Department of Transportation
Federal Aviation Administration
Aircraft Certification Service
Washington, D.C.

TSO-C161a

Effective
Date: 12/17/09

Technical Standard Order

Subject: Ground Based Augmentation System Positioning and Navigation Equipment

1. PURPOSE. This technical standard order (TSO) is for manufacturers applying for a TSO authorization (TSOA) or letter of design approval (LODA). In it, we (the Federal Aviation Administration, or FAA) tell you what minimum performance standards (MPS) your airborne navigation equipment using the Global Positioning System (GPS) augmented by the Ground Based Augmentation System (GBAS), for example the U.S Local Area Augmentation System (LAAS), must first meet for approval and identification with the applicable TSO marking.

2. APPLICABILITY. This TSO affects new applications submitted after its effective date.

a. The original version of this TSO is no longer effective. Generally, we will not accept applications after the effective date of this TSO. We may do so, however, up to six months after it, if we know that you were working against the earlier MPS before the new change became effective and provided you incorporate the ephemeris cyclic redundancy check (CRC) per appendix **2** of this TSO.

b. GBAS equipment approved under a previous TSOA may still be manufactured under the provisions of its original approval provided you incorporate the ephemeris CRC per appendix **2** of this TSO.

3. REQUIREMENTS. New models of GBAS equipment identified and manufactured on or after the effective date of this TSO must meet the MPS for the positioning and navigation equipment in RTCA/DO-253C, *Minimum Operational Performance Standards for GPS Local Area Augmentation System Airborne Equipment*, dated December 16, 2008, section 2 as modified by appendices **1** and **2** of this TSO for airborne equipment class (AEC) C to support Category I precision approach. This MPS also applies to equipment that implements the optional GBAS positioning service. This TSO does not apply to AEC D equipment as the additional requirements to support the GBAS Approach Service Type D and Category III precision approaches have not been validated. A new TSO or a revision to this TSO for AEC D equipment will be issued once these additional requirements are validated.

a. Functionality. This TSO's standards apply to equipment intended to output deviations relative to a precision approach path using GBAS, and to provide position information to a

navigation management unit that outputs deviation commands referenced to a desired flight path. These standards do not address integration issues with other avionics except for automatic dependent surveillance. The positioning and navigation functions are defined in section 2.3 of RTCA/DO-253C. In accordance with section 2.1, equipment obtaining this TSOA must also comply with the position, velocity and time (PVT) output requirements of either, TSO-C145c, TSO-C146c or TSO-C196.

NOTE: TSO-C196, which is based on RTCA/ DO-316, *Minimum Operational Performance Standards for Global Positioning System/Aircraft Based Augmentation System Airborne Equipment*, dated April 14, 2009 is not referenced in RTCA DO-253C. RTCA/DO-316 was published after the publication of DO-253C. TSO-C129a is not applicable to this TSO.

b. Failure Condition Classifications. Failure of the function defined in paragraph **3a** of this TSO is a major failure condition for the position data and a hazardous failure condition for the precision approach navigation data. Loss of the function as defined in paragraph **3a** of this TSO is a minor failure condition for both position data and precision approach data. Develop the system to, at least, the design assurance level equal to these failure condition classifications.

c. Functional Qualification. Demonstrate the required functional performance under the test conditions specified in RTCA/DO-253C, section 2.5.

d. Environmental Qualification. Demonstrate the required performance under the test conditions specified in RTCA/DO-253C, section 2.4 using standard environmental conditions and test procedures appropriate for airborne equipment.

NOTE: Although no specific version of RTCA DO-160 environmental conditions and test procedures are specified, use of RTCA/DO-160D (with Changes 1 and 2 only, incorporated) or earlier versions will require substantiation via the deviation process as discussed in paragraph **3g** of this TSO.

e. Software Qualification. If the article includes software, develop the software according to RTCA, Inc. document RTCA/DO-178B, *Software Considerations in Airborne Systems and Equipment Certification*, dated December 1, 1992. The software design assurance level should be consistent with the failure condition classification defined in paragraph **3b** of this TSO. All software included in the article definition must be developed in accordance with RTCA/DO-178B.

f. Electronic Hardware Qualification. If the article includes a complex custom micro-coded component to accomplish the function, develop the component according to RTCA, Inc. document RTCA/DO-254, *Design Assurance Guidance for Airborne Electronic Hardware,* dated August 19, 2000. All complex custom micro-coded components included in the article definition must be developed in accordance with RTCA/DO-254.

g. Deviations. We have provisions for using alternate or equivalent means of compliance to the criteria in the MPS of this TSO. If you invoke these provisions, you must show that your

equipment maintains an equivalent level of safety. Apply for a deviation under Title 14 of the Code of Federal Regulations (14 CFR) 21.609.

4. MARKING.

a. Mark at least one major component permanently and legibly with all the information in 14 CFR 21.607(d). The marking must include the serial number.

b. Also, mark the following permanently and legibly, with at least the manufacturer's name, subassembly part number, and the TSO number:

(1) Each component that is easily removable (without hand tools), and

(2) Each subassembly of the article that you determined may be interchangeable.

c. If the article includes a deviation per paragraph **3g** of this TSO, the marking must include a means to indicate a deviation was granted.

d. If the component includes a digital computer, then the part number must include hardware and software identification. Or, you can use a separate part number for hardware and software. Either way, you must include a means to show the modification status.

> **NOTE:** Similar software versions, developed and tested to different software levels, must be differentiated by part number.

5. APPLICATION DATA REQUIREMENTS. You must give the FAA aircraft certification office (ACO) manager responsible for your facility a statement of conformance, as specified in 14 CFR 21.605(a)(1) and one copy each of the following technical data to support your design and production approval. Under 14 CFR 21.617(a)(2), LODA applicants submit the same data (excluding paragraph 5h) through their civil aviation authority.

a. Operating instructions and equipment limitations in an installation manual (IM), sufficient to describe the equipment's operational capability. Describe in detail any deviations. If needed, identify equipment by part number, version, revision, and criticality level of software/hardware, classification for use, and environmental categories.

b. Installation procedures and limitations in an IM, sufficient to ensure that the GBAS equipment, when installed according to the installation procedures, still meets this TSO's requirements. Limitations must identify any unique aspects of the installation. The limitations must include a note with the following statement:

> This article meets the **minimum** performance and quality control standards required by a technical standard order (TSO). If you are installing this article on or in a specific type or class of aircraft, you must obtain separate approval for installation.

c. Schematic drawings of the installation procedures.

d. Wiring diagrams of the installation procedures.

e. List of components, by part number, that makes up the GBAS equipment. Include vendor part number cross-references, when applicable.

f. A component maintenance manual (CMM) or IM, as appropriate, covering periodic maintenance, calibration, and repair, for the continued airworthiness of GBAS equipment. Include recommended inspection intervals and service life, as appropriate.

g. Material and process specifications list.

h. The quality control system (QCS) description required by 14 CFR 21.143 and 21.605(a)(3), including functional test specifications. The QCS should ensure that you will detect any change to the approved design that could adversely affect compliance with the TSO MPS, and reject the article accordingly. (Not required for LODA applicants.)

i. Manufacturer's TSO qualification report showing results of testing accomplished according to paragraph **3c** of this TSO.

j. Nameplate drawing with the information required by paragraph **4** of this TSO.

k. List of all drawings and processes (including revision level) that define the article's design.

l. A summary of the test conditions used for environmental qualifications for each component of the article. For example, a form as described in RTCA/DO-160F, *Environmental Conditions and Test Procedures for Airborne Equipment,* appendix A.

m. If the article includes software: a plan for software aspects of certification (PSAC), software configuration index, and software accomplishment summary. We recommend that you submit the PSAC early in the software development process. Early submittal allows us to quickly resolve issues, such as partitioning and determining software levels.

n. If the article includes a complex custom micro-coded component: a plan for hardware aspects of certification (PHAC), hardware verification plan, top-level drawing, and hardware accomplishment summary. We recommend that you submit the PHAC early in the hardware development process. Early submittal allows us to quickly resolve issues.

o. Identify functionality, features or performance contained in the article not evaluated under paragraph **3** of this TSO (i.e. non-TSO functions). These functions are not approved under 14 CFR 21 Subpart O authorization, however they can be approved in conjunction with the TSO authorization under the authority of 14 CFR 21.305(d). You must include the following information with your TSO application:

(1) Description of the non-TSO function(s), such as performance specifications and software, hardware, and environmental qualification levels. Add a statement confirming that the non-TSO functions do not interfere with the article's compliance with the requirements of paragraph 3.

(2) Installation and operating instructions/limitations for the non-TSO function(s). The IM must contain the following statement: **"**The non-TSO functions defined in this section are not part of the TSO approval. The non-TSO function data included in this section is approved under 14 CFR 21.305(d)."

(3) Instructions for continued performance applicable to the non-TSO function(s) defined in paragraph **5o(1).**

(4) Interface requirements and applicable installation test procedures to ensure compliance with the performance data defined in paragraph **5o(1).**

(5) Results of test/analysis, as appropriate, to verify that performance of the hosting TSO article is not affected by the non-TSO function(s).

(6) Results of test/analysis, as appropriate, to verify intended function of the declared non-TSO function(s) as described in paragraph **5o(1).**

6. MANUFACTURER DATA REQUIREMENTS. Besides the data given directly to us, have the following technical data available for review by the responsible ACO or civil aviation authority:

a. Functional qualification specifications for qualifying each production article to ensure compliance with this TSO.

b. Equipment calibration procedures.

c. Corrective maintenance procedures (within 12 months after TSOA or LODA).

d. Schematic drawings.

e. Wiring diagrams.

f. Material and process specifications.

g. The results of the environmental qualification tests conducted according to paragraph **3d** of this TSO.

h. If the article includes software, the appropriate documentation defined in RTCA/DO-178B including all data supporting the applicable objectives in RTCA/DO-178B Annex A, Process Objectives and Outputs by Software Level.

i. If the article includes a complex micro-coded component, the appropriate hardware life cycle data in combination with design assurance level, as defined in RTCA/DO-254 appendix A, Table A-l.

j. If the article contains non-TSO function(s), you must also make available items **6a** through **6i** as they pertain to the non-TSO function(s).

k. If any external equipment was used to validate the article's compliance with the requirements in this TSO such as simulators, stimulators or other similar devices, the appropriate documentation showing its accreditation and suitability for the intended purpose.

7. FURNISHED DATA REQUIREMENTS.

a. If furnishing one or more articles manufactured under this TSO to one entity (such as an operator or repair station), provide one copy of the data in paragraphs **5a** through **5f** and **5l** of this TSO. Add any other data needed for the proper installation, certification, use, or for continued compliance with the TSO, of the GBAS equipment.

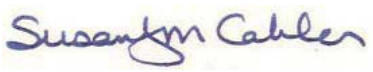
b. If the article contains non-TSO function(s), also include one copy of the data in paragraphs **5o(1)** through **5o(4).**

8. HOW TO GET REFERENCED DOCUMENTS.

a. Order RTCA documents from RTCA Inc., 1828 L Street NW, Suite 805, Washington, D.C. 20036. Telephone (202) 833-9339, fax (202) 833-9434. You can also order copies online at www.rtca.org.

b. Order copies of 14 CFR part 21 from the Superintendent of Documents, Government Printing Office, P.O. Box 979050, St. Louis, MO 63197. Telephone (202) 512-1800, fax (202) 512-2250. You can also order copies online at www.access.gpo.gov. Select "Access," then "Online Bookstore." Select "Aviation," then "Code of Federal Regulations."

c. You can find a current list of technical standard orders and advisory circulars on the FAA Internet website Regulatory and Guidance Library at http://rgl.faa.gov/. You will also find the TSO Index of Articles at the same site.



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APPENDIX 1. MINIMUM PERFORMANCE STANDARD FOR GROUND BASED AUGMENTATION SYSTEM POSITIONING AND NAVIAGATION EQUIPMENT

This appendix prescribes the MPS for GBAS equipment for AEC C and equipment using the GBAS Positioning Service. The applicable standard is RTCA/DO-253C, *Minimum Operational Performance Standards for GPS Local Area Augmentation System Airborne Equipment*, dated December 16, 2008, section 2. We modified it as follow:

1. Except as modified by appendix 2 of this TSO, for all RTCA/DO-253C references to RTCA/DO 246(), use RTCA/DO-246B, *GNSS-Based Precision Approach Local Area Augmentation System (LAAS) Signal-In-Space Interface Control Document (ICD)*, dated November 28, 2001.

2. Page 35, section 2.3.6.4.1, ***modify*** Table 2-7 and the note under the table as highlighted below (rest of section unchanged):

Table 2-7 GPS Tracking Constraints for DD DLL Discriminators

Region (see Figure 2-3)	3 dB Pre-correlation bandwidth, BW	Average Correlator Spacing (d_1 and $2d_1$) [C/A chips]	Instantaneous Correlator Spacing (d_1 and $2d_1$) [C/A chips]	Differential Group Delay	Applicable AEC
1	(-50*x)+12 <BW≤7 MHz	0.1-0.2	0.09-0.22	≤ 600 ns – $D_A - D_C$	C
	2<BW≤7 MHz	0.2-0.6	0.18-0.65		
2	(-50*x)+12<BW≤(133.33*x)+2.667 MHz	0.07-0.085	0.063-0.094	≤ 150 ns – $D_A - D_C$	C & D
	(-50*x)+12<BW≤14MHz	0.085-0.1	0.077-0.11		
	7<BW≤14 MHz	0.1-0.24	0.09-0.26		
3	14<BW≤16 MHz	0.1-0.24	0.09-0.26	≤ 150 ns – $D_A - D_C$	C & D
	(133.33*x)+2.667<BW≤16MHz	0.085-0.1	0.077-0.11		

Note (1): D_A *is the differential group delay contribution of the antenna through the output of the pre-amp.* D_C *is the differential group delay contribution of the installation specific connection between the antenna and the PAN equipment.*

Note (2): x *denotes the average correlator spacing for* d_1 *in C/A chips.*

3. Page 49, section 2.3.8.1.3, ***add*** a new paragraph g. to the list of conditions as follows:

g) The distance (slant range) between the aircraft and the GBAS reference point is less than the maximum GBAS usable distance, if the maximum GBAS usable distance (D_{max}) is provided in the Type 2 message being used *[LAAS-281]*.

4. Page 57, section 2.3.9.5, ***replace*** the differential correction magnitude check, δPR_i equation as follows:

$$\delta PR_i \equiv PRC_i + RRC_i*(t - t_{zcount}) + TC_i$$

5. Page A-6, ***replace*** the Maximum Use Distance (Dmax) definition as follows:

Maximum Use Distance (Dmax) – the maximum distance from the GBAS reference point for which the integrity is assured.

6. If a manufacturer elects to provide the authentication capability in its equipment as specified in section 2.3.7.3 of RTCA/DO-253C, the equipment shall also perform the differential correction magnitude check in section 2.3.9.5.

NOTE: There are additional sections of RTCA DO-246D that are applicable when VDB authentication is implemented. These are specified in appendix **2**.

7. Summary of TSO changes relative to DO-253C.

LAAS Requirement Designator [LAAS-xxx]	Change Status from DO-253C
093	Changed
123	Changed
281	Changed
351 and 352	New application (see item 6 above)

APPENDIX 2. MINIMUM PERFORMANCE STANDARD FOR GNSS-BASED PRECISION APPROACH LOCAL AREA AUGMENTATION SYSTEM (LAAS) SIGNAL-IN-SPACE INTERFACE CONTROL DOCUMENT (ICD)

This appendix prescribes the interface control document for GBAS as it applies to AEC C for this TSO. The applicable standard is RTCA/DO-246B, *GNSS-Based Precision Approach Local Area Augmentation System (LAAS) Signal-in-Space Interface Control Document,* dated November 28, 2001. We modified it as follows:

1. Page 22, ***replace*** the ephemeris CRC bit order of transmission in section 2.4.3.2. *Message Type 1 parameters*, ***with*** the updated definition in the latest revision, RTCA/DO-246D, dated December 16, 2008, section 2.4.3.2.

NOTE: This change reorders the bits of the ephemeris CRC from their previous transmission order of r1, r2, r3, r4 … r16, where r1 is the least significant bit and bit r16 is the most significant bit, to r9, r10, r11 … r16, followed by r1, r2, … r8, where r9 and r1 are the first bits of each byte into the bit scrambler. This change is not backwards compatible with the existing standard. The change was adopted for compatibility with a significant number of current implementations of ground equipment and avionics. This change affects [LAAS-107], [LAAS-117], [LAAS-118], and [LAAS-214]. Other changes to RTCA/DO-246B, reflected in RTCA/DO-246D, to support the newly incorporated GBAS Approach Service Type D are not relevant for this TSO and should not be implemented.

2. Appendix A, ***replace*** appendix A, *Cyclic Redundancy Checks (CRCs),* ***with*** RTCA/DO-246D, appendix A.

3. Page B-2, ***replace*** Table B-1 *Example of Type 1 Message,* ***with*** RTCA/DO-246D, Table B-1.

4. Page B-4, ***replace*** Table B-2 *Example of Type 1 and Type 2 Messages in One Burst* ***with*** RTCA/DO-246D, Table B-2.

5. Page B-7, ***replace*** Table B-3 *Example of Type 4 Message* ***with*** RTCA/DO-246D, Table B-4 as modified below for the runway number valid range.

The valid range for runway number is 0-36.

6. Page B-10, ***replace*** Table B-4 *Example of Type 5 Message* ***with*** RTCA/DO-246D, appendix B, Table B-6, *Example of Type 5 Message*.

7. If a manufacturer elects to provide the authentication capability in its equipment as specified in section 2.3.7.3 of RTCA/DO-253C, the following paragraphs from RTCA DO-246D, dated 16 December 2008 are applicable:

a. *Message Type 2, Additional Data Block 4, VDB Authentication Parameters* description and Table 2-16 in DO-246D, section 2.4.4.1, pages 33 and 35.

b. *Message Type 3 – Null Message* and Table 2-17 *Format of Message Type 3* in DO246D, section 2.4.5, page 37.

c. *Reference Path Identifier* in DO-246D, section 2.4.6.4, page 53.

8. Summary of RTCA/DO-253C requirements affected by our modifications to DO-246B.

Appendix 2 Item number	**LAAS Requirement Designator [LAAS-xxx]**
1	**107, 117, 118, 214**
2	**Editorial**
3	**Editorial**
4	**Editorial**
5	**Editorial**
6	**Editorial**
7	**328, 329, 330 and 331**