DRAFT

Signals-In-Space (SIS)

Interface Control Document (ICD)

for the

Joint Precision Approach and Landing System (JPALS)

Local Area Differential Global Positioning System (LDGPS)

Revision 1.0

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1.0 Scope

1.1 Introduction

This Interface Control Document (ICD) defines the Signal-in-Space (SIS) for the Joint Precision Approach Landing System (JPALS) that supports Service Level 7 (SL 7) precision approach and the differential positioning service. This document should be useful to equipment designers, installers, manufacturers, service providers, and JPALS users.

1.2 System Overview

JPALS provides the Department of Defense (DoD) with a precision approach and landing capability for Fixed Base, Tactical, and Special Mission Operations. JPALS can also provide terminal area operations including missed approach guidance and may potentially support other applications.

Figure 1-1 shows the three required components of the JPALS, specifically: the GPS satellite segment, the Military Airborne Segment (MAS), and the Military Ground Segment (MGS). In addition to these three segments, additional components are required to maintain the operations of the JPALS (e.g., the GPS control segment,); however, these components of the GPS are not considered to be part of the JPALS for the purpose of this ICD.

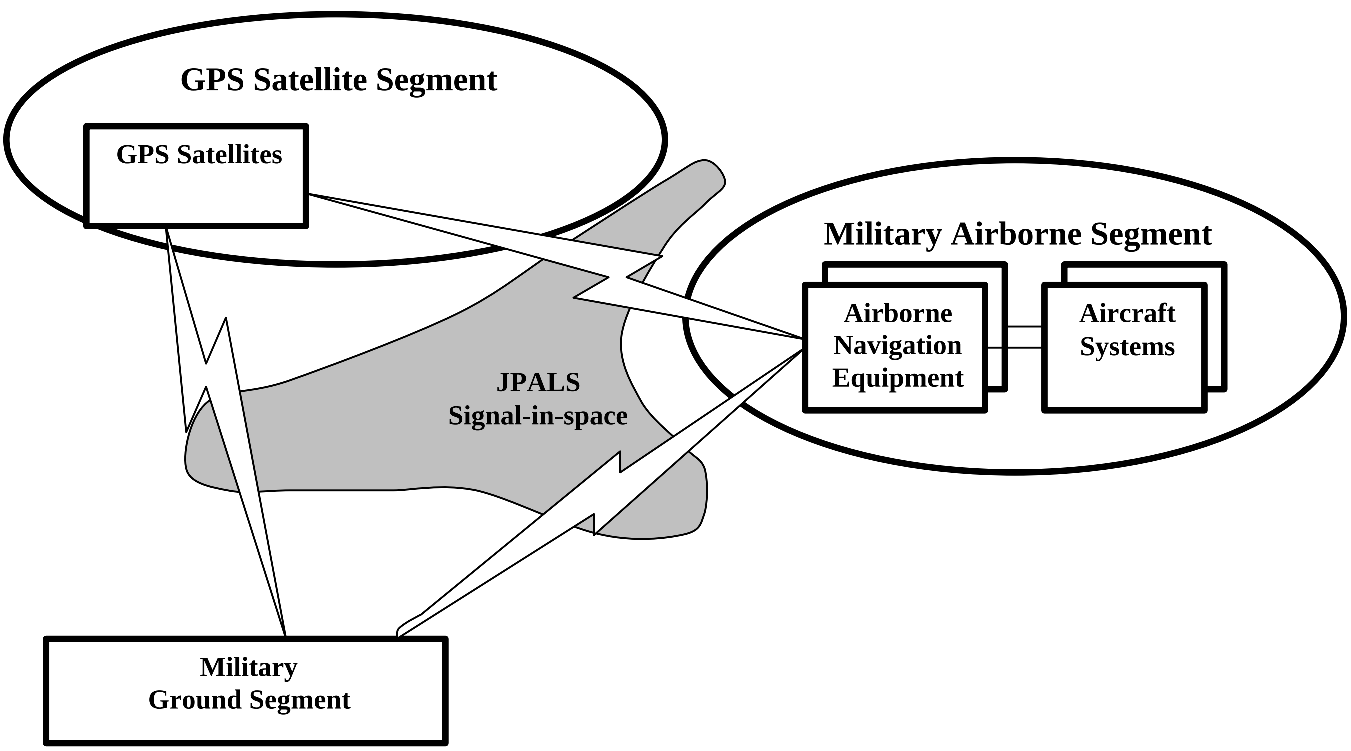


Figure 1-1 Joint Precision Approach Landing System

The JPALS Signal-in-Space is composed of three signals:

a) The navigation signal transmitted from the GPS segment to the MGS,
b) The navigation signal transmitted from the GPS segment to the MAS,
c) The VHF Data Broadcast (VDB) transmitted from the MGS to the MAS.

This document describes the third signal: VHF Data Broadcast. The first two Signal-in-Space signals are defined by ICD-GPS 200C document.

Figure 1-2 depicts the JPALS Signal-in-Space (SIS), the MGS, and the MAS.

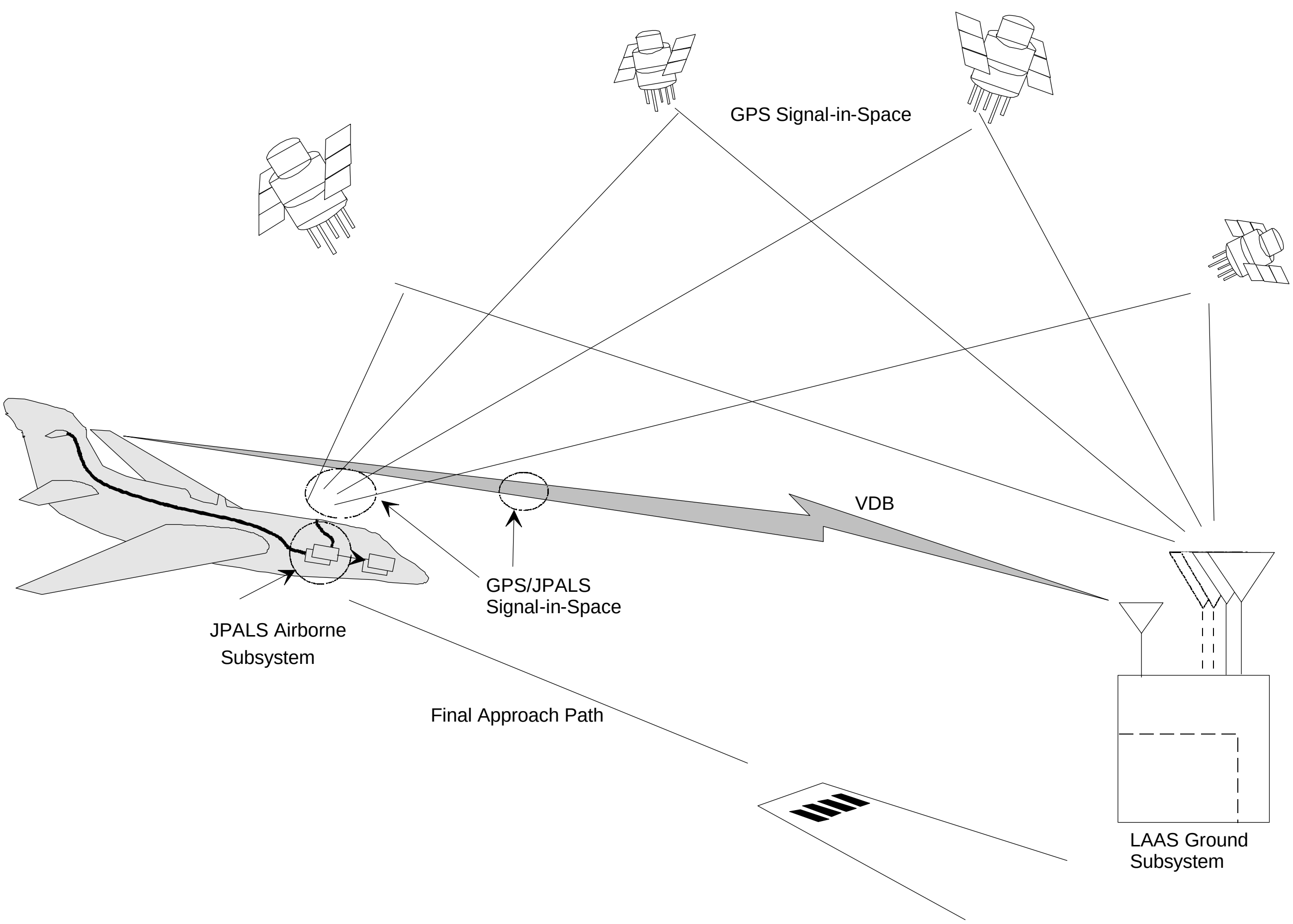


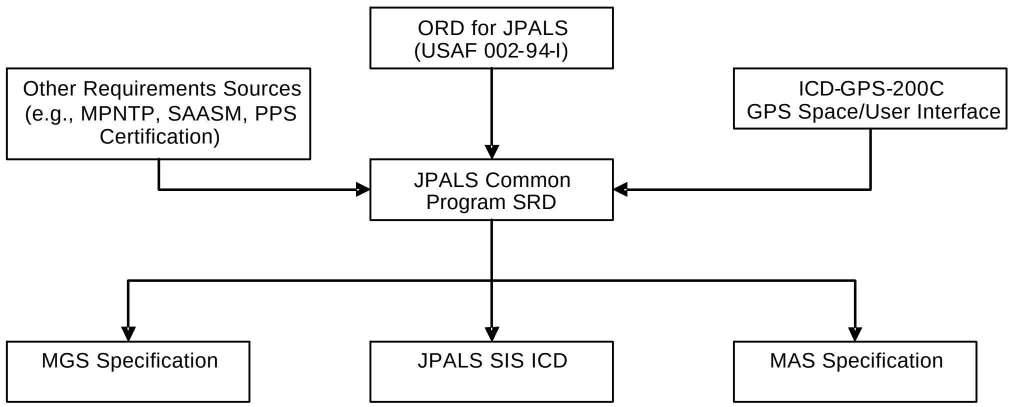
Figure 1-2 JPALS Signal-in-Space Interface Diagram

The MGS provide local differential pseudorange corrections, integrity parameters, and Final Approach Segment (FAS) data that are transmitted via a Very High Frequency (VHF) Data Broadcast (VDB). The MAS receives the MGS differential pseudorange corrections and applies them to the MAS derived GPS data and pseudorange to obtain position with the required accuracy, integrity, continuity and availability.

The differentially corrected position is used, along with the FAS data, to supply vertical and horizontal deviation signals to drive appropriate aircraft systems supporting precision approach.

1.2.1 JPALS Requirements Hierarchy

The Signal-in-Space (SIS) Interface Control Document (ICD) is part of a family of documents that establish the system, performance, and interface requirements for JPALS that have been or are being developed to completely specify JPALS characteristics. Figure 1-3 illustrates the hierarchy of the various JPALS requirements documents for Block I.



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

Figure 1-3 JPALS Requirements Hierarchy for Block I

The Operational Requirements Document (ORD) contains the JPALS operational requirements, which are the primary source for the JPALS performance requirements contained in the Common Program Systems Requirements Document (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 MAS Specification, the JPALS Signal-in-Space (SIS) Interface Control Document (ICD), or the MGS Specification, as applicable.

1.2.2 Evolutionary Acquisition

Error! Reference source not found. is being acquired and developed using an Evolutionary Acquisition strategy. **Error! Reference source not found.** capabilities are being acquired and fielded to meet user demands consistent with the necessary technology development and maturation. The initial **Error! Reference source not found.** capability or system is a **Error! Reference source not found.** tactical **Error! Reference source not found.** system followed by a fixed base **Error! Reference source not found.** system.

Subsequent **Error! Reference source not found.** capabilities are to be fielded as user needs and technology are identified and developed. A new **Error! Reference source not found.** signal code (**Error! Reference source not found.**) and frequency (**Error! Reference source not found.**) as well as **Error! Reference source not found.** III modifications are to be considered and incorporated as they become available.

1.3 Assumptions

1.4 Documents Overview

This document contains the following sections:

1. Scope: Contains introduction, system and document overviews.

2. Reference Documents: Provides a list of the documents referenced in this standard.

3. Data Broadcast Definition: Describes parameters of messages that JPALS uses and their formats.

4. Appendices: Includes Cyclic Redundancy Check, Message Examples, and Glossary, Abbreviations and Acronyms.

2.0 Reference Documents

1. Global Positioning System Standard Positioning Service Signal Specification, U.S. Department of Defense, Washington, DC, June 2, 1995.
2. ICAO, Annex 10, International Standards and Recommended Practices for Aeronautical Telecommunications, Volume I, Radio Navigation Aids.
3. ICAO Document AMCP/3-R/8A (VHF Digital Link Manual)
4. ICD-GPS-200C, Navstar GPS Space Segment/Navigation User Interfaces, April 2000.
5. JPALS MGS SSS
6. JPALS MAS SSS
7. ICD-GPS 200C; *NAVSTAR GPS Space Segment/Navigation User Interfaces;* IRN-200C-005R1, 14 January 2003, ARINC Research Corporation, 2250 E. Imperial Highway, Suite 450, El Segundo, CA 90245-3509.
8. Operational Requirements Document (ORD) for Joint Precision Approach and Landing System (JPALS); USAF-002-94-I; 8 July 2002; Air Force Flight Standards Agency.
9. System Requirements Document (SRD) for the Joint Precision Approach and Landing System (JPALS) Common Program, April 2003, Revision 2.2, Draft V13, Electronic Systems Center, Global Air Traffic Operations/Mobility Command and Control System Program Office (ESC/GA), JPALS Integrated Product Team, Hanscom AFB, MA 01731-2103.
10. RTCA/DO-245; *Minimum Aviation System Performance Standard for the Local Area Augmentation System (LAAS)*, 1998, RTCA, Inc.
11. RTCA/DO-236A *Minimum Aviation System Performance Standard: Required Navigation Performance for Area Navigation*, 13 September, 2000, RTCA, Inc.
12. RTCA/DO-246B; *Global Navigation Satellite System (GNSS**Error! Reference source not found.**) Based Precision Approach Local Area Augmentation System Signal-in-Space - Interface Control Document*, 28 September 1998, RTCA Inc.

2.1 Order of Precedence

In case of a conflict between this document and the referenced documents, the order of precedence in descending order is as listed below unless otherwise noted herein:

Applicable Federal, State, or Local Laws and Regulations
JPALS ORD
JPALS SRD
JPALS SIS ICD (this document)
Other referenced specifications and documents referenced in section 2.

In case of conflict between referenced documents at a lower order of precedence than this document, the more restrictive requirement applies, unless otherwise approved by the Government in the form of a change to this document or by other contractually effective means. Lack of a requirement at a higher level of precedence or a more general requirement at a higher level of precedence is not considered a conflict. The more detailed requirement applies.

3.0 Data Broadcast Definition

This section describes the Signal-in-Space for the JPALS VHF Data Broadcast (VDB). The broadcast is a Time Division Multiple Access (TDMA) VHF data broadcast, which complies with the physical layer of the ISO stack protocol described in ICAO Document AMCP/3-R/8A (VHF Digital Link Manual). The VDB link layer is different than VDL Mode 2. The data broadcast definition includes RF transmission characteristics, broadcast timing structure, data burst content, and message format.

3.1 RF Transmission Characteristics

3.1.1 Symbol Rate

The symbol rate of the JPALS data broadcast is 10,500 symbols/sec ±0.005%. Each symbol defines one of eight states (3 bits) resulting in a nominal bit rate of 31,500 bits/sec.

3.1.2 Emission Designator

The Federal Communications Commission (FCC) emission designator of this modulation technique is 14K0G7DET.

3.1.3 Modulation

Binary data is assembled into symbols, each consisting of 3 consecutive bits. The end of the data is padded by one or two fill bits if necessary to form the last 3-bit symbol of the burst. Symbols are converted to differentially-encoded 8 phase shift keyed (D8PSK) carrier phase shifts ($\Delta\phi_k$) as shown in Table 3-1.

The carrier phase for the k^{th} symbol (ϕ_k) is given by:

$$\phi_k = \phi_{k-1} + \Delta\phi_k$$

The transmitted signal is $H(e^{j(2\pi ft + \phi(t))})$, where $H(\bullet)$ is a raised cosine filter with $\alpha = 0.6$ as defined in Section 3.1.3.1.

Table 3-1 Data Encoding

Message Bits (Note)			**Symbol Phase Shift**
$\mathbf{I_{3k-2}}$	$\mathbf{I_{3k-1}}$	$\mathbf{I_{3k}}$	$Df_{\mathbf{k}}$
0	0	0	0
0	0	1	1π/4
0	1	1	2π/4
0	1	0	3π/4
1	1	0	4π/4
1	1	1	5π/4
1	0	1	6π/4
1	0	0	7π/4

<u>Note</u>: *I_j is the j^{th} bit of the burst to be transmitted, where I_1 is the first bit of the training sequence. The values of Df_k represent counter clockwise rotations in the complex I-Q plane of Figure 3-1.*

D8PSK may be produced as shown in Figure 3-1 by combining two quadrature RF signals which are independently-suppressed-carrier amplitude-modulated by baseband filtered impulses. The baseband filters have a frequency response with the shape of a raised cosine with an excess bandwidth factor (a) equal to 0.6. This characteristic allows a high degree of suppression of adjacent channel energy, with performance dependent only upon hardware implementation of the modulating and amplification circuits.

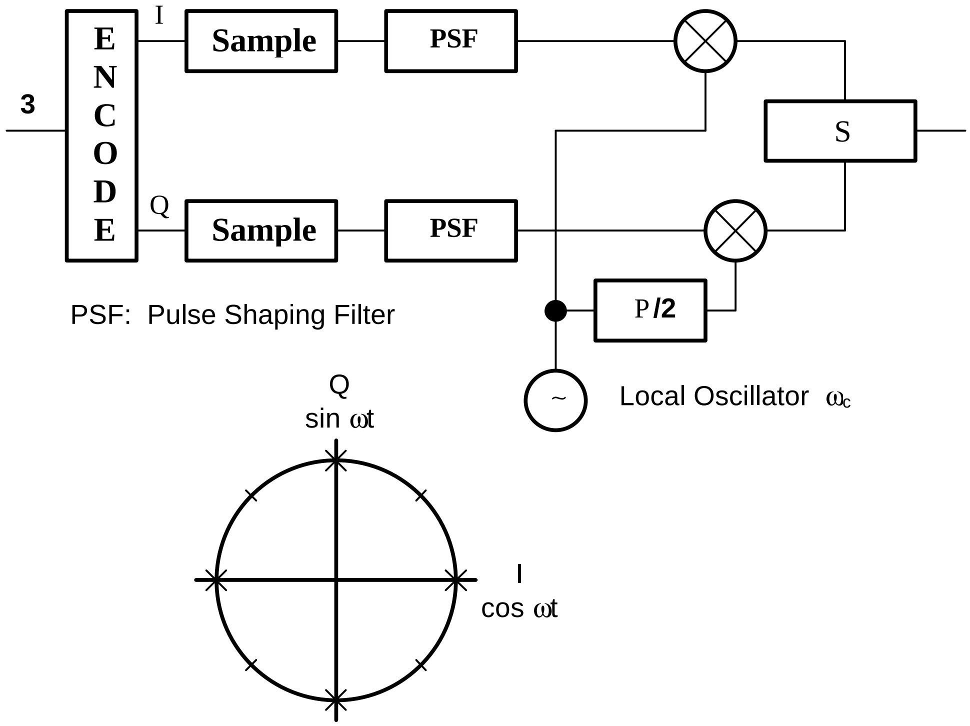


Figure 3-1 D8PSK Data Modulator Example

3.1.3.1 Pulse Shaping Filters

The output of differential phase encoder is filtered by a pulse shaping filter whose output, *s(t)*, is described as follows:

$$s(t) = \sum_{k=-\infty}^{k=\infty} e^{jf_k} h(t-kT)$$

where:

- h = the impulse response of the raised cosine filter
- t = time
- T = duration of each symbol (T=1/10500 second, approximately 95.2 μsec)
- f_k = as defined in Section 3.1.3

This pulse shaping filter has a nominal complex frequency response of a raised-cosine filter with α = 0.6. The frequency response, *H(f)*, and the time response, *h(t)*, of the base band filters are as follows:

$$H(f) = \begin{cases} 1 & 0 \le f < \dfrac{1-a}{2\mathrm{T}} \\ \dfrac{1-\sin\left(\dfrac{p}{2a}(2f\mathrm{T}-1)\right)}{2}, & \dfrac{1-a}{2\mathrm{T}} \le f \le \dfrac{1+a}{2\mathrm{T}} \\ 0 & f > \dfrac{1+a}{2\mathrm{T}} \end{cases}$$

$$h(t) = \frac{\sin\left(\dfrac{pt}{T}\right)}{\dfrac{pt}{T}} \frac{\cos\left(\dfrac{pat}{T}\right)}{1-\left(\dfrac{2at}{T}\right)^2}$$

where:

f is the absolute value of the frequency offset from the channel center.

3.1.3.2 Error Vector Magnitude

The error vector magnitude of the transmitted signal is less than 6.5 percent RMS.

3.2 Broadcast Timing Structure

The high data rate of the physical layer offers more capacity than is required by any single MGS. As a result, spectrum efficiency is achieved through the use of a Time Division Multiple Access (TDMA) technique that partitions the total capacity offered by a single JPALS frequency assignment to individual proximate ground station VDB transmitters. The paragraphs of this subsection describe the time partitioning approach used for the JPALS VHF Data Broadcast.

3.2.1 TDMA Timing Structure

The TDMA timing structure is based on a two level hierarchy as shown in **Figure** 3-2. Each frame is 500 milliseconds in duration. There are two such frames contained in each one-second UTC epoch. The first of these frames starts at the beginning of the UTC epoch and the second starts 0.5 seconds after the beginning of the UTC epoch. The frame is time division multiplexed such that it consists of 8 individual VDB time slots (A - H) of 62.5 millisecond duration.

A VDB time slot establishes the incremental capacity resource that can be assigned to an individual MGS transmission station. Within each time slot, a VDB burst can be transmitted. Bursts can be of variable length up to the maximum allowed within the slot. The following subsection details the timing budget and physical layer overhead required for the maximum length burst.

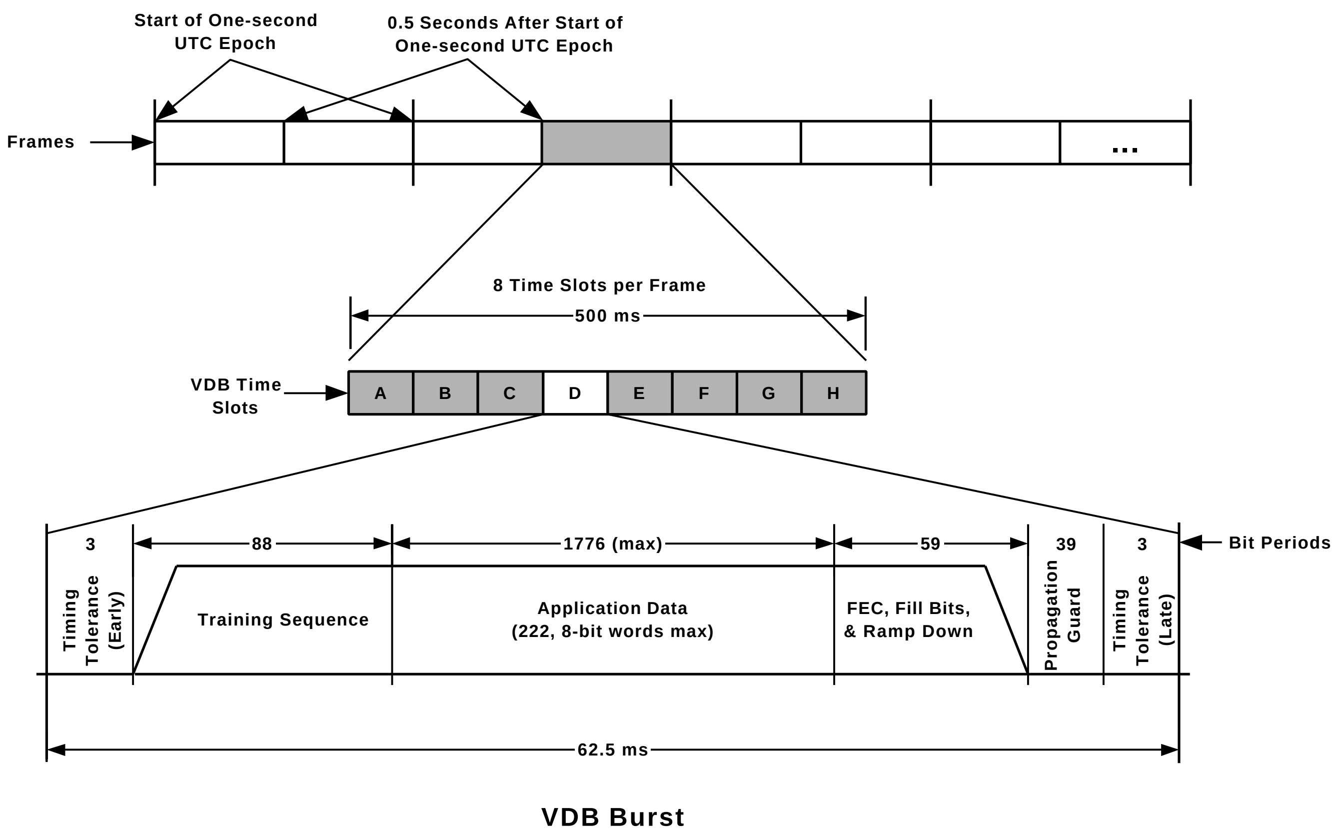


Figure 3-2 TDMA Timing Structure

3.2.2 Time Slot Initiation and Minimum Use

To initiate the use of a time slot, the VDB transmitter will broadcast a burst in that time slot in each of 5 consecutive frames. For each time slot in use, the VDB transmitter will broadcast a burst in at least one frame of every 5 consecutive frames.

3.2.3 Timing Budget for VDB Bursts

Each VDB burst is contained in a 62.5 millisecond time slot. At a rate of 10,500 symbols per second, each time slot contains 656.25 symbol periods.

The transmission of each burst begins 95.2 μs after the start of the time slot, with a total tolerance of ± 95.2 μs. The transmitter power ramps up to 90% of the steady-state power level within two symbol periods (≈ 190.5 μs) after the beginning of the burst, and stabilizes at the steady-state power within five symbol periods (≈ 476.2 μs) after the beginning of the burst. After transmission of the final information symbol of a burst, the transmitter output power level decreases to at least 30 dB below the steady-state power within 285.7 μs. A signal propagation guard time of 1261.9 μs at the end of each slot protects a one way propagation range of approximately 200 nmi. Table 3-2 shows the timing budget for a VDB burst. The start of the synchronization and ambiguity resolution portion of the burst transmitted with horizontal polarization (HPOL) will occur within 10 μs of the start of the burst transmitted with vertical polarization (VPOL), as received at the aircraft.

Table 3-2 Burst Timing

Event	Nominal Event Duration	Nominal Percentage of Steady-State Power
Ramp up	190.5 μs	0% to 90%
Transmitter Power Stabilization	285.7 μs	90% to 100%
Synchronization & Ambiguity Resolution	1523.8 μs	100%
Transmission of Scrambled Data	58761.9 μs	100%
Ramp down	285.7 μs (Note)	100% to 0%

Note: *Event duration indicated for transmission of scrambled data is for the maximum application data length of 1776 bits and two fill bits. The end of the burst occurs within 285.7 ms after the last symbol of the scrambled data.*

3.3 Burst Data Content

Each burst consists of the data elements shown in Table 3-3. The maximum burst duration is 1912 useful bits (239 bytes). Since the communications structure is based on an 88 bit training sequence and a 48-bit application FEC, up to1776 bits (222 bytes) can be used for application data.
As depicted in Figure 3-3, the encoding of the messages follows the sequence: application data formatting, training sequence FEC generation, application FEC generation, and bit scrambling.

Table 3-3 Burst Data Content

Element	Data Content	Number of Bits
Power Stabilization	Section 0	15
Synchronization & ambiguity resolution	Section 3.3.1.2	48
Scrambled Data:		
Station slot identifier (SSID)	Section 3.3.1.3	3
Transmission Length	Section 3.3.1.4	17
Training Sequence FEC	Section 3.3.1.5	5
Application Data	Section 3.3.2	Up to 1776
Application FEC	Section 3.3.3	48
Fill Bits (Note)	Section 3.1.3	0 to 2

Note: *Up to 2 fill bits are added as required for transmission of whole symbols. The number of fill bits varies depending on the number of bits in the application data. Data scrambling of the fill bits is optional and the set value of the fill bits is optional. The fill bits are not part of the application data used by the aircraft receiver.*

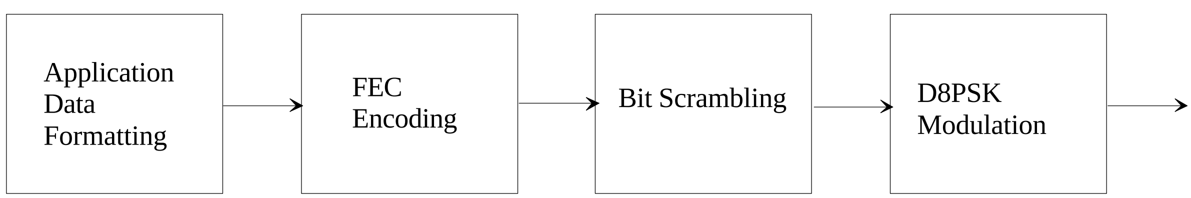


Figure 3-3 Message Encoding

3.3.1 Training Sequence

The data broadcast message begins with a 5-segment demodulator training sequences as shown in Table 3-1. The training sequence allows proper demodulation of the message by the airborne subsystem.

Table 3-4 Training Sequence Format

Segment Sequence	***Training Sequence Description***	***Number of Bits***
1	Power Stabilization	15
2	Synchronization & Ambiguity Resolution	48
3	Station Slot Identifier (SSID)	3
4	Transmission Length	17
5	Training Sequence FEC	5
	TOTAL	88

3.3.1.1 Power Stabilization

The first segment of the training sequence is the 15-bit Power Stabilization field, coded as all zeros. The transmitted signal reaches at least 90% of the steady-state power level within two symbols to allow the airborne receiver's automatic gain control (AGC) at least three symbols settling time.

3.3.1.2 Synchronization and Ambiguity Resolution

The second segment of the training sequence is the 48-bit Synchronization and Ambiguity Resolution field consisting of the following sequence:

010 001 111 101 111 110 001 100 011 101 100 000 011 110 010 000

with the right-most bit (LSB) transmitted first.

<u>Note</u>: *This sequence was designed to have good auto-correlation properties and to facilitate estimation of the center frequency.*

3.3.1.3 Station Slot Identifier

The third segment of the training sequence is the 3-bit Station Slot Identifier (SSID). The SSID is a numeric value from 0 to 7, corresponding to the letter designation (A through H) of the first time slot assigned to a particular ground reference station, where slot A = 0 and slot H = 7. All messages in all time slots employed by a particular ground station use the same SSID. The SSID is transmitted LSB first.

<u>Notes</u>:

1) *The purpose of transmitting the SSID is to provide a low overhead way for the airborne receiver to decide whether to process the rest of the burst data. This provides the avionics manufacturer the opportunity to reduce unnecessary traffic on the data bus.*

2) *SSID Example*

MGS ID	*Time Slots Assigned*	*SSID*
GYUL	*A,C*	*0*
GYMX	*D,F*	*3*
GYSF	*G*	*6*

3) Because SSID values are defined directly from time slot assignments, there is no requirement for Spectrum Management authorities to separately manage the assignment of SSID. It is not intended that the SSID be required in an airborne database.

4) Because the assignment of slots is not guaranteed to be unique within radio range, an airborne user may receive messages from more than one ground station with the same SSID. All messages from a single ground station will have the same SSID; however, all messages received with the same SSID are not necessarily from the same ground station. Therefore, the airborne receiver must also examine the MGS ID in the field of every message header to determine which ground station produced the message.

3.3.1.4 Transmission Length

The fourth segment of the training sequence is the 17-bit Transmission Length. This field indicates the total number of bits in the Application Data and Application FEC. This allows the airborne receiver to determine the length of the Reed-Solomon block. The order of transmission is from least significant bit (LSB) to most significant bit (MSB).

Note: *Although no transmission length exceeds 1824 bits the full 17 bits are included to be consistent with the ICAO Document AMCP/3-R/8A (VHF Digital Link Manual).*

3.3.1.5 Training Sequence FEC

The fifth segment of the training sequence is the Training Sequence FEC. A (25,20) block code is computed over the SSID and Transmission Length segments using the following equation.

$$[P_{1,} ..., P_5] = [SSID_1, ,SSID_3, TL_{1, ...,}TL_{17}]\ H^T$$

where:

P_n is the n^{th} bit of the training sequence FEC (P_1 is transmitted first)

SSID is the n^{th} bit of the Station slot identifier ($SSID_1$=LSB)

TL_n is the n^{th} bit of the transmission length (TL_1=LSB)

H^T is the matrix H transpose function and

H is the parity matrix defined below:

$$H = \begin{matrix} 0&0&0&0&0&0&0&0&1&1&1&1&1&1&1&1&1&1&1&1 \\ 0&0&1&1&1&1&1&1&0&0&0&0&1&1&1&1&1&1&1&1 \\ 1&1&0&0&0&1&1&1&0&0&1&1&0&0&0&0&1&1&1&1 \\ 1&1&0&1&1&0&1&1&0&1&0&1&0&0&1&1&0&0&1&1 \\ 0&1&1&0&1&0&0&1&1&1&1&0&0&1&0&1&0&1&0&1 \end{matrix}$$

Note: *This code is capable of correcting all single bit errors and detecting 75 of 380 possible double bit errors.*

3.3.2 Application Data

The application data consists of one or more message blocks, as defined in Section 3.3.5. The message blocks are mapped directly into the Application Data portion of the VDB burst with no additional overhead of intervening layers. Broadcasting of messages across multiple bursts is not supported; each message must be completely contained within a single burst. The order of transmission for the application data is LSB first followed by the higher order bits of each field.

3.3.3 Application FEC

The application FEC coding is accomplished by means of a systematic fixed length Reed-Solomon (255,249) 2^8-ary code capable of correcting up to three code word symbol errors. The field defining primitive polynomial of the code is as follows:

$$p(x) = x^8 + x^7 + x^2 + x + 1$$

The generator polynomial is given by:

$$g(x) = \prod_{i=120}^{125}\left(x - a^{i}\right) = x^6 + a^{176}x^5 + a^{186}x^4 + a^{244}x^3 + a^{176}x^2 + a^{156}x + a^{225}$$

where:

α is a root of p(x) used for construction of the Galois Field of size 2^8; GF(256), and α^i is the i^{th} primitive element in GF(256).

Virtual fill bits set to zero will be temporarily appended to the application data as necessary to create an input stream to the application FEC encoder and decoder of 1992 bits (249 bytes). These virtual fill bits are not transferred to the bit scrambler or transmitted.

In generating the application FEC, the data to be encoded, m(x), will be grouped into 8 bit Reed-Solomon symbols. The data m(x) is defined by:

$$m(x) = a_{248}x^{248} + a_{247}x^{247} + \ldots + a_{248-length+1}x^{248-length+1} + a_{248-length}x^{248-length} + \ldots + a_1 x + a_0$$

where:

length represents the number of 8-bit bytes in the application data block

a_{248} represents the Message Block Identifier (MBI), with the rightmost bit defined as the LSB and the first bit of the application data sent to the bit scrambler

$a_{248-length+1}$ represents the last byte of the message block CRC, with the leftmost bit defined as the MSB and the last bit of the application data sent to the bit scrambler

$a_{248-length}$, …., a_1, a_0 are the virtual fill bits (if any)

The six Reed-Solomon check symbols (b_i) are defined as the coefficients of the remainder resulting from dividing the message polynomial $x^6m(x)$ by the generator polynomial g(x):

$$b(x) = \sum_{i=0}^{5} b_i x^i = b_5x^5 + b_4x^4 + b_3x^3 + b_2x^2 + b_1x + b_0 = \left[x^6 m(x)\right] \bmod g(x)$$

These 8-bit Reed-Solomon check symbols are appended to the application data.

The Application FEC is ordered such that the first Application FEC bit transferred to the bit scrambler is the MSB of the 6^{th} 8-bit code word, b_0, generated by the FEC encoder, and the last Application FEC bit transferred to the bit scrambler is the LSB of the 1^{st} code word, b_5.

<u>Note</u>: *The order of the transmitted 8-bit Reed-Solomon check symbols of the appended application FEC differs from VDL-2.*

3.3.4 Bit Scrambling

In order to aid clock recovery, a pseudonoise (PN) scrambler with a 15-stage generator register are exclusive OR'ed with the transmitted data stream starting with the station slot identifier and ending with the application FEC. Bit scrambling of any fill bits is optional, and the set value of the fill bits is optional.

<u>Note</u>: *The fill bits are not used by the aircraft receiver, so their value has no impact on system performance.*

The concept of a PN scrambler is shown in Figure 3-4 (the descrambler is identical). The polynomial for the register of the scrambler is $1 + X + X^{15}$. The register content is rotated at the rate of one shift per bit. The initial status of the register, prior to the first station slot identifier bit of each burst, is 1101 0010 1011 001 with the leftmost bit in the first stage of the register. The first output bit of the scrambler/descrambler is sampled prior to the first register shift.

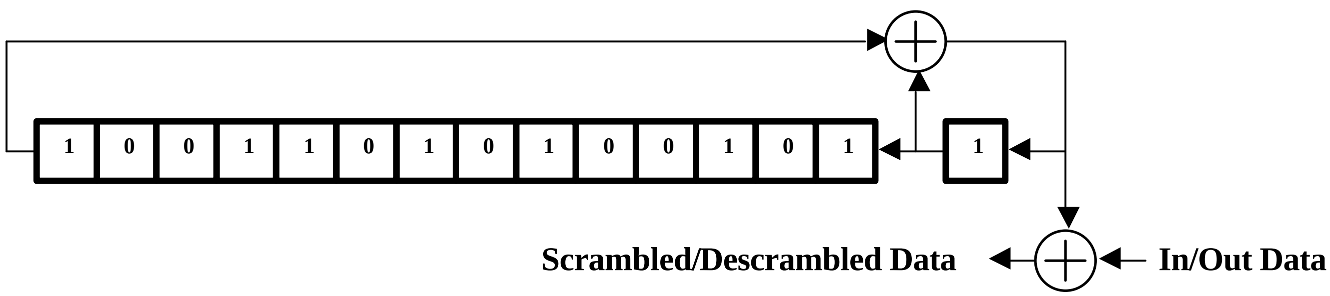


Figure 3-4 Bit Scrambler/Descrambler

3.3.5 Application Layer

The application layer of the ISO Stack Protocol for messages within the VHF data broadcast is described in the following paragraphs. Table 3-5 displays the general construction of a JPALS Message Block. All signed parameters are 2's complement numbers except as noted.

Table 3-5 Format of a JPALS Message Block

Message Block	***Bits***	***Bytes***
Message Block Header	48	6
Message	up to 1696	up to 212
Message Block CRC	32	4

3.3.6 Message Block Header

The Message Block Header contains information relevant to every JPALS transmission. Table 3-6 diagrams a Message Block Header. It consists of a Message Block Identifier (MBI) and a twenty-four bit MGS ID, which identifies the JPALS reference station. These fields are followed by an eight-bit message type field and an eight-bit message length field.

Table 3-6 Format of Message Block Header

Message Header	*Bits*	*Bytes*
Message Block Identifier	8	1
MGS ID	24	3
Message Type	8	1
Message Length	8	1

3.3.6.1 Message Block Identifier

The 8-bit message block identifier (MBI) denotes the start of a message block, and indicates the operating mode of the JPALS message block.

<u>“1010 1010” = a normal LAAS message</u>
<u>“1111 1111” = a LAAS test message</u>
<u>“0101 0101” = a normal JPALS message</u>
<u>“1111 1110” = a JPALS test message</u>

All other codings indicate non-JPALS message formats not supported by this ICD.

3.3.6.2 MGS ID

MGS ID is a four-character (24-bit) alphanumeric field that identifies the ground station broadcasting the message. Each character is represented by bits b_1 through b_6 of its International Alphabet #5 representation (reference section 2.4.2), with bit b_1 transmitted first. Only capital letters, numbers, and “space” are permitted. The right-most character is transmitted first. For a 3-character ID, the right-most (first transmitted) character is “space”.

3.3.6.3 Message Type

Message Type is an 8-bit numeric label identifying the contents of the message.

3.3.6.4 Message Length

Message Length is the length, in bytes, of the Message Block including the message block header, the message and the message block CRC.

3.3.6.5 Military Test Mode

When the station is operating in a mode where the SIS does not conform to the certification requirements of the station or the definition in this ICD, the Message Block Identifier is set to “1111 1110”.

<u>Note:</u> *Individual message transmissions can be set invalid by setting the Message Block Identifier to “1111 1110” for that message.*

3.3.6.6 Civil Test Mode

The JPALS station is required to support the LAAS civil test mode. This mode is anticipated to support civil aircraft test procedure. The Message Block Identifier in this mode is set to “1111 1111”.

<u>Note:</u> *Individual message transmissions can be set invalid by setting the Message Block Identifier to "1111 1111" for that message.*

3.3.7 Cyclic Redundancy Check

A 32-bit cyclic redundancy check (CRC) concludes each message block in order to ensure message integrity.
The generator polynomial G(x) for the message block CRC is:

$$G(x) = x^{32} + x^{31} + x^{24} + x^{22} + x^{16} + x^{14} + x^{8} + x^{7} + x^{5} + x^{3} + x + 1$$

The CRC information field, M(x) is:

$$M(x) = \sum_{i=1}^{n} m_i x^{n-i} = m_1 x^{n-1} + m_2 x^{n-2} + \ldots + m_n x^{0}$$

M(x) is formed from the 48-bit JPALS message block header and all bits of the variable-length Message, excluding the CRC. Bits are arranged in the order transmitted, such that m_1 corresponds to the first transmitted bit of the message block header, and m_n corresponds to the last transmitted bit of the (n-48) message bits.

The CRC is ordered such that r_1 is the first bit transmitted and r_{32} is the last bit transmitted.

Further details of the CRC implementation are provided in Appendix A.

3.4 JPALS Messages

3.4.1 Message Types and Broadcast Rates

The range of the 8-bit message type field of the message block header allows for up to 256 message types. Eight of the 256 message types have been allocated. Message Types 1, 2 and 4 are required, while Message Type 5 is optional. It is intended that unique military information be communicated via Message Type 7 and that experimental, private-use, and proprietary messages be communicated via Message Type 8. Message Type 16 is reserved for Navy Shore-based training and Message Type 32 is reserved for carrier phase measurement to be used for Dual Frequency Smoothing by the airborne user.

Table 3-7 lists the allocated message types, and the required broadcast rates to support SL 7 precision approach and the differential positioning service.

Message Types 0, 3, 5, 6 and 9 through 15 and 17 through 255 are reserved for future operations. It is also intended that these messages be assigned for common-use aviation applications only and be defined in this ICD.

Table 3-7 JPALS VHF Data Broadcast (VDB) Messages and Broadcast Rates

Message Type	***Message Name***	***Minimum Broadcast Rate***	***Maximum Broadcast Rate***
0	Reserved	-	-
1	Differential Corrections	For each measurement type: All measurement blocks, once per frame (note 1)	For each measurement type: All measurement blocks, once per slot (note 1)
2	MGS Related Data	Once per 20 consecutive frames	Once per frame
3	Reserved	-	-
4	Final Approach Segment (FAS) Construction Data	All FAS blocks once per 20 consecutive frames (note 2)	All FAS blocks once per frame (note 2)
5	Reserved	-	-
6	Reserved	-	-
7	Military (TBD)	-	-
8	Test (TBD)	-	-
9 – 15	Reserved	-	-
16	Navy Shore-based training (TBD)	-	-
17-31	Reserved	-	-
32	Carrier Phase Measurement (TBD)	-	-
33 - 255	Reserved	-	-

<u>Note 1</u>: *Each Type 1 message or linked Type 1 message pair broadcast in a given frame includes the complete set of measurement blocks for its measurement type.*

<u>Note 2</u>: *If no final approach segments (FAS) are currently being supported, then it is not necessary*

to transmit Type 4 messages.

3.4.2 Data Format

The order of the application data is reflected in the order of the fields in each Message Type and FAS table from top to bottom.

Bits identified as spare have no defined use and are coded as zeros. In the future, spare bits in a message may be defined to incorporate additional parameters at which point these bits are no longer spare. Spare bits should be ignored except for the purposes of CRC and FEC processing.

Unless otherwise specified, all signed numbers are coded in two's complement format.

Certain JPALS message fields contain alphanumeric data coded using a subset of International Alphabet No. 5 (IA-5).

Table 3-8 shows the coding for this subset of IA-5.

Table 3-8 Subset of International Alphabet No. 5

Binary Code (Note 1)	**Character**	**Binary Code** (Note 1)	**Character**	**Binary Code** (Note 1)	**Character**
000000		010000	P	110000	0 (Note 3)
000001	A	010001	Q	110001	1 (Note 3)
000010	B	010010	R	110010	2 (Note 3)
000011	C	010011	S	110011	3 (Note 3)
000100	D	010100	T	110100	4 (Note 3)
000101	E	010101	U	110101	5 (Note 3)
000110	F	010110	V	110110	6 (Note 3)
000111	G	010111	W	110111	7 (Note 3)
001000	H	011000	X	111000	8 (Note 3)
001001	I (Note 3)	011001	Y	111001	9 (Note 3)
001010	J	011010	Z	111010 to 111111	(Note 2)
001011	K	011011 to 011111	(Note 2)		
001100	L				
001101	M	100000	"space"		
001110	N	100001 to 101111	(Note 2)		
001111	O (Note 3)				

<u>Notes</u>:

1) *Binary code values represent IA-5 bits b_1 through b_6, with b_1 as the right-most bit. IA-5 bits b_7 and b_8 are not used in the JPALS application.*

2) *Values not used for JPALS message fields.*

3) *Values not used for 5-bit Route Indicator field.*

4) *For the coding of the route indicator in the FAS data block, only bits b_1 through b_5 are used.*

Example messages of Message Type 1, 2, and 4 are provided in Appendix B.

3.4.2.1 Message Type 1 – Differential Corrections

3.4.2.1.1 Message Description

Message Type 1 provides the differential correction data for individual GPS ranging sources. The message contains three sections: message information (time of validity, additional message flag, number of measurements and the measurement type), low frequency correction information (ephemeris decorrelation parameter, ranging source ephemeris CRC and ranging source availability duration information) and the ranging source data measurement blocks. The message format is defined in Table 3-9.

Table 3-9 Format of Message Type 1

Data Content	***Bits Used***	***Range of Values***	***Resolution***
Modified Z-count	14	0 – 1199.9 sec	0.1 sec
Additional Message Flag	2	0 – 3	1
Number of Measurements	5	0 – 18	1
Measurement Type	3	0 – 7	1
Ephemeris Decorrelation Parameter (Notes 5)	8	0 – $1.275x10^{-3}$	$5x10^{-6}$ m/m
Ephemeris CRC (Notes 5)	16	-	-
Source Availability Duration (Notes 4, 5	8	0 – 2540 sec	10 sec
For N Measurement Blocks:			
Ranging Source ID	8	1 – 255	1
Issue of Data (IOD)	8	0 – 255	1
Pseudorange Correction (PRC)	16	±327.67 m	0.01 m
Range Rate Correction (RRC)	16	±32.767 m/s	0.001 m/s
σ_{pr_gnd} (Note 3)	8	0 – 5.08 m	0.02 m
B_1 (Note 1)	8	±6.35 m	0.05 m
B_2 (Note 1)	8	±6.35 m	0.05 m
B_3 (Note 1)	8	±6.35 m	0.05 m
B_4 (Note 1)	8	±6.35 m	0.05 m

Notes:

1) *1000 0000 indicates the measurement is not available.*
2) *1111 1111 indicates the source is invalid.*
3) *1111 1111 indicates that value is not computed and should not be used.*
4) *Parameter is associated with the first transmitted measurement block.*

Each Type 1 Message includes low frequency data for one ranging source consisting of the Ephemeris Decorrelation, Ephemeris CRC and Source Availability Duration parameters. The low frequency data corresponds to the first ranging source in the message. Except during an ephemeris change, the ground reference station sequences the first ranging source so that the low frequency data for each GPS ranging source is transmitted at least once every 10 seconds. During an ephemeris change, the low frequency data for each GPS ranging source are transmitted at least once every 27 seconds.

The ground reference station will continuously receive the Ephemeris data from each GPS satellite, but will not use the new Ephemeris data until it has been received continuously for at least two minutes. The new Ephemeris data becomes the basis for the corrections after two and before three minutes have passed. Pseudorange corrections based on the new Ephemeris data will be first transmitted in the Type 1 message in the same message where the "Ephemeris CRC" and the IOD indicate a new data set. Each time the "Ephemeris CRC" changes, the ground reference station sequences the order of the transmission so that the "Ephemeris CRC" is transmitted in all Type 1 messages containing a measurement block for that satellite, for three consecutive frames as shown in the example in Figure 3-5.

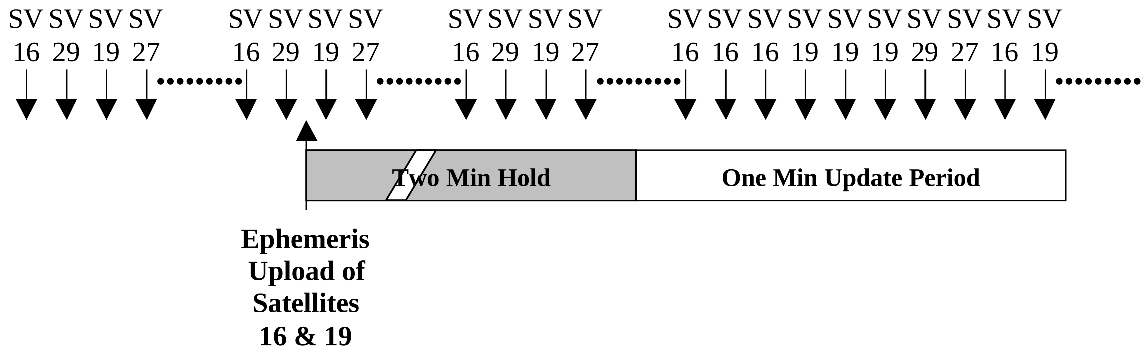


Figure 3-5 Low Frequency Correction Transmission (Ephemeris CRC)

The correction data applies only to a ranging measurement for which the IOD broadcast by the ranging source is identical to the corresponding IOD in the differential correction message, and for which the CRC calculated from the ranging source ephemeris is identical to the most recent ephemeris CRC for that ranging source in a differential correction message.

Note: *Sequencing SBAS satellites and GBRSs through the first ranging source measurement block in Message Type 1 is optional.*

3.4.2.1.2 Message Type 1 Parameters

3.4.2.1.2.1 Modified Z-count

Modified Z-count indicates the reference time for all message parameters in this message. The modified z-count correlates with GPS time, except that it resets on the hour (xx:00), twenty minutes past the hour (xx:20), and forty minutes past the hour (xx:40). For a given measurement type, all Type 1 messages transmitted in a given frame have the same modified z-count. The modified z-count for each measurement type advances each frame.

3.4.2.1.2.2 Additional Message Flag

Additional Message Flag identifies whether the set of corrections (measurement blocks) in a single frame for a particular measurement type is contained in a single Type 1 message or a linked pair of messages. The two messages of a linked pair will have the same Modified Z-count, and each of the two messages will contain at least one measurement block.

0 = All measurement blocks for a particular measurement type are contained in a single Message Type 1.
1 = This is the first transmitted message of a linked pair of Type 1 Messages that together contain the set of all measurement blocks for a particular measurement type.
2 = Reserved.
3 = This is the second transmitted message of a linked pair of Type 1 Messages that together contain the set of all measurement blocks for a particular measurement type.

Note: *When a linked pair of Type 1 messages is used for a particular measurement type, the first message will indicate the number of corrections in the first message and the second message will indicate the number of corrections in the second message. Each message will include the low frequency data for the first ranging source in its own message.*

3.4.2.1.2.3 Number of Measurements

Number of Measurements identifies the number of ranging source measurements in the message.

3.4.2.1.2.4 Measurement Type

Measurement Type identifies the type of ranging signal from which the corrections have been computed:

0 = C/A code L1

1 = C/A code L2

2 = P(Y) code L1

3 = P(Y) code L2

4 – 7 = Reserved

Note: *Measurement type does not indicate the ranging source. The ranging source ID indicates the type of satellite.*

3.4.2.1.2.5 Ephemeris Decorrelation Parameter (P)

Ephemeris Decorrelation Parameter characterizes the impact of residual ephemeris errors due to decorrelation.

Note: *For ground systems that do not broadcast the additional data block 1 in the Type 2 message, this parameter is coded as all zeros.*

3.4.2.1.2.6 Ephemeris CRC:

Ephemeris CRC is the 16-bit cyclic redundancy check (CRC) computed on the satellite ephemeris data set in order to ensure ranging source position integrity.

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

Further details of CRC implementation are provided in Appendix A.

3.4.2.1.2.7 Source Availability Duration:

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

Coding:

"1111 1110" indicates that the duration is greater than or equal to 2540 seconds.

"1111 1111" indicates that the duration information is not provided by the ground facility.

Table 3-10 GPS Satellite Ephemeris Mask

	Byte 1	**Byte 2**	**Byte 3**		**Byte 1**	**Byte 2**	**Byte 3**
Subframe 1:							
Word 3	00000000	00000000	00000011	Word 4	00000000	00000000	00000000
Word 5	00000000	00000000	00000000	Word 6	00000000	00000000	00000000
Word 7	00000000	00000000	11111111	Word 8	11111111	11111111	11111111
Word 9	11111111	11111111	11111111	Word 10	11111111	11111111	11111100
Subframe 2:							
Word 3	11111111	11111111	11111111	Word 4	11111111	11111111	11111111
Word 5	11111111	11111111	11111111	Word 6	11111111	11111111	11111111
Word 7	11111111	11111111	11111111	Word 8	11111111	11111111	11111111
Word 9	11111111	11111111	11111111	Word 10	11111111	11111111	00000000
Subframe 3:							
Word 3	11111111	11111111	11111111	Word 4	11111111	11111111	11111111
Word 5	11111111	11111111	11111111	Word 6	11111111	11111111	11111111
Word 7	11111111	11111111	11111111	Word 8	11111111	11111111	11111111
Word 9	11111111	11111111	11111111	Word 10	11111111	11111111	11111100

Note: The order of the Ephemeris Mask corresponds to order of bits transmitted from GPS satellites.

3.4.2.1.2.8 Ranging Source ID:

Ranging Source ID identifies the ranging source to which corrections and/or availability data are applicable.

1 to 36 = a GPS satellite whose PRN is equal to the Ranging Source ID value.

37 = reserved.

38 to 61 = a GLONASS satellite whose slot is equal to the Ranging Source ID value plus 37.

62 to 119 = reserved.

120 to 138 = an SBAS satellite whose PRN is equal to the Ranging Source ID value.

139 to 255 = reserved.

3.4.2.1.2.9 Issue of Data:

Issue of Data is the IOD associated with the ephemeris data used to determine pseudorange and range rate corrections. The IOD for GPS ranging sources is coded to match the GPS IODE parameter. A coding of "1111 1111" is used for SBAS ranging source.

3.4.2.1.2.10 Pseudorange Correction:

Pseudorange Correction is defined as the correction to the ranging source SIS pseudorange. A differential pseudorange correction is the average of the corrections based on measurements from multiple ground reference receivers. The pseudorange corrections are based on carrier smoothed code pseudorange measurements. The Pseudorange Correction (PRC) is applicable at the time defined in the Type 1 message.

3.4.2.1.2.11 Range Rate Correction:

Range Rate Correction is the rate of change of the pseudorange correction. The Range Rate Correction (RRC) is multiplied by the age of the correction [determined from the current time (t) minus the time of applicability of the PRC determined from the modified z-count (t_{zcount})] and added to the PRC and the measured pseudorange (P_n).

3.4.2.1.2.12 σ_{pr_gnd}:

σ_{pr_gnd} is the standard deviation of a normal distribution that bounds the SIS contribution to the error in the corrected pseudorange at the MGS reference point. A coding of "1111 1111" indicates that corrections for a ranging source have been identified as invalid by the ground system.

3.4.2.1.2.13 B1 through B4:

B1 through B4 are the differences between the broadcast pseudorange corrections and the corrections calculated by excluding the specific reference receiver measurement. A coding of "1000 0000" indicates that the associated JPALS reference receiver is not present, or that its measurement was not used to compute the pseudorange correction. At least two valid B values will be provided with each pseudorange correction.

Note: B1 through B4 are the estimates of the error resulting from specific reference receiver measurements on the pseudorange corrections.

3.4.2.2 Message Type 2 - MGS Related Data

3.4.2.2.1 Message Description

Message Type 2 identifies the exact location for which the differential corrections provided by the ground augmentation system are referenced. The MGS reference point is defined in WGS-84 coordinates. The message also contains configuration data and data to compute a tropospheric correction. The message format is shown in **Table 3-11**.

Additional data blocks may be appended to the end of the Type 2 message. Currently there is only one additional data block defined. In the future other additional data blocks may be defined and appended to the end.

Table 3-11 Format of Message Type 2

Data Content	*Bits Used*	*Range of Values*	*Resolution*
Ground Station Reference Receivers	2	2 - 4	-
Ground Station Accuracy Designator	2	-	-
Spare	1	-	-

Ground Station Continuity/Integrity Designator	3	-	-
Local Magnetic Variation	11	± 180°	0.25°
Spare	5	-	-
$\sigma_{vert\_iono\_gradient}$	8	0 – 25.5 x 10^{-6} m/m	0.1 x 10^{-6} m/m
Refractivity Index	8	16 - 781	3
Scale Height	8	0 - 25500 m	100 m
Refractivity Uncertainty	8	0 – 255	1
Latitude	32	± 90.0°	0.0005 arcsec
Longitude	32	± 180.0°	0.0005 arcsec
Reference Point Height	24	± 83886.07 m	0.01 m
Additional data block 1 (if provided)			
Reference station data selector	8	0 to 48	1
Maximum use distance (D_{max})	8	2 to 510 km	2 km
$K_{md\_e\_POS,GPS}$	8	0 to 12.75	0.05
$K_{md\_e\_CAT1,GPS}$	8	0 to 12.75	0.05

3.4.2.2.2 Message Type 2 Parameters

3.4.2.2.2.1 Ground Station Reference Receivers

The number of GPS reference receivers installed in this system.

0 = Ground Station with 2 reference receivers installed

1 = Ground Station with 3 reference receivers installed

2 = Ground Station with 4 reference receivers installed

3 = Reserved

3.4.2.2.2.2 Ground Station Accuracy Designator

The letter designator indicating the minimum signal in space accuracy performance provided by the ground station as defined in RTCA/DO-245().

0 = Ground Subsystem has accuracy designation A

1 = Ground Subsystem has accuracy designation B

2 = Ground Subsystem has accuracy designation C

3 = Spare

3.4.2.2.2.3 Ground Station Continuity/Integrity Designator (GCID):

GCID is a numerical designator that indicates the operational status of MGS.

0 = Reserved

1 = GCID 1

2 = GCID 2

3 = GCID 3

4 = GCID 4

5 = Reserved

6 = Reserved

7 = Unhealthy

3.4.2.2.2.4 Local Magnetic Variation

Local Magnetic Variation is the published local magnetic variation at the differential reference point. A positive value represents an east variation (clockwise from true north). A coding of "100 0000 0000" indicates that precision approach paths provided by this ground station are published based on true bearing.

3.4.2.2.2.5 $\sigma_{vert\_iono\_gradient}$

$\sigma_{vert\_iono\_gradient}$ is the standard deviation of a normal distribution associated with the residual ionospheric uncertainty due to spatial decorrelation.

3.4.2.2.2.6 Refractivity Index (N_R):

Refractivity Index is the estimated tropospheric refractivity index at the reference point, coded as a two's complement value with an offset of 400 (i.e., a tropospheric refractivity index of 400 would be coded as all zeros).

3.4.2.2.2.7 Scale Height (h_0)

Scale Height is the parameter for scaling the tropospheric refractivity as a function of differential altitude.

3.4.2.2.2.8 Refractivity Uncertainty (σ_N)

Refractivity Uncertainty defines the standard deviation of a normal distribution associated with the residual tropospheric uncertainty.

3.4.2.2.2.9 Latitude

Latitude is the latitude of the ground station reference point and is defined in WGS-84 coordinates and transmitted in arc seconds. A positive value denotes North latitude; a negative value denotes South latitude.

3.4.2.2.2.10 Longitude

Longitude is the longitude of the ground station reference point and is defined in WGS-84 coordinates and transmitted in arc seconds. A positive value denotes East longitude; a negative value denotes West longitude.

3.4.2.2.2.11 Reference Point Height

Reference Point Height is the height of the ground station reference point above the WGS-84 ellipsoid.

3.4.2.2.2.12 Reference Station Data Selector (RSDS)

RSDS is the numerical identifier that is unique on a frequency in the broadcast region and used to select the station for the differential positioning service.

1111 1111 = Positioning service is not provided

3.4.2.2.2.13 Maximum Use Distance

Maximum Use Distance is the maximum distance (in km) from the MGS reference point for which the integrity is assured.

0 = No distance limitation

3.4.2.2.2.14 $K_{md\_e\_POS,GPS}$

$K_{md\_e\_POS,GPS}$ is the multiplier for computation of the ephemeris error position bound for the MGS positioning service derived from the probability of missed detection given that there is an ephemeris error in a GPS satellite. For MGS that do not broadcast corrections for GPS ranging sources or that do not provide the MGS positioning service, this parameter is coded as all zeros.

3.4.2.2.2.15 $K_{md\_e\_CAT1,GPS}$

$K_{md\_e\_CAT1,GPS}$ is the multiplier for computation of the ephemeris error position bound for SL 7 precision approach derived from the probability of missed detection given that there is an ephemeris error in a GPS satellite. For GBAS ground sub-systems that do not broadcast corrections for GPS ranging sources, this parameter is coded as all zeros.

3.4.2.3 Message Type 3 – (Reserved)

3.4.2.4 Message Type 4 - Final Approach Segment (FAS) Construction Data

3.4.2.4.1 Message Description

The Type 4 message format is defined in Table 3-12. Message Type 4 contains one or more data sets that contain approach data, associated vertical/lateral alert limits, and/or the Terminal Area Path (TAP). The TAP defines the intermediate fix (IF), track-to-fix (TF) and radius-to-fix (RF) legs, compatible with DO-236. The capability exists to add additional leg types and operation types. Terminal area operations with an associated RNP RNAV type are assumed not to be conducted at latitudes north of 85° N and south of 85° S (reference DO-236A, section 1.5.8). Part of the data set includes the FAS data block and TAP data block, both of which are terminated with a FAS/TAP CRC described below. In addition, each Type 4 message is terminated with a separate message CRC (as defined in the message definition).

Each FAS data block contains the parameters that define a single precision approach. The FAS path is a line in space defined by the Landing Threshold Point/Fictitious Threshold Point (LTP/FTP), Flight Path Alignment Point (FPAP), Threshold Crossing Height (TCH), and the Glide Path Angle (GPA). The local level plane for the approach is a plane perpendicular to the local vertical passing through the LTP/FTP (i.e., tangent to the ellipsoid at the LTP/FTP). Local vertical for the approach is normal to the WGS-84 ellipsoid at the LTP/FTP. The Glide Path Intercept Point (GPIP) is where the final approach path intercepts the local level plane. A typical Final Approach Segment Diagram is shown in Figure 3-6.

A TAP consists of an IF leg followed by one or more legs (RF, TF, etc.).

The protected FAS and TAP data blocks are validated individually by the civil authorities. Contents of a typical FAS data block are depicted in Figure 3-6. Contents of the TAP are depicted in Figure 3-7. The data blocks also include data that allow for an unambiguous FAS selection against the desired approach charts. Selection of a unique TAP will result in automatic selection of the FAS and/or missed approach for that runway (if applicable). A Data Set Length field at the beginning of each data set provides the number of bytes in the data set. Other data sets may be defined in the future.

Table 3-12 Format of Message Type 4

Data Content	***Bits Used***	***Range of Values***	***Resolution***
For N Data Sets:			
Data Set Length	8	2 – 212	1
FAS, TAP, or MA Data Block	304 or 96 + K[(32 +F(96)) ⊕ (32 +T(64)) ⊕ (32 +R(96))], or 104+ 8X+ K[(32 +F(96)) ⊕ (32 +T(64)) ⊕ (32 +R(96))], respectively See Note Below Table.	-	-
FAS or TAP Vertical Alert Limit / Approach Status	8	0 – 25.4 m	0.1 m
FAS or TAP Lateral Alert Limit / Approach Status	8	0 – 50.8 m	0.2 m

<u>Note:</u> *Because the broadcast can be standard FAS, or one of two types of variable data blocks, the contents number of bits depends on the usage of one or more defined legs. The TAP data block includes 96 bits plus N pathpoints. The "K" multiplier is for the Nth number of pathpoints included in either the TAP or MA data block. The "F" multiplier is for each IF leg that is included in either a TAP or MA data block. The "T" multiplier is for each TF leg included in either a TAP or MA data block. The "R" multiplier is for each RF leg included in either a TAP or MA data block . The MA data block also include "X" number of links to another RPDS.*

3.4.2.4.2 Message Type 4 Parameters

3.4.2.4.2.1 Data Set Length

Data Set Length indicates the number of bytes in the data set. A data set includes a FAS or TAP data block, FASVAL or TAPVAL, FASLAL or TAPLAL, and the data set length field.

Note: While the current definition of Type 4 messages has a fixed data set length, the TAP is variable depending on K, the number of pathpoints associated with the Nth data set. A TAP is generally linked to a FAS data block, except when the TAP is intended to designate a missed approach path or departure path. The TAPs may appear in a Type 4 message independent of the FAS data block. It is expected that additional FAS data blocks will be defined to support other operations (as identified in the Operation Type field).

3.4.2.4.2.2 FAS Data Block

FAS Data Block contains the construction data for a Final Approach Segment. The content of the data block is defined in Section 3.4.2.4.2.8.

3.4.2.4.2.3 TAP Data Block

TAP Data Block contains the construction data linking one or more legs to a specific FAS. The content of the data block is defined in Section 2.4.6.3.

3.4.2.4.2.4 FAS Vertical Alert Limit/Approach Status

This is the value of the broadcast vertical alert limit. A coding of "1111 1111" indicates that the vertical guidance is not available.

3.4.2.4.2.5 TAP Vertical Alert Limit/Approach Status:

This is the value of the broadcast vertical alert limit. A coding of "1111 1111" indicates that the vertical guidance is not available.

3.4.2.4.2.6 FAS Lateral Alert Limit/Approach Status:

This is the value of the broadcast lateral alert limit. A coding of "1111 1111" indicates that the approach is not available.

3.4.2.4.2.7 TAP Lateral Alert Limit/Approach Status:

This is the value of the broadcast lateral alert limit. A coding of "1111 1111" indicates that the procedure is not available.

3.4.2.4.2.8 Final Approach Segment (FAS) and Terminal Area Path (TAP) Data Block

The Final Approach Segment Data Block, defined in

Table **3-13**, contains the parameters that define a single precision approach. The Terminal Area Path Data Block, defined in Table 2-16, contains the parameters that define a terminal area path. Other FAS Data Blocks may be defined in the future. Figure 3-6 depicts a final approach segment and illustrates the parameters that define the approach path. The data block includes data that allow for an unambiguous FAS and TAP selection from the approach chart.

Each FAS data block ends with a FAS CRC to protect the approach design data. The protected FAS and TAP data blocks are validated individually by the civil authorities. A separate message CRC protects each complete JPALS message.

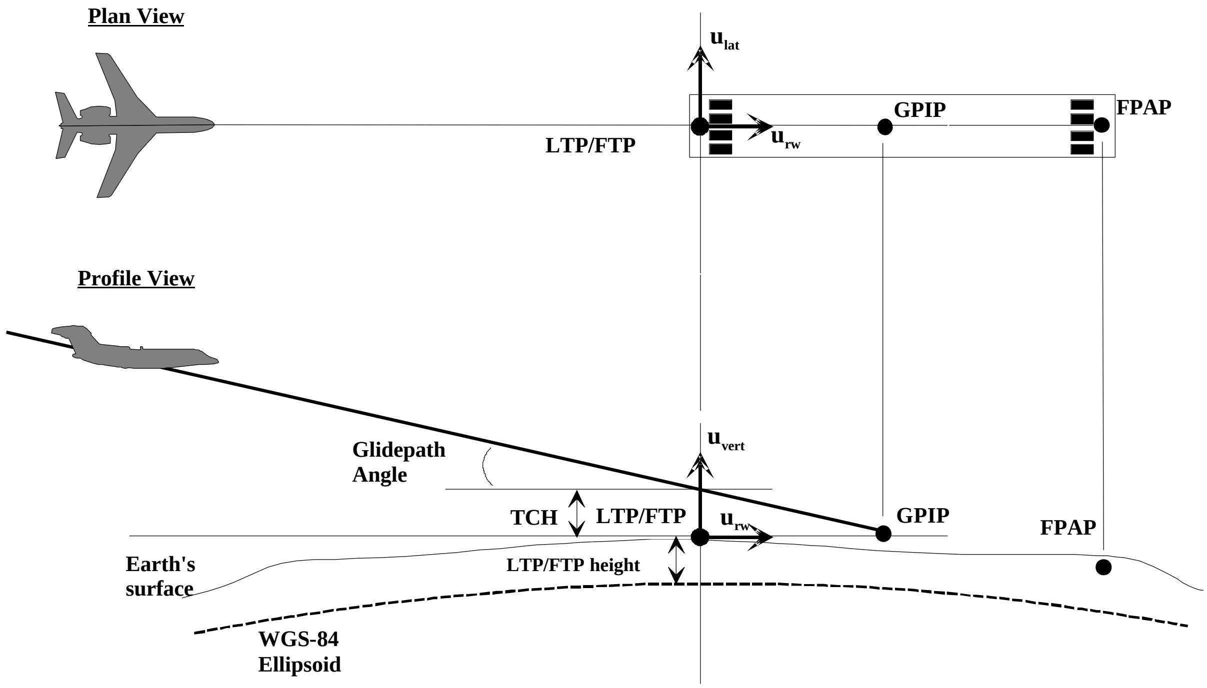


Figure 3-6 Final Approach Segment Diagram

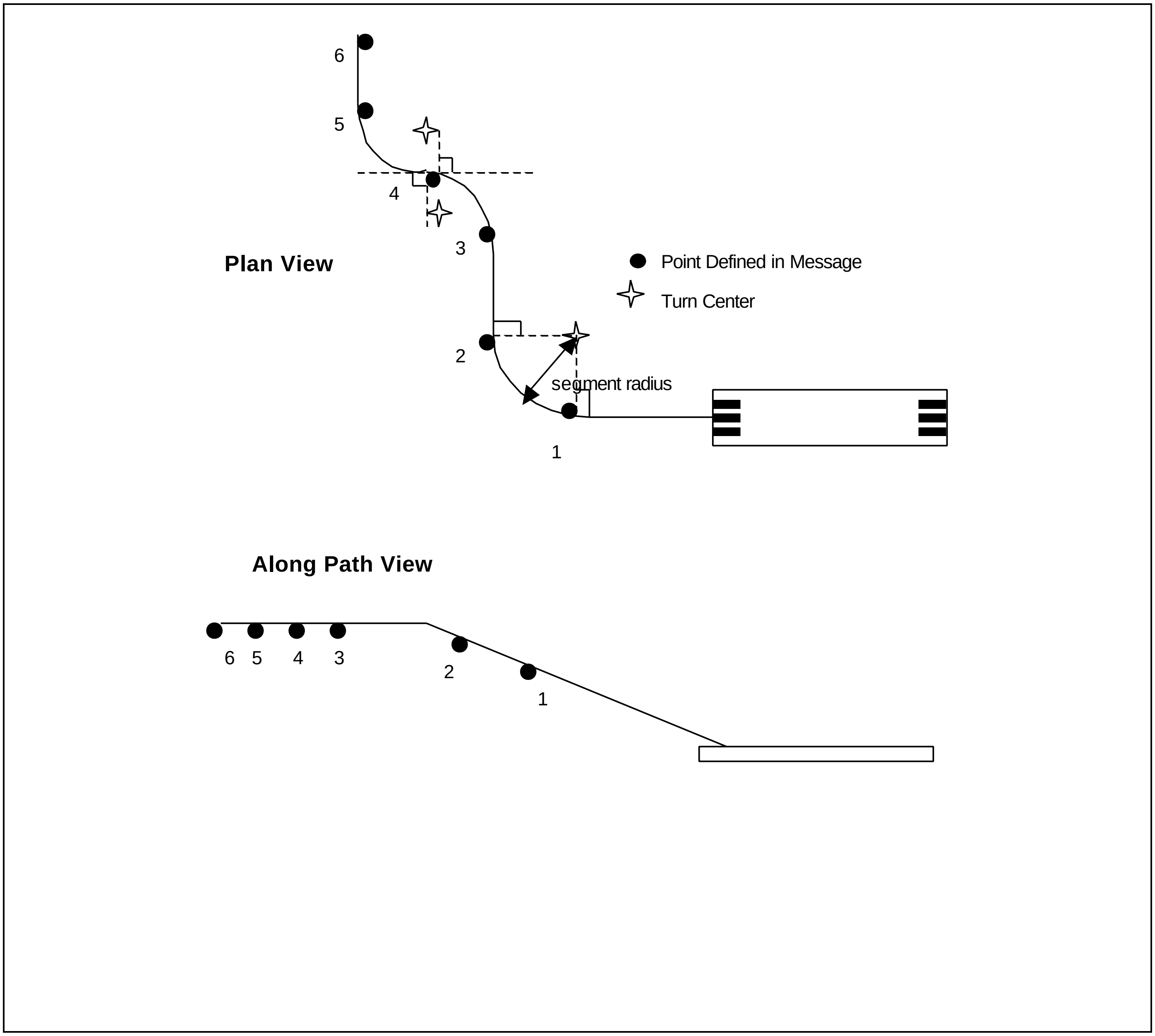


Figure 3-7 Curved Segment TAP Example

<u>Note:</u> Figure 2-9 is an example of the capability provided through the message types defined in this ICD. Waypoint 6 is the Intermediate Fix, where the procedure begins. Waypoint 5 begins a Radius-to-Fix leg that is followed by another Radius-to-Fix leg at Waypoint 4. Waypoint 3 is a Track-to-Fix leg, along which the final descent begins. Waypoint 2 is a Radius-to-Fix leg that ends at the Final Approach Segment, Waypoint 1.

Table 3-13 Final Approach Segment (FAS) Data Block

Data Content	***Bits Used***	***Range of Values***	***Resolution***
Operation Type	4	0 – 15	1
SBAS Service Provider	4	0-15	1
Airport ID	32	-	-
Runway Number	6	0 – 36	1
Runway Letter	2	-	-
Approach Performance Designator	3	0 – 7	1
Route Indicator	5	-	-
Reference Path Data Selector	8	0 – 48	1
Reference Path ID	32	-	-
LTP/FTP Latitude	32	± 90.0 °	0.0005 arcsec
LTP/FTP Longitude	32	± 180.0 °	0.0005 arcsec
LTP/FTP Height	16	-512.0 – 6041.5 m	0.1 m
ΔFPAP Latitude	24	± 1 °	0.0005 arcsec
ΔFPAP Longitude	24	± 1 °	0.0005 arcsec
Approach Threshold Crossing Height (TCH)	15	0 – 1638.35 m or 0- 3276.7 ft	0.05 m or 0.1 ft
Approach TCH Units Selector	1	-	-
Glide Path Angle (GPA)	16	0 - 90.0 °	0.01°
Course Width at Threshold	8	80.0 to 143.75 m	0.25 m
ΔLength Offset	8	0 to 2032 m	8 m
Final Approach Segment CRC	32	-	-

Table 3-14 TAP DATA Block

Data Content	***Bits Used***	***Range of Values***	***Resolution***
Operation Type	4	0 – 15	1
Spare	4	-	-
Reference Path Data Selector	8	0 – 254	1
Reference Path ID	32	-	-
Number of Path Points – N	6	2 – 63	-
Spare	2	-	-
For N Pathpoints:			
TAP Leg Type	4	0 - 15	1
Spare	4		
TAP Leg Data Byte Count	5	0 - 31	1
Spare	3		
TAP Leg Data	See Tables 2-18 – 2-20	See Tables 2-18 – 2-20	See Tables 2-18 – 2-20
Lateral Displacement Sensitivity at Point n	8	80.0 - 2120 m	8 m
Vertical Displacement Sensitivity at Point n	8	3.0 - 258 m	1 m
TAP Leg Additional Data	1	0 – 1	-
Height Reference Datum	1	0 – 1	-
Altitude Crossing Description	2	0 - 3	-
TAP Point Description - GSL	4	1 - 10	1
Spare (placeholder)	6		
FAS RPDS or Continuation Link	8	0- 255	1
TAPCRC	32	-	-

Table 3-15 TAP Missed Approach Data Block

Data Content	***Bits Used***	***Range of Values***	***Resolution***
Operation Type	4	0 – 15	1
Spare	4	-	-
Reference Path Data Selector	8	0~~50~~-254	1
Reference Path ID	32	-	-
Number of linked RPDS - X	8	1-255	1
Link to RPDS 1 . . X	8 * X	-	-
Number of Path Points – N	6	2 – 63	-
Spare	2	-	-
For N Pathpoints:			
Leg Type	~~3~~4	0-~~7~~15	1
Spare	~~4~~		
Leg Data Byte Count	5	0 - 31	1
Spare	3		
Leg Data	See Tables 2-18 – 2-20	See Tables 2-18 – 20	See Tables 2-18 – 2-20
Lateral Displacement Sensitivity at Point n	8	80.0 - 2120 m	8 m
Vertical Displacement Sensitivity at Point n	8	3.0 - 258 m	1 m
TAP Leg Additional Data	1	0 – 1	-
Height Reference Datum	1	0 – 1	-
Altitude Crossing Description	2	0 – 3	-
TAP Point Description -GSL	4	1-10	1
Continuation	8	0-255	1
TAP CRC	32	-	-

Table 3-16 TAP IF Leg Data, Type 0 (Initial Fix)

Data Content	***Bits Used***	***Range of Values***	***Resolution***
Leg Latitude	24	±90.0°	0.00001 Deg.
Leg Longitude	24	±180.0°	0.000025 Deg.
Leg Height	16	-512.0 –15872 m	0.25 m
Leg Waypoint Name	30	A-Z	IA-5
Spare	2	-	-

Table 3-17 TAP TF Leg Data, Type 1 (Track to Fix)

Data Content	***Bits Used***	***Range of Values***	***Resolution***
Leg Latitude	24	±90.0°	0.00001 Deg.
Leg Longitude	24	±180.0°	0.000025 Deg.
Leg Height	16	-512.0 –15872 m	0.25 m

Table 3-18 TAP RF Leg Data, Type 2 (Radius to Fix)

Data Content	***Bits Used***	***Range of Values***	***Resolution***
Leg Latitude	24	±90.0°	0.00001 Deg
Leg Longitude	24	±180.0°	0.000025 Deg.
Leg Height	16	-512.0 –15872 m	0.25 m
ΔLatitude Turn Center	16	±0.819°	0.000025 Deg
ΔLongitude Turn Center	16	±0.189°	0.000025 Deg

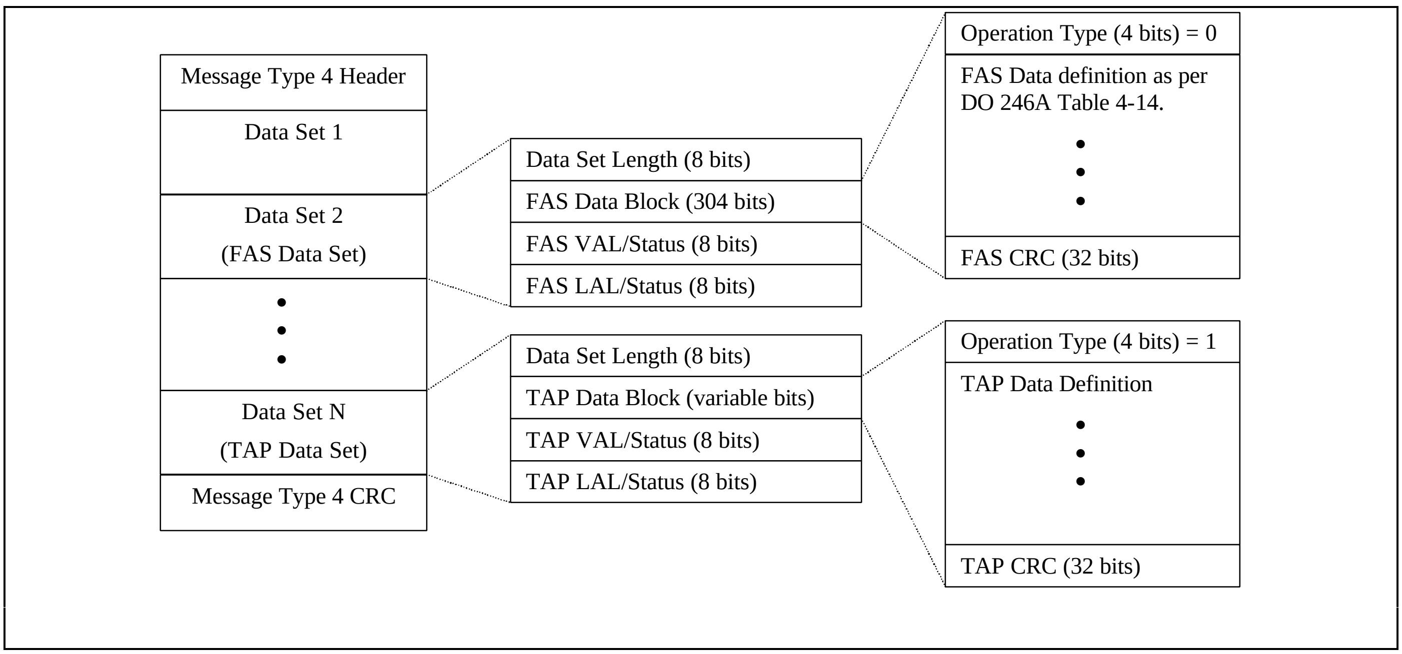


Figure 3-8 Message Type 4 Structure Extended to Accommodate Terminal Area Path (TAP) Data Sets.

3.4.2.4.3 Final Approach Segment and Terminal Area Path Parameters

3.4.2.4.3.1 Operation Type

Operation Type indicates whether the operation is a straight-in approach path, terminal area path, missed approach, or other operation to be defined later. The convention for coding is as follows:

0 = straight-in approach path

1 = Terminal Area Path definition

2 = Missed Approach

3-15 = spare

Note: Missed Approach may not have vertical guidance indications.

3.4.2.4.3.2 SBAS Service Provider

This field is used by SBAS equipment to associate the data with an SBAS service provider. This field has no application for the JPALS user and should be ignored (except for the CRC and FEC calculations) in this JPALS application.

3.4.2.4.3.3 Airport Identification

Airport Identification represents the three or four alphanumeric characters used to designate airport facilities. Each character is coded using bits b1 to b6 of its International Alphabet No. 5 representation (reference Section 3.4.2). For each character, bit b1 is transmitted first, and two zero bits are appended after bit b6, so that 8 bits are transmitted for each character. The right-most character is transmitted first. Only upper case letters, numbers, and IA-5 “space” (“10 0000”) are used. When a three-character identifier is used, the right-most (first transmitted) character is IA-5 "space".

3.4.2.4.3.4 Runway Number

Runway Number represents the approach runway number. The designation 0 identifies heliport operations.

3.4.2.4.3.5 Runway Letter

Runway Letter represents the runway letter, where used to differentiate between parallel runways. The convention for coding is as follows:

0 = no letter	2 = C (center)
1 = R (right)	3 = L (left)

3.4.2.4.3.6 Approach Performance Designator

Approach Performance Designator represents the general information about the approach design. The convention for the coding is as follows:

0 = Spare

1 = SL 7

2 = Reserved for SL 8

3 = Reserved for SL 9

4 - 7 = Spare

3.4.2.4.3.7 Route Indicator

Route Indicator is a single alphabetic character used to differentiate between multiple approaches to the same runway end, coded using bits b_1 to b_5 of International Alphabet No. 5 (reference Section 3.4.2). Only upper case letters (excluding “I” and “O”), or IA-5 “space” may be used.

3.4.2.4.3.8 Reference Path Data Selector (RPDS)

RPDS is a numerical identifier (unique in the broadcast region) used to select the FAS, TAP, or MA data block (desired approach or path).

Note: *The Reference Path Data Selector is the only identifier guaranteed to be unique to one FAS data block among all of the FAS data blocks within the radio range of the ground reference station on the tuned frequency.*

Note: *Values 0-48 are selected via receiver channeling. Values 49-254 are reserved for Continuation fields(links).*

3.4.2.4.3.9 Reference Path Identifier

Reference Path Identifier represents the three or four alphanumeric characters used to designate the reference path. Alphanumeric characters are coded using bits b_1 to b_6 of International Alphabet No. 5 (reference Section 3.4.2). For each character, bit b_1 is transmitted first, and two zero bits are appended after bit b_6, so that 8 bits are transmitted for each character. The right-most character is transmitted first. Only upper case alpha characters, numbers, and IA-5 "space" ("10 0000") are used. When a three-character identifier is used, the right-most (first transmitted) character is IA-5 "space".

3.4.2.4.3.10 LTP/FTP Latitude

This represents the latitude of the LTP/FTP in arc seconds. Positive values denote north latitude and negative values denote south latitude.

3.4.2.4.3.11 LTP/FTP Longitude

This represents the longitude of the LTP/FTP in arc seconds. Positive values denote east longitude and negative values denote west longitude.

3.4.2.4.3.12 LTP/FTP Height

This represents the height of the LTP/FTP above the WGS-84 ellipsoid. This is coded as an unsigned value with an offset of –512 meters. A zero value in this field places the LTP/FTP 512 m below the WGS-84 ellipsoid.

3.4.2.4.3.13 DFPAP Latitude

This represents the difference of latitude of the runway Flight Path Alignment Point (FPAP) from the LTP/FTP, defined in WGS-84 coordinates and transmitted in arc seconds. Positive values denote the FPAP latitude north of LTP/FTP latitude. Negative values denote the FPAP latitude south of the LTP/FTP latitude.

3.4.2.4.3.14 DFPAP Longitude

This represents the difference of longitude of the runway Flight Path Alignment Point from the LTP/FTP defined in WGS-84 coordinates and transmitted in arc seconds. Positive values indicate the FPAP longitude east of LTP/FTP longitude. Negative values indicate the FPAP longitude west of LTP/FTP longitude.

3.4.2.4.3.15 Approach Threshold Crossing Height (TCH)

Approach TCH is the height of the FAS path above the LTP/FTP defined in either feet or meters as indicated by the Approach TCH Units Selector.

3.4.2.4.3.16 Approach TCH Units Selector

Approach TCH Units Selector defines the units used to describe the Approach Threshold Crossing Height. The coding is:

0 = feet
1 = meters

3.4.2.4.3.17 Glide Path Angle (GPA)

GPA represents the angle of the FAS path (glide path) with respect to the horizontal plane tangent to the WGS-84 ellipsoid at the LTP/FTP.

3.4.2.4.3.18 Course Width at Threshold

This is the lateral displacement from the path defined by the FAS at the LTP/FTP at which full-scale course deviation indicator (CDI) deflection is attained. The Course Width field is ignored if Runway Number is coded as 0 (helicopter pad). Instead, the receiver uses a course width of 38 m (125 ft) at the LTP/FTP.

3.4.2.4.3.19 DLength Offset

This is the distance from the stop end of the runway to the FPAP. A coding of 1111 1111 indicates that the value is not provided.

3.4.2.4.3.20 FAS CRC

See CRC code definition

3.4.2.4.3.21 Number of Path Points - N

This indicates the total number of path points included in this TAP data block.

3.4.2.4.3.22 Leg Type

The type of leg that this point defines.

0 = IF Initial fix

1 = TF Track to fix

2 = RF Radius to fix

3-~~7~~15 = Spare

3.4.2.4.3.23 Leg Data Byte Count

The number of bytes that are contained in the Tap Leg Data section of this pathpoint.

IF Leg = 12

TF Leg = 8

RF Leg = 14

3.4.2.4.3.24 Leg Data:

This data defines the leg. Its size in bytes is given in the “Leg data byte count”:

3.4.2.4.3.25 Lateral Displacement Sensitivity at Point n

This field is the lateral displacement from the path at Point n at which full-scale lateral course deviation indicator (CDI) deflection is attained.

3.4.2.4.3.26 Vertical Displacement Sensitivity at Point n

This field is the vertical displacement from the path at Point n at which full-scale vertical course deviation indicator (CDI) deflection is attained.

3.4.2.4.3.27 TAP Leg Additional Data

Additional data required for some leg types. The actual meaning depends on the Leg type.

For RF Leg: 0 = Right Turn and 1 = Left Turn

3.4.2.4.3.28 Height Reference

The coordinate system used for the height value of this leg

0 = WGS-84

1 = MSL

3.4.2.4.3.29 Altitude Crossing Description

Designate whether a waypoint should be crossed "at", "at or above" or "at or below" specified altitudes.

0 = "At" altitude

1 = "At or Above" altitude

2 = "At or Below" altitude

3 = spare

3.4.2.4.3.30 TAP Point Description – GSL

GSL defines the GPS Service Level (GSL) associated with the next leg.

3.4.2.4.3.31 FAS RPDS

This is the RPDS value for the Final Approach Segment which terminates this TAP. The tunable range is 0-48; values above 48 can be used with a TAP or MA data block only. For a TAP that does not terminate in a FAS, a value of "1111 1111" in this field indicates no FAS is associated with the TAP.

3.4.2.4.3.32 Continuation Link

This is the RPDS for the next segment that is a continuation of the previous segment, in the 49-255 range. A value of "1111 1111" in this field indicates there is no continuation.

3.4.2.4.3.33 TAP CRC

See CRC code definition.

3.4.2.4.3.34 CRC Code:

CRC Code is a 32 bit cyclic redundancy check (CRC) appended to the end of each FAS, TAP and MA Data Block in order to ensure approach data integrity.

The generator polynomial G(x) for the message block CRC is:

$$G(x) = x^{32} + x^{31} + x^{24} + x^{22} + x^{16} + x^{14} + x^{8} + x^{7} + x^{5} + x^{3} + x + 1$$

The CRC information field, *M(x), is*

$$M(x) = \sum_{i=1}^{272} m_i x^{272-i} = m_1 x^{271} + m_2 x^{270} + \ldots + m_{272} x^{0}$$

M(x) is formed from all bits of the associated FAS data block, excluding the CRC. Bits are arranged in the order transmitted, such that m_1 corresponds to the LSB of the operation type field, and m_{272} corresponds to the MSB of the ΔLength Offset field.

The CRC is ordered such that r_1 is the first transmitted bit and r_{32} is the last transmitted bit.

Further details of CRC implementation are provided in Appendix A.

3.4.2.4.3.35 Number of Linked RPDS

The number of FAS and TAP RPDS that link to this MA data block.

3.4.2.4.3.36 Link to RPDS

TAP or FAS that the missed approach data is linked to.

3.4.2.4.3.37 Leg Latitude

This field indicates the latitude of the point in the definition referenced to WGS84.

3.4.2.4.3.38 Leg Longitude

This field indicates the longitude of the point in the definition referenced to WGS84.

3.4.2.4.3.39 Leg Height

This field indicates the height of the point above the reference datum. Coding of FFFF indicates height is not provided.

3.4.2.4.3.40 Leg Waypoint Name

A 5 letter pronounceable word, 6 bits per letter IA5; A-Z.

3.4.2.4.3.41 DLongitude Turn Center

This field represents the difference of longitude of the Turn Center from the termination waypoint of the previous leg (the waypoint defined in the TAP RF leg data message), defined in WGS-84 coordinates and transmitted in arc degrees. Positive values denote the Turn Center latitude east of the waypoint latitude. Negative values denote the Turn Center latitude west of the waypoint latitude.

3.4.2.4.3.42 DLatitude Turn Center

This field represents the difference of latitude of the Turn Center from the termination waypoint of the previous leg (the waypoint defined in the TAP RF leg data message), defined in WGS-84 coordinates and transmitted in arc degrees. Positive values denote the Turn Center latitude north of the waypoint latitude. Negative values denote the Turn Center latitude south of the waypoint latitude.

3.4.2.5 Message Type 7 – (Reserved) for Military

Message Type 7 is reserved for military applications.

3.4.2.6 Message Type 8 – (Reserved) for Test

Message Type 8 is reserved for test.

3.4.2.7 Message Type 16 – (Reserved) for Navy Shore-based Training.

Message Type 16 is reserved for Navy Shore-based training. Currently proposed message parameters for Message Type 16 are provided in Appendix C.

3.4.2.8 Message Type 32 – (Reserved) for Carrier Phase Measurement

Message Type 32 is reserved for Carrier Phase Measurement for use in Dual Frequency Smoothing.

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Appendix A

Cyclic Redundancy Checks (CRCs)

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A.1 CRC Definition

Cyclic Redundancy Check fields are appended to critical data components to increase the level of assurance that the data are correct and increase system integrity.

Each CRC is calculated as the remainder R(x) of the modulo-2 division of two binary polynomials:

$$\left\{\frac{\left[x^k M(x)\right]}{G(x)}\right\}_{\bmod 2} = Q(x) + \frac{R(x)}{G(x)}$$

where:

k is the number of bits in the particular CRC.

M(x) is the information field, which consists of the sequence of data items to be protected by the particular CRC, represented as a polynomial.

G(x) is the generator polynomial specified for the particular CRC.

Q(x) is the quotient of the division.

R(x), the remainder of the division, contains the CRC:

$$R(x) = \sum_{i=1}^{k} r_i x^{k-i} = r_1 x^{k-1} + r_2 x^{k-2} + \ldots + r_k x^0$$

Note 1: *The M(x) and G(x) polynomials are defined in Section 2.4.3.2 for the ephemeris CRC, Section 2.3.7 for the message block CRC, and Section 2.4.6.4 for the FAS CRC.*

Note 2: *Coefficient r_1 is the first bit of the CRC to be transmitted.*

Figure A-1 shows an example polynomial division circuit to generate the 16-bit Ephemeris CRC field in the Type 1 message. The register is seeded with all zeros. After all bits of M(x) are clocked into the register, the CRC is in the register with coefficient r_1 in position x^{15}.

Figure A-2 shows an example polynomial division circuit to generate the 32-bit JPALS message CRC. The same implementation could be used to generate the FAS CRC. The register is initially seeded with all zeros. After all bits of M(x) are clocked into the register, the CRC is in the register with coefficient r_1 in position x^{31}.

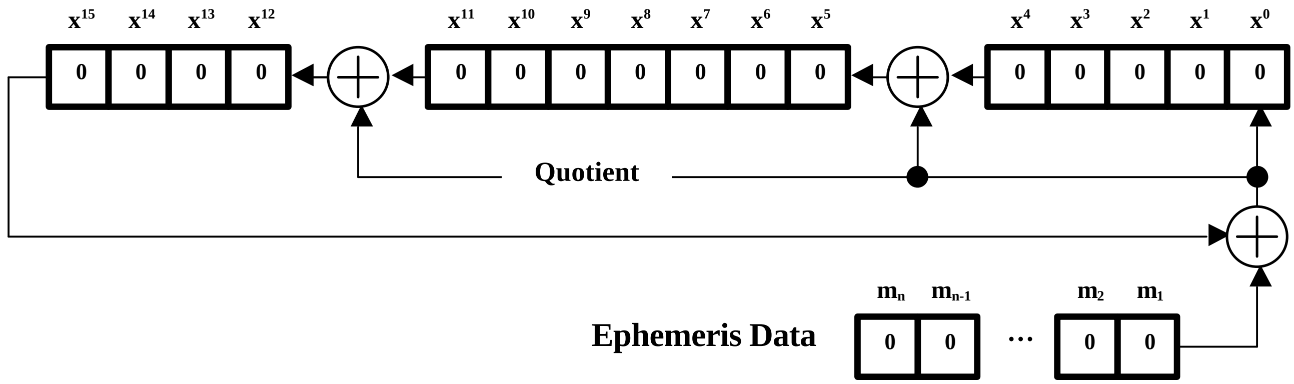

Figure A-1 Example of Ephemeris CRC Generator Circuit

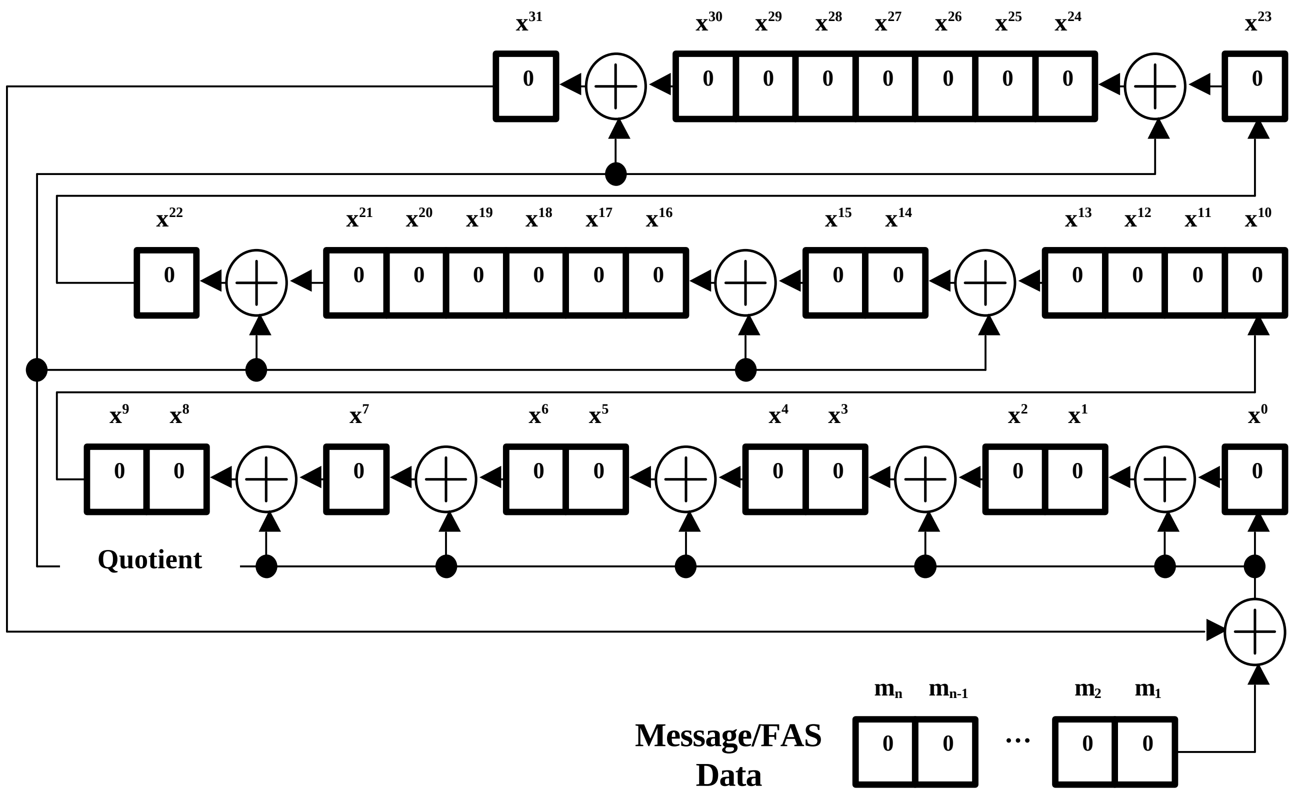

Figure A-2 Example of JPALS Message or FAS Data Block CRC Generator Circuit

Table A-1 provides examples of 16-bit ephemeris CRC values calculated using various artificial bit patterns for the ephemeris data. Table A-2 provides examples of 32-bit JPALS message or FAS data block CRC values calculated using various artificial bit patterns and lengths for M(x).

Table A-1 Examples of 16-bit Ephemeris CRC

Length of M(x)	**Ephemeris Data** (Note 1)	**CRC** (Note 2)
n = 576 bits	1111… 1111	0110 0001 0110 1110
n = 576 bits	1010 … 1010	1011 1001 1011 1011
n = 576 bits	0101 … 0101	1101 1000 1101 0101

Notes:

1) *The ephemeris data is shown with Subframe 1, bit 61* at *left, Subframe 3, bit 294 at right. This data must be ANDed with ephemeris mask and reordered by reversing bits within each byte to form M(x) for CRC calculation.*

2) *The CRC values are shown with r_1 at right.*

Table A-2 Examples of 32-bit JPALS Message or FAS Data Block CRC

Length of M(x)	**M(x) Bit Pattern** (Note)	**CRC** (Note)
n = 272 bits	1111… 1111	0001 1100 0100 0110 1010 1011 1110 0011
n = 480 bits	1111… 1111	0010 1101 0110 0101 0100 1111 0111 1010
n = 272 bits	1010 … 1010	1000 1110 1000 0111 1100 1110 0100 0011
n = 480 bits	1010 … 1010	0011 0110 0100 0110 0111 0101 1010 1100
n = 272 bits	0101 … 0101	1001 0010 1100 0001 0110 0101 1010 0000
n = 480 bits	0101 … 0101	0001 1011 0010 0011 0011 1010 1101 0110

Note: M(x) values are shown with m_1 at right. CRC values are shown with r_1 at lower right.

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Appendix B

Message Examples

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B.1 Message and FAS Example

This appendix provides examples of the coding of JPALS Type 1, 2, and 4 messages. The examples illustrate the coding of the various application parameters, including the CRC and FEC parameters, and the results of bit scrambling and D8PSK symbol coding.

Note: *The engineering values for the message parameters have been selected to illustrate the message coding process. They are not necessarily representative of realistic values.*

Table B-1 provides an example of a Type 1 message. For illustration purposes, the Additional Message Flag field is coded to indicate that this is the first of two Type 1 messages to be broadcast within the same frame. (Table B-2 provides the companion message.)

Table B-2 provides examples of a Type 1 message and a Type 2 message coded within a single burst (i.e., two messages to be broadcast within a single transmission slot). The Additional Message Flag field of the Type 1 message is coded to indicate that it is the second of two Type 1 messages to be broadcast within the same frame. The Type 2 message includes Additional Data Block 1.

Note: *A second Type 1 message is not typically required, except to broadcast more ranging source corrections than a single message can accommodate.*

Table B-3 provides an example of a Type 4 message containing two FAS data blocks.

Table B-4 provides an example of a Type 5 message. In this example, source availability durations common to all approaches are provided for two satellites. Additionally, source availability durations for two individual approaches are provided: two satellites for one approach, one satellite for another approach.

Table B-1 Example of Type 1 Message

DATA CONTENT	*Bits Used*	*Range of Values*	*Resolution*	*Value*	*Binary Representation (Note 1)*
Power Stabilization	15	-	-	-	000 0000 0000 0000
Synchronization and Ambiguity Resolution	48				0100 0111 1101 1111 1000 1100 0111 0110 0000 0111 1001 0000
Station Slot Identifier	3	-	-	E	100
Transmission Length	17	0 – 1824 bits	1 bit	536 bits	0 0000 0010 0001 1000
Training Sequence FEC	5	-	-	-	00001
Message Block Header					
Message Block Identifier	8	-	-	"Normal"	1010 1010
MGS ID	24			BELL	000010 000101 001100 001100
Message Type Identifier	8	–1-8	1	1	0000 0001
Message Length	8	10 – 222 bytes	1 byte	61 bytes	0011 1101
Message					
Modified Z-count	14	0 – 1199.9 s	0.1 s	100 s	00 0011 1110 1000
Additional Message Flag	2	0 – 3	-	1^{st} of pair	01
Number of Measurements	5	0 - 18	1	4	00100
Measurement Type	3	0 – 7	-	C/A L1	000
Ephemeris Decorrelation Parameter (P)	8	0 – $1.275x10^{-3}$ m/m	$5x10^{-6}$ m/m	$1x10^{-4}$	0001 0100
Ephemeris CRC	16	-	-	-	0000 0000 0000 0000 (Note 2)
Source Availability Duration	8	0 - 2540 s	10 s	Not provided	1111 1111
Measurement Block 1					
Ranging Source ID	8	1 - 255	1	2	0000 0010
Issue of Data (IOD)	8	0 - 255	1	255	1111 1111
Pseudorange Correction (PRC)	16	±327.67 m	0.01 m	+1.0 m	0000 0000 0110 0100
Range Rate Correction (RRC)	16	±32.767 m/s	0.001 m/s	-0.2 m/s	1111 1111 0011 1000
σ_{pr_gnd}	8	0 - 5.08 m	0.02 m	0.98 m	0011 0001
B_1	8	±6.35 m	0.05 m	+0.10 m	0000 0010
B_2	8	±6.35 m	0.05 m	+0.15 m	0000 0011
B_3	8	±6.35 m	0.05 m	-0.25 m	1111 1011
B_4	8	±6.35 m	0.05 m	Not used	1000 0000
Measurement Block 2					
Ranging Source ID	8	1 - 255	1	4	0000 0100
Issue of Data (IOD)	8	0 - 255	1	126	0111 1110
Pseudorange Correction (PRC)	16	±327.67 m	0.01 m	-1.0 m	1111 1111 1001 1100
Range Rate Correction (RRC)	16	±32.767 m/s	0.001 m/s	+0.2 m/s	0000 0000 1100 1000
σ_{pr_gnd}	8	0 - 5.08 m	0.02 m	0.34 m	0001 0001

DATA CONTENT	*Bits Used*	*Range of Values*	*Resolution*	*Value*	*Binary Representation (Note 1)*
B_1	8	±6.35 m	0.05 m	+0.20 m	0000 0100
B_2	8	±6.35 m	0.05 m	+0.30 m	0000 0110
B_3	8	±6.35 m	0.05 m	-0.50 m	1111 0110
B_4	8	±6.35 m	0.05 m	Not used	1000 0000
Measurement Block 3					
Ranging Source ID	8	1 - 255	1	12	0000 1100
Issue of Data (IOD)	8	0 - 255	1	222	1101 1110
Pseudorange Correction (PRC)	16	±327.67 m	0.01 m	+1.11 m	0000 0000 0110 1111
Range Rate Correction (RRC)	16	±32.767 m/s	0.001 m/s	-0.2 m/s	1111 1111 0011 1000
σ_{pr_gnd}	8	0 - 5.08 m	0.02 m	1.02 m	0011 0011
B_1	8	±6.35 m	0.05 m	+0.10 m	0000 0010
B_2	8	±6.35 m	0.05 m	+0.25 m	0000 0101
B_3	8	±6.35 m	0.05 m	-0.25 m	1111 1011
B_4	8	±6.35 m	0.05 m	Not used	1000 0000
Measurement Block 4					
Ranging Source ID	8	1 - 255	1	23	0001 0111
Issue of Data (IOD)	8	0 - 255	1	80	0101 0000
Pseudorange Correction (PRC)	16	±327.67 m	0.01 m	-2.41 m	1111 1111 0000 1111
Range Rate Correction (RRC)	16	±32.767 m/s	0.001 m/s	-0.96 m/s	1111 1100 0100 0000
σ_{pr_gnd}	8	0 - 5.08 m	0.02 m	0.16 m	0000 1000
B_1	8	±6.35 m	0.05 m	+0.20 m	0000 0100
B_2	8	±6.35 m	0.05 m	+0.30 m	0000 0110
B_3	8	±6.35 m	0.05 m	-0.50 m	1111 0110
B_4	8	±6.35 m	0.05 m	Not used	1000 0000
Message Block CRC	32	-	-	-	1100 0010 1111 0011 0000 1011 1100 1010
Application FEC	48				0110 0011 1110 1001 1110 0000 1110 1101 0010 1001 0111 0101
Input to Bit Scrambling (Note 3)	0 46 10 10 55 30 CA 10 80 BC 17 C2 20 28 00 00 FF 40 FF 26 00 1C FF 8C 40 C0 DF 01 20 7E 39 FF 13 00 88 20 60 6F 01 30 7B F6 00 1C FF CC 40 A0 DF 01 E8 0A F0 FF 02 3F 10 20 60 6F 01 53 D0 CF 43 AE 94 B7 07 97 C6				
Output from Bit Scrambling	0 60 27 98 1F 2F D2 3B 5F 26 C2 1B 12 F4 46 D0 09 81 B6 25 1C 18 D0 7C 2A 7F B9 55 A8 B0 27 17 3A 60 EB 5F 1B 3B A5 FE 0A E1 43 D7 FA D7 B3 7A 65 D8 4E D7 79 D2 E1 AD 95 E6 6D 67 12 B3 EA 4F 1A 51 B6 1C 81 F2 31				
Fill Bits	-	-	-	-	
D8PSK Symbols (Note 4)	0000 0035 1120 4546 3165 0100 1270 7716 7164 5524 7403 5772 2623 4621 4531 1123 2246 0075 5223 2477 1661 7052 0475 0422 0772 4363 4073 3535 0512 0746 4574 1125 2254 5252 7317 1513 5104 7466 1317 1745 1062 2642 1715 7064 6734 5046 3654 1025 0713 5576 5574 5512 222				

Note 1: In the Binary Representation column, the rightmost bit is the LSB of the binary

parameter value, and is the first bit transmitted or sent to the bit scrambling process. All data fields are sent in the order specified in the table.

Note 2: *For examples of Ephemeris CRC calculation, see Appendix A, Table A-1.*

Note 3: *This string is coded in hexadecimal with the first bit to be sent to the bit scrambling process as its MSB. The first character represents a single bit.*

Note 4: *Symbols are represented by their differential phase with respect to the first symbol of the message, in units of p/4 radians (e.g., a value of 5 represents a phase of 5p/4 radians relative to the first symbol).*

Table B-2 Example of Type 1 and Type 2 Messages in One Burst

Data Content	***Bits Used***	***Range of Values***	***Resolution***	***Value***	***Binary Representation*** *(Note 1)*
Power Stabilization	15	-	-	-	000 0000 0000 0000
Synchronization and Ambiguity Resolution	48	-	-	-	0100 0111 1101 1111 1000 1100 0111 0110 0000 0111 1001 0000
Station Slot Identifier	3	-	-	E	100
Transmission Length	17	0 – 1824 bits	1 bit	544 bits	0 0000 0010 0010 0000
Training Sequence FEC	5	-	-	-	00000
First Message Block (Type 1 Message)					
Message Block Header					
Message Block Identifier	8	-	-	"Normal"	1010 1010
MGS ID	24			BELL	000010 000101 001100 001100
Message Type Identifier	8	1 - 8	1	1	0000 0001
Message Length	8	10 – 222 bytes	1 byte	28 bytes	0001 1100
Message					
Modified Z-count	14	0 – 1199.9 s	0.1 s	100 s	00 0011 1110 1000
Additional Message Flag	2	0 3	-	2nd of pair	11
Number of Measurements	5	0 – 18	1	1	00001
Measurement Type	3	0 - 7	-	C/A L1	000
Ephemeris Decorrelation Parameter (P)	8	0 – 1.275×10^{-3} m/m	5×10^{-6} m/m	0(SBAS)	0000 0000
Ephemeris CRC	16	-	-	-	0000 0000 0000 0000 (Note 2)
Source Availability Duration	8	0 - 2540 s	10 s	Not provided	1111 1111
Measurement Block 1					
Ranging Source ID	8	1 - 255	1	122	0111 1010
Issue of Data (IOD)	8	0 - 255	1	2	0000 0010
Pseudorange Correction (PRC)	16	±327.67 m	0.01 m	+1.0 m	0000 0000 0110 0100
Range Rate Correction (RRC)	16	±32.767 m/s	0.001 m/s	-0.2 m/s	1111 1111 0011 1000

Data Content	***Bits Used***	***Range of Values***	***Resolution***	***Value***	***Binary Representation*** *(Note 1)*
σ_{pr_gnd}	8	0 - 5.08 m	0.02 m	1.96 m	0110 0010
B_1	8	±6.35 m	0.05 m	+0.10 m	0000 0010
B_2	8	±6.35 m	0.05 m	+0.15 m	0000 0011
B_3	8	±6.35 m	0.05 m	-0.25 m	1111 1011
B_4	8	±6.35 m	0.05 m	Not used	1000 0000
Message Block CRC	32	-	-	-	1011 0101 1101 0000 1011 1100 0101 0010
Second Message Block (Type 2 Message)					
Message Block Header					
Message Block Identifier	8			Normal	1010 1010
MGS ID	24	-	-	BELL	000010 000101 001100 001100
Message Type Identifier	8	1 - 8	1	2	0000 0010
Message Length	8	10 – 222 bytes	1 byte	34 bytes	0010 0010
Message					
Ground Station Installed Receivers	2	2 - 4	1	3	01
Ground Station Accuracy Designator	2	-	-	B	01
Spare	1	-	-	-	0
Ground Station Continuity/Integrity Designator	3	0 – 7	1	1	001
Local Magnetic Variation	11	± 180°	0.25°	E58.0°	000 1110 1000
Spare	5	-	-	-	0000 0
$\sigma_{vert\_iono\_gradient}$	8	0 - 25.5 mm/km	0.1 mm/km	0	0000 0000
Refractivity Index	8	16 to 781	3	379	1111 1001
Scale Height	8	0 - 25,500 m	100 m	100 m	0000 0001
Refractivity Uncertainty	8	0 – 255	1	20	0001 0100
Latitude	32	± 90.0°	0.0005 arcsec	N45° 40’ 32” (+164432”)	0001 0011 1001 1010 0001 0001 0000 0000
Longitude	32	± 180.0°	0.0005 arcsec	W93° 25’ 13” (-336313”)	1101 0111 1110 1000 1000 1010 1011 0000
Reference Point Height	24	± 83,886.07 m	0.01 m	892.55 m	0000 0001 0101 1100 1010 0111
Additional Data Block 1					
Reference Station Data Selector	8	0 – 48	1	5	0000 0101
Maximum Use Distance (D_{max})	8	2 – 510 km	2 km	50 km	0001 1001
$K_{md\_e\_POS,GPS}$	8	0 – 12.75	0.05	6	0111 1000
$K_{md\_e\_CAT1,GPS}$	8	0 – 12.75	0.05	5	0110 0100
$K_{md\_e\_POS,GLONASS}$	8	0 – 12.75	0.05	0	0000 0000
$K_{md\_e\_CAT1,GLONASS}$	8	0 – 12.75	0.05	0	0000 0000

Data Content	*Bits Used*	*Range of Values*	*Resolution*	*Value*	*Binary Representation (Note 1)*
Message Block CRC	32	-	-	-	0101 1101 0111 0110 0010 0011 0001 1110
Application FEC	48	-	-	-	1110 1000 0100 0101 0011 1011 0011 1011 0100 0001 0101 0010
Input to Bit Scrambling (Note 3)	0 41 10 00 55 30 CA 10 80 38 17 C3 80 00 00 00 FF 5E 40 26 00 1C FF 46 40 C0 DF 01 4A 3D 0B AD 55 30 CA 10 40 44 A4 17 00 00 9F 80 28 00 88 59 C8 0D 51 17 EB E5 3A 80 A0 98 1E 26 00 00 78 C4 6E BA 4A 82 DC DC A2 17				
Output from Bit Scrambling	0 67 27 88 1F 2F D2 3B 5F A2 C2 1A B2 DC 46 D0 09 9F 09 25 1C 18 D0 B6 2A 7F B9 55 C2 F3 15 45 7C 50 A9 6F 3B 10 00 D9 71 17 DC 4B 2D 1B 7B 83 72 D4 F7 CA 62 C8 D9 12 25 5E 13 2E 13 E0 42 44 37 45 68 29 5A B9 55 65				
Fill Bits	-	-	-	-	0
D8PSK Symbols (Note 4)	0000 0035 1120 4546 3165 0105 6744 3352 3520 1160 3050 1336 6202 3576 1206 6670 7400 7653 3001 0255 3103 1274 2617 2772 7623 6442 4117 7201 3513 1033 3342 1734 4275 1235 6034 2057 6627 0254 1743 1214 0342 1036 7031 6613 4656 7433 6654 7730 3473 2201 4060 7506 0144 44				

<u>Note 1</u>: In Binary Representation column, the rightmost bit is the LSB of the binary parameter value, and is the first bit transmitted or sent to the bit scrambling process. All data fields are sent in the order specified in the table.

<u>Note 2</u>: For examples of Ephemeris CRC calculation, see Appendix A, <u>Table A-1</u>.

<u>Note 3</u>: This string is coded in hexadecimal with the first bit to be sent to the bit scrambling process as its MSB. The first character represents a single bit.

<u>Note 4</u>: Symbols are represented by their differential phase with respect to the first symbol of the message, in units of p/4 radians (e.g., a value of 5 represents a phase of 5p/4 radians relative to the first symbol). Fill bits are 0.

<u>Note 5:</u> In the example, the fill bits are not scrambled.

Table B-3 Example of Type 4 Message

Data Content	*Bits Used*	*Range of Values*	*Resolution*	*Value*	*Binary Representation (Note 1)*
Power Stabilization	15	-	-	-	000 0000 0000 0000
Synchronization and Ambiguity Resolution	48	-	-	-	0100 0111 1101 1111 1000 1100 0111 0110 0000 0111 1001 0000
Station Slot Identifier	3	-	-	D	011
Transmission Length	17	0 – 1824 bits	1 bit	784 bits	0 0000 0011 0001 0000
Training Sequence FEC	5	-	-	-	00000
Message Block Header					

Data Content	***Bits Used***	***Range of Values***	***Resolution***	***Value***	***Binary Representation*** *(Note 1)*
Message Block Identifier	8	-	-	"Normal"	1010 1010
MGS ID	24	-	-	CMJ	0000 1100 1101 0010 1010 0000
Message Type Identifier	8	1 - 8	1	4	0000 0100
Message Length	8	10 - 222 bytes	1 byte	92 bytes	0101 1100
Message					
Data Set 1					
Data Set Length	8	2 – 212 bytes	1 byte	41 bytes	0010 1001
Operation Type	4	0 – 15	1	0	0000
SBAS Service Provider	4	0 - 15	1	15	1111
Airport ID	32	-	-	LFBO	0000 1100 0000 0110 0000 0010 0000 1111
Runway Number	6	0 – 36	1	15	00 1111
Runway Letter	2	-	-	R	01
Approach Performance Designator	3	0 – 7	1	Cat I	001
Route Indicator	5	-	-	C	00001
Reference Path Data Selector	8	0 – 48	1	3	0000 0011
Reference Path ID	32	-	-	GTBS	0000 0111 0001 0100 0000 0010 0001 0011
LTP/FTP Latitude	32	± 90.0°	0.0005 arcsec	43.6441075°N	0001 0010 1011 1010 1110 0010 1000 0110
LTP/FTP Longitude	32	± 180.0°	0.0005 arcsec	1.345940°W	0000 0000 1001 0011 1101 1110 1001 0000
LTP/FTP Height	16	-512.0 – 6041.5 m	0.1 m	197.3 m	0001 1011 1101 0010
ΔFPAP Latitude	24	± 1°	0.0005 arcsec	-0.025145°	1111 1101 0011 1100 1100 1100
ΔFPAP Longitude	24	± 1°	0.0005 arcsec	0.026175°	0000 0010 1110 0000 0010 1100
Approach Threshold Crossing Height (TCH)	15	0- 3276.7 ft 0 – 1638.35 m	0.1 ft 0.05 m	17.05 m.	000 0001 0101 0101
Approach TCH Units Selector	1	-	-	meters	1
Glidepath Angle (GPA)	16	0 - 90.0 °	0.01°	3°	0000 0001 0010 1100
Course Width	8	80.0 - 143.75 m	0.25 m	105	0110 0100
ΔLength Offset	8	0 – 2032 m	8 m	0 m	0000 0000
Final Approach Segment CRC	32	-	-	-	1010 0010 1010 0101 1010 1000 0100 1101
FAS Vertical Alert Limit / Approach status	8	0 – 25.4 m	0.1 m	10 m	0110 0100

Data Content	***Bits Used***	***Range of Values***	***Resolution***	***Value***	***Binary Representation*** *(Note 1)*
FAS Lateral Alert Limit / Approach status	8	0 – 50.8 m	0.2 m	40 m	1100 1000
Data Set 2					
Data Set Length	8	2 – 212 bytes	1 byte	41 bytes	0010 1001
Operation Type	4	0 – 15	1	0	0000
SBAS Service Provider	4	0 – 15	1	1	0001
Airport ID	32	-	-	LFBO	0000 1100 0000 0110 0000 0010 0000 1111
Runway Number	6	0 – 36	1	33	10 0001
Runway Letter	2	-	-	R	01
Approach Performance Designator	3	0 – 7	1	Cat I	001
Route Indicator	5	-	-	C	00011
Reference Path Data Selector	8	0 – 48	1	21	0001 0101
Reference Path ID	32	-	-	GTN	0000 0111 0001 0100 0000 1110 0010 0000
LTP/FTP Latitude	32	± 90.0 °	0.0005 arcsec	43.6156350°N	0001 0010 1011 0111 1100 0001 1011 1100
LTP/FTP Longitude	32	± 180.0 °	0.0005 arcsec	1.3802350°E	0000 0000 1001 0111 1010 0011 0001 1100
LTP/FTP Height	16	-512.0 – 6041.5 m	0.1 m	197.3 m	0001 1011 1011 0101
ΔFPAP Latitude	24	± 1 °	0.0005 arcsec	0.02172375°	0000 0010 0110 0010 1111 1011
ΔFPAP Longitude	24	± 1 °	0.0005 arcsec	-0.0226050°	1111 1101 1000 0100 0011 1100
Approach Threshold Crossing Height (TCH)	15	0- 3276.7 ft 0 – 1638.35 m	0.1 ft 0.05 m	15.25 m.	000 0001 0011 0001
Approach TCH Units Selector	1	-	-	meters	1
Glidepath Angle (GPA)	16	0 - 90.0 °	0.01°	3.01°	0000 0001 0010 1101
Course Width	8	80.0 - 143.75 m	0.25 m	105	0110 0100
ΔLength Offset	8	0 – 2032 m	8 m	0 m	0000 0000
Final Approach Segment CRC	32				1010 1111 0100 1101 1010 0000 1101 0111
FAS Vertical Alert Limit / Approach status	8	0 – 25.4 m	0.1 m	10 m	0110 0100
FAS Lateral Alert Limit / Approach status	8	0 – 50.8 m	0.2 m	40 m	1100 1000
Message Block CRC	32	-	-	-	0101 0111 0000 0011 1111 1110 1001 1011

Data Content	***Bits Used***	***Range of Values***	***Resolution***	***Value***	***Binary Representation*** *(Note 1)*
Application FEC	48	-	-	-	0001 1011 1001 0001 0010 1010 1011 1100 0010 0101 1000 0101
Input to Bit Scrambling (Note 2)	1 82 30 00 55 05 4B 30 20 3A 94 0F F0 40 60 30 F2 98 C0 C8 40 28 E0 61 47 5D 48 09 7B C9 00 AD D8 33 3C BF 34 07 40 AA 81 34 80 26 00 B2 15 A5 45 26 13 94 08 F0 40 60 30 86 90 A8 04 70 28 E0 3D 83 ED 48 38 C5 E9 00 4B D8 DF 46 40 3C 21 BF 8C 81 B4 80 26 00 EB 05 B2 F5 26 13 D9 7F C0 EA A1 A4 3D 54 89 D8				
Output from Bit Scrambling	1 A4 07 88 1F 1A 53 1B FF A0 41 D6 C2 9C 26 E0 04 59 89 CB 5C 2C CF 91 2D E2 2E 5D F3 07 1E 45 F1 53 5F C0 4F 53 E4 64 F0 23 C3 ED 05 A9 E6 7F FF FF B5 49 81 DD A3 F2 B5 40 9D A0 17 90 12 60 64 7C CF E3 BE A0 1E 72 FF 61 6E E4 02 44 D9 1E D2 FD 63 D1 12 C3 5A 00 0E F8 89 FE 4C 12 0C 78 4F 9D 55 08 16 F6				
Fill Bits	0-2	-	-	-	0
D8PSK Symbols (Note 3)	0000 0035 1120 4546 3165 0432 2300 7716 6217 0713 0525 5667 3176 7243 4537 7776 1577 6346 1661 5705 4361 5214 5764 0513 3401 6775 2142 3130 4443 0613 0115 0266 7743 4175 5603 2762 4163 0527 5365 4001 5247 0514 2032 2575 3334 6255 5437 7076 0565 2760 6314 4462 4316 3101 3537 2225 0120 7604 0752 6435 1034 5771 4077 7704 1566 5273 6001 2232 4007 4020 3144 3362 7544 44				

<u>Note 1</u>: *In the Binary Representation column, the rightmost bit is the LSB of the binary parameter value, and is the first bit transmitted or sent to the bit scrambling process. All data fields are sent in the order specified in the table.*

<u>Note 2</u>: *This string is coded in hexadecimal with the first bit to be sent to the bit scrambling process as its MSB. The first character represents a single bit.*

<u>Note 3</u>: *Symbols are represented by their differential phase with respect to the first symbol of the message, in units of p/4 radians (e.g., a value of 5 represents a phase of 5p/4 radians relative to the first symbol).*

<u>Note 4</u>: *In the example, the fill bits are not scrambled.*

Table B-4 Example of Type 5 Message

Data Content	***Bits Used***	***Range of Values***	***Resolution***	***Value***	***Binary Representation*** *(Note 1)*
Power Stabilization	15	-	-	-	000 0000 0000 0000
Synchronization and Ambiguity Resolution	48	-	-	-	0100 0111 1101 1111 1000 1100 0111 0110 0000 0111 1001 0000
Station Slot Identifier	3	-	-	D	011
Transmission Length	17	0 – 1824 bits	1 bit	272 bits	0 0000 0001 0001 0000

Data Content	***Bits Used***	***Range of Values***	***Resolution***	***Value***	***Binary Representation*** *(Note 1)*
Training Sequence FEC	5	-	-	-	00011
Message Block Header					
Message Block Identifier	8	-	-	"Normal"	1010 1010
MGS ID	24	-	-	CMJ	000011 001101 001010 100000
Message Type Identifier	8	1 - 8	1	5	0000 0101
Message Length	8	10 – 222 bytes	1 byte	28 bytes	0001 1100
Message					
Modified Z-count	14	0 – 1199.9 s	0.1 s	100 s	00 0011 1110 1000
Spare	2	-	-	-	00
Number of Impacted Sources	8	0 - 31	1	2	0000 0010
First impacted source					
Ranging Source ID	8	1 - 255	1	4	0000 0100
Source Availability Sense	1	-	-	will cease	0
Source Availability Duration	7	0 - 1270 s	10 s	50 s	000 0101
Second impacted source					
Ranging Source ID	8	1 - 255	1	3	0000 0011
Source Availability Sense	1	-	-	will start	1
Source Availability Duration	7	0 - 1270 s	10 s	200 s	001 0100
Number of Obstructed Approaches	8	0 - 255	1	2	0000 0010
First obstructed approach					
Reference Path data Selector	8	0 – 48	1	21	0001 0101
Number of Impacted Sources for first obstructed approach	8	0 - 31	1	2	0000 0010
First impacted ranging source of first obstructed approach					
Ranging Source ID	8	1 – 255	1	12	0000 1100
Source Availability Sense	1	-	-	will cease	0
Source Availability Duration	7	0 – 1270 s	10 s	250 s	001 1001
Second impacted ranging source of first obstructed approach					
Ranging Source ID	8	1 – 255	1	14	0000 1110
Source Availability Sense	1	-	-	will cease	0
Source Availability Duration	7	0 – 1270 s	10 s	1000 s	110 0100
Second obstructed approach					
Reference Path data Selector	8	0 – 48	1	14	0000 1110
Number of Impacted Sources for second obstructed approach	8	0 - 31	1	1	0000 0001
First impacted ranging source of second obstructed approach					

Data Content	***Bits Used***	***Range of Values***	***Resolution***	***Value***	***Binary Representation*** *(Note 1)*
Ranging Source ID	8	1 – 255	1	12	0000 1100
Source Availability Sense	1			will cease	0
Source Availability Duration	7	0 – 1270 s	10 s	220 s	001 0110
Message Block CRC	32	-	-	-	1101 1011 0010 1111 0001 0010 0000 1001
Application FEC	48	-	-	-	0011 1110 1011 1010 0001 1110 0101 0110 1100 1011 0101 1011.
Input to Bit Scrambling (Note 2)	1 82 20 18 55 05 4B 30 A0 38 17 C0 40 20 50 C0 94 40 A8 40 30 4C 70 13 70 80 30 34 90 48 F4 DB DA D3 6A 78 5D 7C				
Output from Bit Scrambling	1 A4 17 90 1F 1A 53 1B 7F A2 C2 19 72 FC 16 10 62 81 E1 43 2C 48 5F E3 1A 3F 56 60 18 86 EA 33 F3 B3 09 07 26 28				
Fill Bits	0-2	-	-	-	
D8PSK Symbols (Note 3)	0000 0035 1120 4546 3165 0432 2056 6605 5106 7602 4161 2447 7363 4632 2070 0103 2240 0660 1332 1241 6623 1163 6437 7711 0173 1157 4302 3234 4514 6644 444				

Note 1: *In the Binary Representation column, the rightmost bit is the LSB of the binary parameter value, and is the first bit transmitted or sent to the bit scrambling process. All data fields are sent in the order specified in the table.*

Note 2: *This string is coded in hexadecimal with the first bit to be sent to the bit scrambling process as its MSB. The first character represents a single bit.*

Note 3: *Symbols are represented by their differential phase with respect to the first symbol of the message, in units of p/4 radians (e.g., a value of 5 represents a phase of 5p/4 radians relative to the first symbol)*

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Appendix C

MT 16 Message Parameters

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Table D-4. Format of Message Type 16, Carrier Phase Data

Data Content	***Bits Used***	***Range of Values***	***Resolution***
Modified Z-count	14	0 to 1 199.9s	0.1 sec
Additional Message Flag	2	0 to 3	1
Number of Measurements	5	32	1
Measurement Type	3	0 to 7	1
For N Measurement Blocks			
Ranging Source ID	8	1 to 255	1
Issue of Data (IOD)	8	0 to 255	
Carrier Phase	32	± 8388608 cycles	2^{-8} cycles
$Sigma_{cp}$	8	51.0 mm	0.2 mm
$B1_{cp}$	8	± 127.0mm	1.0 mm
$B2_{cp}$	8	± 127.0mm	1.0 mm
$B3_{cp}$	8	± 127.0mm	1.0 mm
$B4_{cp}$	8	± 127.0mm	1.0 mm

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Appendix D

Glossary, Abbreviations, and Acronyms

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AC - Advisory Circular

AGC - Automatic Gain Control

APL - Airport Pseudolite

CFR - Code of Federal Regulations

CRC - Cyclic Redundancy Check

Differential GNSS (DGNSS) - Differential GNSS is an augmentation, the purpose of which is to determine position errors at one or more known locations and subsequently transmit derived information to other GNSS receivers in order to enhance the accuracy, integrity, and availability of the position estimate. (Source: Adapted from the ICAO FANS GNSS Technical Subgroup).

D8PSK - Differential 8-state Phase Shift Keying

FCC - Federal Communications Commission

FEC - Forward Error Correction

Fictitious Threshold Point (FTP) - The FTP is a point functionally equivalent to a Landing Threshold Point, except that the FTP is not located on the runway centerline.

Final Approach Segment (FAS) - The straight line segment that prescribes the three-dimensional geometric path in space that an aircraft is supposed to fly on final approach.

Flight Path Alignment Point (FPAP) - The FPAP is used in conjunction with the LTP/FTP and the geometric center of the WGS-84 ellipsoid to define the geodesic plane of a precision final approach, landing and flight path. The FPAP is typically located at or near the runway stop end. The FPAP may have the same latitude/longitude as the LTP/FTP for the approach to the opposite end of the same runway.

Glide Path Angle (GPA) - The glide path angle is an angle, defined at the Threshold Crossing Point (directly above the LTP/FTP at a height equal to the TCH), that establishes the intended descent gradient for the final approach flight path of a precision approach path. It is measured between the final approach path and the plane containing the LTP/FTP that is parallel to the tangent to the WGS-84 ellipsoid.

Glide Path Intercept Point (GPIP) - The GPIP is the point at which the extension of the final approach path intercepts the plane containing the LTP/FTP that is parallel to the tangent to the WGS-84 ellipsoid at the LTP/FTP.

Global Navigation Satellite System (GNSS) - GNSS is a world-wide position, velocity, and time determination system, that includes one or more constellations, receivers, and system integrity monitoring, augmented as necessary to support the required navigation performance for the actual phase of operation. (Source: RTCA GNSS Task Force Working Group 2: adapted from the ICAO FANS GNSS Technical Subgroup).

Global Positioning System (GPS) - The satellite-based navigation system operated by the United States.

GLONASS - Global Navigation Satellite System (of the Russian Federation).

H_0 Hypothesis - The H_0 hypothesis assumes the situation where no faults are present in the range measurements (includes both the signal and the receiver measurements) used in the ground station to compute the differential corrections.

H_1 Hypothesis - The H_1 hypothesis assumes the situation when a fault is present in one or more range measurements and is caused by one of the reference receivers used in the ground station.

Height Above Touchdown (HAT) - Specifically, the height above the LTP/FTP. In using this term for airborne equipment specifications, care should be taken to define the point on the aircraft (e.g., GPS antenna, wheel height, or center of mass) that applies.

ICAO - International Civil Aviation Organization

ICD - Interface Control Document

ID - Identifier

IOD - GPS Issue of Data

ISO - International Standards Organization

JPALS - Joint Precision Approach and Landing System

LAAS - Local Area Augmentation System

LDGPS - Local Area Differential Global Positioning System

Landing Threshold Point (LTP) - The LTP is a point at the designated center of the landing runway defined by latitude, longitude, ellipsoidal height, and orthometric height. The LTP is used in conjunction with the FPAP and the geometric center of the WGS-84 ellipsoid to define the geodesic plane of a precision final approach flight path to touchdown and rollout. The LTP is a surveyed reference point used to connect the approach flight path with the runway. The LTP is typically coincident with the designated runway threshold, but may be displaced from the threshold.

LSB - Least Significant Bit

MAS - Military Airborne Segment

Mask Angle - A fixed elevation angle referenced to the user's horizon below which satellites are ignored by the receiver software. Mask angles are used primarily in the analysis of GNSS performance, and are employed in some receiver designs. The mask angle is driven by the receiver antenna characteristics, the strength of the transmitted signal at low elevations, receiver sensitivity and acceptable low elevation errors.

MBI - Message Block Identifier

MGS - Military Ground Segment

MPNTP – Master Positioning Navigation and Timing Plan

MSB - Most Significant Bit

Navigation - The means by which an aircraft is given guidance to travel from one known position to another known position. The process involves referencing the actual aircraft position to a desired course.

nmi - Nautical Mile

Non-Precision Approach - A standard instrument approach path in which no glideslope/glide path is provided. (Source: FAA document 7110.65G)

ORD - Operational Requirements Document

PCR - Pseudorange Correction Rate

PPS - Precise Positioning Service

PRC - Pseudorange Correction

Precision Approach - A standard instrument approach path in which a glideslope/glide path is provided. (Source: FAA document 7110.65G)

PRN - Pseudorandom Number

Pseudolite - A pseudolite (pseudo-satellite) is a ground-based GNSS augmentation that provides an additional navigation ranging signal which is at GNSS ranging source signal-in-space frequencies. The augmentation may include additionally differential GNSS corrections. (Adapted from the FANS GNSS Technical Subgroup).

Pseudorange - The distance from the user to a ranging source plus an unknown user clock offset distance. With four ranging source signals it is possible to compute position and offset distance. If the user clock offset is known, three ranging source signals would suffice to compute a position.

Reference Receiver - A subsystem of the Ground Subsystem that is used to make pseudorange measurements and may contain more than one receiver.

RF - Radio Frequency

RFI - Radio Frequency Interference

RMS - Root Mean Squared

RSS - Root Sum Square

SAASM - Selective Availability and Anti-Spoofing Module

Satellite-Based Augmentation System (SBAS) - is a differential GNSS employing satellite transponders to broadcast differential corrections, integrity information and additional ranging signals usable over an extensive geographical area for the supported phases of operation.

sec – seconds

Selective Availability (SA) - A set of techniques for denying the full accuracy and selecting the level of positioning, velocity, and time accuracy of GPS available to users of the Standard Positioning Service (L1 frequency) signal.

SL 7 - JPALS guidance quality Service Level 7

SL 8 - JPALS guidance quality Service Level 8

SL 9 - JPALS guidance quality Service Level 9

SIS - Signal-in-Space

SRD - System Requirements Document

Standard Positioning Service (SPS) - The standard specified level of positioning, velocity and timing accuracy that is available, without qualifications or restrictions, to any user on a continuous worldwide basis.

TBD - To Be Determined

TCH - Threshold Crossing Height

TDMA - Time Division Multiple Access

TOW - Time of Week

UTC - Universal Coordinated Time

VDB - VHF Data Broadcast

WGS-84 - World Geodetic Survey – 1984