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System Requirements Document (SRD)

for the

Joint Precision Approach and Landing System (JPALS)

Local-area Differential Global Positioning System (LDGPS)

Revision 2.4

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1. Scope

1.1 Identification

This System Requirements Document (SRD) contains system level requirements for the Joint Precision Approach and Landing System (JPALS) Local-area Differential Global Positioning System (LDGPS) Program. Requirements in this document were derived to support the Operational Requirements Document (ORD) for JPALS (USAF 002-94-I), Block I, Interoperable JPALS.

ORD Block I addresses Interoperable JPALS and references four operating environments, Fixed Base, Tactical, Special Mission and Shipboard. This SRD addresses the JPALS requirements for the Fixed Base, Tactical, and Special Mission environments. The US Navy (Naval Air Systems Command (PMA-213)) is preparing a separate SRD that establishes the JPALS requirements for the shipboard environment, they are not included in this SRD.

ORD Block II addresses the Autonomous Landing Capability (ALC). This is a separate landing capability being developed for a limited number of aircraft types, including select Air Mobility Command (AMC) and Air Force Special Operation Command (AFSOC) aircraft. ALC requirements are not included in this SRD.

ORD Block III, Shipboard Backup System, address a unique shipboard landing capability based on an improved Instrument Carrier Landing System (ICLS+) for the Navy. ICLS+ requirements are not included in this SRD.

The SRD does not address airfield infrastructure requirements such as airfield lighting and marking.

1.2 System Overview

JPALS is intended to provide a rapidly deployable, adverse weather, adverse terrain, day-night, survivable, and mobile precision approach and landing capability (PALC) that supports the principles of forward presence, crisis response and mobility. The capability should enable U.S. forces to land on any suitable surface world-wide (land and sea), under both peacetime and hostile conditions, with ceiling and/or visibility the limiting factor. The capability should support interoperability among the DoD to support joint operations, training and logistics. The capability will provide transparent coexistence with the domestic and international air traffic control/airspace system. The system is intended to be interoperable with military forces of allied nations to the greatest extent possible.

A JPALS analysis of alternatives determined that JPALS should be based on LDGPS technology. LDGPS augments the existing Global Positioning System (GPS) for use in safety-critical navigation applications. Augmentation is necessary because the stand-alone Standard Positioning Service (SPS) and Precise

Positioning Service (PPS) provided by GPS are insufficient to meet the accuracy, integrity, continuity, and availability demands of precision approach and landing operations. The basic concept of LDGPS is as follows: First, ranging sources (i.e., GPS satellites) provide both the LDGPS ground station and the LDGPS-equipped aircraft with ranging signals. Then, the ground station produces ground-monitored differential corrections and integrity-related information as well as data defining the desired flight path. These data are transmitted over a data link to the aircraft. The aircraft then uses the data to calculate a differentially-corrected position estimate and generates guidance with respect to the desired path. The aircraft also provides appropriate annunciations of system performance (e.g., alerts). Therefore, this SRD assumes that the JPALS shore based (fixed, tactical and special mission) program requirements must be met using a system based on LDGPS.

1.3 Operating Environment

US forces conduct operations throughout the spectrum of threat environments. These operations may occur before, at, or beyond the forward edge of the battle area. The system must operate in an environment that includes a large number of Radio Frequency (RF) emitters (both friendly and unfriendly) and hostile electronic attack assets that operate across the electromagnetic spectrum.

Figure 1-1 depicts the three types of landing operations supported by LDGPS. The paragraphs that follow briefly describe these three landing environments: Fixed Base, Tactical, and Special Mission.

The fixed base aircraft precision approach and landing operating environment (military and civil) is generally a prepared field with a well established airfield infrastructure. The probability of hostile action at fixed bases can vary from low to high. Aircraft activity will range from low to high air traffic and for a relatively long period of time. The duration of the fixed base deployment is intended to be a permanent installation. The fixed base operating environment will involve military aircraft, allied aircraft, and Civil Reserve Air Fleet (CRAF) aircraft.

The tactical aircraft precision approach and landing operating environment (military and civil) is unprepared assault strips, bare bases, or expeditionary fields with limited airfield infrastructure. There is a high potential for enemy hostile action influencing tactical operations. Sustained air traffic may not be as high as fixed bases; however, surge launch and recovery rates may exceed fixed base rates. The duration of a tactical deployment can range from several days to several months or longer. The tactical operating environment will involve military aircraft and may involve allied and CRAF aircraft.

The special mission precision approach and landing operating environment may be unprepared assault strips, bare bases, expeditionary fields, and in areas with limited or no infrastructure. This operating environment may be in politically denied territory or within enemy lines, with a corresponding high potential for enemy encounter. Special mission operations may be clandestine in nature and can involve many aircraft types and numbers but for a shorter period of time in comparison to fixed base or tactical operations. Operations security usually requires communication-out operations for all aircraft.

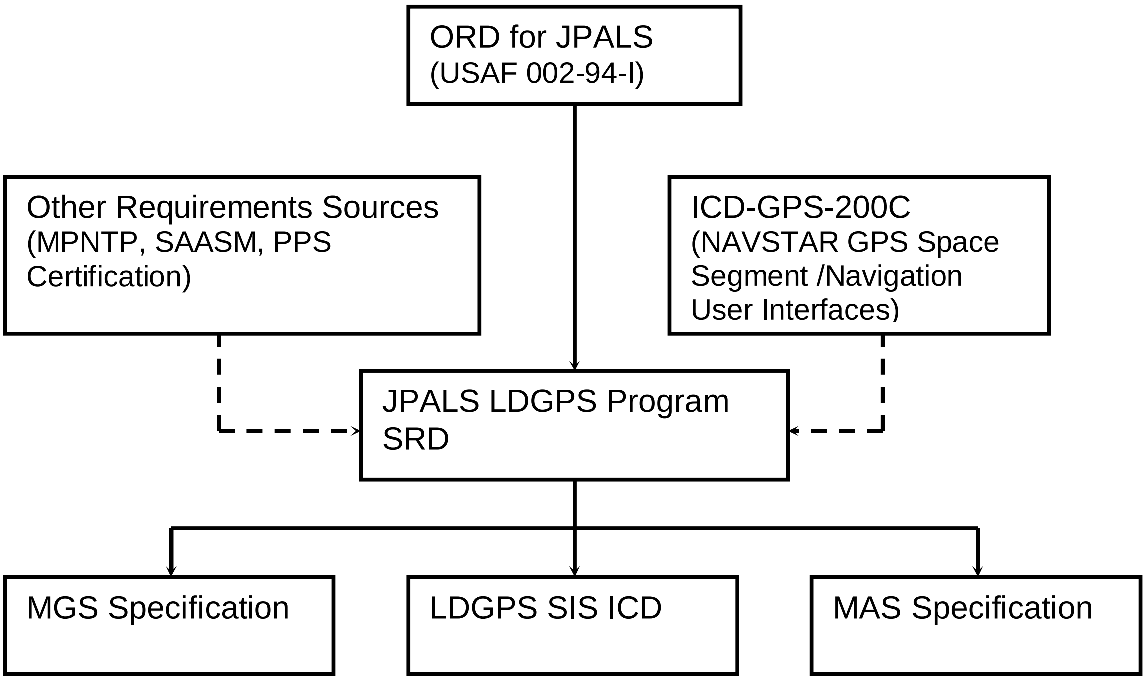
The JPALS Concept of Operations is being developed by the Air Force Flight Standards Agency (AFFSA) and will be added in a future update of the SRD.

Figure 1-1 JPALS Operational Environments

1.4 JPALS Requirements Hierarchy

The SRD is part of a family of documents that establish the system, performance, and interface requirements for JPALS that have been or will be developed to completely specify JPALS characteristics. Figure 1-2 illustrates the hierarchy of the various JPALS requirements documents for Block I.

The ORD contains the JPALS operational requirements, which are the primary source for the JPALS performance requirements contained in the LDGPS Program SRD. Other documents also contain requirements or capabilities that establish performance requirements that must be met by JPALS. From the SRD, JPALS performance requirements are then allocated to the MGS Specification, the JPALS SIS ICD, or the MAS Specification, as applicable.



ICD	Interface Control Document	MPNTP	Master Positioning Navigation and Timing Plan
MGS	Military Ground Segment	MAS	Military Airborne Segment
PPS	Precise Positioning Service	ORD	Operational Requirements Document
SIS	Signal In Space	SAASM	Selective Availability and Anti-Spoofing Module

Figure 1-2: JPALS Requirements Hierarchy for Block I

1.5 Evolutionary Acquisition

JPALS will be acquired and developed using an Evolutionary Acquisition strategy as described in DODI 5000.2, para 3.3. JPALS capabilities will be acquired and fielded to meet user demands consistent with the necessary technology development and maturation and user needs. The JPALS blocks will start with a JPALS tactical SL7 (Category I) system for the Marine Corps Short Take-Off and Vertical Landing (STOVL) Joint Strike Fighter (JSF) variant. The second block extends the JSF capability to include other terminal area procedures (TAPs).. Subsequent blocks will extend this capability to fixed base operations (Block 3) and tactical SL8 (Category II) capabilities (Block 4). These blocks and their capabilities are summarized in Table 1-1.

Table 1-1 JPALS Block Developments

JPALS Blocks	Capabilities	Guidance Quality	Platform
Block 1	Tactical, Category I; Straight in Approach; Autoland* to CAT I DH	SL7	JSF (Shore based operations, all variants (CV, STOVL, CTOL))
Block 2	Block 1 plus Terminal Area	SL7	JSF (Shore based

	Navigation; Missed Approach; Takeoff; Miscellaneous Approach (offsets, curved/ segmented, etc)		operations, all variants except only STOVL will use Takeoff)
Block 3	Block 1 and Block 2 capabilities but for Fixed Base	SL7	JSF (shore based operations, all variants)
Block 4	Block 1 and Block 2 capabilites for Category II, Autoland* to CAT II DH	SL8	TBD

* Autoland support is defined as providing the applicable guidance quality (e.g., SL7) with a service volume that provides guidance to touch down .

Subsequent JPALS capabilities will be fielded as user needs and technology are identified and developed.

Capabilities for JPALS that include complex approach procedures, missed approach procedures, departure, taxi, and terminal area navigation are being defined and investigated by the RTCA and FAA for civil application. The primary issues with each procedure are the guidance quality, service volume and unique data message requirements.

[Note: A missed approach capability should be considered for the JSF. RTCA has defined a message block for missed approaches that is proposed to be transmitted with each MT4 FAS data block. Also, RTCA is proposing to provide lateral guidance only and reverting to baroaltimeter altitude data for vertical. Guidance quality has not been defined yet.]

A new GPS signal code (M-code) and frequency (L5) as well as GPS III modifications will be considered and incorporated as they become available.

1.6 Document Overview

Section 1 contains general information on the scope and organization of this SRD and on the purpose of JPALS. Section 2 contains a list of applicable reference documents, portions of which are incorporated by reference or offered as guidance material. Section 3 contains a system description, functional requirements, modes of operation, and all applicable performance, interface, personnel, logistics, and environmental requirements. Section 4 provides quality assurance provisions to demonstrate compliance with Section 3 requirements. Appendix A provides an acronym list. Appendix B contains system vulnerability requirements (there is a separate classified supplement to Appendix B).

Use of the word "shall" in this SRD indicates a mandatory requirement in Section 3 to be verified in accordance with (IAW) Section 4. In some cases the SRD will identify both a threshold and an objective for a given performance requirement. All thresholds are mandatory and represent a minimum level of performance that must be met by JPALS. The objective values or levels for a given performance requirement are considered performance goals and represent a desired level of performance. Some requirement thresholds are further identified as Key Performance Parameters or KPPs. All KPP requirements for a given system must be achievable and met in order for the system to enter development and production and to be accepted by the user. The KPPs for JPALS are summarized in Table 1-2.

Table 1-2 JPALS KPP Summary

Key Performance Parameter	Threshold	Objective
1. Landing Minima / Guidance Quality		
Basic Capability (Fixed Base, Tactical, and Special mission)	SL 7*	SL 9*
Advanced Capability (Fixed Base and Tactical)	SL 8	SL 9*
2. Interoperability		
All top-level IERs will be satisfied to the standards specified in the threshold and objective values	100% of top-level IERs designated critical	100% of top-level IERs
3. Operational Availability (Ao)		
A_o: Fixed	≥ 99.5 %	≥ 99.6 %
A_o: Tactical	≥ 99.0 %	≥ 99.5 %
A_o: Special mission	Same as Objective	≥ 98.0 %
4. Vulnerability to GPS Signal Disruption / Spoofing		
All	Resistance to collateral jamming, specific value TBD	Resistance to collateral jamming, specific value TBD
All	System availability in a jamming environment, specific value TBD	System availability in a jamming environment, specific value TBD
6. C4I/Standardization, Interoperability, and Commonality		

Key Performance Parameter	Threshold	Objective
JPALS Airfields	JPALS equipped airfields shall support landing of all Service aircraft equipped with JPALS avionics, as well as civil aircraft with JPALS compatible avionics such as the Local Area Augmentation System (LAAS) supporting military operations at locations where civil aircraft are supported	Same as threshold plus allied aircraft
JPALS Avionics	JPALS avionics equipment must allow any aircraft the capability to conduct precision approach and landing to all required mission locations equipped with ICAO precision approach ground stations	Same as threshold

* Table 3-1

[The SRD also contains a number of notes or comments throughout the document to indicate areas where there is still some question on what to specify for a given performance requirement. The JPALS IPT will resolve all of these SRD questions and remove any corresponding notes or comments, prior to the start of Milestone B (SDD).]

2. Applicable Documents

The following documents of the exact issue shown form a part of this document to the extent specified. In the event of conflict between this document and the documents referenced herein, the contents of this document shall be considered a superseding requirement.

Table 2-1: Applicable Documents

#	Document	Title
1.	RTCA/DO-245 28 Sep 98	Minimum Aviation System Performance Standards (MASPS) for the LAAS
2.	RTCA/DO-246B 28 Sep 98	Global Navigation Satellite System (GNSS) Based Precision Approach LAAS Signal-in-Space (SIS) ICD
3.	RTCA/DO-253A 11 Jan 00	Minimum Operational Performance Standards (MOPS) for GPS LAAS Airborne Equipment
4.	RTCA/DO-229C 28 Nov 01	Minimum Operational Performance Standards (MOPS) for GPS/Wide Area Augmentation System (WAAS) Airborne Equipment
5.	USAF-002-94-I 19 Nov 02	Operational Requirements Document (ORD) for Joint Precision Approach and Landing System (JPALS), USAF 002-94-I, Air Force Flight Standards Agency (Draft)
6.		DoD GPS Standard Positioning Service (SPS) Performance Standard, October 2001
7.	ICD-GPS-200C IRN005R1 14 Jan 03	NAVSTAR GPS Space Segment/Navigation User Interfaces
8.	STANAG 4392 Edition 2 Annex D Latest Draft	A Data Interchange Format for NAVSTAR GPS, Format and Usage of Precise Positioning Service (PPS) DGPS Messages for Aviation and other High Performance Applications (North Atlantic Treaty Organization (NATO) Restricted)
9.	STANAG 4550 Edition 1 (Draft 3) 15 Oct 01	North Atlantic Treaty Organization (NATO) STANAG 4550, For Use of Differential Global Positioning System (DGPS) for Military Precision Approach and Landing, NATO Unclassified
10.	SS-GPS-001A 12 Mar 98	Selective Availability and Anti-Spoofing Module (SAASM)
11.	RTCA/DO-254 19 Apr 00	Design Assurance Guidance for Airborne Electronic Hardware

12.	RTCA/DO-178B 1 Dec 92	Software Considerations in Airborne Systems and Equipment Certification
13.	FAA-E-2937A 17 Apr 02	LAAS Ground Facility Specification for Category 1
14.	CJCSI 6130.01C 31 Mar 03	2000 Chairman of the Joint Chiefs of Staff (CJCS) Master Positioning, Navigation, and Timing Plan
15.	TBD	Precise Positioning Service (PPS) Certification
16.	17 February 1999	JPALS Security Classification Guide
16	DODI 5000.2 12 May 2003	Operation of the Defense Acquisition System
17	NASA TN D-5153 1969	The Use of Pilot Rating in the Evaluation of Aircraft Handling Qualities, George E. Cooper, Robert P. Harper Jr., NASA Langley

[Add CONOPS, Siting, and AES reports as they become available]

3. Requirements

3.1 System Definition

3.1.1 Major Component List

JPALS consists of two separate segments: a ground segment and an airborne segment as notionally depicted in Figure 3-1. A block diagram of the JPALS system is presented in Figure 3-2. The JPALS ground segment consists of three major components:

- multiple GPS receiver systems (GPS receiver, antenna and antenna electronics)
- a processing unit
- a data link transmitting unit with its antenna

The ground segment sends differential GPS corrections, integrity monitoring data and airfield runway information to the airborne segment. The processing unit gathers the receiver data, performs the integrity monitoring and computes the data for transmission. Multiple GPS receiver systems are used to minimize multipath effects and enhance integrity monitoring.

The JPALS airborne segment consists of three major components:

- a GPS receiver system (GPS receiver, antenna and antenna electronics)
- a data link receiving unit with its antenna
- a processing unit.

The airborne segment combines in the processing unit the GPS receiver data with the differential correction data to form the navigation solution. The processing unit also combines the ground and air based integrity monitoring information to make an integrity determination. The requirements for both the airborne and ground segment are defined in the following text.

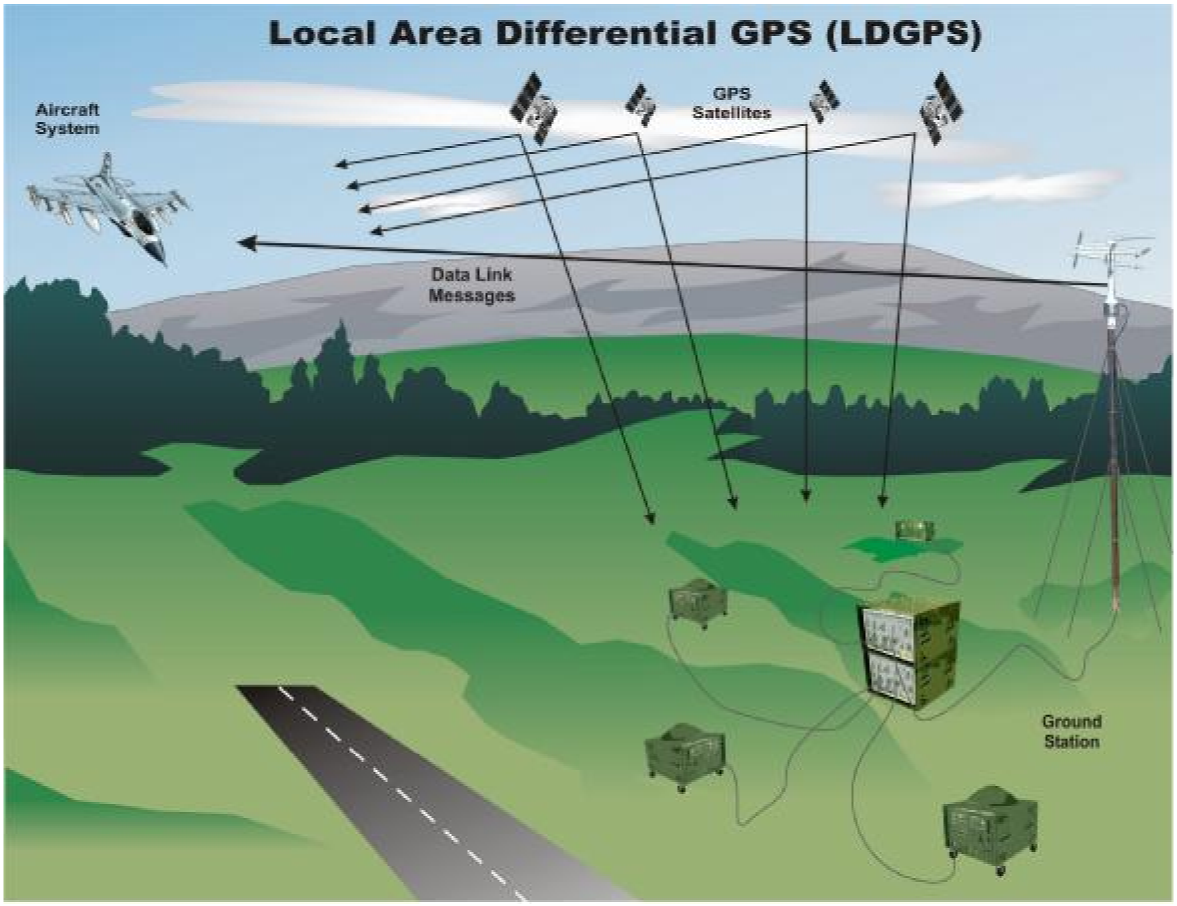


Figure 3-1 Notional JPALS

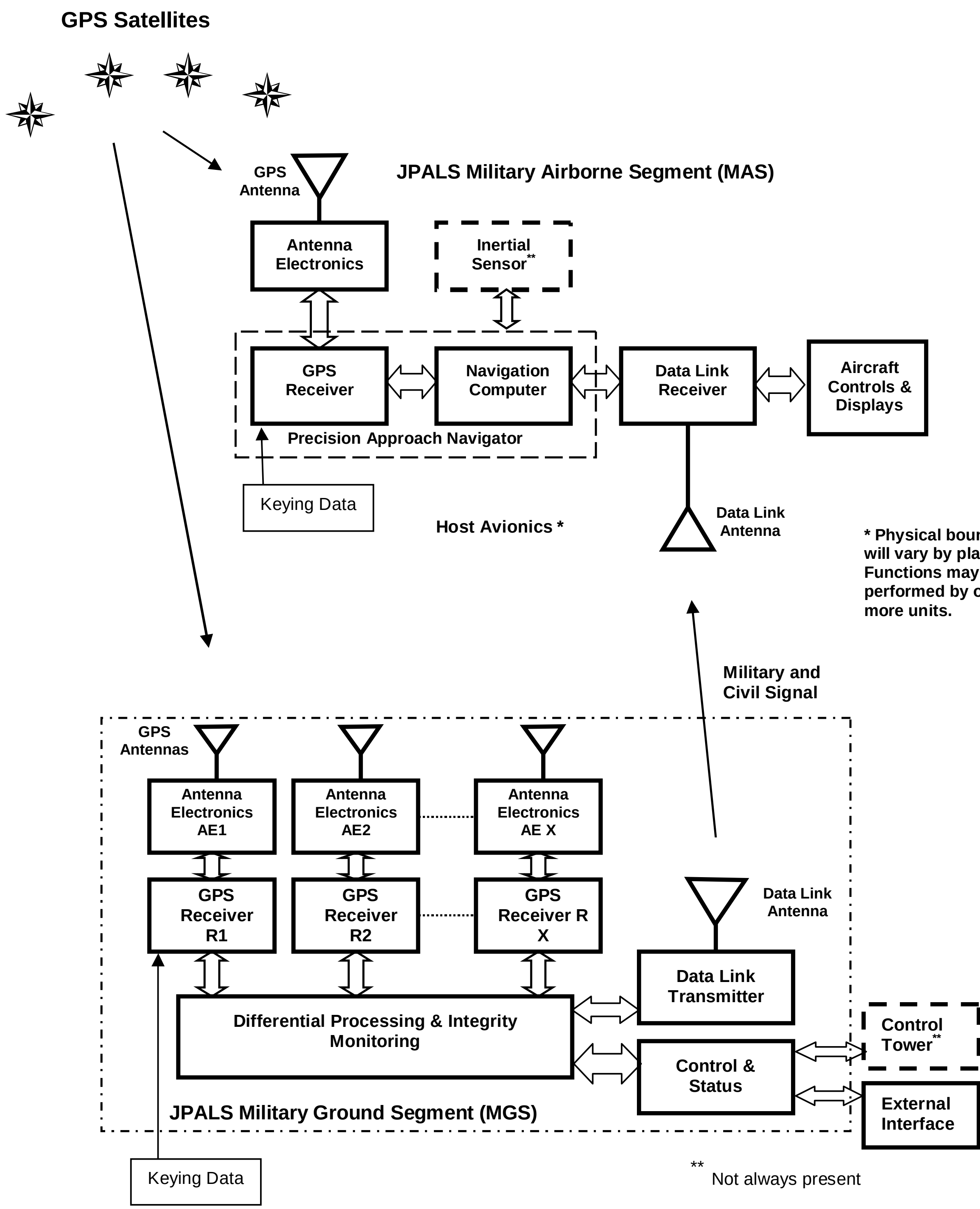


Figure 3-2 JPALS Block Diagram

3.1.1.1 Ground Segment

The JPALS ground segment is equipment installed on the ground within the local area where JPALS operations are to be performed, usually near a runway. Three ground segment equipment configurations have been identified: fixed base, tactical, and special mission. The JPALS ground segment shall be referred to herein as the Military Ground Segment (MGS).

The MGS shall be capable of supporting the functional requirements in Section 3.2.1.

The fixed base equipment configuration shall support fixed base operational (as defined in Sec 1.3) environments.

The tactical equipment configuration shall nominally support tactical operational (as defined in Sec 1.3) environments.

The special mission configuration shall nominally support special missions (as defined in Sec 1.3) operational environments.

All requirements shall apply to all configurations unless noted in the text.

3.1.1.2 Airborne Segment

The JPALS airborne segment is hardware and software installed on an aircraft intended to perform JPALS operations. The JPALS airborne segment shall be referred to, herein, as the Military Airborne Segment (MAS).

The MAS shall be capable of supporting the functional requirements in section 3.2.1.

3.1.2 Modes of Operation

The JPALS shall support two mutually exclusive modes of operation: a military mode and a civil mode.

3.1.2.1 Military Mode

The Military mode MGS shall transmit corrections for the GPS L1 P(Y) or the L2 P(Y) signal.

3.1.2.2 Civil Mode

The civil mode MGS shall transmit corrections for the L1 C/A signal.

3.1.3 Interface Definition

3.1.3.1 MGS External Interfaces

The MGS external interfaces are summarized in Figure 3-2..

The MGS shall receive GPS satellite signals for pseudorange and carrier phase measurements and navigation message data IAW ICD-GPS-200.

The MGS shall accept and use keying data for P(Y) signal acquisition and tracking.

The MGS shall provide an external interface to select the mode of operation (civil vs. military mode as defined in 3.1.2).

The MGS shall provide an external interface to define or modify the approach data parameters of the data link broadcast.

The MGS in Civil mode shall transmit an elliptically polarized non-encrypted VHF Data Broadcast (VDB) IAW ICAO SARPS, Annex 10, Vol 1, section 3.7.3.5 GBAS requirements.

The MGS in Military mode shall transmit Data Broadcast (DB) messages in support of military combat operations IAW LDGPS SIS ICD.

> *Note: The frequency and Information Assurance requirements of the military data link are under investigation.*

The MGS shall provide its health information (i.e. status signal) to the local control tower or other remote location.

The MGS shall provide an operator interface feedback to support maintenance functions.

3.1.3.2 MAS External Interfaces

The MAS external interfaces are summarized in Figure 3-2.

The MAS shall receive GPS satellite signals for pseudorange and carrier phase measurements and navigation message data IAW ICD GPS-200.

The MAS shall accept and use keying data for P(Y) signal acquisition and tracking.

The MAS shall be capable of receiving an elliptically polarized non-encrypted VHF Data Broadcast (VDB) IAW ICAO SARPS, Annex 10, Vol 1, section 3.7.3.5 GBAS requirements.

The MAS shall be capable of receiving an MGS data broadcast IAW LDGPS SIS ICD.

> *Note: The frequency and Information Assurance requirements of the military data link are under investigation.*

The MAS shall accept the input of data and provide output data to support a means for the flight crew to select and verify the desired approach is activated.

The MAS shall output deviation guidance and distance to landing threshold point/ fictitious threshold point (LTP/FTP) data to drive the flight instruments and/or the automatic flight control system.

3.2 Characteristics

3.2.1 Functional Requirements

3.2.1.1 Approach and Landing Guidance

JPALS shall provide the user aircraft with guidance data that the aircraft can use to align laterally and vertically with the computed path.

JPALS shall provide the user aircraft with the range to the LTP/FTP while the aircraft is on a final approach segment (FAS).

JPALS shall provide an indication to the aircraft if a loss of integrity is detected.

JPALS shall provide the user aircraft with guidance data that the aircraft uses to align laterally and vertically along a missed approach path to the designated missed approach waypoint.

JPALS shall provide range to the missed approach waypoint while performing a missed approach operation.

The MGS shall use data from multiple GPS receivers for its processing.

The MGS shall compute differential GPS corrections for all satellites it can track in phase and code.

The MGS shall monitor the integrity of all GPS signals it uses to compute corrections and the integrity of MGS equipment and functions.

The MGS shall compute integrity parameters for usage by the MAS.

The MGS shall transmit correction, integrity, and FAS data for usage by the MAS IAW LDGPS SIS ICD.

The MAS shall compute a navigation solution based on differential corrections, GPS measurements and GPS navigation message data.

The MAS shall monitor the integrity of its navigation solution using both integrity data from the MGS and MAS GPS measurement data.

The MAS shall only use and apply MGS corrections that match in code (C/A or P(Y)) and frequency (L1 or L2) the satellites tracked by the MAS.

The MAS shall provide the flight crew with a means to verify that the desired approach was activated.

The MAS shall provide guidance only when the FAS and differential corrections are from the same MGS.

3.2.1.2 Interoperability

The JPALS airborne segment shall provide the functions specified herein when landing at airfields equipped with Ground Based Augmentation Systems (GBAS), as specified in ICAO SARPS Annex 10.
The JPALS ground segment shall provide the functions specified herein for LAAS civil users equipped and conforming with Ground Based Augmentation Systems (GBAS), as specified in ICAO SARPS Annex 10.

3.2.2 Performance Requirements

3.2.2.1 Guidance Quality.

JPALS performance is specified in terms of defined levels of service called Service Levels. A Service Level (SL) defines a particular set of Guidance Quality requirements (Accuracy, Integrity and Continuity). Service levels are not rigidly tied to weather minima or operation type. Normally, in order to perform a particular operation, a suitable JPALS service level is used within the service volume, if it is available. The availability of a particular JPALS service level, however, is neither a sufficient nor a necessary condition for an aircraft to be able to perform the operation, because even if a suitable level of JPALS service is available, the actual instrument approach minimums also depend on other factors such as the availability of visual landing aids, aircraft and runway configuration, crew qualifications, etc. The availability of a particular JPALS service level is not a necessary condition, because other systems could be used in some aircraft (e.g., a heads-up display or synthetic vision) to augment JPALS allowing operations that have more stringent requirements than could be supported by JPALS alone.

The JPALS Signal in Space (SIS) shall meet the accuracy, integrity, and continuity requirements for the JPALS Signal in Space (SIS) for each service level as summarized in Table 3-1. These guidance quality requirements assume a fault free MAS. All accuracy numbers are 95% Navigation Sensor Error (NSE) values. The values for NSE accuracy and alert limits shown below are those required at the lowest height above threshold (HAT), if applicable for the operation.

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

Table 3-1 Service Level (SL) Definitions

Service Level	NSE Accuracy lateral 95% (at threshold)	NSE Accuracy vertical 95% (at threshold)	Integrity Risk	Time to alert (to the aircrew)	Alert Limits (FASVAL = vertical FASLAL = lateral) (at threshold)	Continuity Risk	Typical Operation
SL 7	16.0 m (52 ft)	4.0 m (13 ft)	$2x10^{-7}$ per approach	6 s	FASLAL ≤ 40.0 m (130 ft) FASVAL ≤ 10.0 m (33 ft)	$8x10^{-6}$ in any 15 s	CAT I Precision Approach, CAT I Autoland
SL 8	6.9 m	2 m	10^{-9} per approach	2 s	FASLAL ≤ 17.3 m FASVAL ≤ 5.3 m	$4x10^{-6}$ in any 15 s	CAT II Precision Approach, CAT II Autoland
SL 9	TBD	TBD	TBD	TBD	TBD	TBD	CAT IIIa Precision Approach

The SLs defined in the above table are related to the ORD Basic and Advanced Landing Capabilities of JPALS as shown in Table 3-2.

Table 3-2 JPALS Guidance Quality Requirements

System	Threshold	Objective	KPP
Basic Capability (Fixed base, Tactical, Man Transportable)	SL 7	SL 9	X
Advanced Capability (Fixed Base, Tactical)	SL 8	SL 9	X

JPALS SL7 guidance quality requirements are taken from the RTCA Minimum Aviation System Performance Standards (MASPS) for the Local Area Augmentation System (LAAS), DO-245. The SL8 and SL9 requirements are taken from the International Civil Aviation Organization (ICAO) Annex 10, Instrument Landing System (ILS) and Microwave Landing System (MLS) requirements.

JPALS shall support precision approaches based on “straight-in” procedures (i.e., those supported by ILS and MLS) as well as other TAPs, e.g., missed approach, terminal area navigation, and departure guidance.

[Note: The FAA and RTCA have not yet defined the guidance quality and related approach path data requirements for TAPs, other than straight in approach procedures. These requirements will be added as they are defined.]

The following paragraphs specify the required accuracy, integrity, and continuity for the TAPs supported by JPALS.

3.2.2.1.1 Precision Approach Accuracy.

The JPALS SIS accuracy requirements are defined in terms of the output from a fault-free MAS. The probability that the vertical NSE and the lateral NSE are within their applicable limits (defined below and in Table 3-1) shall be at least 0.95 for the desired service level.

3.2.2.1.1.1 SL-7 Accuracy.

The 95% vertical NSE accuracy for SL 7 shall be:

less than or equal to (≤) 4.0 meters (m) at a height above the threshold (HAT) between 100 ft and 200 ft (100ft < HAT ≤ 200ft) (see Figure C-1) and

≤ 0.0117(m/ft)*HAT(ft)+1.66 m for HATs between 200 ft and 1290 ft (200ft < HAT ≤ 1290ft) and

≤ 16.7 m for HATs above 1290 ft (HAT > 1290ft).

The 95% lateral NSE accuracy for SL 7 shall be:

less than or equal to (≤) 16.0 meters (m) at distances (D) from the LTP/FTP between 291m and 873m (291m< D ≤ 873m) and

≤ 0.00176*D(m) + 14.46m for distances to the LTP/FTP between 873m and 7500m (873m< D ≤ 7500m) and

≤ 27.7m for distances to the LTP/FTP greater than 7500m (D > 7500m).

3.2.2.1.1.2 SL 8 Accuracy

The 95% vertical NSE accuracy for SL 8 shall be:

less than or equal to (≤) 2.0 meters (m) at a height above the threshold (HAT) between 50 ft and 100 ft (50ft < HAT ≤ 100ft) (see Figure C-1) and

≤ 0.0117(m/ft)*HAT(ft)+0.83 m for HATs between 100 ft and 1290 ft (100ft < HAT ≤ 1290ft) and

≤ 15.9 m for HATs above 1290 ft (HAT > 1290ft).

The 95% lateral NSE accuracy for SL 8 shall be:

less than or equal to (≤) 6.9 meters (m) at distances (D) from the LTP/FTP between 0m and 291m (0m< D ≤ 291m) and

≤ 0.000835*D(m) + 6.66m for distances to the LTP/FTP between 291m and 7212m (291m< D ≤ 7212m) and

≤ 12.7m for distances to the LTP/FTP greater than 7212m (D > 7212m).

Note: The SL 8 accuracy requirements are being revisited by the FAA and RTCA for Cat II/III under LAAS. The JPALS program should also independently verify the applicability of the accuracy requirements for military operations. In lieu of these efforts we could use the current LAAS MASPs accuracy requirements

3.2.2.1.2 Precision Approach Integrity.

The JPALS SIS integrity requirement is defined in terms of the output from a fault-free MAS. The probability that the NSE exceeds the lateral or the vertical alert limits without annunciation for longer than the time-to-alert shall not exceed the integrity risk probability shown below for the desired SL. The time-to-alert requirement is defined to begin at the point in time at which a failure condition affects the guidance provided to the aircrew, and to end when the alert condition is detectable at the fault-free MAS.

3.2.2.1.2.1 SL 7 Integrity.

For SL 7, the probability that the NSE exceeds the lateral or the vertical alert limits without annunciation for longer than the time-to-alert, shall not exceed 2×10^{-7} per approach.

The SL 7 time-to-alert shall not exceed 6 seconds.

The SL 7 Vertical Alert Limit (VAL) shall be:

- 10m at a height above the threshold (HAT) between 100 ft and 200 ft (100ft < HAT ≤ 200ft) and

- 0.02925(m/ft)*HAT(ft)+4.15 m for HATs between 200 ft and 1340 ft (200ft < HAT ≤ 1340ft) and

- 43.35m for HATs above 1340 ft (HAT > 1340ft).

The SL 7 Lateral Alert Limit (LAL) shall be:

- 40m at a distances from the LTP/FTP (D) between 291m and 873m (291m< D ≤ 873m) and

- 0.0044*D(m) + 36.15m for distances to the LTP/FTP between 873m and 7500m (873m< D ≤ 7500m) and

- 69.15m for distances to the LTP/FTP greater than 7500m (D > 7500m).

3.2.2.1.2.2 SL 8 Integrity

For SL 8, the probability that the NSE exceeds the lateral or the vertical alert limits without annunciation for longer than the time-to-alert, shall not exceed 10^{-9} per approach.

The SL 8 time-to-alert shall not exceed 2 seconds.

The SL 8 Vertical Alert Limit (VAL) shall be:

- 5.3m at a height above the threshold (HAT) between 100 ft and 200 ft (100ft < HAT ≤ 200ft) and

- 0.02925(m/ft)*HAT(ft)-0.55m for HATs between 200 ft and 1340 ft (200ft < HAT ≤ 1340ft) and

- 38.65m for HATs above 1340 ft (HAT > 1340ft).

The SL 8 Lateral Alert Limit (LAL) shall be:

- 17.3m at a distances from the LTP/FTP (D) between 291m and 873m (291m< D ≤ 873m) and

- 0.0044*D(m) + 13.45m for distances to the LTP/FTP between 873m and 7500m (873m< D ≤ 7500m) and

- 46.45m for distances to the LTP/FTP greater than 7500m (D > 7500m).

Note: The SL 8 integrity requirements are being revisited by the FAA and RTCA for Cat II/III under LAAS. The JPALS program should also independently verify the applicability of the integrity requirements for military operations. In lieu of these efforts we could use the current LAAS MASPs integrity requirements

3.2.2.1.3 Precision Approach Continuity.

The JPALS SIS continuity requirement is defined in terms of the output from a fault-free MAS. Given that a SL is available at a point in time, the probability of an unscheduled interruption of navigation performance meeting applicable SL accuracy and integrity, shall not exceed the continuity risk probability specified below for the desired SL.

3.2.2.1.3.1 SL 7 Continuity.

Given that SL 7 is available at a point in time, the probability of unscheduled interruption of navigation performance meeting the applicable SL 7 accuracy and integrity requirements above, shall not exceed $8x10^{-6}$ / 15 seconds.

3.2.2.1.3.2 SL 8 Continuity.

Given that SL 8 is available at a point in time, the probability of unscheduled interruption of navigation performance meeting the applicable SL 8 accuracy and integrity requirements above, shall not exceed $4x10^{-6}$ / 15 seconds.

Note: The SL 8 continuity requirements are being revisited by the FAA and RTCA for Cat II/III under LAAS. The JPALS program should also independently verify the applicability of the continuity requirements for *military operations. In lieu of these efforts we could use the current LAAS MASPs continuity requirements*

3.2.2.2 Autoland (including rollout) – Guidance Quality

Autoland (including rollout) guidance is applicable to fixed base and tactical equipment, but not special mission. Autoland guidance is provided to aircraft touch down.

3.2.2.3 Missed Approach Guidance – Guidance Quality

Missed Approach guidance is applicable to fixed base and tactical equipment, but not special mission.

3.2.2.3.1 Missed Approach Accuracy

JPALS missed approach accuracy shall support a horizontal NSE of less than or equal to (≤) TBD meters (m).

JPALS missed approach accuracy shall support a vertical NSE of less than or equal to TBD meters (m).

3.2.2.3.2 Missed Approach Integrity

JPALS missed approach alert limit for integrity shall be TBD meters vertical and TBD meters lateral.

JPALS missed approach integrity shall have a probability of NSE exceeding the alert limit (AL) of TBD.

The time to alert shall not exceed TBD seconds.

3.2.2.3.3 Missed Approach Continuity.

Once the missed approach has commenced, the probability of unscheduled interruption of navigation performance meeting the missed approach accuracy and integrity requirements above, shall not exceed TBD.

3.2.2.4 Take-off and Departure Guidance - Guidance Quality

Take-off and Departure guidance is applicable to fixed base and tactical equipment, but not special mission.

3.2.2.4.1 Take-off and Departure Accuracy.

JPALS take-off and departure accuracy shall have a horizontal NSE of less than or equal to (≤) TBD meters (m).

JPALS take-off and departure accuracy shall have a vertical NSE of less than or equal to TBD meters (m).

3.2.2.4.2 Take-off and Departure Integrity

JPALS take-off and departure alert limit for integrity shall be TBD meters.

JPALS take-off and departure integrity shall have a probability of NSE exceeding the alert limit (AL) of ≤ TBD per hour.

The time to alert shall not exceed TBD seconds.

3.2.2.4.3 Take-off and Departure Continuity.

Once the take-off and departure has commenced, the probability of unscheduled interruption of navigation performance meeting the take-off and departure accuracy and integrity requirements above, shall not exceed TBD / hour.

3.2.2.5 Taxi Guidance – Guidance Quality

Taxi guidance is applicable to fixed base and tactical equipment, but not special mission. This requirement is intended to support unmanned aircraft. Note that the following requirements assume that visibility is sufficient for personnel of control units to exercise control over all traffic on the basis of visual surveillance.

3.2.2.5.1 Taxi Accuracy.

JPALS taxi accuracy shall support a horizontal NSE of less than or equal to (≤) TBD meters (m).

3.2.2.5.2 Taxi Integrity.

JPALS taxi integrity shall have a probability of NSE exceeding the alert limit (AL) of ≤ TBD per hour.

The time to alert shall not exceed TBD seconds.

3.2.2.5.3 Taxi Continuity.

Once the taxi/roll-out has commenced, the probability of unscheduled interruption of navigation performance meeting the taxi accuracy and integrity requirements above, shall not exceed TBD / hour.

3.2.2.6 Service Volume.

The service volume is the volume of airspace (azimuth, glide path, and range from the intended point of landing) in which JPALS meets all the guidance quality requirements. The JPALS system shall have the capability to service converging, intersecting, and parallel runways and opposite end approaches. The JPALS service volume is intended to support all of the above TAPs including autoland.

JPALS shall support the following minimum service volume when there is no blockage of line-of-sight due to local terrain or obstacles:

a. Laterally:

1. Encompassing 360° around the data link 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 data link 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.

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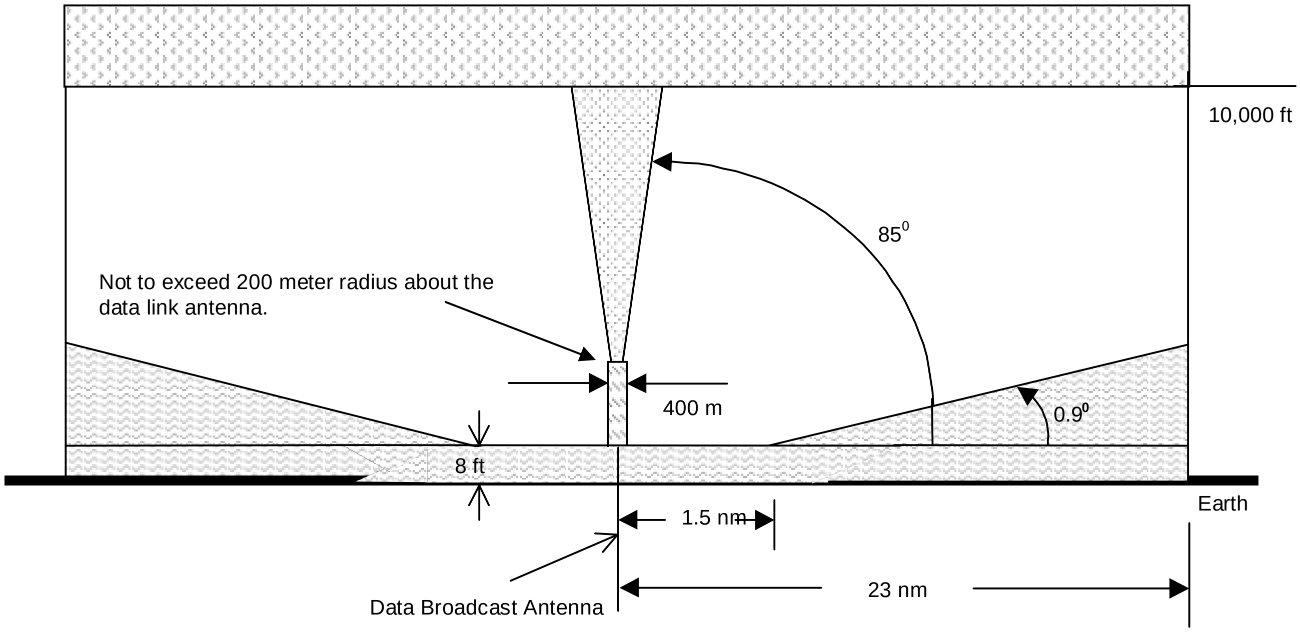

Figure 3-3 Service Volume

3.2.2.6.1

3.2.2.7 Operational Availability.

Operational availability (A_o) is the probability that, the JPALS system is ready to perform its specified function, in its specified operational environment, when c alled for at a random point in time. Operational availability includes the effects of failures or outages of ground or space systems. It does not include avionics failures or the effects of scheduled JPALS ground system maintenance or training which can be scheduled to avoid an impact on operations at a particular site.

The GPS signal in space availability is a function of constellation characteristics and reliability assumptions. The assumed GPS constellation is defined in RTCA D0-229C, the Minimum Operational Performance Standards (MOPS) for Wide Area Augmentation System (WAAS) Airborne Equipment, Appendix B, Standard GPS/WAAS Assumptions, Paragraph B.1, GPS Constellation. The assumed GPS failure rate information and related assumptions are contained in RTCA DO-245, the Minimum Aviation System Performance Standards (MASPS) for Local Area Augmentation System (LAAS), Appendix F, LAAS Availability Considerations, Paragraph F3, Assumptions for Prediciting LAAS Availability.

The operational availability of the JPALS is presented below and summarized in Table 3-3 for the required operating environment which excludes intentional interference or jamming conditions. Availability under intentional interference or jamming conditions is specified in Appendix B.

3.2.2.7.1 Fixed Base A_o.

The JPALS fixed base A_o shall be greater than or equal to (≥) 99.5% (threshold) or A_o is ≥ 99.6% (objective).

3.2.2.7.2 Tactical A_o.

The JPALS tactical A_o shall be greater than or equal to (≥) 99.0% (threshold) or A_o is ≥ 99.5% (objective).

3.2.2.7.3 Special mission A_o.

The JPALS special mission A_o shall be greater than or equal to (≥) 98.0% (threshold and objective).

Table 3-3 Operational Availability

Parameter/System	Threshold	Objective	KPP
Fixed Base A_o	≥ 99.5 %	≥ 99.6 %	X
Tactical A_o	≥ 99.0%	≥ 99.5 %	X
Special mission A_o	≥ 98.0	≥ 98.0	X

3.2.2.8 Vulnerability to GPS Disruption/Spoofing

Vulnerability to Disruption/Spoofing is the ability of JPALS to operate in an electromagnetic environment that includes both offensive and defensive electronic warfare (EW) as well as extensive collocated electromagnetic interference (EMI). JPALS has two electromagnetic signals of concern: the GPS satellite signal and the data link signal. The vulnerability of GPS satellite signal to the electromagnetic environment is defined in Appendix B. The JPALS program will rely on the GPS encrypted signal to mitigate the spoofing of the GPS signal itself

3.2.2.9 LDGPS SIS Data link

The JPALS MGS data link transmitter shall meet the performance requirements contained in RTCA DO-246B, GNSS-Based Precision Approach Local Area Augmentation System (LAAS) Signal-In-Space (SIS) Interface Control Document (ICD) to support the recovery of CRAF.

The JPALS equipped aircraft shall be capable of conducting the applicable (supported) TAPs against civil GBASs that broadcast a GNSS SIS meeting the requirements of RTCA DO-246B.

The JPALS data link requirements for military operations are TBD. The need for the mitigation of hostile electromagnetic disruption for the data link is TBD. The DoD GPS Security Policy and CJCSI 6130.01C state that systems using (broadcasting) PPS differential corrections must be encrypted during military combat operations. Clarification of this requirement is pending, however, it appears that a waiver could be granted if the military PPS correction broadcast meets information assurance requirements. The Navy requires a special data message to support Navy ground-based training operations. This message will include a broadcast GPS carrier phase data. The specific performance requirements will be provided by the Navy (PMA-213). Army and AFSOC rotary aircraft that conduct shipboard operations may also train using this message.

Note: The military data link is intended to operate while precluding a hostile force's ability to identify the presence of a signal, classify the emitting platform, locate its source of origin, and decode operationally significant data in order to impose a threat.

3.2.2.10 Information Exchange Requirements.

JPALS is a closed system that exchanges information between aircraft sensor suites, satellites and ground reference systems (either civil or military) to determine exact position, time and velocity of an aircraft. The JPALS Shore based Information Exchange Requirements (IER) are summarized in Table 3-4.

Table 3-4 Shore Based Information Exchange Requirements

Rationale/ UJTL Number	Event	Information Characterization	Sending Node	Receiving Node	Critical	Format	Timelines	Classification	Remarks
ST 1.3.3 ST 1.4 ST 4.4 OP 1.2.4.3 OP 1.2.4.4 OP 1.3.2 OP 4.5.1 OP 4.6	Periodic scan for data	Situational Awareness-Status Information	JPALS Ground Segment	Airfield Tower	Yes	Data – JPALS System Requirement Document (SRD)	2 Sec	U	System operational status provided via visual indications to ATC facilities
		Guidance Information	JPALS Ground Segment (will be interoperable with civil and allied aircraft)	Aircraft (JPALS Receiver or Pilot)	Yes	Data Per JPALS Signal-in-space Interface Control Document (ICD)	0.5 Sec	U	GPS differential corrections, approach data, and integrity data provided to the airborne segment with the service volume.

Rationale/ UJTL Number	Event	Information Characterization	Sending Node	Receiving Node	Critical	Format	Timeliness	Classification	Remarks
			GPS Satellite	Airborne and Ground Segments	Yes	Data ICD-GPS-200 – NAVSTAR GPS Space Segment Navigation User Interfaces	< 1sec NOTE: This is the pseudo-range measurement rate; the carrier phase measurements will be at a 10 hz rate or <0.1 sec. This assumes the GPS receiver has completed acquisition, has collected the nav message and is operating in State 5 with code and carrier track.	U-FR	The GPS satellites transmit a continuous modulated signal from which the ground and airborne receiver make range and rate of change of range measurements to compute position

3.2.3 Physical Characteristics

3.2.3.1 Set-up Time

The set-up time is the time to assemble and perform ground checks on the ground unit. Other actions that may include site survey, database development, TERPS development, and flight inspection will be required prior to allowing precision approach activity. Their times are not included in the set-up time.

The system set-up for the tactical JPALS shall be complete in 1 hour.

The system set-up for the special mission JPALS shall be complete in 30 minutes, reference Table 3-5. The tactical MGS system three-person set-up team will consist of JPALS maintenance and on-site ATCALS personnel. In addition, it is assumed that the power source for the tactical system will be in place during or before set up. Special mission site survey and data base development time constraints are TBD but should be no longer than that required for current tactical systems.

Table 3-5 Set-up Time

Parameter/System	Threshold	Objective
a) Set-up time: tactical	≤ 1 hour	≤ 30 minutes
b) Set-up time: special mission	≤ 30 minutes	≤ 30 minutes
c) Site survey and data base development time: tactical	≤ 3 hours	≤ 1 hour
d) Site survey and data base development time: special mission	TBD	TBD

The time requirements also do not include the time to perform the official flight inspection (not calibration) per The United States Flight Inspection Manual (TM 95-225, NAVAIR 16-1-520, AFMAN 11-225).

An objective of JPALS is to eliminate the need of the official flight inspection for the mobile MGS.

3.2.3.2 Power

The MGS shall use a standard ground support generator.

The MGS shall be compatible with standard worldwide commercial electrical power.

The fixed base MGS shall have an uninterruptible power supply (UPS).

The MAS shall be designed to operate on existing aircraft power without impacting aircraft power bus capacity.

The special mission equipment shall operate off a self-contained power supply.

3.2.3.3 Dimensions

The size of the MAS shall be less than or equal to the size of existing systems that perform precision approach and landing functions.

There are no specific size requirements for the ground equipment other than those derived from the Transportability requirements in section 3.2.7

3.2.3.4 Weight

The weight of the MAS shall be less than or equal the weight of existing systems that perform precision approach and landing functions.

There are no specific weight requirements for the ground equipment other than those derived from the Transportability requirements in section 3.2.7

3.2.4 MGS Reliability

The following MGS Mean Time Between Failure (MTBF) thresholds and objectives have been established to reduce logistics footprint and LCC over legacy systems. For purposes of this SRD, MTBF refers to failures that render the system non operational. The MGS requirements are summarized in Table 3-6.

Table 3-6 MGS **Reliability**

Parameter/System	Threshold	Objective
a) MTBF: Fixed	≥ 4,000 hours	≥ 5,000 hours
b) MTBF: Tactical and Special mission	≥ 3,600 hours	≥ 4,400 hours

Note: MGS Reliability requirements may need to be changed to support system continuity and availability requirements.

3.2.5 MGS Maintainability

3.2.5.1 MGS Maintenance Concept.

Current planning requires MGS maintenance to be performed at two levels: organizational(O) and depot(D). Scheduled maintenance inspections shall be sufficient to ensure system components are operational and/or prepared for deployment.

An integrated capability for system hardware and software maintenance shall be required.

The MGS shall include a remote monitoring capability..
Operation and maintenance tasks, including set-up and tear-down shall be capable of being performed in full chemical warfare ensemble or cold weather gear.

3.2.5.2 MGS Scheduled Maintenance.

The maximum amount of MGS scheduled maintenance tasking (hours and system down time) required to ensure system performance while in an actual operational environment is presented in Table 3-7. Periodic maintenance includes the time required to complete the routine checks, inspections, replenishment, and other tasks necessary to assure normal and sustained operation.

The MGS equipments scheduled maintenance shall not exceed 2 hours per 30 day period (T) and 1 hour per 90 day period (O).

Table 3-7 MGS **Scheduled Maintenance**

Environment	Threshold	Objective
All	≤ 2 hours per 30 days	≤ 1 hour per 90 days

3.2.5.3 MGS Maintenance Planning.

MGS organizational level maintenance shall utilize Built-in-Test-Equipment (BITE) to the maximum extent possible.

The digital technical order shall be incorporated into the BITE to facilitate fault isolation and decrease repair time.

Depot support equipment shall be that type of automatic test equipment approved by the service selected to be the source of repair, or the commercial equivalent tester available from the JPALS manufacturer.

A capability to correct failures of hardware, firmware, and software shall be required and demonstrated by the initial operational test and evaluation (IOT&E) phase.

A decision on implementing organic depot versus contract depot maintenance will be based on a Source of Repair Assignment Process (SORAP).

3.2.5.4 Built-in-Test (BIT).

The avionics and ground station design shall include the use of BIT, in conjunction with the digital technical order, permitting the isolation, removal, and replacement of faulty units. The requirements for avionics and ground are presented in Table 3-8 and Table 3-9, respectively.

JPALS shall include a means of recording system faults.

Table 3-8 JPALS Avionics Built-in-Test (BIT)

	Threshold	Objective
i) Fault Detection	If standalone avionics, the fraction of failures detected (FFD) using self test shall be greater than 95%. The FFD using periodic BIT shall be greater than 90% for the selected mode. 100% of critical failures will be detected. If JPALS is a modification to existing system, fault detection will be IAW host system requirements	Same as threshold except FFD using self-test shall be greater than 98%
ii) Fault Isolation	If standalone avionics, 95% of failures detected shall be isolated to a single LRU using periodic BIT and self test. 100% of failures detected shall be isolated to a single LRU using BIT, self test, support equipment and technical orders. If JPALS is a modification to existing system, fault isolation will be IAW host system requirements	Same as threshold
iii) Failure Detection FalseAlarms	If standalone avionics, less than 2% of all indicated faults shall be attributed to JPALS avionics periodic BIT and self test false alarms. If JPALS is a modification to existing system, false alarm rates will be IAW host system requirements	Same as threshold

Table 3-9 JPALS Ground Station BIT

	Threshold	Objective
i) Fault Detection	The FFD using self-test shall be greater than 95%. 100% of critical failures will be detected	Same as threshold except FFD using BIT and self-test shall be greater than 98%
ii) Fault Isolation	95% of the failures detected shall be isolated to a single line replaceable unit using BIT and self test. 100% of failures detected shall be isolated to a single LRU using BIT, self test, support equipment and technical orders	Same as threshold
iii) Mean TimeBetween False Alarms	The mean time between BIT false alarms shall exceed 50,000 hours	Same as threshold

3.2.5.5 MGS Corrective Maintenance

Corrective Mean-Time-To-Repair is defined as the average man-hours required to correct an alarm or service and alert condition.

The mean-time-to-repair of the -MGS equipment shall not exceed 30 min [20 min objective]. This is not applicable to special mission since no maintenance personnel are deployed.

Corrective maintenance time includes: fault detection and diagnostic isolation time, removal of the failed LRU, installation of the new LRU, initialization of the new LRU, and all adjustments required to return the system to an operational condition.

3.2.6 Environmental Conditions

3.2.6.1 Interference

The fixed base MGS shall meet all requirements of this specification in the presence of interference as specified in Appendix B for fixed base operating environments.

The tactical MGS shall meet all requirements of this specification in the presence of interference as specified in Appendix B for tactical operating environments.

The special mission MGS shall meet all requirements of this specification in the presence of interference as specified in Appendix B for the special mission operating environments.

The MAS shall meet all requirements of this specification in the presence of interference as specified in Appendix B for all operating environments in which it is intended to be deployed.

Note: Although JPALS is not a likely target for hostile signal disruption, JPALS could employ signals or frequencies that are vulnerable to collateral jamming. The specific levels of interference or jamming under which JPALS shall meet its applicable navigation system performance are contained in Appendix B.

[Insert reference to classified ACC GPS ORD and LAAS MASPS Appendix H Interference Environment. Distinguish between military P(Y) modes and civil C/A modes. Also consider reference to environment called out in classified DAE specification.]

3.2.6.2 Threat Environment

The requirements of this specification shall be met under the conditions of intentional jamming and/or spoofing of the GPS signal as defined in Appendix B.

The requirements of this specification shall be met under the conditions of interference, and intentional jamming and/or spoofing of the data link signals, as defined in Appendix B

3.2.6.3 Environment, Safety and Health (ESH).

The JPALS equipment shall incorporate environmental, safety, and health planning throughout the program life cycle.
The program shall ensure that the equipment can be tested, operated, maintained, repaired, and disposed of in compliance with applicable federal, state, interstate, and local environmental laws and regulations, executive orders, treaties, and agreements.

The contractor shall certify that the JPALS MAS/MGS design and equipment is safe for their intended environment before installation and operation in airborne platforms and the MGS ground station.

The contractor will identify, evaluate, track, and resolve all safety deficiencies before start of FQT/ system test. This is to ensure the system is safe to operate, or residual hazards have been mitigated to acceptable levels of risk.

3.2.6.4 Operational Environment Conditions.

JPALS provides safe landing guidance in all terrain environments and conditions of adverse weather in which an aircraft may be expected to conduct an approach to a landing. Both airborne and ground equipment will be considered. Parameters contained in Table 3-10, are not inclusive. Additional parameters may be developed in the future based on the specific technology employed by JPALS. Table 3-10 may be selectively implemented depending the airborne design (i.e., Gun Fire Vibration would not be required for the C-17).

JPALS shall be qualified IAW MIL-STD-810 or other equivalent standard (RTCA DO-160D).

JPALS shall also physically survive the range of environmental conditions that airfields and aircraft platforms are expected to encounter without experiencing significant physical damage.

Table 3-10 Natural Environment

Parameter	Threshold	Objective
Precipitation (effects on signal and sensor)	16 mm/hr in 5 NM wide rain cell without signal degradation below precision landing system parameters/minima	25 mm/hr in 5 NM wide rain cell without signal degradation below precision landing system parameters/minima
Fog (effects on signal and sensor)	Operate in advection and radiation fogs without signal degradation below precision landing system parameters / minima	Same as threshold
Salt Fog	TBD	TBD
Chemical and Biological	TBD	TBD
Fungus	TBD	TBD
Shock and Vibration	TBD	TBD
Storage Temperature	TBD	TBD
Lightning Protection	TBD	TBD
Humidity	TBD	TBD
Temperature (effects on ground equipment and signal)	-51 degrees Celsius to +49 degrees Celsius	-70 degrees Celsius to +60 degrees Celsius
Wind (effects on ground equipment)	Signal will remain within limits up to 75 knots. No damage to equipment and remain in position up to 101 knots	Same as threshold
Snow (effects on signal)	Withstand up to two feet of accumulation without signal degradation	Same as threshold
Elevation (effects on ground equipment)	-200 feet to 14,000 feet (MSL)	-200 feet to 14,000 feet (MSL)
Ice and hail (effects on signal and ground equipment)	Withstand up to ½ inch accumulation of ice or ½ inch diameter size hail without damage or signal degradation	Same as threshold
Blowing Sand and Dust (effects on signal and ground equipment)	Withstand sand concentration of 2.2g/M3 in 40 kt wind without damage or signal degradation below precision landing system parameters / minima	Same as threshold
Temperature and Altitude	TBD	TBD
Sunshine	TBD	TBD
Surrounding Air Pressure	TBD	TBD
Explosive Atmosphere	TBD	TBD

Parameter	Threshold	Objective
Vibration (Airborne)	TBD	TBD
Gunfire Vibration	TBD	TBD
Crash Safety	TBD	TBD
Design Shock	TBD	TBD
Acceleration	TBD	TBD
Fluids	TBD	TBD
Performance Dynamics	TBD	

3.2.7 Transportability

The MGS is intended to be worldwide transportable by ground, air, and sea. The design should permit rapid on/off loading by personnel. The MGS shall be transportable by worldwide rail systems and 1.25-ton and larger trucks over paved or smooth dirt surfaces. The tactical and special mission have additional transportability requirements.

3.2.7.1 Tactical MGS

The Tactical MGS shall be 3-man transportable (65 lbs each)

The Tactical MGS shall be independently air transportable by:

- single C-130 or
- sling-loaded by a single CH-47,CH-53, UH-60.

The sling load limit is 8,000 lbs.

[Note: this section needs clarification and addition requirements, e.g. load and volume restrictions on aircraft.]

3.2.7.2 Special mission MGS

The Special mission MGS shall be 2-man portable (31 lbs each) and Shall be air droppable.

The Special mission MGS shall be independently air transportable by:

- single C-130 or
- sling-loaded by a single CH-47,CH-53, UH-60.

The sling load limit is 8,000 lbs.

[Note: this section needs clarification and addition requirements, e.g. load and volume restrictions on aircraft.]

3.3 Design and Construction

3.3.1 Electromagnetic Radiation

3.3.1.1 Ground Compatibility

The MGS shall not degrade the effectiveness of the ground's defensive systems, nor restrict aircraft handling and aircraft parking.

The MGS will be electromagnetically compatible with command, control, communication, computers and intelligence (C4I) infrastructure for all aircraft, and ground-based components in the operating environment in which it will be deployed.

To ensure electromagnetically compatibility, the civil MGS unwanted emissions, including spurious and out-of-band emissions, shall be compliant with the levels shown in Table 3-11.

To ensure electromagnetically compatibility, the military MGS unwanted emissions, including spurious and out-of-band emissions, shall be compliant with the levels shown in Table 3-12.

The total power in any transmitter harmonic or discrete signal shall be than or equal to -53dBm .

Table 3-11 Unwanted Civil Emissions

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

Notes:

1) If the authorized transmitter power exceeds 150 watts, then the relative unwanted emissions requirements and the maximum unwanted emission requirements both apply. This column indicates the bandwidth over which the maximum unwanted emission levels is to be met.
2) The relative unwanted emission level is to be computed using the same bandwidth for desired and unwanted signals. This may require conversion of the measurement for unwanted signals done using the bandwidth indicated in the maximum unwanted emission level column.
3) This value is driven by measurement limitations. Actual performance is expected to be better.
The relationship is linear between single adjacent points designated by the adjacent channels identified above.

Table 3-12 Unwanted Military Emissions

Frequency	Relative unwanted emissions level (note 2)	Maximum unwanted emissions level (note 1)
TBD		

3.3.1.2 Airborne Compatibility

The MAS shall have no degrading mission impact to radar cross section.

The MAS, including all required aircraft interfaces, shall be electromagnetically compatible with current aircraft equipment.

The MAS shall be capable of being interoperable with host aircraft interface requirements.

3.3.2 Interchangeability / Modularity

TBD

3.3.3 Safety

TBD

3.3.4 Human Factors

The JPALS operational user interface shall be designed to allow operators and maintainers to perform their duties without increasing levels of workload and fatigue as compared to current systems.

Accepted human factors and engineering principles shall be used to optimize performance and reduce workload where practical.

The user interface shall provide efficient workload management through the effective use of graphical displays, text displays, and presentation of system and task status information.

Design of controls, displays, symbology, and operating procedures shall promote smooth, expeditious and error free system operation.

System messages and displays presented to operators shall be appropriate and relevant to operators' activities and knowledge levels.

Except for use of pre-existing displays, any aircraft or tactical/special mission visual display, readout, or operator message shall be visible at night with or without night vision devices and selectable by the user.

User interface commands shall be designed to minimize operator performance errors and preclude operator errors on critical tasks through the use of error checking and user validation.

3.3.4.1 Flyability

JPALS shall have a pilot workload which is less than or equal to existing precision approach systems. In other words JPALS SL7 straight-in approaches shall be no harder to execute than their ILS counterpart approach.

JPALS flying quality shall not adversely affect the ability of the pilot to use the system for precision approach or any other operation supported by JPALS.

A Modified Cooper-Harper pilot rating system as defined in ref 17 shall be used to assess JPALS flying qualities.

3.3.5 Software

The JPALS software shall meet host platform airworthiness requirements.

In support of airworthiness requirements MAS software shall be developed IAW RTCA DO-178 or an equivalent standard.

The JPALS MGS software shall also be developed IAW DO-278 or an equivalent standard.

[Note: is the applicable standard FAA-STD-026A or DO-278?]

3.3.6 Hardware

The MAS hardware shall meet host platform airworthiness requirements.

In support of airworthiness requirements MAS hardware shall be developed IAW the design assurance requirements of RTCA DO-254 or an equivalent standard.

The JPALS MGS hardware shall also be developed IAW the design assurance requirements of RTCA DO-254 or an equivalent standard.

3.4 Logistics

JPALS will be a fully deployable, self-contained (batteries, fuel, and power generators included) system for tactical operations and minimize the required number of maintenance and support personnel for all operations.

3.4.1 Sustainability

Mission sustainability is defined as the length of time after initial deployment JPALS can operate in the operating environment.

The JPALS tactical equipment shall be capable of sustaining at least a 60 day deployment at a 24 hour per day utilization rate, using deployment package logistics assets and on-site support personnel for mission limiting failures or required scheduled maintenance as summarized in Table 3-13

Table 3-13 Sustainability

Environment	Threshold	Objective
a) Tactical	Sustain a 60 day deployment at a 24 hour per day utilization rate, using deployment package logistics assets and on-site support personnel for mission limiting failures or required scheduled maintenance	Same as threshold
b) Special mission	Sustain a 72 hour deployment (4 hours full operation and 68 hours in standby) using only power sources provided in the deployment package without a critical failure or need for any scheduled maintenance and should be able to operate off generator power, if required.	Same as Threshold except 8 hours of full operations and 64 hours in standby

3.4.2 Mean Logistics Delay Time

For the purposes of showing compliance with requirements in this specification, the following mean logistics delay time may be assumed: 2 hrs requisition response time for spares on-site, 48 hrs for spares off site.

3.4.3 Spares

Sparing shall be based on the performance based logistics supply support philosophy. A common supply support management approach for jointly shared items and individual service performance based logistics philosophies for unique items will be employed. Spares shall be provisioned with sufficient lead-time to allow delivery prior to or concurrent with testing, equipment installation, and the IOC. Estimated quantities of components by type shall be compiled by the services as the program matures.

The tactical MGS deployment package for tactical operations shall include on-site spares for up to a 60-day deployment.

The tactical MGS deployment package for tactical operations shall be stocked such that the most critical 80% of spares are included.

3.4.4 Support Equipment

JPALS maintenance shall have minimal reliance on external support equipment, and if needed, common support equipment shall be used. Any JPALS ground system shall not require a unique ground support power generator. If ground equipment is required, JPALS shall be compatible with standard worldwide commercial and existing aerospace ground equipment.

3.4.4.1 Peculiar Support Equipment

The requirement for peculiar support equipment (PSE) in the design of the JPALS system shall be kept to absolute minimum. The goal is to have no PSE required. TBD.

3.5 Personnel and Training

Operation and maintenance of JPALS shall not increase current service manpower authorizations or skill level requirements.

The total number of dedicated maintenance and/or logistics personnel needed to support JPALS per shift for deployed ground stations is defined in Table 3-14; non-deployed ground stations including fixed base, tactical and special mission systems when in garrison in Table 3-15 and JPALS avionics in Table 3-16.

Table 3-14 Personnel Requirements for Deployed Ground Stations

System	Threshold	Objective
a) Tactical*	1 person	No personnel required
b) Special mission	No personnel required	Same as threshold

Table 3-15 Personnel Requirements for Non-Deployed Ground Stations

Environment	Threshold	Objective
All	Not to exceed current authorized levels	Reduce current authorized levels

Table 3-16 Personnel Requirements for JPALS Avionics

Aircraft	Threshold	Objective
All	Not to exceed authorized levels	Reduce current authorized levels

3.5.1 Installation Personnel

The total number of personnel needed to field-assemble and perform ground checks on the tactical MGS equipment shall not exceed three persons.

3.5.2 Maintenance Personnel

The total number of dedicated maintenance and/or logistics personnel needed to support deployed MGS equipment shall not exceed one (1) person per shift (no personnel per shift objective.). No personnel required for Special mission.

3.5.3 Training

No unique skills shall be required for the operation or maintenance of JPALS.

3.5.4 Geospatial Information and Services (GI&S) Support

Systems requiring GI&S support shall be capable of accepting National Imagery and Mapping Agency (NIMA) standard products. JPALS shall use WGS-84 geodetic survey data.

4. Qualification Requirements

This section specifies proposed qualification and acceptance requirements for JPALS (Civil and Military Modes). Functional performance verification requirements are depicted in Table 4-1, JPALS Requirements Verification Matrix. Standard verification methodologies described in paragraph 4.1 shall be implemented during all phases of JPALS system development, production and delivery. A quality management system shall be established for the maintenance of, and means of identifying, collecting, indexing, filling, storing, maintaining, retrieving, and disposing of pertinent quality documentation and records, as appropriate, IAW the best commercial practice.

4.1 Verification Strategy

The contractor/s must consider that Prime/Sub contractor cooperative agreements may be required in order to develop both the JPALS MGS and MAS segment. The MGS/MAS may be developed on dual tracks requiring exchange of design/test data, hardware and software to support development/test. After each segment has undergone contractor design, development and test (laboratory/field) both segments will come together for a system demonstration leading to a Formal Qualification Test (FQT)/System Test of the JPALS software and system performance. System Test will require field deployment installation and operation of the MGS while the MAS will require installation and check out of JPALS avionics/Antenna electronics on a JPALS modified aircraft. Flight demonstration/testing will be conducted in both benign and electronic jamming environments in open air ranges (TBD) to demonstrate (statistically relevant) functional performance and to gather data to validate JPALS models. Completion of this phase will lead to development of a production/pre production MAS system for installation on a operational aircraft leading to deployment and follow on production of a fielded JPALS. Additionally, a MGS production system will be fielded at the same time. The contractor could be required to provide maintenance/technical support during Development/Operational Test (DT/OT) conducted by the Government. The Government test program will be conducted by a Responsible Test Organization (RTO) and will consist of both Developmental and Operational test events. Headquarters Air Force Operational Test and Evaluation Command will lead operational and suitability tests conducted in realistic field environments.

[Note: This table need to be updated using cross references.]

Table 4-1 JPALS Requirements Verification Matrix

Requirement Description	Inspection	Analysis	Demo	Test
3.1 System Definition				
3.1.1 Major Component List				
3.1.1.1 Ground Segment				
3.1.1.2 Airborne Segment				
3.1.2 Modes of Operation				
3.1.2.1 Military Mode				
3.1.2.2 Civil Mode				
3.1.3 Interface Definition				
3.1.3.1 MGS External Interfaces				
3.1.3.2 MAS External Interfaces				
3.2 Characteristics				
3.2.1 Functional Requirements				
3.2.1.1 Approach and Landing Guidance				
3.2.1.2 Interoperability				
3.2.2 Performance Requirements				
3.2.2.1 Guidance Quality.				
3.2.2.1.1 Precision Approach Accuracy.				
3.2.2.1.1.1 SL-7 Accuracy.				
3.2.2.1.1.2 SL 8 Accuracy				
3.2.2.1.2 Precision Approach Integrity.				
3.2.2.1.2.1 SL 7 Integrity.				
3.2.2.1.2.2 SL 8 Integrity				
3.2.2.1.3 Precision Approach Continuity.				
3.2.2.1.3.1 SL 7 Continuity.				
3.2.2.1.3.2 SL 8 Continuity.				
3.2.2.2 Autoland (including rollout) – Guidance Quality				
3.2.2.3 Missed Approach Guidance – Guidance Quality				
3.2.2.3.1 Missed Approach Accuracy				
3.2.2.3.2 Missed Approach Integrity				
3.2.2.3.3 Missed Approach Continuity.				
3.2.2.4 Take-off and Departure Guidance - Guidance Quality				
3.2.2.4.1 Take-off and Departure Accuracy.				
3.2.2.4.2 Take-off and Departure Integrity				

Requirement Description	Inspection	Analysis	Demo	Test
3.2.2.4.3 Take-off and Departure Continuity.				
3.2.2.5 Taxi Guidance – Guidance Quality				
3.2.2.5.1 Taxi Accuracy.				
3.2.2.5.2 Taxi Integrity.				
3.2.2.5.3 Taxi Continuity.				
3.2.2.6 Service Volume.				
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Error! Reference source not found. Error! Reference source not found.				
3.2.2.7 Operational Availability.				
3.2.2.7.1 Fixed Base A_o.				
3.2.2.7.2 Tactical A_o.				
3.2.2.7.3 Special mission A_o.				
3.2.2.8 Vulnerability to GPS Disruption/Spoofing				
3.2.2.9 LDGPS SIS Data link				
3.2.3 Physical Characteristics				
3.2.3.1 Set-up Time				
3.2.3.2 Power				
3.2.3.3 Dimensions				
3.2.3.4 Weight				
3.2.4 MGS Reliability				
3.2.5 MGS Maintainability				
3.2.5.1 MGS Maintenance Concept.				
3.2.5.2 MGS Scheduled Maintenance.				
3.2.5.3 MGS Maintenance Planning.				
3.2.5.4 Built-in-Test (BIT).				
3.2.5.5 MGS Corrective Maintenance				
3.2.6 Environmental Conditions				
3.2.6.1 Interference				
3.2.6.2 Threat Environment				
3.2.6.3 Environment, Safety and Health (ESH).				

Requirement Description	Inspection	Analysis	Demo	Test
3.2.6.4 Operational Environment Conditions.				
3.2.7 Transportability				
3.2.7.1 Tactical MGS				
3.2.7.2 Special mission MGS				
3.3 Design and Construction				
3.3.1 Electromagnetic Radiation				
3.3.1.1 Ground Compatibility				
3.3.1.2 Airborne Compatibility				
3.3.2 Interchangeability / Modularity				
3.3.3 Safety				
3.3.4 Human Factors				
3.3.4.1 Flyability				
3.3.5 Software				
3.3.6 Hardware				
3.4 Logistics				
3.4.1 Sustainability				
3.4.2 Mean Logistics Delay Time				
3.4.3 Spares				
3.4.4 Support Equipment				
3.4.4.1 Peculiar Support Equipment				
3.5 Personnel and Training				
3.5.1 Installation Personnel				
3.5.2 Maintenance Personnel				
3.5.3 Training				
3.5.4 Geospatial Information and Services (GI&S) Support				

4.2 Verification Methodologies

The functional performance requirements of Section 3 shall be verified by one or more of the below five methods. In all cases, the method of verification shall successfully verify the requirement has been met; specifically, that JPALS meets all installed system performance requirements. The purpose of verification is to ensure system requirements are understood and correctly implemented. Verification, when accomplished incrementally, provides insight to the Government as the design matures and the program progresses to ensure early identification of problems. Verification of COTS/NDI system components may require presentation of existing qualification and verification data to insure COTS/NDI items are suitable for safe operation in the JPALS worldwide environment. Developmental components shall require verification throughout the development, test, and production process. Lower level product verifications shall add up to and contribute to verification for the integrated system from the component and subsystem levels up to the system level. Incremental verification uses increasingly more rigorous criteria at various stages throughout program to provide progressive insight into contractor's progress. Program milestones and specific success criteria shall be developed by the contractor showing the use of incremental verification in the design effort.

4.2.1 Inspection

Inspection is used to determine system characteristics by examination of the item and comparing the item with descriptive documentation, engineering drawings, computer program listings to determine conformance with specified requirements. Inspection is generally nondestructive and consists of visual examinations (including system documentation) or simple measurements without the use of precision measurement equipment.

4.2.2 Analysis

Verification shall be performed by evaluation or simulation using mathematical representations, charts, graphs, circuit diagrams, and data reduction. Analysis or review of simulation data is a study method resulting in data used to verify conformance of characteristics with specified requirements. Worst-case data may be derived from design solutions where quantitative performance cannot be demonstrated cost-effectively. In addition to performing parametric analysis to define system requirement parameters, simulations are also used.. Modeling and simulations shall be used to perform early testing of units, subsystems and systems. Modeling and simulations shall be used to finding and resolving system design issues as early as possible in the design and development process.

4.2.3 Demonstration

Demonstration is a variation of the test method used to verify requirements by go/no-go criteria without the use of elaborate measurement equipment. In general software functional requirements are validated by demonstration since the functionality must be observed through some secondary media.

4.2.4 Test

Test is used to verify performance requirements. The test process will generate data, and these data are normally recorded by precision measurement equipment or procedures. Analysis or review is subsequently performed on the data derived from the testing. Analysis as described here is an integral part of this method and should not be confused with the "analysis" described in paragraph 4.1.2, Analysis. Quantitative values are measured, compared against previous predicated success criteria and then evaluated to determine the degree of compliance.

4.2.5 Qualification by Similarity *

A qualification by similarity is a prediction based on existing data with detailed examination of the differences and similarities between the previously qualified item and the item under consideration. The contractor may propose this method for use to the Government on a case by case basis.

5. Packaging

The Tactical MGS shall be packaged so as to be air droppable.

Preservation, packaging, and packing of the JPALS MGS and MAS shall insure that no damage shall be incurred during handling, storage and shipment from the source of supply to the Government-designated destination.

Level A preservation and packaging and Level A packing shall be provided IAW MIL-STD-2073. Design criteria of MIL-STD-2073 and MIL-P-90024 shall be applicable. Markings shall be IAW MIL-STD-129.

> *Note: Need to verify need for and applicability of Mil-Std/Specs or could substitute commercial practices.*

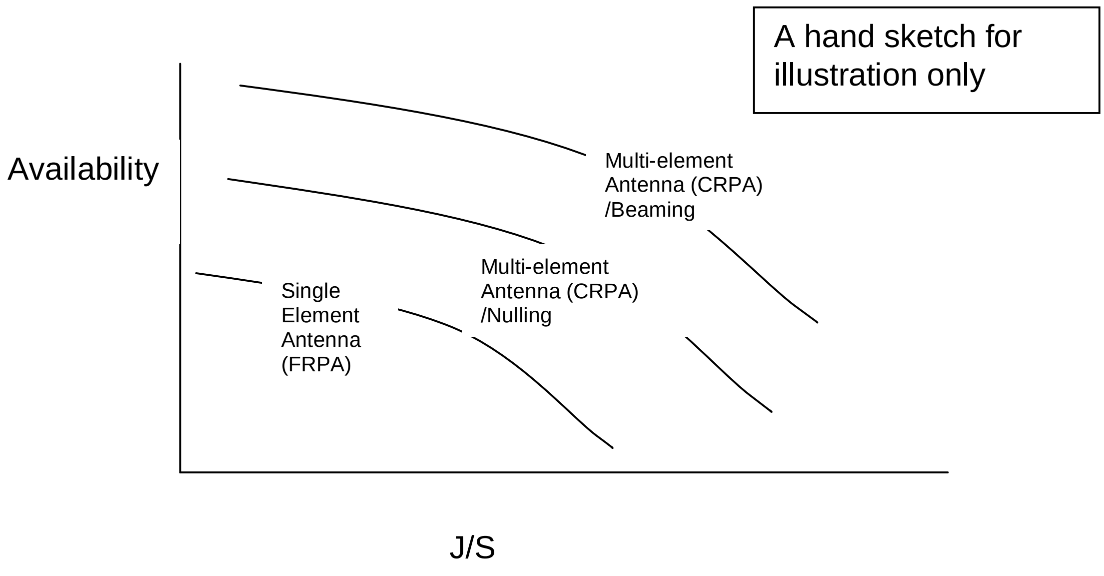
Appendix A. Acronyms

Appendix B. Vulnerability Requirements

The specific levels of GPS interference or jamming under which JPALS shall meet its applicable navigation system performance are contained in this Appendix and its classified version.

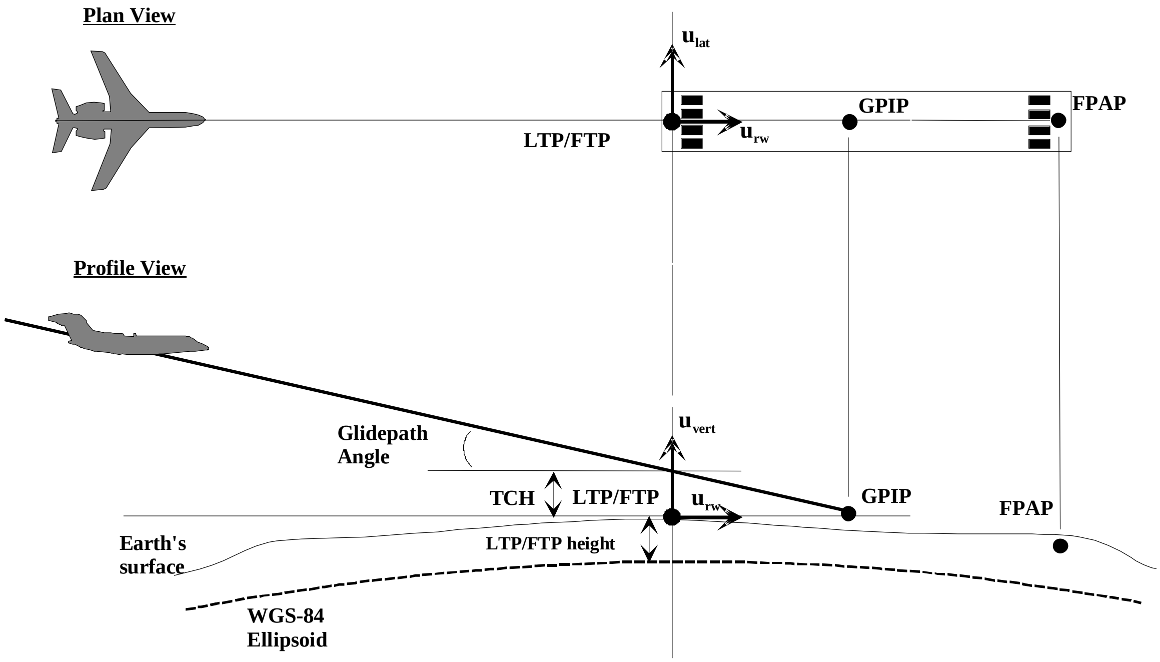
The JPALS system is likely to be exposed to GPS collateral jamming rather than being a direct jamming target. The intensity of jamming will likely be different for airborne and ground units and different operations will likely experience different jamming levels. A variety of jammer types will make up the jamming environment and different jamming mitigation technologies will have different responses to the expected jamming environment. Thus, the levels of interference, the mitigation technology and resulting system performance are presented in graphic form as follows.

[Note: for illustration purposes only, this type of plot would be classified using J/S, another layer or dimension could be jammer type.]



Appendix C. Final Approach Segment Data Definition

The ground subsystem shall transmit the Final Approach Segment (FAS) data as defined in the LDGPS SIS ICD. The relationship of the FAS data shall be consistent with the following definitions as depicted in Figure C-1.



Note: It is not a requirement that the FPAP be defined on the centerline of the runway, as in the case of offset approaches or helipad approaches.

Figure C-1 Straight-in Final Approach Segment Path Definition

The final approach path is defined in the following manner:

- The LTP/FTP is a position over which the final approach path passes at a relative height specified by the Threshold Crossing Height (TCH);
- The vertical unit vector (u_{vert}) is defined to be the normal to the WGS 84 ellipsoid at the LTP/FTP;
- The local level plane is defined as the plane which is orthogonal to u_{vert} and contains the LTP/FTP;
- The unit vector in the along-track direction (u_{rw}) is defined by the intersection of the local level plane and a plane containing the LTP/FTP, the FPAP, and the vertical unit vector;

- The lateral unit vector (u_{loc}) is in the local level plane and perpendicular to the along-track vector;
- The final approach path is defined as a line in the plane containing the vertical and along-track unit vectors with a glide path angle (GPA) with respect to the local level plane that passes at a defined distance, the TCH, above the LTP/FTP;
- The Glide Path Intercept Point (GPIP) is where the final approach path intercepts the local level plane.

The Flight Path Alignment Point (FPAP) is defined to be a point on the WGS-84 surface that is at the same height above the ellipsoid as the LTP/FTP, and is in the vertical plane which contains the final approach path and the LTP/FTP. This point is used to support the definition of the vertical plane that contains the final approach path.

Note: Nominally, the LTP/FTP *is located at the intersection of the runway threshold and the runway centerline and the FPAP would be at a latitude and longitude that is at the intersection of the runway centerline and the far end of the runway. More generic terminology has been used to define the final approach segment to allow the terminology to be applicable for all FAS path definitions (e.g., offset approaches, displaced runway thresholds, heliports).*