English Translation Version for Reference Only

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Approved by：Xu Chaoqun

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.

Circuit Card Assembly Functional Sensors using Satellite-Based Augmentation System (SBAS) for Navigation and Non-Navigation Position/Velocity/Time Output

1. Purpose.

This China Civil Aviation Technical Standard Order (CTSO) is for manufacturers applying for Satellite-Based Augmentation System (SBAS) Circuit Card Assembly (CCA) Functional Sensor CTSO authorization (CTSOA). This CTSO prescribes the minimum performance standards(MPS) that Circuit Card Assembly Functional Sensors using SBAS CCA for Class Beta position/velocity/time (PVT) 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-21-R4.

3. Requirements

New models of SBAS CCA functional sensors identified and manufactured on or after the effective date of this CTSO must meet the MPS qualification and documentation requirements in RTCA, Inc. Document No. RTCA/DO-229E, “Minimum Operational Performance Standards for Global Positioning System/Satellite-Based Augmentation System Airborne Equipment,” dated December 15, 2016, Section 2.1. Functional class Beta and the operational classes are defined in RTCA/DO-229E, section 1.4 and Appendix 1 adds a new section 1.8.3.

Note: Manufacturers have the option to use the RTCA/DO-229E change described in Appendix 2. The change is based on a past commonly granted deviation.

a. Functionality.

(1) This CTSO’s standards apply to equipment intended to provide PVT 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)). 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 PVT outputs will provide the necessary capability for the end-use equipment.

(2) CTSO-C204a equipment has a limitation requiring the end-use

manufacturer to receive a CTSO-C145e CTSOA. To receive a CTSO-C145e CTSOA, the end-use equipment manufacturer is required to repeat selected performance tests in the end-use equipment and perform the environmental qualification tests in RTCA/DO-229E. These limitations must be documented in the installation/instruction manual (see paragraph 5.a).

b. Failure Condition Classifications.

(1) Failure of the function defined in paragraph 3.a resulting in 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.a resulting in 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.a for en route through approach LP/LPV position data is a Major failure condition.

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

c. Functional Qualification. Demonstrate the required functional performance under the test conditions specified in RTCA/DO-229E, Section 2.5.

d. Environmental Qualification. None. The SBAS CCA functional sensor has a limitation requiring environmental qualification by the end-use equipment manufacturer at the end-use equipment level.

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, or RTCA, Inc. document 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.b of this CTSO.

f. 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.b of this CTSO. For custom airborne electronic hardware determined to be simple, RTCA/DO-254, paragraph 1.6 applies.

Note: Applicants should refer to AC 20-152 (latest revision) for guidance on implementing RTCA/DO-254.

g. 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.

h. 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-21-R4.

4. Marking.

a. Mark at least one major component permanently and legibly with all the information in 21.423(b) of CCAR-21-R4. 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. The SBAS CCA functional sensor 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-21-R4 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 CCA functional sensor, when installed according to the

installation or operational procedures, still meet this CTSO's requirements. Limitations must identify any unique aspects of the installation. The limitations must include a note with the following statement:

(a) "Equipment manufacturers using the <insert equipment model> SBAS CCA functional sensor for navigation or non-navigation end-use applications are required to receive a CTSO-C145e CTSOA. The end-use equipment manufacturer is required to perform the testing described in CTSO-C145e appendix 1 with the SBAS CCA functional sensor installed in the end-use equipment to receive a CTSO-C145e authorization."

(b) "End-use equipment manufacturers are required to complete full environmental qualification at the end-use equipment level."

(c) "This article meets the minimum performance and quality control standards required by a China civil aviation technical standard order (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; and,

(c) Functional description.

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

(6) List of replaceable components, by part number, that makes up the SBAS CCA functional 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 can satisfy the requirements of RTCA/DO-229E 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 CCA functional sensor. Include recommended inspection intervals and service life, as appropriate.

c. If the article includes software: a plan for software aspects of

certification (PSAC), software configuration index, and software accomplishment summary.

d. If 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 CCA functional sensor and other systems to ensure proper functioning of the integrated system. This includes information on environmental characteristics necessary for reliable operation after integration such as maximum and minimum operating temperature of the SBAS CCA. 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.

h. If the equipment has not been demonstrated as compatible with satellite communications (SatCom) state in the limitations 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, the applicant must declare these functions and include the following information with 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) don’t 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-21-R4, 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.c 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. If the article includes software, the appropriate documentation defined in RTCA/DO-178B specified in paragraph 3.f of this CTSO, including all data supporting the applicable objectives in RTCA/DO-178B Annex A, Process Objectives and Outputs by Software Level.

g. 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.

h. 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).

i. All the data necessary to evaluate the geo stationary (GEO)

satellite bias as defined in RTCA/DO-229E, Section 2.1.4.1.5.

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 CCA functional 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. ADDITIONs TO RTCA/DO-229E.

This appendix adds a new section 1.8.3 on cybersecurity and GPS spoofing mitigation to RTCA/DO-229E. The new section 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 2. OPTIONAL CHANGES TO RTCA/DO-229E ADDRESSING COMMON DEVIATION REQUESTS.

This appendix describes changes to RTCA/DO-229E based on deviations commonly granted in the past. Manufacturers have the option to use these changes to the specified sections in RTCA/DO-229E. Implementing these changes 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 last 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.