RTCA, Inc.
1150 18th Street NW, Suite 910
Washington, DC 20036, USA

GNSS-Based Precision Approach Local Area Augmentation System (LAAS) Signal-in-Space Interface Control Document (ICD)

RTCA DO-246E
July 13, 2017

Prepared by: SC-159
© 2017 RTCA, Inc.

Copies of this document may be obtained from

RTCA, Inc.
1150 18th Street, NW, Suite 910
Washington, DC 20036-4001, USA

Telephone: 202-833-9339
Facsimile: 202-833-9434
Internet: www.rtca.org

Please visit the RTCA Online Store for document pricing and ordering information.

FOREWORD

This document was prepared by Special Committee 159 (SC-159) and approved by the RTCA Program Management Committee (PMC) on July 13, 2017.

RTCA, Incorporated is a not-for-profit corporation formed to advance the art and science of aviation and aviation electronic systems for the benefit of the public. The organization functions as a Federal Advisory Committee and develops consensus-based recommendations on contemporary aviation issues. RTCA's objectives include but are not limited to:

- coalescing aviation system user and provider technical requirements in a manner that helps government and industry meet their mutual objectives and responsibilities;
- analyzing and recommending solutions to the system technical issues that aviation faces as it continues to pursue increased safety, system capacity, and efficiency;
- developing consensus on the application of pertinent technology to fulfill user and provider requirements, including development of minimum operational performance standards for electronic systems and equipment that support aviation; and
- assisting in developing the appropriate technical material upon which positions for the International Civil Aviation Organization and the International Telecommunications Union and other appropriate international organizations can be based.

The organization's recommendations are often used as the basis for government and private sector decisions as well as the foundation for many Federal Aviation Administration Technical Standard Orders and several advisory circulars.

Since RTCA is not an official agency of the United States Government, its recommendations may not be regarded as statements of official government policy unless so enunciated by the U.S. government organization or agency having statutory jurisdiction over any matters to which the recommendations relate.

"Disclaimer"

This publication is based on material submitted by various participants during the SC approval process. Neither the SC nor RTCA has made any determination whether these materials could be subject to valid claims of patent, copyright or other proprietary rights by third parties, and no representation or warranty, expressed or implied is made in this regard. Any use of or reliance on this document shall constitute an acceptance thereof "as is" and be subject to this disclaimer.

This Page Intentionally Left Blank.

EXECUTIVE SUMMARY

RTCA/DO-246E was prepared by Special Committee 159 (SC-159). This document supersedes RTCA/DO-246D, but the content of the ICD was maintained to be backward compatible with all LAAS MOPS compliant equipment specified in DO-253 as amended by applicable FAA TSOs.

This Interface Control Document (ICD) defines the Signal-in-Space for the Global Navigation Satellite System (GNSS) based Local Area Augmentation System (LAAS). The LAAS has global application as a Ground-Based Augmentation System (GBAS) to GNSS. The GNSS/GBAS Signal-in-Space is composed of three signals:

1. the navigation signal transmitted from the GNSS satellites to the ground subsystem,
2. the navigation signal transmitted from the GNSS satellites to the airborne subsystem, and
3. the VHF Data Broadcast (VDB) transmitted from the GBAS ground subsystem to the airborne subsystem.

This document is complementary to the LAAS MOPS avionics standard defined in RTCA/DO-253D. It is also complementary to the International Civil Aviation Organization Annex 10 Volume I Ground Based Augmentation System (GBAS) standards and recommended practices (SARPs) for GBAS approach service types C (GAST C) and D (GAST D) as well as the differentially corrected positioning service (DCPS). Together, GAST C and GAST D support all categories of approach and landing operations with vertical and lateral guidance, as well as guided takeoff. DCPS supports horizontal positioning in a local airport and terminal area environment. This revision of DO-246 includes changes resulting from:

1. the final validation of GAST D and the promulgation of Annex 10 with GAST D by ICAO, and
2. maintenance updates for the other GBAS services including GAST C (previously referred to as “Category I precision approach”) and DCPS.

Additional broadcast features have been included in this ICD for LAAS to support operations that have been identified as beneficial by some operators, but these additional broadcast features have not yet been harmonized or standardized internationally. Such additional features include the optional broadcast of a subset of RTCA/DO 236()-compatible terminal area path (TAP) data within Type 4 Messages to provide additional support for terminal area operations. This initial TAP broadcast development was intended to be compatible with the GAST C, GAST D, and DCPS GBAS services, but further development may be needed.

This Page Intentionally Left Blank.

TABLE OF CONTENTS

1.0 PURPOSE AND SCOPE 1

1.1 Introduction 1
1.2 LAAS System Interface Description 2
1.3 GBAS Services 3
1.3.1 GBAS Positioning Service 3
1.3.2 GBAS Approach Services 3

2.0 DATA BROADCAST DEFINITION 5

2.1 RF Transmission Characteristics 5
2.1.1 Symbol Rate 5
2.1.2 Emission Designator 5
2.1.3 Field Strength 5
2.1.4 Spectral Characteristics 6
2.1.4.1 Carrier Frequencies 6
2.1.4.2 Unwanted Emissions 6
2.1.4.3 Adjacent Channel Emissions 7
2.1.4.4 Adjacent Temporal Interference 8
2.1.4.5 Carrier Frequency Stability 8
2.1.5 Modulation 8
2.1.5.1 Pulse Shaping Filters 10
2.1.5.2 Error Vector Magnitude 11
2.2 Broadcast Timing Structure 11
2.2.1 TDMA Timing Structure 11
2.2.2 Time Slot Initiation and Minimum Use 12
2.2.3 Timing Budget for VDB Bursts 12
2.3 Burst Data Content 13
2.3.1 Training Sequence 14
2.3.1.1 Power Stabilization 14
2.3.1.2 Synchronization and Ambiguity Resolution 14
2.3.1.3 Station Slot Identifier 15
2.3.1.4 Transmission Length 15
2.3.1.5 Training Sequence FEC 15
2.3.2 Application Data 16
2.3.3 Application FEC 16
2.3.4 Bit Scrambling 17
2.3.5 Application Layer 18
2.3.6 Message Block Header 18
2.3.6.1 Test Mode 18
2.3.7 Cyclic Redundancy Check 19

2.4 LAAS Messages 19
2.4.1 Message Types and Broadcast Rates 19
2.4.2 Data Format 22
2.4.3 Message Type 1 - Differential Corrections – 100 Second Smoothed Pseudoranges 23
2.4.3.1 Message Description 23
2.4.3.2 Message Type 1 Parameters 25
2.4.4 Message Type 2 - GBAS Related Data 29
2.4.4.1 Message Description 29
2.4.4.2 Message Type 2 Parameters 31
2.4.5 Message Type 3 – Null Message 33
2.4.5.1 Message Description 33
2.4.5.2 Message Type 3 Parameters 34
2.4.6 Message Type 4 - Final Approach Segment and Terminal Area Path Construction Data 34
2.4.6.1 Message Description 34
2.4.6.2 Message Type 4 Parameters 35
2.4.6.3 Final Approach Segment (FAS) and Terminal Area Path (TAP) Data Block 36
2.4.6.4 Final Approach Segment and Terminal Area Path Parameters 44
2.4.7 Message Type 5 - Ranging Source Availability (optional) 50
2.4.7.1 Message Description 50
2.4.7.2 Message Type 5 Parameters 50
2.4.8 Message Type 6 - (Reserved) Differential Carrier Corrections 51
2.4.9 Message Type 7 – (Reserved) for Military 51
2.4.10 Message Type 8 – (Reserved) for Test 51
2.4.11 Message Type 11 - Differential Corrections – 30 Second Smoothed Pseudoranges 51
2.4.11.1 Message Description 51
2.4.11.2 Message Type 11 Parameters 52

3.0 REFERENCES 55

4.0 MEMBERSHIP MARCH 2017 57

APPENDIX A: CYCLIC REDUNDANCY CHECKS (CRC) **A-1**

APPENDIX B: MESSAGE AND FAS EXAMPLE **B-1**

APPENDIX C: PRELIMINARY CARRIER CORRECTIONS MESSAGE DEFINITIONS (INFORMATIVE) **C-1**

C.1 Carrier Correction C-1
C.1.1 Definition of Parameters C-1
C.2 Message Table - Carrier Corrections C-2

APPENDIX D: RESERVED **D-1**

APPENDIX E: GLOSSARY, ABBREVIATIONS, AND ACRONYMS **E-1**

TABLE OF TABLES

Table 2-1: Unwanted Emissions 6
Table 2-2: Power Transmitted in Adjacent Channels 8
Table 2-3: Data Encoding 9
Table 2-4: Burst Timing 13
Table 2-5: Burst Data Content 13
Table 2-6: Training Sequence Format 14
Table 2-7: Format of a LAAS Message Block 18
Table 2-8: Format of Message Block Header 18
Table 2-9: GBAS Message Types for Supported Service Types 20
Table 2-10: LAAS VHF Data Broadcast (VDB) Messages and Broadcast Rates 21
Table 2-11: Subset of International Alphabet No. 5 22
Table 2-12: Format of Message Type 1 23
Table 2-13: GPS Satellite Ephemeris Mask 27
Table 2-14: Format of Message Type 2 30
Table 2-15: Additional Data Block 3, GFC D Ephemeris Kmd and Ionospheric Parameters 30
Table 2-16: Additional Data Block 4, VDB Authentication Parameters 31
Table 2-17: Format of Message Type 3 34
Table 2-18: Format of Message Type 4 35
Table 2-19: Final Approach Segment (FAS) Data Block 38
Table 2-20: TAP Data Block 39
Table 2-21: TAP Missed Approach Data Block 40
Table 2-22: TAP IF Leg Data, Type 0 (Initial Fix) 41
Table 2-23: TAP TF Leg Data, Type 1 (Track to Fix) 41
Table 2-24: TAP RF Leg Data, Type 2 (Radius to Fix) 42
Table 2-25: TAP DD/TF Leg Data, Type 3 (Dynamic Downwind-Track to Fix) 42
Table 2-26: Format of Message Type 5 50
Table 2-27: Format of Message Type 11 52
Table A-1: Examples of 16-bit Ephemeris CRC A-3
Table A-2: Examples of 32-bit LAAS Message or FAS Data Block CRC A-4
Table B-1: Example of Type 1 Message B-2
Table B-2: Example of Type 1 and Type 2 Messages in One Burst B-4
Table B-3: Example of Type 2 Message Containing Data Blocks 1, 3, and 4 ..... B-7
Table B-4: Example of Type 4 Message B-11
Table B-5: Example of Type 4 FAS and TAP Message B-14
Table B-6: Example of Type 5 Message B-19
Table B-7: Example of Type 11 Message B-21
Table B-8: Example of Type 1 Message Block with Non-zero Ephemeris CRC Value B-23
Table C-1: Preliminary Format of Message Type 6 ..... C-2

TABLE OF FIGURES

Figure 1-1: Ground Based Augmentation System (GBAS) 2
Figure 1-2: LAAS Signal-in-Space Interface Diagram 3
Figure 2-1: D8PSK Data Modulator Example 10
Figure 2-2: TDMA Timing Structure 12
Figure 2-3: Message Encoding 14
Figure 2-4: Bit Scrambler/Descrambler 17
Figure 2-5: Low Frequency Correction Transmission (Ephemeris CRC) 24
Figure 2-6: Illustration of Error Estimate (B) Parameters 26
Figure 2-7: Pseudorange Correction Computation 28
Figure 2-8: Final Approach Segment Diagram 36
Figure 2-9: Curved Segment TAP Example 37
Figure 2-10: DD/TF Illustration 43
Figure 2-11: Message Type 4 Structure Extended to Accommodate TAP Data Sets 44
Figure A-1: Example of Ephemeris CRC Generator Circuit A-2
Figure A-2: Example of LAAS Message or FAS Data Block CRC Generator Circuit A-2

1.0 Purpose and Scope

1.1 INTRODUCTION

This Interface Control Document (ICD) defines the Signal-in-Space for the Global Navigation Satellite System (GNSS) based Local Area Augmentation System (LAAS). The LAAS has global application as a Ground-Based Augmentation System (GBAS) to the GNSS.

The content of this ICD that supports Category I Precision Approach and the differential positioning service is intended to be consistent with standards developed by the International Civil Aviation Organization (ICAO) and The European Organization for Civil Aviation Equipment (EUROCAE).

Within this document, the terms "LAAS" and "GBAS" are not synonymous. "LAAS" refers to the system being proposed by the RTCA to meet the operational objectives for the United States (US) National Air Space (NAS) as documented in RTCA/DO-245(). This system may also be suitable for implementation in other areas. "GBAS" refers to any system compliant with the ICAO standards (through and including Amendment 91 to ICAO Annex 10).

LAAS may implement the GBAS approach service and/or the positioning service based on GPS and, optionally, visible SBAS/WAAS geostationary satellites. The GBAS approach service has an optional broadcast of ephemeris error bound parameters. LAAS requires the broadcast of the ephemeris bound parameters. LAAS requires the broadcasting of additional information when supporting GBAS Approach Service Type (GAST) D (see Section 1.3.2).

Additional broadcast features have been included in this ICD for LAAS to support operations that have been identified as beneficial by some operators but they have not yet been harmonized or standardized internationally.

- Format definitions for the optional broadcast of a subset of RTCA/DO-236()-compatible terminal area path (TAP) data to provide additional support for terminal area operations have been included. This initial TAP broadcast development was intended to be compatible with the GBAS CAT I approach and positioning services and CAT II/III services, but further development may be needed.
- RTCA has developed requirements to support multiple Approach Service Types intended to support precision approach operations in all-weather minimums. Consequently, there are now two basic classes of ground stations and airborne user equipment: equipment that is single Approach Service Type capable and equipment that is multiple Approach Service Type capable.

The requirements and the corresponding ICD modifications necessary to support TAP have not been harmonized internationally. This version of the ICD includes no new changes to TAP related signal format definitions.

This document should be useful to equipment designers, installers, manufacturers, service providers, and LAAS users.

Figure 1-1 shows the three required components of GBAS including the GNSS satellite subsystem, the airborne subsystem, and the GBAS ground subsystem. Figure 1-2 shows similar subsystem components for LAAS. The GNSS satellite subsystem satellite constellation for LAAS differs from GBAS in that it only includes GPS and SBAS satellites with provisions to add other core satellite constellations in the future. In addition to these three subsystems, additional components are required to maintain the operations of GBAS or LAAS (e.g., the GPS control segment); however, these additional GNSS components are not considered to be part of the LAAS for the purpose of this ICD.

© 2017 RTCA, Inc.

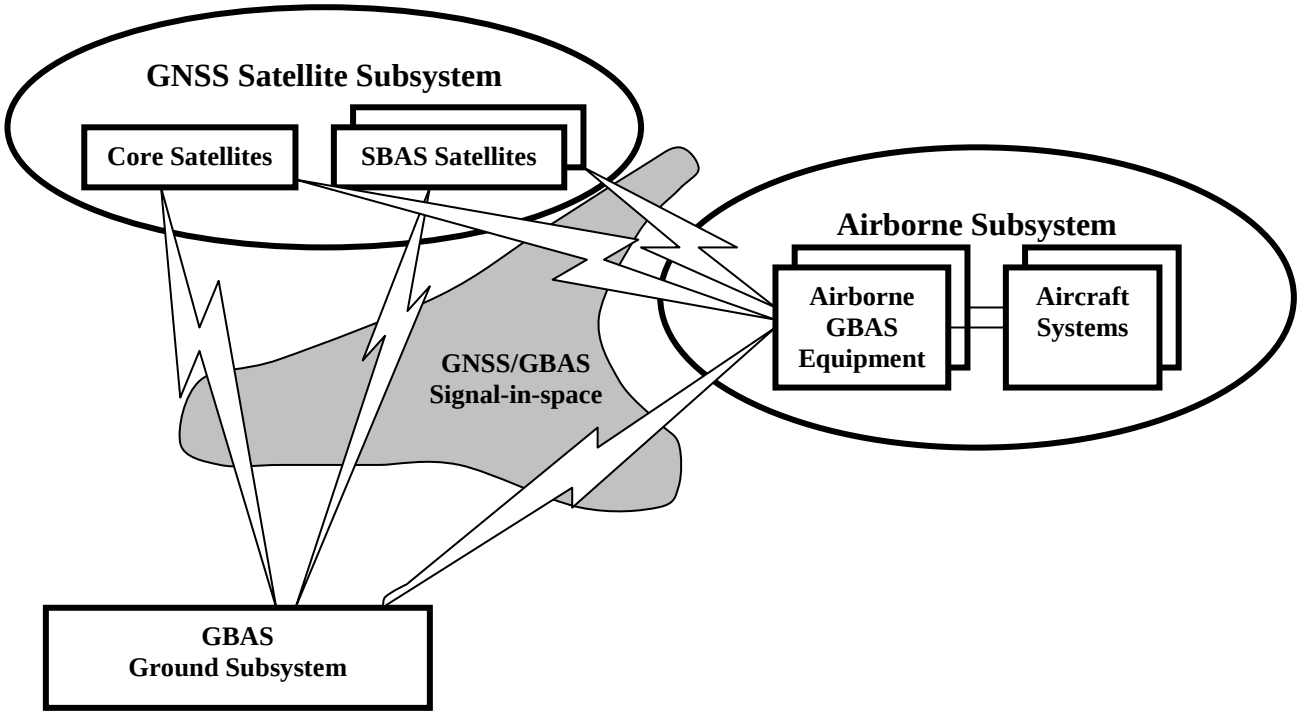


Figure 1-1: Ground Based Augmentation System (GBAS)

The GNSS/GBAS Signal-in-Space is composed of three signals:

1. the navigation signal transmitted from the GNSS satellites to the ground subsystem,
2. the navigation signal transmitted from the GNSS satellites to the airborne subsystem, and
3. the VHF Data Broadcast (VDB) transmitted from the GBAS ground subsystem to the airborne subsystem.

1.2 LAAS SYSTEM INTERFACE DESCRIPTION

The LAAS system operates using three interfaces shown in Figure 1-2. There are three unique interfaces that are defined in this ICD. The first interface (Interface I) is the GPS satellite ranging source interface. The definition of this interface already exists in the form of: the IS-GPS-200D, Navstar GPS Space Segment/Navigation User Interfaces, which defines the nominal signal characteristics and performance of the GPS satellites. Performance above and beyond the minimum guaranteed by the GPS SPS Signal Specification is ensured through signal quality monitoring at the LAAS ground station. Several LAAS specific ranging source signal performance requirements have been identified to fully characterize anomalous ranging source conditions, which are not naturally corrected by the differential operation of the LAAS.

Note: *The IS-GPS-200 is periodically updated. Manufacturers should use the latest version as an informative document.*

The second interface (Interface II) is the Satellite-Based Augmentation System (SBAS) signal in space and is defined in the SBAS Signal Specification (Appendix A of RTCA/DO-229()).

© 2017 RTCA, Inc.