English Translation Version for Reference Only

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China Civil Aviation Technical Standard Order

This China Civil Aviation Technical Standard Order (CTSO) is issued according to Part 37 of the China Civil Aviation Regulations (CCAR-37). Each CTSO is a criterion which the concerned aeronautical materials, parts or appliances used on civil aircraft must comply with when it is presented for airworthiness certification.

Airborne Navigation Sensors Using The Global Positioning System Augmented By The Satellite Based Augmentation System (SBAS)

1. Purpose.

This China Civil Aviation Technical Standard Order (CTSO) is for manufacturers applying for airborne navigation sensors using the global positioning system (GPS) augmented by the satellite based augmentation system (SBAS) CTSO authorization (CTSOA). This CTSO prescribes the minimum performance standards(MPS) that airborne navigation sensors using the GPS augmented by the SBAS must first meet for approval and identification with the applicable CTSO marking.

2. Applicability.

This CTSO affects new application submitted after its effective date.

Major design changes to article approved under this CTSO will require a new authorization in accordance with section 21.353 of CCAR-21R4.

3. Requirements

New models of airborne navigation sensors using the GPS augmented by the SBAS identified and manufactured on or after the effective date of this CTSO must meet the MPS qualification and documentation requirements for functional equipment Class Beta in RTCA, Inc. document RTCA/DO-229E, *Minimum Operational Performance Standards for Global Positioning System/Satellite-Based Augmentation System Airborne Equipment* dated December 15, 2016, Section 2.1. Class Beta equipment is defined in RTCA/DO-229E, Section 1.4 and Appendix 2 adds a new section 1.8.3.

Note: Manufacturers have the option to use the RTCA/DO-229E change described in Appendix 3. The change is based on a past commonly granted deviation.

a. An alternate method for applicants is to apply for CTSO-C145e using their existing approved design data plus additional substantiation data showing compliance with the changes in RTCA/DO-229E. The three areas where requirements changed are: 1) expanding the SBAS pseudorandom noise (PRN) codes (i.e., PRN range of 120 thru 158); 2) ensuring a graceful degradation to GPS-only operations; and, 3) prohibiting use of the broadcast Navigation Message Correction Table.

Note 1: It is not necessary for applicants to re-submit previously approved deviations. Previously approved deviations, and any limitations,

will apply to the CTSO-C145e CTSOA.

Note 2: Applicants with Class 1 and 2, revision ‘b’ equipment must not have claimed the 3db broadband intrasystem noise credit.

b. CTSO-C145e applicants have the option to use a CTSO-C204a SBAS CCA functional sensor. Applicants choosing to use a CTSO-C204a SBAS CCA can take certification compliance credit by virtue of the CTSO-C204a CTSOA for:

- Meeting the MPS section 2.1 requirements;
- The hardware/software qualification;
- The failure condition classification; and,
- MPS section 2.5 performance testing (functional qualification) except those specified in Appendix 1 of this CTSO.

c. The CTSO-C145e applicant using a CTSO-C204a SBAS CCA functional sensor shall perform the testing described in Appendix 1 and satisfy the remaining paragraphs in this CTSO not covered by the bullets above to receive a CTSO-C145e CTSOA.

Note: The end-use manufacturer using a CTSO-C204a SBAS CCA functional sensor as part of their CTSO-C145e application assumes full responsibility for the design and function under their CTSO-C145e authorization.

d. Functionality.

This CTSO’s standards apply to equipment intended to provide

position, velocity, time information for a navigation management unit application that outputs deviation commands keyed to a desired flight path, or a non-navigation application such as automatic dependent surveillance-broadcast (ADS-B) or terrain awareness and warning system (TAWS). In navigation applications, pilots or autopilots will use the deviations output by the navigation management unit to guide the aircraft. In non-navigation applications, the position, velocity, time outputs will provide the necessary input for the end-use equipment. These TSO standards do not address integration issues with other avionics.

e. Failure Condition Classifications.

(1) Failure of the function defined in paragraph 3.d resulting in misleading information for en route, terminal, approach lateral navigation (LNAV), and approach LNAV/vertical navigation (VNAV) position data is a Major failure condition.

(2) Failure of the function defined in paragraph 3.d resulting in misleading information for approach localizer performance without vertical guidance (LP), and approach localizer performance with vertical guidance (LPV) position data is a Hazardous failure condition.

(3) Loss of the function defined in paragraph 3.d for enroute through approach LP/LPV position data is a Major failure condition.

(4) Design the system to at least these failure condition classifications.

f. Functional Qualification.

(1) Demonstrate the required functional performance under the test conditions specified in RTCA/DO-229E, Section 2.5, or

(2) When using a CTSO-C204a SBAS CCA functional sensor, demonstrate the required performance under the test conditions in appendix 1 of this CTSO.

g. Environmental Qualification.

Demonstrate the required performance under the test conditions specified in RTCA/DO-229E, Section 2.4 using standard environmental conditions and test procedures appropriate for airborne equipment. RTCA/DO-229E requires the use of RTCA/DO-160E, *Environmental Conditions and Test Procedures for Airborne Equipment*, dated December 9, 2004, Sections 4.0 through 8.0 and 10.0 through 25.0. You may use a different standard environmental condition and test procedure than RTCA/DO-160E, provided the standard is appropriate for the SBAS sensor.

Note1: The use of RTCA/DO-160D (with Changes 1 and 2 only, incorporated) or earlier versions is generally not considered appropriate and will require substantiation via the deviation process as discussed in paragraph 3.k of this CTSO.

Note 2: Applicants using a CTSO-C204a SBAS CCA sensor must perform the environmental qualification with the SBAS CCA in the

end-use equipment.

h. Software Qualification.

If the article includes software, develop the software according to RTCA/DO-178C, *Software Considerations in Airborne Systems and Equipment Certification*, dated December 13, 2011, including referenced supplements as applicable, to at least the software level consistent with the failure condition classification defined in paragraph 3.e of this CTSO. The applicant may also develop the software according to RTCA/DO-178B, dated December 1, 1992.

(2) Applicants using a CTSO-C204a SBAS CCA sensor may use CTSO-C204a as substantiation for the software qualification.

i. Electronic Hardware Qualification.

If the article includes complex custom airborne electronic hardware, develop the component according to RTCA/DO-254, dated April 19, 2000, *Design Assurance Guidance for Airborne Electronic Hardware*, to at least the design assurance level consistent with the failure condition classification defined in paragraph 3.e of this CTSO. For custom airborne electronic hardware determined to be simple, RTCA/DO-254, paragraph 1.6 applies.

(2) Applicants using a CTSO-C204a SBAS CCA sensor may use CTSO-C204a as substantiation for the hardware qualification.

j. Barometric-aided Fault Detection and Exclusion (FDE).

If the equipment uses barometric-aiding to enhance FDE availability, then the equipment must meet the requirements in RTCA/DO-229E, appendix G.

k. Deviations.

For using alternative or equivalent means of compliance to the criteria in this CTSO, the applicant must show that the equipment maintains an equivalent level of safety. Apply for a deviation under the provision of 21.368(a) in CCAR-21R4.

4. Marking.

a. Mark at least one major component permanently and legibly with all the information in 21.423(b) of CCAR-21R4. 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 CTSO number:

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

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

c. If the article includes software and/or airborne electronic hardware, then the article part numbering scheme must identify the software and

airborne electronic hardware configuration. The part numbering scheme can use separate, unique part numbers for software, hardware, and airborne electronic hardware.

d. The applicant may use electronic part marking to identify software or airborne electronic hardware components by embedding the identification within the hardware component itself (using software) rather than marking it on the equipment nameplate. If electronic marking is used, it must be readily accessible without the use of special tools or equipment.

e. At least one major component must be permanently and legibly marked with the operational equipment class (for example, Class 2) as defined in RTCA/DO-229E, Section 1.4.2.

5. Application Data Requirements.

The applicant must furnish the responsible certification personnel with the related data to support design and production approval. The application data include a statement of conformance as specified in section 21.353(a)(1) in CCAR-21R4 and one copy each of the following technical data:

a. A Manual(s) containing the following:

(1) Operating instructions and equipment limitations sufficient to describe the equipment’s operational capability.

(2) Describe in detail any deviations.

(3) Installation procedures and limitations sufficient to ensure that the SBAS sensor, when installed according to the installation or operational procedures, still meets this CTSO'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 CTSO. Installation of this article requires separate approval."

(4) For each unique configuration of software and airborne electronic hardware, reference the following:

(a) Software part number including revision and design assurance level;

(b) Airborne electronic hardware part number including revision and design assurance level;

(c) Functional description.

(5) 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-160G, *Environmental Conditions and Test Procedures for Airborne Equipment*, Appendix A.

(6) Schematic drawings, wiring diagrams, and any other documentation necessary for installation of the SBAS sensor.

(7) List of replaceable components, by part number, that makes up the SBAS sensor. Include vendor part number cross-references, when applicable.

(a) If the equipment can satisfy the requirements of RTCA/DO-229E only when used with a particular antenna, make the use of that antenna (by part number) a requirement on the installation. Include this requirement in the installation manual (IM) as a limitation.

(b) If the equipment is installed with a standard antenna, include maximum tolerable currents and voltages into the antenna port. See CTSO-C144a, Passive Airborne Global Navigation Satellite System (GNSS) Antenna, applicable only to operational Class 1 equipment, or CTSO-C190, Active Airborne Global Navigation Satellite System (GNSS) Antenna, applicable to all equipment operational classes.

b. Instructions covering periodic maintenance, calibration, and repair, for the continued airworthiness of the SBAS sensor. Include recommended inspection intervals and service life, as appropriate.

c. If not using a CTSO-C204a SBAS functional sensor and the article includes software: a plan for software aspects of certification (PSAC), software configuration index, and software accomplishment summary.

d. If not using a CTSO-C204a SBAS functional sensor and the article includes simple or complex custom airborne electronic hardware: a

plan for hardware aspects of certification (PHAC), hardware verification plan, top-level drawing, and hardware accomplishment summary (or similar document, as applicable).

e. A drawing depicting how the article will be marked with the information required by paragraph 4 of this CTSO.

f. Adequate specifics on the interface between the SBAS sensor and other systems to ensure proper functioning of the integrated system. If the equipment depends on any external inputs (like baro-aided FDE) to satisfy the requirements of RTCA/DO-229E, make those inputs a requirement in the installation. Include this requirement in the IM as a limitation.

g. If the software qualification limits eligibility of the equipment to certain aircraft types, identify the qualification level, and that the equipment is not eligible for all aircraft types. For example, RTCA/DO-178B (or RTCA/DO-178C) Level C software may be associated with a hazardous failure condition for certain aircraft types. Identify other limitations applicable to the failure condition classification, for example, that two installed units are necessary.

h. If the equipment has not been demonstrated as compatible with satellite communications (SatCom) record in the limitations section that the equipment should not be installed in SatCom equipped aircraft.

i. Identify functionality or performance contained in the article not

evaluated under paragraph 3 of this CTSO (that is, non-CTSO functions). Non-CTSO functions are accepted in parallel with the CTSO authorization. For those non-CTSO functions to be accepted, you must declare these functions and include the following information with your CTSO application:

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

(2) Installation procedures and limitations sufficient to ensure that the non-CTSO function(s) meets the declared functions and performance specification(s) described in paragraph 5.i.(1).

(3) Instructions for continued performance applicable to the non-CTSO function(s) described in paragraph 5.i.(1).

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

(5) Test plans, analysis and results, as appropriate, to verify that performance of the hosting CTSO article is not affected by the non-CTSO function(s).

(6) Test plans, analysis and results, as appropriate, to verify the

function and performance of the non-CTSO function(s) as described in paragraph 5.i.(1).

(7) Alternatively, identify non-CTSO functionality or performance contained in the article not evaluated under paragraph 3 and submit previously accepted data for the non-CTSO function for acceptance in parallel with this CTSO application.

j. The quality system description required by section 21.358 of CCAR-21R4, including functional test specifications. The quality system should ensure that it will detect any change to the approved design that could adversely affect compliance with the CTSO MPS, and reject the article accordingly.

k. Material and process specifications list.

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

m. Manufacturer's CTSO qualification report showing results of testing accomplished according to paragraph 3.f of this CTSO.

6. Manufacturer Data Requirements.

Besides the data given directly to the authorities, have the following technical data available for review by the authorities:

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

b. Equipment calibration procedures.

c. Schematic drawings.

d. Wiring diagrams.

e. Material and process specifications.

f. The results of the environmental qualification tests conducted according to paragraph 3.g of this CTSO.

g. If the article includes software, the appropriate documentation defined in the version of RTCA/DO-178 or RTCA/DO-178C specified by paragraph 3.h of this CTSO, including all data supporting the applicable objectives in Annex A, Process Objectives and Outputs by Software Level.

h. If the article includes complex custom airborne electronic hardware, the appropriate hardware life cycle data in combination with design assurance level, as defined in RTCA/DO-254, Appendix A, Table A-l. For simple custom airborne electronic hardware, the following data: test cases or procedures, test results, test coverage analysis, tool assessment and qualification data, and configuration management records, including problem reports.

i. If not using CTSO-C204a, all the data necessary to evaluate the geo stationary (GEO) satellite bias as defined in RTCA/DO-229E, Section 2.1.4.1.5.

j. If the article contains non-CTSO function(s), the applicant must

also make available items 6.a through 6.h as they pertain to the non-CTSO function(s).

7. Furnished Data Requirements.

a. If furnishing one or more articles manufactured under this CTSO to one entity (such as an operator or repair station), provide one copy or technical data and information specified in paragraphs 5.a and 5.b of this CTSO. Add any data needed for the proper installation, certification, use, or for continued compliance with the CTSO, of the SBAS sensor.

b. If the article contains declared non-CTSO function(s), include one copy of the data in paragraphs 5.i.(1) through 5.i.(4).

8. Availability of Referenced Documents.

Order RTCA documents from:

Radio Technical Commission for Aeronautics, Inc.

1150 18th Street NW, Suite 910, Washington D.C. 20036

You may also order them online from the RTCA Internet website at:

www.rtca.org.

APPENDIX 1. END-USE EQUIPMENT MANUFACTURER TESTS FOR SBAS CCA FUNCTIONAL POSITION, VELOCITY, TIME (PVT) SENSORS USED FOR NAVIGATION AND NON-NAVIGATION APPLICATIONS

1. Scope.

This appendix describes the required supplementary equipment level testing, in addition to the environmental testing of RTCA/DO-229E, section 2.4, required by the end-use equipment manufacturer to receive a CTSO-C145e Class Beta authorization when using a CTSO-C204a SBAS CCA functional sensor. These test procedures are intended to streamline and simplify the CTSO-C145e authorization process for the end-use equipment manufacturer by allowing credit for the design and selected testing done at the SBAS CCA functional sensor level. However, the end-use equipment manufacturer retains full responsibility for the design and control of the article per their CTSO-C145e CTSOA.

2. General Principles.

(a) Testing methods for GPS/SBAS equipment have been standardized by RTCA/DO-229E and serve as the basis for CTSO-C145e. RTCA/DO-229E was written with the perspective of equipment that can be installed on aircraft. Section 2.4 specifically addresses the issues of the environment in which the equipment operates and provides approved test methods to validate performance in this environment. Section 2.4

represents RTCA consensus in identifying which RTCA/DO-229E requirements are sensitive to environmental effects. These requirements are listed in the environmental tables referenced in section 2.4.1.

(b) The determination that a MOPS requirement is susceptible to the environment does not depend on whether or not the implementation is a CCA within some host equipment. This is the same concept as an equipment enclosure designed to protect against a benign environment compared to one designed for a severe environment; the identification of susceptible requirements is the same.

(c) Therefore this appendix uses the tables of RTCA/DO-229E, section 2.4.1 to identify the MOPS requirements susceptible to environmental affects for an SBAS CCA functional sensor in the end-use equipment. The focus is on the change in environment seen by the SBAS CCA functional sensor as a result of its installation in the end-use equipment. For example, other components inside the end-use equipment may radiate RF energy that could interfere with the GPS functions; therefore the ambient testing done at CCA level is not equivalent to tests done in the end-use equipment. This is the basis for defining the RTCA/DO-229E, section 2.5 performance tests that need to be repeated by the end-use equipment manufacturer.

(d) The Class Beta environmental table referenced in RTCA/DO-229E, section 2.4.1 are the prime source to determine the

MOPS performance requirements susceptible to environmental conditions. Based on the table, the susceptible requirements can be grouped in two categories: those susceptible to most types of environmental conditions (described in section 3) and those susceptible to just a few (described in section 4).

Note: The Tables for Class Beta-1, -2, and -3 equipment identify similar requirements susceptible to the installed environment. The only difference is the applicable MOPS requirements consistent with the operational class (i.e., class -1, - 2, or -3).

3. Performance Requirements Susceptible to Most Environmental Conditions.

The RTCA/DO-229E requirements for Accuracy (2.1.3.1, 2.1.4.1, and 2.1.5.1) and Sensitivity and Dynamic Range (2.1.1.10) are sensitive to most environmental conditions. However, these requirements are linked to the message loss rate requirement in 2.1.1.3.2. Section 3.1 and 3.2 below identifies the testing end-use equipment manufacturers are required to repeat to demonstrate the SBAS CCA functional sensor continues to meet the Accuracy, Dynamic Range, and Message Loss Rate performance requirements after installation in the end-use equipment. All tests will be run under conditions where the end-use equipment functions are fully enabled to create the worst-case environment.

3.1 RTCA/DO-229E, 2.5.8 Accuracy Test.

(a) The accuracy test described in section 2.5.8 is actually a joint test covering both accuracy, and sensitivity and dynamic range. This joint testing also applies under environment as stated in section 2.4.1.1.5 with environmental adaptation as described in section 2.4.1.1.1.

(b) The demonstration of accuracy is done in accordance with section 2.5.8.1 only for the test case with a broadband external interference noise. This test must be repeated when the CCA is installed in the end-use equipment and it is sufficient to perform it using broadband interference.

(1) The environmental testing is limited to broadband interference as it represents the worst case signal to noise condition which is the most sensitive to environmental effects. This applies equally to the environment for the CCA created by the end-use equipment.

(2) Section 2.5.8 contains a measurement accuracy test in 2.5.8.1 with the detailed test procedure in 2.5.8.2. The 2.5.8.1 test must be run under the worst case environment identified in the “Additional considerations for internal interference sources” section below. The measurement accuracy testing can be combined with the message loss rate testing in 2.5.2.1.

(3) Section 2.5.8.3 is a 24-Hour actual satellite accuracy test. The section 2.5.8.3 test exposes the equipment to a variety of signal conditions and data processing conditions over varying satellite geometry

that will increase confidence that no unforeseen interactions between components within the end-use equipment and the SBAS CCA functional sensor goes undetected. The 24 hr testing in 2.5.8.3 can be combined with the 24 hr message loss rate testing in 2.5.2.4 (see Additional Considerations for Internal Interference Sources section).

(4) Section 2.5.8.4 (SBAS Tracking Bias) is an analysis of the GPS hardware and is therefore not necessary to repeat at the end-use equipment level as long as no extra RF components that affect the RF filtering response are inserted in the RF path. Otherwise the end-use equipment manufacturer must repeat the SBAS Tracking Bias test as well.

(c) The test threshold is relaxed from 110% to 125% as specified in table 2-25 of the 2.5.8.2.1 test procedure to shorten test time. However, Section 2.5.8 testing (excluding the SBAS Tracking Bias test in 2.5.8.4) for the CCA in the end-use equipment shall be under ambient conditions per section 2.5 with the 110% test pass threshold for maximum test sensitivity.

(d) The Section 2.5.8 testing (excluding the SBAS Tracking Bias test in 2.5.8.4) will be repeated against the accuracy requirement consistent with the desired operational class (i.e., 2.1.3.1, 2.1.4.1, and 2.1.5.1 accuracy requirements as appropriate).

(e) Only the broadband external interference noise test case using

minimum satellite power will be executed in most cases to shorten test time. Section 2.5.8.1 testing will be repeated for both minimum and maximum satellite power for the worst case environment only.

3.2 RTCA/DO-229E, 2.5.2 Message Loss Rate Test.

(a) Section 2.5.2 specifies the message loss rate test for the 2.1.1.3.2 message loss rate requirement. This test is conducted in conjunction with the 2.5.8 accuracy testing. Section 2.5.2.2 defines the test procedure to collect data verifying the SBAS message loss rate in the presence of interference using the test cases where the SBAS satellite is at minimum power. Section 2.5.2.3 defines the pass/fail criteria.

(b) The test in section 2.5.2.2 will be performed during the measurement accuracy broadband interference test case described in paragraph 3.1.

(c) The test procedure in section 2.5.2.4.1 is run in conjunction with the 2.5.8.3 24-hour accuracy test. Section 2.5.2.4.2 defines the pass/fail criteria for the test case described in paragraph 3.1(b)(3).

4. Performance Requirements Partially Susceptible to Environmental Conditions.

(a) The class Beta tables (tables 2-14, 2-16, and 2-18) in section 2.4.1 of RTCA/DO- 229E indicates the requirements for Initial Acquisition Time (2.1.1.7) and Satellite Reacquisition Time (2.1.1.9) are sensitive to four environmental conditions: Icing, Lightning Induced

Transient Susceptibility, Lightning Direct Effects, and Normal/Abnormal Operating Conditions. The requirements for Loss of Navigation (2.1.1.13.2, 2.1.4.12.2, and 2.1.5.12.2) and Loss of Integrity (2.1.1.13.1, 2.1.4.12.1, and 2.1.5.12.1) are sensitive to low and high operating temperature.

(b) The Lightning Induced Transient Susceptibility, Lightning Direct Effects, or Icing environmental conditions are not pertinent to the environment created by the end-use equipment relative to the SBAS CCA functional sensor. However, the end-use equipment manufacturer remains responsible for meeting the overall environmental qualification at the end-use equipment level.

(c) Loss of navigation and loss of integrity indications are limited to temperature testing and the information in RTCA/DO-229E, sections 2.4.1.1.2 and 2.4.1.1.3 is appropriate. The purpose is to ensure that the interface used to indicate the loss of navigation is functional under environmental conditions after the SBAS CCA functional sensor is installed in the end-use equipment. Sections 2.4.1.1.2 and 2.4.1.1.3 indicate that any source that generates the indication can be used since it is the interface and not the detection mechanism that is verified. The temperature testing done at the end-use equipment level is the worst-case scenario. It is not necessary to repeat the CCA level test at room temperature in the end-use equipment since the environmental

qualification adequately addresses testing for these requirements.

(d) RTCA/DO-160E section 16 relates to aircraft power supply (refer to TSO paragraph 3.g for environmental qualification requirements). Sections 16.5.1.2 and 16.6.1.2 are for supply voltage modulation (ac) /ripple (dc). Given the potential susceptibility of the SBAS CCA functional sensor to power supply noise, it is prudent to repeat tests at the end-use equipment level on this basis.

(e) Sections 4.1 and 4.2 identify the testing end-use equipment manufacturers are required to repeat to demonstrate the SBAS CCA functional sensor continues to meet the Acquisition Time and Reacquisition Time performance requirements relative to Normal/Abnormal Operating Conditions after installation in the end-use equipment. All tests will be run under conditions where the end-use equipment functions are fully enabled to create the worst-case environment.

4.1 2.5.4 Initial Acquisition Test Procedures.

The information in RTCA/DO-229E, section 2.4.1.1.4 on the initial acquisition test in section 2.5.4 applies. The end-use equipment manufacturer shall repeat the initial acquisition testing described in RTCA/DO-229E, section 2.5.4.

4.2 2.5.6 Satellite Reacquisition Time Test.

The end-use equipment manufacturer is required to repeat the

Satellite Reacquisition Time testing in RTCA/DO-229E, section 2.5.6.

5. Additional Considerations for Internal Interference Sources.

(a) Installing a SBAS CCA functional sensor into end-use equipment that also includes other functions requires careful evaluation of potential internal radiated and conducted interference. The end-use equipment manufacturer must evaluate each operating mode to determine if the mode changes the environment for the installed SBAS CCA functional sensor. If there is only one environment or there is clearly one worst case environment, then the accuracy and message loss rate testing in section 3 can be run in that operating mode only. For example, if the end-use equipment includes an RF transmitter that radiates at one frequency; one could reasonably argue that setting the transmitter at full power with maximum data throughput will generate a clear worst-case environment in which to run all testing.

(b) In the case of multiple environments, the accuracy and message loss rate tests can either be run under each environment or the methodology in RTCA/DO-229E, section 2.4.1.2.3 can be used to run an aggregate with approximately equal time in each mode. The methodology in section 2.4.1.2.3 must be used to identify modes of greatest susceptibility under which the combined accuracy and message loss rate are repeated in addition to the aggregate test. For example, the 2.4.1.2.3 methodology is appropriate for end-use equipment that contains a high

power transmitter operating on a large number of frequencies such that it is impractical to run a test at each frequency. This is analogous to the large number of frequencies that need to be tested during RTCA/DO-160E RF and Induced Signal Susceptibility testing and is the reason why the section 2.4.1.2.3 methodology was developed.

(c) It is sufficient to identify one worst case environment when performing acquisition and 24 hour accuracy testing.

6. Summary.

(a) The end-use equipment manufacturer that incorporates an SBAS CCA functional sensor is required to repeat the following RTCA/DO-229E, section 2.5 testing under ambient conditions (see section 5) after installing the SBAS CCA functional sensor in the end-use equipment:

- The section 2.5.8 Accuracy (excluding the SBAS Tracking Bias test in 2.5.8.4) adapted per section 2.4.1.1.1 except that the 110% test pass threshold is used.

  Note: Excluding the SBAS Tracking Bias test is acceptable, provided the end-use equipment does not insert in the RF signal path, components that affect the filtering response. Otherwise the end-use equipment manufacturer must repeat the SBAS Tracking Bias test as well.

- The section 2.5.2 Message Loss Rate Test.

- The section 2.5.4 Initial Acquisition Test.
- The section 2.5.6 Satellite Reacquisition Time Test.

(b) The end-use equipment manufacturer remains responsible for completing a full environmental qualification evaluation (see CTSO paragraph 3.g) at the end-use equipment level. The end-use equipment manufacturer that incorporates an SBAS CCA functional sensor is required to repeat Loss of Navigation indication and Loss of Integrity indication as part of the environmental qualification according to RTCA/DO-229E, sections 2.4.1.1.2 and 2.4.1.1.3 respectively.

APPENDIX 2. ADDITIONs TO RTCA/DO-229E.

This appendix describes required modifications and additions to RTCA/DO-229E for compliance with this CTSO. This appendix adds a new section 1.8.3 on cybersecurity and GPS spoofing mitigation and corrects a long-standing mistake in the section 2.4 environmental requirements tables.

The new section 1.8.3 contains no new requirements but provides information for cybersecurity and spoofing mitigation to make RTCA/DO-229E consistent with the new RTCA MOPS template and RTCA/DO-253D.

1.8.3 Cybersecurity and Spoofing Mitigation.

This section contains information to address intentional interference to the GPS. Spoofing is caused by RF waveforms that mimic true signals in some ways, but deny, degrade, disrupt, or deceive a receiver's operation when they are processed. Spoofing may be unintentional, such as effects from the signals of a GPS repeater, or may be intentional and even malicious. There are two classes of spoofing. Measurement spoofing introduces RF waveforms that cause the target receiver to produce incorrect measurements of time of arrival or frequency of arrival or their rates of change. Data spoofing introduces incorrect digital data to the target receiver for its use in processing of signals and the calculation of PNT. Either class of spoofing can cause a range of effects, from incorrect

outputs of PNT to receiver malfunction. The onset of effects can be instantaneous or delayed, and the effects can continue even after the spoofing has ended. Improperly used or installed GNSS re-radiators act like spoofers. Re-radiators replay and GNSS emulator devices can present misleading information to GNSS equipment and/or could cause lasting effects.

Equipment manufacturers should implement measures to mitigate processing of erroneous data. Cross-checks of GNSS sensor data against independent position sources and/or other detection monitors using GNSS signal metrics or data checks can be implemented in the antenna, receiver, and/or through integration with other systems at the aircraft level. Data validity checks to recognize and reject measurement and data spoofing should be implemented in the receiver. Additional guidance and best practices related to GPS equipment can be found in the U.S. Department of Homeland Security document “Improving the Operation and Development of Global Positioning System (GPS) Equipment Used by Critical Infrastructure”1 and IS-GPS-200 Revision H, IRN003 28 July 2016. RTCA/DO-326A and ED-202A along with RTCA/DO-355 and ED-204 may also be useful to assess vulnerabilities and identify mitigations.

Aircraft equipment information vulnerabilities (such as cybersecurity risks) have been present for digital systems since the

development of the personal computer (PC) in the late 70's and even longer for RF systems, and the advent of internet connectivity has substantially increased those risks. Typically, access to navigation receivers has been controlled such that they are considered vulnerable only through RF signals and OEM and/or aircraft operator controlled processes for maintenance and update. In some cases, aircraft GNSS receivers may be field loadable by approved personnel, requiring physical access and physical interface to the ground receivers. However, it is expected that not all aircraft in the future will rely on such physical isolation for the security of avionics. Internet and Wi-Fi connectivity have become popular as a means for aircraft or equipment manufacturers to update installed avionics software, to update databases, or provide an alternate means of communicating with the flight crew or cabin (e.g., in-flight entertainment, weather, etc.).

In most countries, the State provides oversight of safety-of-flight systems (sometimes referred to as "authorized services") which provide information to aircraft, such as ILS, VOR, GNSS, and DME, to name a few. However, the State typically does not provide oversight on "non-trusted"2 connectivity such as the internet, Wi-Fi, or manufacturer-supplied equipment interfaces which permit input of externally-supplied data into aircraft systems. A manufacturer may expose aircraft information vulnerability through equipment design, or

become vulnerable as a result of being connected to a common interface. Therefore, it is important that manufacturers consider aircraft information security risk mitigation strategies in their equipment design, particularly when the equipment is responsible for an interface between the aircraft and aircraft-external systems.

Apart from any specific aircraft-information-security-related performance requirements that are contained in the MOPS, it is recommended that manufacturers look at a layered approach to aircraft information security risk mitigation that includes both technical (e.g., software, signal filtering) and physical strategies. From a technical perspective, for example, this could include signal spoofing detection capabilities or more stringent, multi-factored authentication techniques such as passwords, PINs, and digital certificates. From a physical perspective, a manufacturer could consider connectors that require special tools to remove to prevent passenger tampering; although, navigation avionics are typically located in an avionics bay inaccessible to passengers. And finally, but just as important, manufacturers should consider supply chain risk management; for example, if a manufacturer is outsourcing software code development, is the contractor and its staff properly vetted?

Civil Aviation Authorities (CAAs) have a regulatory interest when an applicant’s design makes use of a non-trusted connectivity where the

installation can potentially introduce aircraft information security vulnerability. This requires the applicant to address not only the information security vulnerabilities and mitigation techniques for the new installation, but to also consider how vulnerability could propagate to existing downstream systems. Additionally, aircraft manufacturers should consider establishing appropriate procedures for aircraft operators to maintain security protection of the equipment during the life of the equipment installation in the aircraft. Therefore, it is recommended that manufacturers reference their equipment aircraft information security review and mitigation strategies so that the applicants can consider them, if necessary, in meeting the installation regulatory requirements.

Table 2-14 through Table 2-20.

The tables incorrectly reference and label RTCA/DO-160 sections 16.5.1.2 and 16.6.1.2 regarding “2.1.1.7 Acquisition Time” and “2.1.1.9 Reacquisition Time.” Change the table references as follows:

The MOPS Initial Acquisition Time requirement (2.1.1.7) applies to both AC and DC equipment under abnormal operating condition (DO-160E section 16.5.2 and 16.6.2) and the Satellite Reacquisition Time requirement (2.1.1.9) applies to both AC and DC equipment under normal operating condition (DO-160E section 16.5.1 and 16.6.1).

APPENDIX 3. OPTIONAL CHANGES TO RTCA/DO-229E ADDRESSING COMMON DEVIATION REQUESTS.

This appendix describes a potential change to RTCA/DO-229E based on deviations commonly granted in the past. Manufacturers have the option to use this change to the specified section in RTCA/DO-229E. Using this option to RTCA/DO-229E should reduce the need for deviation requests.

2.1.5 Requirements for LPV and LP Approach Operations

Add the following note after the paragraph:

Note: It is acceptable for manufacturers to not implement LP approach capability in their equipment provided the equipment has an appropriate limitation and LP approaches are not available for selection by the pilot.