.
c. T – Test is a method of verification that will measure equipment performance under specific configuration-load conditions and after the controlled application of known stimuli. Quantitative values are measured, compared against previous predicted success criteria, and evaluated to determine the degree of compliance.

d. D – Demonstration is a method of verification where qualitative versus quantitative validation of a requirement is made during a dynamic test of the equipment. Demonstration activities are further characterized by the following:
   1. If a requirement is validated by test during first article qualification testing and the requirement has enough significance that it is re-tested during acceptance test, then this acceptance testing can be indicated in the VRTM as a Demonstration.
   2. Software functional requirements are validated by demonstration since the functionality must be observed through secondary media.

4.1.2 RELIABILITY TEST

A 14-day continuous operation stability test shall be conducted after the requirements of this specification have been met. The LGF system shall meet specification requirements without failure of hardware or software. Any failure shall require a rerun of the 14-day test.

Appendix A

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Appendix B

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Appendix C

Verification Requirements Traceability Matrix

Item No.	Section Number	Section Title	Compliance	Remarks
1.	1.	Scope		
2.	1.1	Identification		
3.	1.2	System Overview		
4.	1.3	Document Overview		
5.	2.0	Applicable Documents		
6.	2.1	Government Documents		
7.	2.1.1	Specification		
8.	2.1.1.1	Federal Aviation Administration		
9.	2.1.2	Standards		
10.	2.1.2.1	Federal Aviation Administration		
11.	2.1.2.2	Military		
12.	2.1.3	FAA orders		
13.	2.1.4	Other Government Documents		
14.	2.2	Non-Government Documents		
15.	3.0	Requirements		Title
16.	3.1	LGF General Requirements		Title
17.	3.1.1	Coverage Volume		Definition Only
18.	3.1.1.1	VDB Coverage Volume	T, A	
19.	3.1.1.1.1	Minimum Field Strength	T, A	
20.	3.1.1.1.2	Maximum Field Strength	T, A	
21.	3.1.2	Integrity		Introduction
22.	3.1.2.1	LGF Integrity Risk		Title
23.	3.1.2.1.1	Category I Precision Approach	A	
24.	3.1.2.1.2	Differentially Corrected Positioning Service	A	
25.	3.1.2.2	Protection Level Integrity Risk	A	

Item No.	Section Number	Section Title	Compliance	Remarks
26.	3.1.2.2.1	Category I Precision Approach	A	
27.	3.1.2.2.2	Differentially Corrected Positioning Service	A	
28.	3.1.2.3	Integrity in the Presence of Excessive Radio Frequency Interference (RFI)	A	
29.	3.1.3	Continuity		Title
30.	3.1.3.1	VDB Transmission Continuity	A	
31.	3.1.3.2	Reference Receiver and Ground Integrity Monitoring Continuity	A	
32.	3.1.4	States and Modes		Title
33.	3.1.4.1	States	D	
34.	3.1.4.2	Modes	D	
35.	3.1.5	Executive Monitoring		Title
36.	3.1.5.1	Fault Monitoring	D	
37.	3.1.5.1.1	Fault Recovery	D	
38.	3.1.5.1.2	Generation of Alerts	D	
39.	3.1.5.1.3	Generation of Service Alerts		Definition
40.	3.1.5.1.3.1	Continuity Faults	T	
41.	3.1.5.1.3.2	Environmental Faults	T	
42.	3.1.5.1.4	Generation of Constellation Alerts	T	
43.	3.1.5.1.5	Generation of Alarms	T	
44.	3.1.6	Software Design Assurance	I	
45.	3.1.7	Complex Electronic Hardware Design Assurance	I	
46.	3.2	Data Broadcast		Title
47.	3.2.1	Broadcast Data Requirements	D	
48.	3.2.1.1	LAAS Message Block	I	
49.	3.2.1.1.1	Message Block Header		Title
50.	3.2.1.1.1.1	Message Block Identifier	T	
51.	3.2.1.1.1.2	Ground Station Identification	T	

Item No.	Section Number	Section Title	Compliance	Remarks
52.	3.2.1.1.1.3	Message Type Identifier	T	
53.	3.2.1.1.1.4	Message Length	T	
54.	3.2.1.1.2	Cyclic Redundancy Check (CRC)	T	
55.	3.2.1.2	Type 1 Message – Differential Corrections	T	
56.	3.2.1.2.1	Modified Z-Count	T	
57.	3.2.1.2.2	Additional Message Flag	T	
58.	3.2.1.2.3	Number of Measurements	T	
59.	3.2.1.2.4	Measurement Type	T	
60.	3.2.1.2.5	Ephemeris CRC	T	
61.	3.2.1.2.6	Source Availability Duration	T	
62.	3.2.1.2.6.1	Reception Mask	T	
63.	3.2.1.2.6.2	Azimuth/Elevation Sector Masking	T	
64.	3.2.1.2.7	Ephemeris Decorrelation Parameter (P)	T	
65.	3.2.1.2.8	Ranging Source Measurement Block	T	
66.	3.2.1.2.8.1	Ranging Source Identification	T	
67.	3.2.1.2.8.2	Ranging Signal Sources	T	
68.	3.2.1.2.8.3	Conditions for Transmitting the Ranging Source Measurement Block	T	
69.	3.2.1.2.8.3.1	Valid GPS Navigation Data	T, A	
70.	3.2.1.2.8.3.2	Valid SBAS Navigation Data	T, A	
71.	3.2.1.2.8.3.3	Invalid GPS C/A Code	T	
72.	3.2.1.2.8.4	Issue of Data	T	
73.	3.2.1.2.8.5	Pseudorange Corrections	D	
74.	3.2.1.2.8.5.1	Smoothed Pseudorange		In detail below
75.	3.2.1.2.8.5.1a	One-sided noise bandwidth	A, I	
76.	3.2.1.2.8.5.1b	Strongest Correlation Peak	A, T	
77.	3.2.1.2.8.5.1c	Correlator Spacing	A, I	
78.	3.2.1.2.8.5.2	GPS Predicted Range	T, I	

Item No.	Section Number	Section Title	Compliance	Remarks
79.	3.2.1.2.8.5.3	SBAS Predicted Range	T, I	
80.	3.2.1.2.8.5.4	GPS Smoothed Pseudorange Correction	T, I	
81.	3.2.1.2.8.5.5	SBAS Smoothed Pseudorange Correction	T, I	
82.	3.2.1.2.8.5.6	Broadcast Correction	T, I	
83.	3.2.1.2.8.5.6.1	Conditions for Broadcast Corrections	T, A	
84.	3.2.1.2.8.6	Range Rate Correction (RRC)	T	
85.	3.2.1.2.8.6.1	Condition for Valid RRC	T	
86.	3.2.1.2.8.7	Sigma Pseudorange Ground	A, T	
87.	3.2.1.2.8.7.1	GPS Sigma Pseudorange Accuracy	A, T	
88.	3.2.1.2.8.7.2	SBAS Sigma Pseudorange Accuracy	A, T	
89.	3.2.1.2.8.7.3	Condition for Valid Sigma Pseudorange Ground	A, D	
90.	3.2.1.2.8.8	B-Values	T	
91.	3.2.1.2.8.8.1	Conditions for Broadcast	A, D	
92.	3.2.1.3	Type 2 Message – Differential Reference Point	T	
93.	3.2.1.3.1	Ground Station Installed Receivers	T	
94.	3.2.1.3.2	Ground Station Accuracy Designator	T	
95.	3.2.1.3.3	Continuity and Integrity Designator	T	
96.	3.2.1.3.4	Local Magnetic Variation	T	
97.	3.2.1.3.5	Sigma Ionosphere	T	
98.	3.2.1.3.5.1	Condition for valid Sigma Ionosphere	A	
99.	3.2.1.3.6	Refractivity Index	T	
100.	3.2.1.3.7	Scale Height	T	
101.	3.2.1.3.8	Refractivity Uncertainty	T	
102.	3.2.1.3.9	Reference Point		Title
103.	3.2.1.3.9.1	Latitude	T	
104.	3.2.1.3.9.2	Longitude	T	
105.	3.2.1.3.9.3	Reference Point Height	T	
106.	3.2.1.3.10	Reference Station Data Selector (RSDS)	T	

Item No.	Section Number	Section Title	Compliance	Remarks
107.	3.2.1.3.11	Maximum Use Distance (D_{max})	T	
108.	3.2.1.3.12	Ephemeris Fault-Free Missed Detection Parameters		Title
109.	3.2.1.3.12.1	$K_{md\_e\_POS, GPS}$	T	
110.	3.2.1.3.12.2	$K_{md\_e\_CAT I, GPS}$	T	
111.	3.2.1.3.12.3	$K_{md\_e\_POS, GLONASS}$	T	
112.	3.2.1.3.12.4	$K_{md\_e\_CAT I, GLONASS}$	T	
113.	3.2.1.4	Type 4 Message – Final Approach Segment Data	T	
114.	3.2.1.4.1	Data Set Length	T	
115.	3.2.1.4.2	FAS Data Block	T, I	
116.	3.2.1.4.3	FAS VAL/Approach Status	T	
117.	3.2.1.4.3.1	TAP VAL	T	
118.	3.2.1.4.4	FAS LAL/Approach Status	T	
119.	3.2.1.4.4.1	TAP LAL	T	
120.	3.2.2	Radio Frequency Transmission Characteristics	T(I)	Previously qualified COTS may be verified with prequalification artifacts
121.	3.2.2.1	Signal Polarization	T	
122.	3.2.3	Radio Frequency Broadcast Monitoring	T(I)	Previously qualified COTS may be verified with prequalification artifacts
123.	3.3	Operation and Maintenance		Definition
124.	3.3.1	System Requirements		Title
125.	3.3.1.1	LGF Configuration		Title
126.	3.3.1.1.1	Standard LGF Equipment Configuration	I	
127.	3.3.1.1.2	Additional VDB Subsystems	N/A	
128.	3.3.1.2	Primary Power	T	
129.	3.3.1.3	Supplementary Power	T	
130.	3.3.1.3.1	Power Supply	T	

Item No.	Section Number	Section Title	Compliance	Remarks
131.	3.3.1.4	Environmental Sensors	I, T	
132.	3.3.1.4.1	Intrusion Detector	I	
133.	3.3.1.4.2	Smoke Detector	I	
134.	3.3.1.4.3	AC Power	I	
135.	3.3.1.4.4	Inside Temperature	I	
136.	3.3.1.5	Fault Diagnostics, Built-in-Test, and Isolation Procedures	D	
137.	3.3.1.6	Reliability, Maintainability, and Availability of LGF Equipment		Title
138.	3.3.1.6.1	Reliability	A	
139.	3.3.1.6.2	Maintainability		Title
140.	3.3.1.6.2.1	Mean Time To Repair (MTTR)	A	
141.	3.3.1.7	Security	D	
142.	3.3.1.7.1	Access Control		Title
143.	3.3.1.7.1.1	Access Levels	D	
144.	3.3.1.7.2	Security Management		Title
145.	3.3.1.7.2.1	System Identification	D	
146.	3.3.1.7.3	Accountability and Traceability		Title
147.	3.3.1.7.3.1	Audit Log File Recording	D	
148.	3.3.1.7.3.2	Audit Log File Maintenance	D	
149.	3.3.1.7.3.3	Audit Log File Archive	D	
150.	3.3.1.8	Physical Design for Certification	A, I	
151.	3.3.1.8.1	System Verification Requirements	A, I	
152.	3.3.1.9	Electronic Equipment, General Requirements	A, I	Previously qualified COTS may be verified with prequalification artifacts
153.	3.3.1.9.1	VDB and Reference Receiver Antenna Masts	I	
154.	3.3.1.9.2	Grounding, Bonding, Shielding and Transient	I	

Item No.	Section Number	Section Title	Compliance	Remarks
		Protection		
155.	3.3.2	Control and Display	I	
156.	3.3.2.1	Local Status Panel		Title
157.	3.3.2.1.1	LSP – Modes and Service Alerts	T	
158.	3.3.2.1.1.1	LSP – Initialization	T	
159.	3.3.2.1.2	LSP – Aural Signal	D	
160.	3.3.2.1.3	LSP – Silence Switch	D	
161.	3.3.2.2	Maintenance Data Terminal	I	
162.	3.3.2.2.1	Restart	D	
163.	3.3.2.2.2	States and Modes Display	D	
164.	3.3.2.2.3	Alerts and Alarm Display	T	
165.	3.3.2.2.4	VDB Display	D	
166.	3.3.2.2.5	VDB Control	D	
167.	3.3.2.2.6	VDB Message Data	D	
168.	3.3.2.2.7	System Power Display	D	
169.	3.3.2.2.8	Alerts and Alarm Status Display	D	
170.	3.3.2.2.9	Alerts and Alarm Threshold Display	D	
171.	3.3.2.2.10	Alerts and Alarm Threshold Control	D, T	
172.	3.3.2.2.11	Monitor By-Pass		Title
173.	3.3.2.2.11.1	By-Pass Annunciation	D	
174.	3.3.2.2.12	Static Site Data Display	D	
175.	3.3.2.2.13	Static Site Data Control	D, T	
176.	3.3.2.2.14	Approach Status Display	D	
177.	3.3.2.2.15	Approach Control	D, T	
178.	3.3.2.2.15.1	LNAV Only Approach	D, T	
179.	3.3.2.2.16	Diagnostics Display	D	
180.	3.3.2.2.17	Diagnostics Control	D, T	
181.	3.3.2.2.18	Temperature Display	D	

Item No.	Section Number	Section Title	Compliance	Remarks
182.	3.3.2.2.19	Adjustment Storage	A, I	
183.	3.3.2.2.20	Processing and Memory Load Display	D	
184.	3.3.2.2.21	Logons Display List	D	
185.	3.3.2.2.22	Azimuth/Elevation Sector	D	
186.	3.3.2.2.23	Airborne Accuracy Designator	D	
187.	3.3.2.3	Air Traffic Status Unit (ATSU)	I	
188.	3.3.2.3.1	ATSU – Operational Status Display	D	
189.	3.3.2.4	Remote Interface Management System (RIMS)	I	
190.	3.3.3	Recording	D	
191.	3.3.3.1	System Events	D	
192.	3.3.3.2	VDB Recording	D	
193.	3.3.3.3	Reference Receiver Data	D	
194.	3.3.4	Interface Requirements		Title
195.	3.3.4.1	LSP Interface	I	
196.	4	Verification		
197.	4.1	General Testing Requirements		
198.	4.1.1	Verification Methods		
199.	4.1.2	Reliability Test		

Appendix D
Acronyms

A

A
Analysis
AC
Alternating Current
AGL
Above Ground Level
ANSI
American National Standards Institute
ARTCC
Air Route Traffic Control Center
ASIC
Application Specific Integrated Circuit
ATC
Air Traffic Control
ATSU
Air Traffic Status Unit
AVS
Additional Very High Frequency Data Broadcast Subsystem

B

BIT
Built-in-Test

C

CAT I
Category I operations
CIO
Chief Information Officer
CRC
Cyclic Redundancy Check

D

DC
Direct Current
Dmax
Maximum Use Distance
dpi
Dots Per Inch
DT
Development Test

E

EPOL
Elliptical polarization

F

FAA
Federal Aviation Administration
FAS
Final Appraoch Segment

FCC
Federal Communication Commission
FPAP
Flight Path Alignment Point
FTP
Fictitious Threshold Point

G

GBAS
Ground-Based Augmentation System
GCID
Ground Continuity and Integrity Designator
GPA
Glidepath Angle
GPS
Global Positioning System

H

HOW
Hand-over-Word
HPOL
Horizontal polarization
HWCI
Hardware Configuration Item

I

I
Inspection
ID
Identification
IOD
Issue of Data
IODC
IOD Clock
IODE
IOD Ephemeris

L

LAAS
Local Area Augmentation System
LGF
LAAS Ground Facility
LNAV
Lateral Navigation
LRU
Line Replaceable Unit
LSP
Local Status Panel
LTP
Landing Threshold Point

M

MASPS
Minimum Aviation System Performance Standards
MDT
Maintenance Data Terminal

MI
Misleading Information
MIB
Management Information Base
MOPS
Minimum Operational Performance Standards
MTBCF
Mean Time Between Critical Failures
MTBF
Mean Time Between Failure
MTTR
Mean-Time-to-Repair

N

NAS
National Airspace System
NDI
Non-Developmental Item
RIMS
Remote Interface Management System
NVM
Non-Volatile Memory

O

OSHA
Occupational Safety and Health Agency
OT
Operational Test

P

P
Ephemeris Decorrelation Parameter
PAT
Production Acceptance Test
PLD
Programmable Logic Device
PPP
Point-to-Point Protocol
PRC
Pseudorange Correction

R

RFI
Radio Frequency Interference
RMDT
Remote MDT
RNAV
Area Navigation
RR
Reference Receiver
RRC
Range Rate Correction
RSDS
Reference Station Data Selector
RSP
Remote Status Panel

S

SAT
Site Acceptance Test
SBAS
Satellite-Based Augmentation System
SPS
Standard Positioning Service
SSA
System Safety Assessment

T

T
Test
TCH
Threshold Crossing Height
TDMA
Time Division Multiple Access
TRACON
Terminal Radar Approach CONtrol

U

UL
Underwriters Laboratories
URA
Use Range Accuracy

V

VDB
VHF Data Broadcast
VHF
Very High Frequency
VRTM
Verification Requirements Test Matrix
VSWR
Voltage Standing Wave Ratio

W

WAAS
Wide Area Augmentation System
WJHTC
William J. Hughes Technical Center

Appendix E
Ranging Source Failure Threat Model

This appendix contains the description of each of the ranging source and environment failures listed in sections 3.1.2.1.1. & 3.1.2.1.2 of this document along with a threat model (if applicable) for their characterization.

A Signal Deformation Threat Model

Signal deformation is defined to be any GPS ranging source that is distorted as given by the following threat model:

1. Each falling edge of the positive chips in the C/A code is delayed by Δ seconds, where $0 \le \Delta \le 120$ nanoseconds.
2. Each falling edge of the positive chips in the C/A code is advanced by Δ seconds, where $0 \le \Delta \le 120$ nanoseconds.
3. The distorted C/A code is the output of a second order linear system that has the standard C/A code as an input. The system is characterized by a damping factor, σ, and a resonant frequency, f_d, as shown:

C/A Code →
$$\frac{(2\pi f_0)^2}{s^2 + 2\sigma s + (2\pi f_0)^2}$$
→ Distorted C/A Code (1)

where $f_0 = \frac{1}{2\pi}\sqrt{\sigma^2 + (2\pi f_d)^2}$ and (2)
s is the complex frequency used in Laplace transforms.

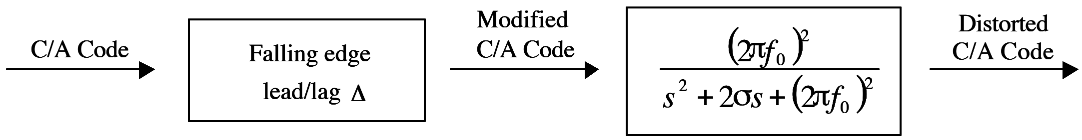
Each step, e_0, in the input C/A sequence results in a second order step response that is given by

$$e(t) = e_0\left\{1 - \exp(-\sigma t)\left[\cos 2\pi f_d t + \frac{\sigma}{2\pi f_d}\sin 2\pi f_d t\right]\right\}, \quad (3)$$

for this waveform,
$0.8\text{x}10^6 \le \sigma \le 8.8\text{x}10^6$ nepers/second
$4\text{x}10^6 \le f_d \le 17\text{x}10^6$ cycles/second.

4. The distorted C/A code is the output of a second order linear system characterized by a damping factor and a resonant frequency with an input of a modified standard C/A code, where every falling edge of the positive chip in the modified C/A code is:
   a) Delayed by Δ seconds, where $0 \le \Delta \le 120$ nanoseconds

b) Advanced by Δ seconds, where $0 \leq \Delta \leq 120$ nanoseconds



(4)

This waveform has the combined effects of items 1, 2, and 3, but the damping factor and resonant frequency are varied over a smaller range, specifically:

$$0.8\text{x}10^6 \leq \sigma \leq 8.8\text{x}10^6 \text{ nepers/second}$$
$$7.3\text{x}10^6 \leq f_d \leq 13\text{x}10^6 \text{ cycles/second.}$$

No threat of signal deformation exists for SBAS in accordance with SARPS.

The parameters are based on the airborne tracking constraints defined in LAAS MOPS.

B Low Power

C/N_0 estimation of the GPS signal is a critical piece in the design of low power monitor in the LGF. Factors effecting the C/N_0 estimation are RFI and cross correlation. The low power monitor has to be designed so as to distinguish RFI and satellite cross correlation effects from a genuine low power signal caused due to a ranging source failure.

C Code/Carrier Divergence

Any failure in the signal generation function of the GPS satellites would introduce a discrepancy in the code and carrier phase velocities. This results in divergence between the code and the carrier phase. Code-carrier divergence (CCD) would also be caused by ionospheric activity. Both satellite failures and ionospheric error component can be detected by monitoring this code carrier divergence.

In a differential system like LAAS where the distance between the aircraft and the LGF is small when compared to the distance to the satellite, the observed CCD could be the same provided the filter and tracking loop implementations in the aircraft and LGF are identical. Though RTCA/DO-253(A) specifies all the requirements for the airborne receiver design, it does not require matching of the airborne and ground filter implementations. Hence receivers manufactured by different vendors may experience different code-carrier divergence error values. Thus, the CCD monitor in the LGF has to be designed so as to support different airborne receiver implementations.

D Excessive Pseudorange Acceleration

Excessive acceleration refers to a rapid change in the pseudorange measurements (such as a ramp or a step error) over a very short time period. Excessive acceleration among the satellite measurements is caused due to satellite clock errors. The need for this monitor rose primarily due Selective Availability (SA). SA refers to the deliberate degradation of GPS ranging accuracy by introducing controlled errors into each of the GPS satellite clocks (known as clock dither). This clock dithering would introduce abrupt changes into the code and carrier phase measurements of the GPS satellites resulting in large positioning errors for the stand-alone user. Though SA was turned off on June 1, 2000 by the presidential order, it is imperative that the GPS signal measurements are properly monitored for any excessive acceleration errors.

E Erroneous GPS Ephemeris Broadcast

An ephemeris causing an error in the computed satellite position that is orthogonal to the satellite line-of-sight will cause an effective differential ranging error between the LGF and aircraft. Therefore the LGF is required to detect significant ephemeris discrepancies in the satellite broadcast. However, because the impact of an undetected ephemeris error depends on satellite geometry and the distance between the LGF and the aircraft, each individual aircraft within the LAAS service volume must ultimately assess the navigational impact of such an error separately. Accordingly, along with DGPS ranging correction, the LGF would also broadcast an ephemeris decorrelation parameter (P), giving users information regarding the Minimum Ephemeris Detectable Error (MEDE) achievable by the ephemeris monitor. To verify that the navigation data from the ranging sources meets the LAAS integrity requirement, the airborne subsystem uses P to compute the VEB and LEB as defined in section 3.3.2.13 of RTCA/DO-245A. The P-value is defined as:

$$P = \frac{MEDE}{PR} \tag{5}$$

where MEDE is the minimum satellite position error that can be detected by the monitor with a probability of missed detection consistent with the integrity risk allocation to ranging source failures.

The basic types of ephemeris threats identified are:

<u>Type A</u>: The broadcast ephemeris data is erroneous following a satellite maneuver. This can be further subdivided as follows:

- *<u>Type A1</u>*: The occurrence of the satellite maneuver is known to the LGF
- *<u>Type A2</u>*: The LGF is unaware of the satellite maneuver

<u>Type B</u>: The broadcast ephemeris is erroneous but no satellite maneuvers are involved.

Because the ephemeris messages for each satellite are created and broadcasted independently, and ephemeris anomalies are low probability events, the likelihood of multiple simultaneous ephemeris failures is assumed to be negligible. Also it is assumed that unannounced and unintentional maneuvers (Type A2) represent a very small subset of all spacecraft maneuvers, and need not be considered in LAAS for GCID 1. For GCID 2 through 4, all threats should be monitored. GCID classification is defined in section 1.5.2.1.1 of RTCA/DO-245A. One acceptable monitoring methodology for each of these threats is described in section E 2.3.3 of RTCA/DO-245A.

F Ionospheric Delay

The ionosphere is considered a dispersive media since it alters the velocity of a wave passing through it according to the frequency of the wave. The ionosphere consists of free electrons and ions that are formed as a result of ionization of gas molecules by the sun's ultraviolet radiation energy. For the GPS signals, the ionosphere simultaneously induces a delay in the carrier signal while speeding up the modulating signal. Under nominal ionospheric conditions, the s_{vig} parameter broadcast by the LGF sufficiently overbounds this delay. However under active ionospheric conditions, anomalous ionospheric gradients may exist that result in errors large enough to cause loss of integrity for the user aircraft. Under these circumstances additional monitoring is deemed necessary in the LGF. For CAT I precision approach applications, no ionospheric monitoring capability has been put in place in the aircraft. The possibility of an anomalous ionospheric gradient was discovered while studying WAAS "Super Truth" data collected during an ionospheric storm that occurred on 6th of April, 2000.

The gradient parameters of the proposed ionospheric model were developed based on WAAS Super Truth data analysis. A schematic of these parameters are shown below.

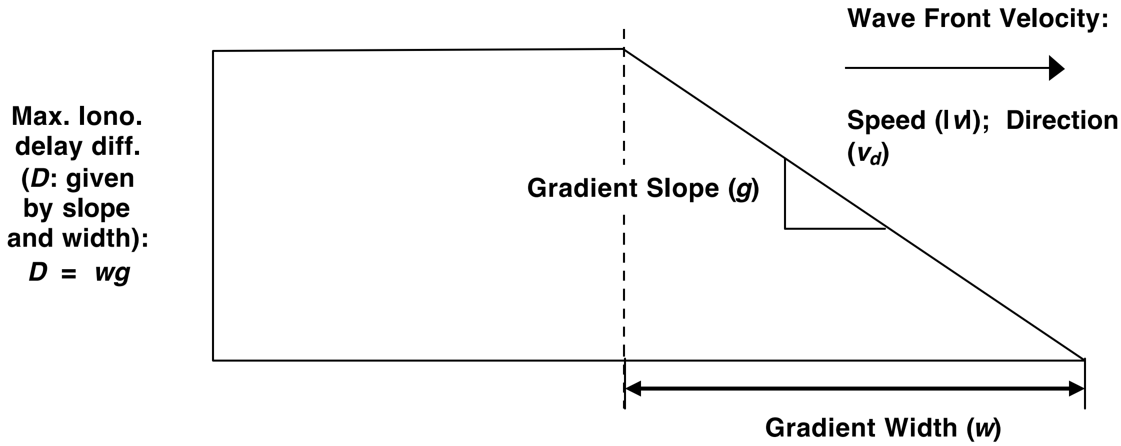


Figure E-1. Threat Model of Anomalous Ionosphere Gradient

Note that this linear model of the anomalous ionospheric wavefront is a simplification in reality. Non-linear effects appear in the time series of the anomaly but this model suffices to estimate the threat.

The linear model shown above has three parameters associated with it. These are listed below along with their respective units of measurement.

1 Gradient speed ($|v|$) measured in m/s
2 Gradient width (w) measured in Km
3 Gradient slope (g) measured in mm/Km

The maximum delay (D) introduced as a result of this gradient is defined as the product of the gradient width and slope. That is D = wg.

Shown below are the parametric bound values as of August 2005.

Elevation	**Speed**	**Width**	**Slope**	**Max Error**

Low elevation < 12°	100 – 1000 m/s	25 – 200 km	30 – 150 mm/km	50 m
High elevation = 12°	100 – 1000 m/s	25 – 200 km	30 – 500 mm/km	50 m

Note that the current threat model as shown above is not an absolute bound of possible error that may occur in the infinite future. Rather it is a rational analysis of observed gradients in all data currently analyzed with some conservatism added onto it. It is recognized that this safety of life operation requires us to continue to monitor this phenomenon until it is fully characterized.

Appendix F

Usage of LGF Test and Alarm Indicators

Several fields in the VHF data broadcast can indicate that an approach is unusable. This appendix describes those fields and how they are used.

F-1. Message Block Identifier

The message block identifier is part of the message header and is part of each message broadcast. The LGF will broadcast Type 1, Type 2 and Type 4 messages. When the message block header is 1010 1010, it is an indication that the message can be used for navigation. When the message block header is 1111 1111, it is an indication that the message cannot be used for navigation and is officially called a "Test" message. The LGF specification requires a "Test Mode" in which test conditions can be run or the system is undergoing maintenance that may cause the conditions of the LGF radiated signal to be out of tolerance. Flight inspection avionics will have the capability to override the test message block header to flight check the LGF signal without concern that the flying public may use the signal. This capability is similar to removing the ident from a VOR or ILS facility.

F-2 Blank Type 1 Messages

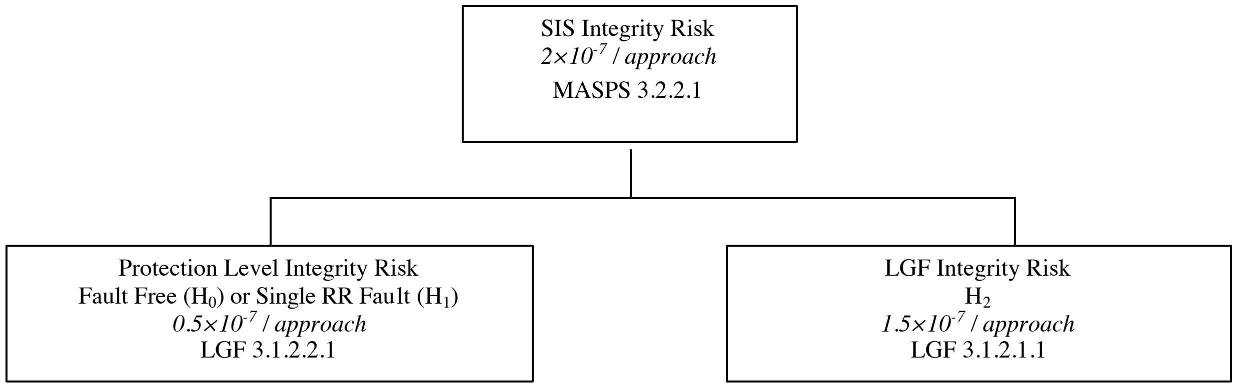
The Type 1 message provides a "Number of Measurements" field, which indicates the number of pseudorange corrections contained in the message. When this field is set to zero, the LAAS airborne receiver cannot use differential corrections from the LGF and therefore all LGF-based operations cease. This message field will be used to indicate an alarm at the LGF. The time from when the fault is detected to when it is annunciated at the aircraft includes the fact that the Type 1 message is broadcast at 2 Hz.

F-3 Ground Continuity Integrity Designator

The Ground Continuity Integrity Designator (GCID) Field is contained in the Type 2 message and indicates the operational status of the LGF. This specification addresses Category I precision approaches and indicates this with a GCID value of 1. The LGF indicates a value
of 7 for the GCID when the ground station signal does not comply with the Category I requirements for integrity and continuity. It is important to note that while the LGF may be in Test mode, the LGF can change the GCID according to the actual performance level of the signal. If a fault in the LGF has been corrected, maintenance or flight inspection may prefer to perform additional checks of the system while in Test, and a true indication from the GCID of the actual performance must be provided. If the GCID is broadcasting 1, for Category I precision approach, then maintenance will be assured that corrections are included in the broadcast and not have to monitor the VDB messages. Conversely, a GCID of 7 indicates that the system is still unusable and the Number of Measurements Field has been set to zero.

Appendix G
Risk Allocation Trees

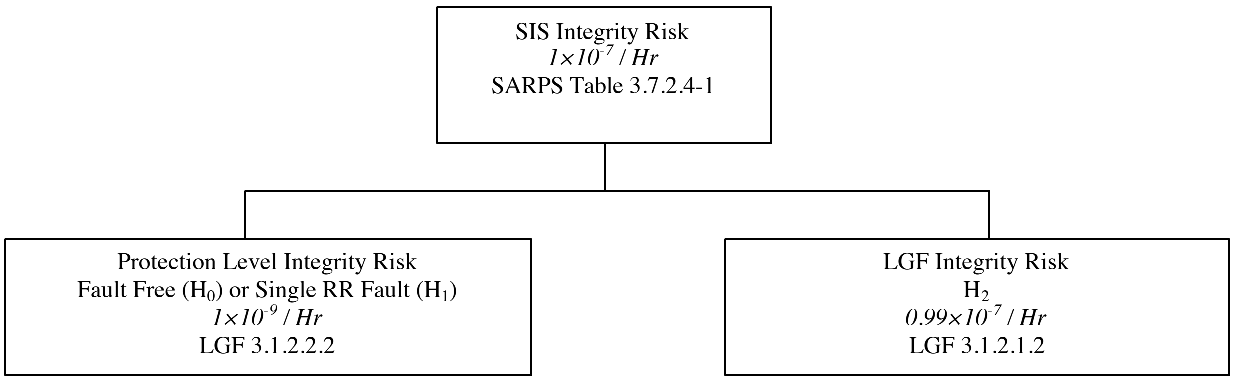
LAAS LGF Integrity Risk Allocation (Precision Approach)



Note: References to MASPS in this appendix represent RTCA/DO-245(Minimum Aviation System Performance Standards for Local Area Augmentation System, September 1998).

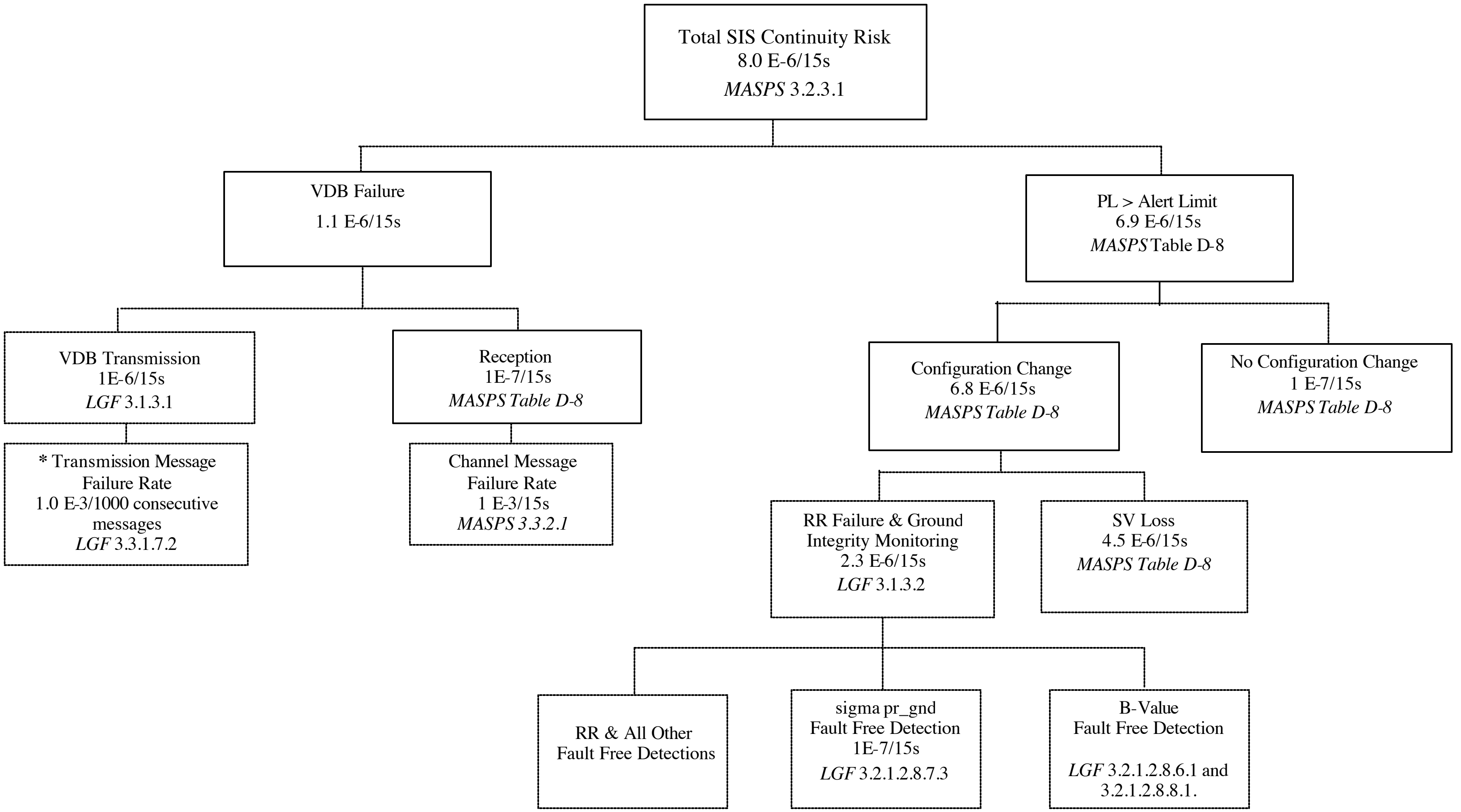
Appendix G

LAAS LGF Integrity Risk Allocation (Differentially Corrected Positioning Service)



Appendix G

Continuity Risk Allocations Continuity Risk Allocations



** Note: This is a VDB design requirement and is not specifically included to ensure continuity.*

Appendix H

Final Approach Segment – Definitions

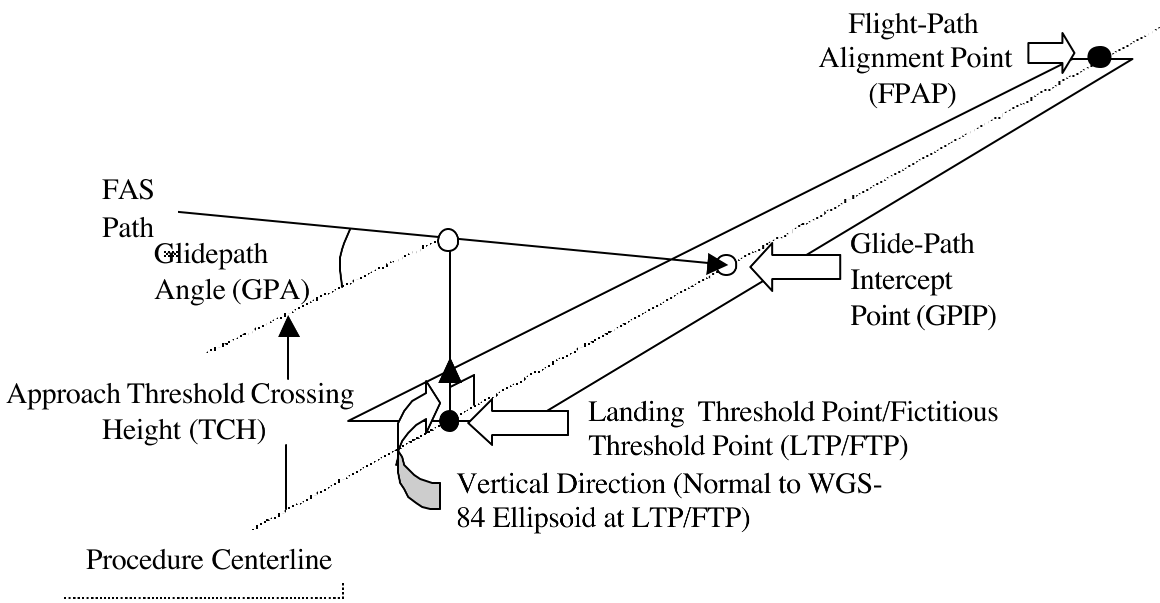


Figure H-1. Final Approach Segment Diagram

H – 1. Final Approach Segment Path Definition

The Final Approach Segment (FAS) path is a line in space defined by the Landing Threshold Point/Fictitious Threshold Point (LTP/FTP), Flight Path Alignment Point (FPAP), Threshold Crossing Height (TCH) and 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.

H – 2. LTP/FTP Definition

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. It is normally located at the intersection of the runway centerline and the threshold.

H – 3. Final Path Alignment Point Definition

The Flight Path Alignment Point (FPAP) is a point at the same height as the LTP/FTP that is used to define the alignment of the approach. The origin of angular deviations in the lateral direction is defined to be 305 meters (1000 ft) beyond the FPAP along the lateral FAS path. For an approach aligned with the runway, the FPAP is at or beyond the stop end of the runway.