Initial Federal Aviation Administration (FAA) Flight Inspection Criteria for Precision Instrument Approach Procedures Supported by the Local Area Augmentation System (LAAS)

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ABSTRACT

This paper provides an overview of initial Federal Aviation Administration (FAA) flight inspection criteria for the evaluation of precision instrument approach procedures supported by the Local Area Augmentation System (LAAS).

The Global Positioning System (GPS) is a world-wide position, velocity, and time determination system. GPS has been accepted by the International Civil Aviation Organization (ICAO) as an integral part of the Global Navigation Satellite System (GNSS). Civil use of GPS for oceanic, en route, terminal, non-precision, and special precision approach flight operations has been authorized in the United States of America National Airspace System (NAS). The Standard Positioning Service (SPS) provided by GPS is insufficient to meet the integrity, continuity, accuracy, and availability demands of instrument approach procedures, particularly those for precision approach and landing operations. Aircraft, space, and ground-based augmentation systems are used either separately or jointly to meet the more demanding requirements associated with these operations.

LAAS is a safety-critical ground-based augmentation system based on differential GPS concepts. The LAAS Ground Facility (LGF) augments the GPS SPS by calculating differential corrections that are broadcast to the user along with integrity and operational information. LAAS is capable of supporting precision and non-precision approach procedures. In addition, it is capable of supporting terminal and airport surface guidance procedures. In order to implement LAAS within the NAS, flight inspection criteria must be developed for these LAAS applications.

This paper provides an overview of initial FAA flight inspection requirements, procedures, and analysis methodologies for the evaluation of precision instrument approach procedures supported by LAAS. These requirements, procedures, and methodologies are applicable for the evaluation of procedures with Decision Altitudes (DA) of not less then 200 feet Above Ground Level (AGL). This paper provides background material on LAAS, the rationale used for developing the initial flight inspection criteria, discussion of initial flight inspection procedures, evaluation criteria and tolerances. Also, it addresses efficiencies that may be gained during the inspection of an LGF servicing multiple runways. Further, a status of the development of flight inspection criteria for terminal and airport surface procedures is presented.

.INTRODUCTION

This section provides a high-level discussion of the major GPS components and how LAAS is used to augment GPS performance to meet requirements for navigation and landing operations. The key LAAS subsystems are introduced with discussions then focusing on the ground subsystem.

GPS is an integrated system comprised of the following three components: the satellite constellation or space segment; the ground control and monitoring network also knows as the operational control segment; and, the user segment commonly referred to as the GPS receiver [1]. The space segment nominally consists of a 24-satellite constellation with each satellite providing ranging signals and data to the GPS receiver. The operational control segment maintains the satellites in terms of orbital location and functionality, as well as monitoring the health and status of each satellite. Although the satellites are monitored by the control segment, the requisite user alarm, warning functionality typical of navigation, approach, and landing systems is not provided. Further, enhancement of the GPS SPS is normally required to meet the accuracy, integrity, availability and continuity performance requirements for instrument operations.

Enhancement of the GPS SPS can be accomplished by using airborne based augmentation systems (ABAS), satellite based augmentation systems (SBAS), and/or ground-based augmentation systems (GBAS). As referred to herein, LAAS is the specific realization of the GBAS architecture adopted by the United States of America. LAAS is intended to be an all-weather navigation service meeting ICAO Standards and Recommended Practices (SARPS) in terms of performance and interoperability. It consists of the following three primary subsystems: 1) the satellite subsystem; 2) the ground subsystem; and, 3) the airborne subsystem [2]. For LAAS, the satellite subsystem is GPS, which was discussed previously. It provides ranging signals to both the airborne subsystem and the ground subsystem.

As previously stated, the ground subsystem for LAAS is referred to as the LGF [2]. The LGF produces ground-monitored differential corrections for each satellite in view, integrity-related information, and definition of the final approach segment, missed approach, or Terminal Area Path (TAP) based on path point data stored within its local navigation database. These data are transmitted throughout the entire service volume by the VHF Data Broadcast (VDB) transmitter to the aircraft avionics comprising the airborne subsystem. Thus, LAAS is capable of providing service simultaneously to all aircraft in the service volume. Also, the LGF provides for both local and remote status, control, and maintenance interfaces.

The airborne subsystem applies the LGF-generated differential corrections to the GPS ranging signals to obtain a differentially-corrected position solution with the required accuracy, integrity, continuity, and availability. In addition to the integrity information broadcast by the VDB, the airborne subsystem also employs Receiver Autonomous Integrity Monitoring (RAIM) as a means of GPS ranging signal fault detection on the airborne side [3]. The more-precise position solution and the path point data transmitted by the VDB are used to calculate lateral and vertical guidance with respect to the final approach path (precision approach), TAP or other supported instrument procedures. Proportional guidance deviation outputs, in “ILS look-alike” fashion, are provided to aircraft displays and navigation systems. The airborne subsystem also provides appropriate annunciations of system performance to the user, e.g., alerts and flags. In addition to deviation outputs, a position-velocity-time (PVT) output with integrity is provided to support enhanced navigation and surveillance operations.

In general, LAAS provides a flexible positioning service capable of supporting precision approach, TAP, departure procedures, airport surface operations, and enhanced area navigation (RNAV). It enables “precision RNAV” in the terminal area that provides the level of navigation serviced required for supporting curved arrival, approach, and departure procedures. The position accuracy is well suited for supporting airport surface operations by enabling both enhanced situational awareness and electronic guidance. The PVT output can be used to support surveillance applications within local and terminal areas; it can be used as a source of position information for Automatic Dependent Surveillance-Broadcast (ADS-B) equipment.

The objective of a commissioning LAAS flight inspection is the evaluation of a particular LGF and all of the instrument flight procedures to be support by that facility [4][5][6]. The rationale for this objective is discussed further in the following section. Since the inspection activity is “LGF-based”, the LGF and related matters will be discussed in more detail at this point.

LAAS is intended to provide radio navigation vertical and lateral guidance for instrument precision approach and landing from 20 nm from the runway threshold through touchdown and rollout. It will nominally require only one LGF at an airport to provide service to all runways and aircraft in the service volume. The ground subsystem will be modular and will have appropriate redundancy to support all runway ends, and it is capable of being installed entirely on the airport. An LGF generally consists of the following four main equipment groups: reference receiver; VDB equipment; processor; and operations and maintenance.

The reference receiver group usually consists of four reference receiver stations, each station containing a GPS reference receiver, a reference receiver antenna, associated cables, equipment racks, and antenna mounts. The reference receivers may be located in an environmentally controlled shelter or individual equipment enclosures located in proximity to the reference receiver antenna. Although there are limitations on the location of the reference receiver antennas relative to the runways being serviced, they are not constrained to be in close proximity (i.e., 1,000 feet) to those runways. The reference receiver antennas should be sited in protected, low-multipath (GPS signal reflection) locations with an unobstructed view of the sky.

The VDB equipment group consists of the VDB transmitter, antenna, monitor, associated cables, equipment racks, and antenna mounts. Although it may be preferable from a logistic view point to site the reference receiver antennas and VDB antenna in the same location, the VDB antenna may be independently sited to provide adequate signal coverage. If required, two or more VDB equipment groups can be used to satisfy coverage requirements at complex airports or airports having coverage-related siting issues. The use of multiple VDB groups is one method for satisfying both airborne and airport surface coverage requirements, since antenna installation requirements differ in the case of airborne versus surface coverage.

The processor group consists of dedicated micro-processors, operationally pertinent data, and software that perform the differential correction computations and integrity processes, and VDB message generation functions, as well as human interfaces (display), associated communication cables, and equipment racks. Operationally pertinent data includes the navigation database containing the all procedure data that is broadcast to users within the LAAS service volume. This group is housed in the primary LGF equipment shelter, which may also contain the reference receivers.

The operations and maintenance group includes equipment to perform those control and status functions normally required for a landing aid. Including items such as a local status and control panel, maintenance data terminal/terminal interface, remote status panel/interface, and an air traffic control unit/interface.

It is important to realize that LAAS uses an earth-centered, earth-fixed (ECEF) reference system based on the WGS-84 datum instead of being source-referenced like conventional radio navigation systems. Because of this, reference receiver antenna locations, runway threshold coordinates, obstacle locations, and all path point data must be accurately surveyed relative to each other. Further, if the coordinates for these items are surveyed separately by different entities and/or accomplished over an extended period of time, then accuracy of the absolute coordinates becomes important.

LAAS INSPECTION CRITERIA DEVELOPMENT

This section discusses the impetus for developing flight inspection criteria for LAAS. Next, the design and site qualification activities that are assumed to be accomplished prior to flight inspection are overviewed, as well as the rationale employed when developing the initial FAA LAAS flight inspection criteria. This section concludes with an overview of when flight inspection should be conducted and discussion of system accuracy assessment during flight inspection.

In order to facilitate the integration of LAAS into the NAS, standards must be developed based on specific operational requirements and system architectures. These standards provide, in terms of system-architecture-specific parameters, the minimum performance required to support a given operation. The standards development process includes the generation of flight inspection criteria. These criteria address the specific system parameters to be assessed and the assessment methodology employed to ensure that the installed-system performance is suitable for supporting the intended instrument flight procedures (IFPs). Such flight inspection criteria must be developed and verified to enable implementation of LAAS.

The FAA effort to develop LAAS flight inspection criteria was initiated nearly a decade ago with the identification four distinct activities to be accomplished [4]. The first activity involved identifying those system-specific parameters that should be recorded during flight inspection of LAAS IFPs. Once the identification of parameters was completed, the next activity was to develop candidate methodologies for assessing the data collected for these parameters, as well as specifying other evaluations to be performed (e.g., obstacle evaluation). This activity includes determining tolerances and other conditions that must be satisfied for a facility or procedure to be put in service. The third activity is the development of flight inspection criteria and procedures that ensure a thorough yet efficient inspection of the service volume and IFPs. That is, how to accomplish effective, meaningful sampling of the service volume. The final activity is verification of the inspection criteria and procedures. This activity is accomplished through implementation of the criteria and procedures, which provides the opportunity to assess the technical merit of the specific parameters considered, data collection and assessment methodologies utilized, and any implementation issues that may arise during the actual application of the criteria. Additionally, revision of the criteria and procedures to improve effectiveness and efficiency may occur as operational experience is gained with a given system.

Developing effective LAAS flight inspection criteria requires understanding what other test and qualification activities will be accomplished and the objectives of those activities. Thus, an overview of the activities that are assumed to be accomplished prior to flight inspection will be discussed at this point.

LAAS receiver standards specify performance requirements, the manner in which data transmitted by the VDB is to be used, and that receivers shall not provide hazardously misleading information in the presence of Radio Frequency Interference (RFI) [6]. Thus, it is assumed the receiver design approval process and installation qualification procedures ensure compliance with the receiver standards in the operational environment.

Similar standards and guidance material exist for the LGF [2][6]. Specifically, it is assumed the aggregate of the system design approval, site qualification activities, and installation qualification procedures successfully accomplish the following:

-Verifying suitable GPS signal level and signal quality exist at each reference receiver antenna sites;

-Ensuring installation and systematic errors are addressed such as accurate determination of each reference receiver antenna phase center or that the maximum use distance parameter (D_{max}) is set appropriately;

-Addressing/monitoring long term variation in range error due to environmental changes; and,

-Ensuring data sampling intervals, techniques and spatial correlation between reference receiver antennas are addressed as required to ensure compliance with accuracy and integrity requirements.

Based on the system design approval and installation qualification procedures discussed above, it should be realized that LAAS flight inspection criteria are not intended to, nor required to provide an assessment of either LGF or LAAS receiver equipment performance. Once design approval and installing qualification procedures are completed, one relies on the monitoring and built-in tests inherent to the equipment to detect and announce faults.

Thus, the development of FAA LAAS flight inspection criteria is based on the need to assess the site-specific elements of a LAAS instrument approach procedure and to confirm service availability. Specifically, flight inspection is used to confirm procedure design, final segment alignments, obstacle clearance, GPS signal reception, and VDB signal reception within the coverage volume. Flight inspection should be performed for the following situations [4][6]:

-Prior to commissioning on each runway served for each procedure;

-When interference is reported or suspected and elimination of the interference cannot be verified by ground-based testing;

- Existing procedures are revised or new procedures are introduced at an operational facility;

- Whenever changes to the LGF configuration are made such as hardware/software changes having the potential to affect the internal navigation database or coding/construction of the VDB messages, changes in reference receiver and/or VDB antenna phase center locations, or change in VDB antenna type; and,

-Whenever physical changes occur at the site having the potential to effect GPS signal reception and VDB coverage, such as new obstructions or construction.

Although the FAA LAAS flight inspection criteria specifies which parameters are measured and under which conditions, this section will close with a short discussion of assessing system accuracy as it pertains to flight inspection. Traditionally, system accuracy is measured and assessed during the flight inspection of ground-based navigation aids. However, LAAS system accuracy is time varying on a sub-hourly basis due to variation in satellite geometry. Thus, LGF accuracy tests must be accomplished continuously, which is only feasible by conducting ground-based assessments. Further, the LGF accuracy performance is specified in the range domain, thus testing and monitoring in the range domain is required to ensure compliance with the accuracy requirement. Although a flight inspection recording showing in-tolerance accuracy performance is not a sufficient condition for verifying system performance, it is a necessary condition. Thus, position domain accuracy measurements performed during flight inspection can provided a meaningful functional check.

OVERVIEW OF FAA DRAFT ORDER 8200.LAAS

This section provides an overview of FAA draft Order 8200.LAAS [5]. This draft order contains initial FAA flight inspection procedures, requirements, and analysis for the evaluation of LAAS precision instrument approach procedures. The current version of the order is applicable to the evaluation of procedures with DAs of not less than 200 feet AGL. Since preliminary criteria for TAP procedures and airport surface procedures supporting enhanced situational awareness are under development at this writing, sections in the order have been reserved for inclusion of this material when available [7]. Similarly, as Category II/III LAAS equipment becomes available or as additional operational experience is gained, this order is expected to be reviewed and revised as appropriate.

In addition to the cover letter, FAA draft Order 8200.LAAS consists of the following four appendices: Appendix 1 - Background Material for LAAS; Appendix 2 - Flight Inspection Evaluation of LAAS Instrument Approach Procedures; Appendix 3 - Records and Reports Required for LAAS Flight Inspection; and Appendix 4 - Acronyms and Definitions. The introduction section of this paper is based heavily on the material contained in Appendix 1. The material for Appendix 3 is under development, and draft material for this appendix is not available in the current version of the order. Thus, the focus of this section is to provide an overview of Appendix 2, which addresses pre-flight requirements; flight inspection procedures for commissioning, periodic and special inspections; data analyses and evaluations to be performed; and tolerances.

Pre-flight Requirements

The material contained in Order 8200.LAAS on pre-flight requirements focuses on those items specifically related to preparing for a LAAS flight inspection and captures general preparation requirements by reference to FAA Order 8200.1[8]. Requirements for calibration of the flight inspection system draws attention to the fact the VDB antenna may radiate both horizontally and vertically polarized signals, thus calibration of both antennas on the flight inspection aircraft are to be performed. The next item addressed is determining the LGF maximum use distance (D_{max}) since this parameter influences the distance at which orbit maneuvers are performed. The LAAS Final Approach Segment (FAS) data blocks, which have been developed and coded into binary data files by the procedure designer, are to be downloaded to removable disk media. Flight inspection system access to each FAS data block is confirmed before mission departure, including confirmation that the Cyclic Redundancy Check (CRC) remainder is correct to ensure no errors occurred during data transfer.

Additional pre-flight requirements exist for the inspection of an LGF supporting parallel runways, and these requirements center on defining approach sectors. An approach sector bounds the area of airspace common to all the approach procedures having the same approach and landing direction. Thus, a set of parallel runways will have two approach sectors associated with them, one for each landing direction. The methodology for evaluation of the approach sector, as opposed to assessing each runway end individually, permits sufficient assessment of each approach procedure while improving the efficiency of the inspection by eliminating redundant VDB coverage assessments.

The first step in defining an approach sector is determining the coordinates of the Fictitious Approach Sector Alignment Point (FASAP) and Fictitious Approach Sector Landing Threshold Point (FASLTP) for each approach sector. The approach sector centerline runs parallel to the runway centerlines and is located midway between the centerlines of the two outer-most runways (see Figure 1). The FASAP and FASLTP are located abeam the furthest most runway stop end and threshold, respectively, and on the approach sector centerline as illustrated in Figure 1.

The second step is to determine the four coordinates for the left and right limit boundaries of the approach sectors for each set of parallel runways. The right limit boundary is defined by a radial rotated 10˚counterclockwise from the controlling runway centerline. The left limit boundary is defined by a radial rotated 10˚clockwise from the other controlling runway centerline. The final step is to determine the Right Boundary Alignment Point #1 (RBAP1), Right Boundary Alignment Point #2 (RBAP2), Left Boundary Alignment Point #1 (LBAP1), and Left Boundary Alignment Point #2 (LBAP2) as indicated by Figure 2.

Flight Inspection Procedures

This portion of Appendix 2 provides the flight inspection procedures for commissioning, periodic, and special inspections. The check list for initial or commissioning inspections includes material addressing the evaluation of VDB coverage and the LAAS instrument approach procedures to be supported. This material will be discussed first, followed by discussion of requirements for period and special flight inspections.

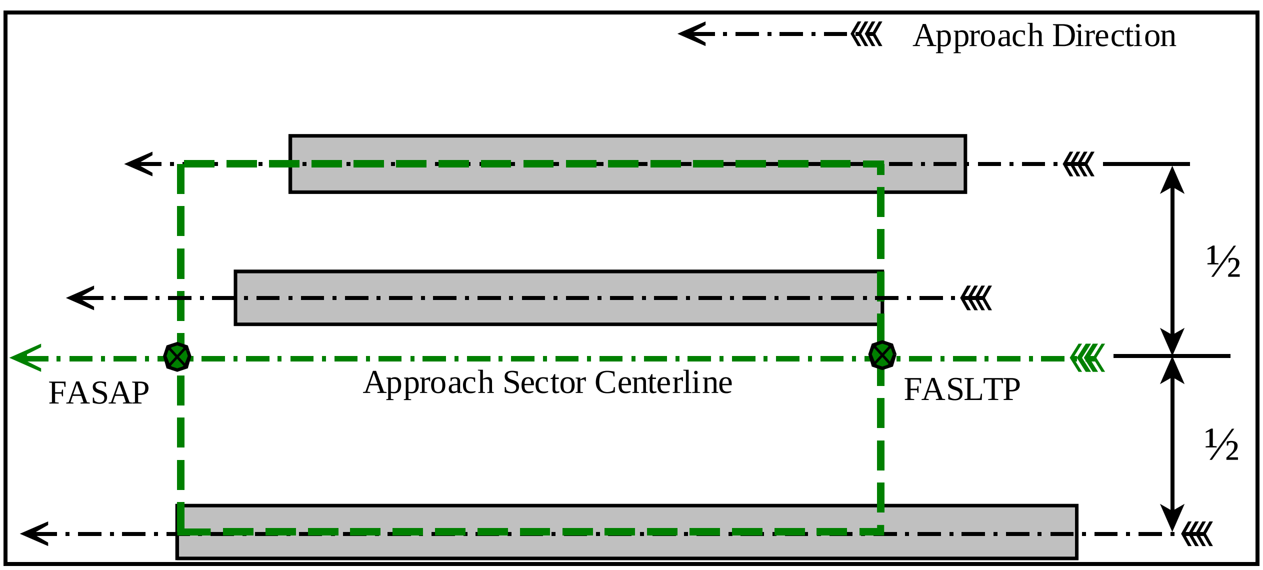

Figure 1. Determining Approach Sector Centerline, FASAP, and FASLTP.

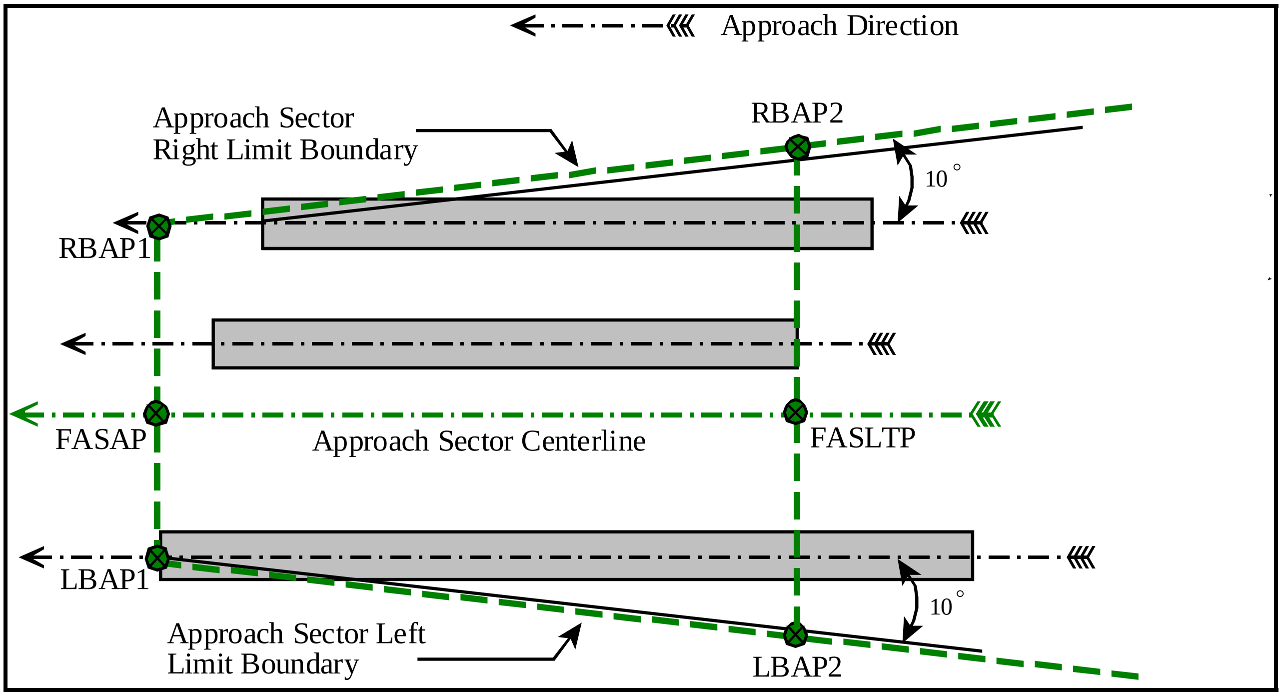

Figure 2. Determining Right/Left Boundary and Boundary Alignment Points.

VDB Coverage Assessments. The service volume for LAAS is constrained by both the Radio Frequency (RF) signal coverage provided by the VDB antenna(s) and the maximum use range (D_{max}) from the LGF for which the broadcast differential corrections are applicable. Thus, the RF signal coverage of the VDB must encompass the area of intended terminal and approach operations. Since the outer limit of the service volume is defined by D_{max}, D_{max} must also be set appropriately for each facility. Facility-based coverage assessments are specified to evaluate both the VDB RF signal coverage and the suitability of the value used for D_{max}. In addition, procedure-based coverage assessments are specified for evaluating RF signal coverage within the service volume for procedurally significant airspace. Coverage assessments are performed with the VDB power output at the alarm limit and coverage is validated for both horizontally and vertically polarized signals. The coverage evaluation is based on loss of signal and data continuity alerts, and this evaluation methodology is based on current inspection equipment capabilities.

Facility-based coverage assessments consist of orbits flown at the extremes of the LGF service volume (D_{max}). Two orbits are required for initial coverage evaluations. One orbit is flown at the lower coverage limit as computed using the criteria provided. Since the typical value for D_{max} is 23 nm, this orbit will normally be flown at 2,300 feet above site level. A second orbit is flown at 10,000 ft above site level. Clear line-of-sight (LOS) from the VDB transmit antenna to the lower extreme coverage limit may not exist for the entire 360 degrees of azimuth. Such situations may cause unavoidable outages of the VDB signal during inspection of the lower coverage limit. In this case, an additional orbit, partial or whole as required, is performed at the lowest altitude where clear LOS from the VDB transmit antenna to the lower extreme coverage limit exists for the entire 360 degrees of azimuth.

Procedure-based coverage assessments are intended to verify coverage along TAP procedures, initial and intermediate approach segments, final approach segments, missed approach segments, and on the airport surface. These VDB coverage assessments are performed with the power output at the RF power alarm point. Detailed evaluations are performed to assess coverage for each instrument approach procedures. Table 1 provides the requirements for assessing VDB coverage for each approach procedure and is based primarily on recommendations from Reference [9]. The maneuvers listed in Table 1 are intended to provide assessment of the coverage requirements illustrated in Figure 3. For LGFs servicing multiple runways, each approach procedure shall be evaluated in accordance with Table 1, except for the case of parallel runways.

When the LGF to be evaluated supports approach procedures to parallel runways, approach sectors are defined, one for each landing direction. Table 2 provides modified requirements for assessing parallel runway configurations, and the measured values are the same as those specified in Table 1.

Table 1. VDB Approach Coverage Assessment – Single Runway (See Note 3).

Requirement	Evaluation Area	Method	Measured Value
Normal Approach	From 20 NM to LTP	Fly on path, on course	1) LAAS Receiver maintains "GBAS" Integrity 2) No CDI Flags
Lower-Limit of Approach	From 20 NM to LTP	From 21 NM and 5000 above LGF, fly on course, intercept and fly glide path within 1 dot of full scale below path	Same as above Note 1 Note 2
Upper-Limit of Approach	From 20 NM to LTP	From 21 NM and 8000 above LGF, fly on course, intercept and fly glide path within 1 dot of full scale above path	Same as above Note 1 Note 2
Left-Limit of Approach Note 4	From 20 NM to LTP	From 21 NM, fly on path and offset course to within 1 dot of full scale of "fly right"	1) LAAS Receiver maintains "GBAS" Integrity 2) No CDI Flags Note 2
Right-Limit of Approach Note 4	From 20 NM to LTP	From 21 NM, fly on path and offset course to within 1 dot of full scale of "fly left"	1) LAAS Receiver maintains "GBAS" Integrity 2) No CDI Flags Note 2
Coverage from the Minimum Vectoring Altitude (MVA) Note 4	From 20 NM to 7° glide path	From 21 nm, on course and the MVA or 2,300 feet above LTP, which ever is higher, fly at level altitude until 7-degree path	1) LAAS Receiver maintains "GBAS" Integrity 2) No CDI Flags Note 2
Coverage from Upper Service Volume Note 4	From 20 NM to 7° glide path	From 21 nm, on course and 10,000 feet above LTP fly at level altitude until 7 degree path	1) LAAS Receiver maintains "GBAS" Integrity 2) No CDI Flags Note 2
Missed Approach	From Runway Stop End to 4 NM	Fly runway course, climb at 200 feet per NM	1) LAAS Receiver maintains "GBAS" Integrity 2) No CDI Flags
Roll Out	From Runway End to Runway End	Taxi along runway	1) LAAS Receiver maintains "GBAS" Integrity 2) No Lateral CDI Flags

Note 1: Determine that guidance is available and the CDI is active at the upper and lower vertical procedure extremities.

Note 2: Determine that guidance is available and the CDI is active at the lateral procedure extremities.

Note 3: VDB transmitter power set at the lower limit of the VDB monitor.

Note 4: See Table 2 for requirement when evaluating parallel runway configurations.

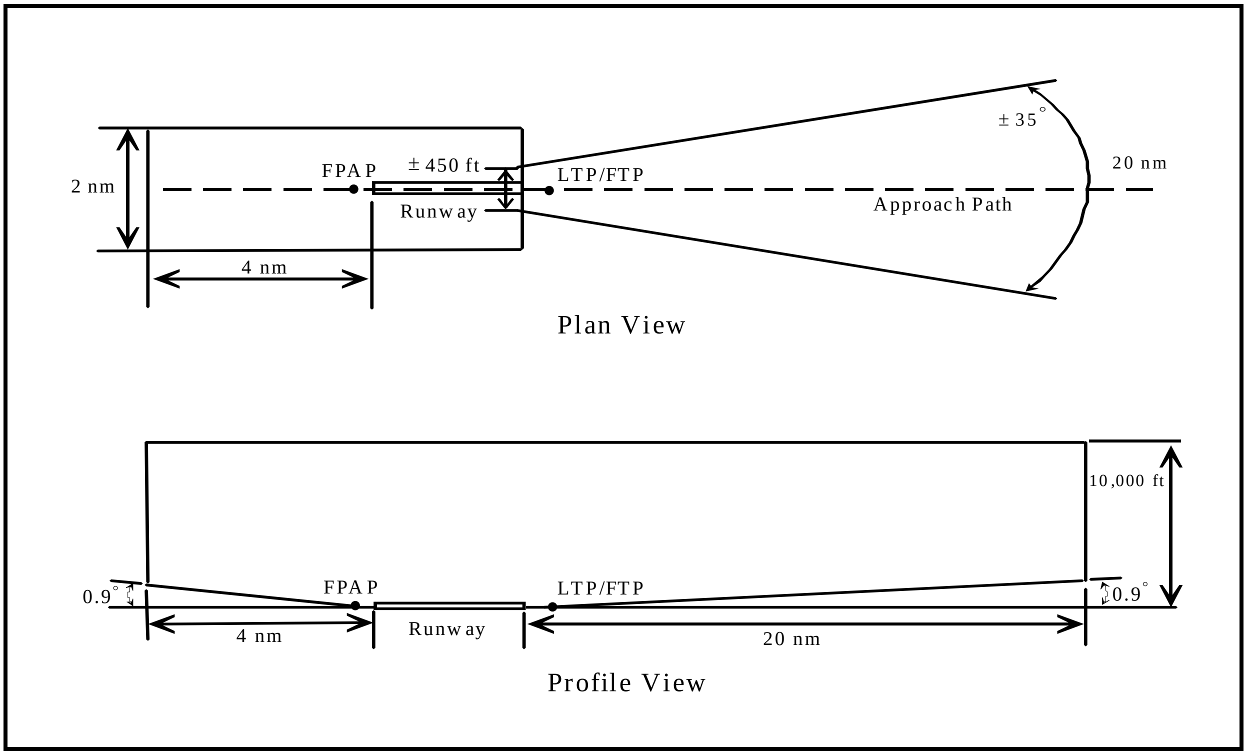

Figure 3. LAAS Approach Coverage Requirements.

Table 2. VDB Approach Coverage Assessment – Parallel Runways.

Requirement	Evaluation Area	Modified Method	Performed For
Normal Approach	From 20 NM to LTP	No change	Each approach procedure
Lower-Limit of Approach	From 20 NM to LTP	No change	Each approach procedure
Upper-Limit of Approach	From 20 NM to LTP	No change	Each approach procedure
Left-Limit of Approach	From 20 NM to LBAP2 (Figure 2)	From 21 NM, on path and fly along left limit of approach sector boundary	For left limit of each approach sector
Right-Limit of Approach	From 20 NM to RBAP2 (Figure 2)	From 21 NM, on path and fly along right limit of approach sector boundary	For right limit of each approach sector
Coverage from MVA	From 20 NM to 7° glide path	From 21 nm, on approach sector centerline and the MVA or 2,300 feet above FASLTP, which ever is higher, fly at level altitude until 7-degree path relative to FASLTP.	For each approach sector centerline
Coverage from Upper Service Volume	From 20 NM to 7° glide path	From 21 nm, on course and 10,000 feet above FASLTP fly at level altitude until 7 degree path relative to FASLTP.	For each approach sector centerline
Missed Approach	From Runway Stop End to 4 NM	No change	For each approach procedures
Roll Out	From Runway End to Runway End	No change	Once for each runway

Instrument Approach Procedures Assessments. All instrument procedures are required to be evaluated to ensure flyability and safety. The evaluation and analysis for the Standard Instrument Approach Procedures (SIAPs) are included by reference to FAA Order 8200.1 [8]. In addition, the following requirements are set forth in draft Order 8200.LAAS.

-Initial and Intermediate Approach Segments: The procedure is flown from the Initial Approach Fix (IAF) to the Final Approach Fix (FAF), maintaining procedural altitudes. The evaluations performed include obstructions, procedure design, supporting navigation systems, and VDB coverage where required.

-Final Approach Segment: The final segment is flown at procedural altitudes until intercepting the glidepath, and then the aircraft descends on the glidepath to the Landing Threshold Point (LTP), Fictitious Threshold Point (FTP). Evaluations performed include obstructions, procedural design, horizontal alignment, glidepath alignment, and VDB coverage. Procedures that support azimuth only approaches shall be evaluated to the Missed Approach Point (MAP).

-Missed Approach Segment: The missed approach procedure is flown from the MAP using the procedural waypoints or associated navigation systems. Evaluations performed include obstructions, procedural design, transition to the missed approach, and VDB coverage.

Periodic/Special Flight Inspection. In general, the need for periodic flight inspection stems from the fact that as time passes system performance can degrade from that measured during the commissioning inspection or the obstacle environment may change. The typical causes for system degradation and methods for mitigating those causes are discussed in references [10][11]. Those causes mitigated by periodic flight inspection include a change in the environment, Radio Frequency Interference (RFI), and modification of the instrument approach procedure. Similarly, special flight inspection evaluations are required subsequent to select maintenance actions to address equipment failures or in response to user complaints.

For LAAS, the purpose of periodic inspection is to ensure that there has not been any degradation of VDB coverage due to environmental changes or equipment repair/replacement, and to ensure that new sources of RFI have not come into existence. Draft Order 8200.LAAS states that commissioned facilities are initially required to be inspected on a 360-day interval. The interval used for subsequent periodic inspections may be increased based on both performance of the individual facility and as NAS wide experience with LAAS is gained. VDB coverage is evaluated at the altitude established for the lower orbit during commissioning, and the evaluation is based on loss of signal and data continuity alerts. For each SIAP, the LGF broadcast FAS data block CRC will be checked to ensure there has been no change or corruption.

Flight Inspection Analysis and Tolerances

This section of Appendix 2 provides a high-level discussion of the need for paper records and electronic collection of data. An overview of what data are collected during each stage of the flight inspection and how the data are analyzed to confirm proper operation of the service is presented. As examples, the horizontal alignment and glidepath angle are evaluated to confirm the aircraft is delivered to the designed LTP/FTP, or how to assess the electromagnetic spectrum if RFI is suspected. Table 3 lists the parameters that must be documented at the time anomalies are found. Table 4 lists the tolerances used for evaluation of collected data. The material in these sections of draft Order 8200.LAAS is expected to become more detailed as operational experience is gained.

Table 3. GPS Satellite Parameters Recorded.

Parameter	Expected Values
Horizontal Protection Level (HPL_{GBAS})	≤ 10m
Vertical Protection Level (VPL_{GBAS})	≤ 10m
Horizontal Dilution of Precision (HDOP)	≤ 4.0
Vertical Dilution of Precision (VDO)P	≤ 4.0
Horizontal Integrity Limit (HIL)	≤ 0.3nm
Figure of Merit (FOM)	≤ 22meters
Satellites Tracked	5 Minimum
Signal-to-Noise Ratio (SNR)	30 dB/ Hz minimum

CONCLUSION AND CLOSING COMMENTS

This paper provided an overview of LAAS, the rationale employed to develop FAA LAAS flight inspection criteria, and draft Order 8200.LAAS. The intent was not to include a verbatim citation of this Order but to inform the international flight inspection community of its status, share the insight used in developing it, and foster continued discussion on the subject.

As discussed herein, LAAS is intended to be an all-weather navigation service meeting ICAO standards in terms of performance and interoperability. It is capable of supporting precision and non-precision approach procedures, as well as supporting TAP and airport surface guidance procedures.

Table 4. Tolerances for LAAS Flight Inspection.

Parameter	Tolerances
Terminal Area Path	(Reserved)
Initial/Intermediate Approach Segment	FAA Order 8200.1
Final Approach Segment FAS data: Bearing to LTP Glidepath Angle FAS Data CRC Threshold Crossing Height Course Alignment w/runway C/L	 ± 0.1° true course $\pm 0.05^0$ No Corruption ±2 m Centerline
Missed Approach Segment	FAA Order 8200.1
Coverage VDB signal	Indicates GBAS mode
Horizontal Protection Level Vertical Protection Level	40m 10m
Co-channel / adjacent channels (VOR or ILS) Annex 10, V1, Attch D Para 7.2	No misleading information
RFI	No misleading information
Maximum Usable Distance (D_{max})	As defined by LGF Site.

In addition to system specifications and equipment design approval procedures, flight inspection criteria must be developed in order to implement LAAS. The FAA effort to develop LAAS flight inspection criteria was initiated nearly a decade ago. During this effort it was realized that developing effective criteria required an understanding of what other test and qualification activities are accomplished prior to flight inspection and the objectives of those activities. The activities assumed to be accomplished prior to flight inspection were discussed herein.

Based on these activities, it is concluded that LAAS flight inspection criteria are not intended to, nor required to provide an assessment of either LGF or LAAS receiver equipment performance. LAAS flight inspection criteria are needed to evaluate the site-specific elements of a LAAS instrument approach procedure and to confirm service availability. Specifically, the objective of flight inspection is to confirm procedure design, final segment alignments, obstacle clearance, GPS signal reception, and VDB signal reception within the coverage volume defined by D_{max}.

This objective is the bases for the initial flight inspection criteria contained in FAA Order 8200.LAAS. As previously stated, these criteria are applicable for the evaluation of procedures with DAs of not less then 200 feet AGL. An overview of Order 8200.LAAS was presented with discussion focusing on Appendix 2, which addresses pre-flight requirements; flight inspection procedures for commissioning, periodic and special inspections; data analyses and evaluations to be performed; and tolerances. Also, it addresses efficiencies that may be gained during the inspection of an LGF servicing multiple runways.

Preliminary flight inspection criteria for TAP procedures and airport surface procedures supporting enhanced situational awareness are under development as of this writing and are expected to be available during fall 2008. Similarly, as Category II/III LAAS equipment becomes available or as additional operational experience is gained, Order 8200.LAAS is expected to be reviewed and revised as appropriate.

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Paper Title: Initial Federal Aviation Administration (FAA) Flight Inspection Criteria for Precision Instrument Approach Procedures Supported by the Local Area Augmentation System (LAAS)

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