# Certification Authorities for Transport Airplanes (CATA)

## CATA Worklist Item (CWI) FAA-03 – CNS Guidance Harmonization

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|---|---|---|---|---|
| Date Raised: | 12-July-2017 | Updated: 29 October 2019 | Status: | **Open** |
| | | | | |
| Subject: | **Communication, Navigation, and Surveillance (CNS) Guidance Harmonization** | | | |
| | | | | |
| Related Issue(s): (Identify Discussion Paper number, if any) | CATA Action Item 2017-12, raised during the 17 May meeting in Renton. | | | |

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**Description of Issue(s)**:
(Give a brief background of issue(s))

NextGen avionics technologies have complex and evolving standards. Although equipment standards (i.e., ED-/DO- documents) as well as TSO/ETSO equipment requirements are generally harmonized, the installation guidance may not be.

**Background:**

The FAA developed a NextGen Avionics Guidance Summary table to assist FAA ACOs in certification of NextGen technologies. The FAA proposed, and the CATA accepted during the May 17 CATA meeting, a proposal to form a quadrilateral SME group to evaluate the FAA summary table with the aim of identifying differences in the listed guidance and the impact of those differences on applicants seeking certification with multiple authorities. Where differences are identified, the SME group will evaluate the potential impact of those differences on installation-level certification of the associated technologies, and seek either harmonization, or clear definition of enveloped requirements to support global acceptance.

**Proposed Prioritization:**
(Per CATA Technical Issues List Prioritization schema, SME proposes along with authority CATA members)

| Question | Answer |
|---|---|
| 1. Is there an active working group related to this issue? | No. Working groups for equipment standards only (i.e., ED-/DO- documents used in the development of TSO/ETSO equipment requirements). None for the installation issues addressed by this CWI. |
| 2. In which documents are there deviations amongst the authorities? | Installation guidance (i.e., AMCs/ACs) |
| 3. Was this issue raised by or at the CMT? | No |
| 4. What is the level of impact on projects in the future (i.e. minor, major, critical)? | Major/Critical |
| 5. How many authorities does the issue impact? | Will depend on each authority's initiatives (i.e., SESAR) or other operational goals. |
| 6. What is the approximate technical complexity of the issue (i.e. low, medium, high)? | High |

**Recommendation:**
(SME proposes expected resolution of the issue)

The targeted outcome of this activity is to update the FAA summary table noted in the Background section to include associated CMT partner authority requirements and harmonization status. From this reference point the SME team will identify appropriate harmonization tasks, if any, and ultimately document in a suitable vehicle (to be proposed by the SME team) the enveloped set of requirements necessary to support global acceptance.

**CATA Decision**:
(Using CATA criteria for determination of technical issues)

As noted in the Background section the CATA accepted this tasking at the May 2017 meeting.

## Interim CATA Position:

(Explain agreement, dissent or conclusion on this CWI)

Release of the entire avionics technology guidance summary, including the completed Surveillance portion with added "Enveloped Requirements to Comply with all Authorities" completed. The summary table is appended directly to this CWI form.

This action represents an interim step toward closure of the CWI. Additional interim releases will be considered by the CATA as the Navigation, Communication, and other components of the analysis are completed.

## Interim Release of CWI:

| CATA Representative | Name | Signature | Date |
|---|---|---|---|
| ANAC | Marcelo Leite<br>Daniel Pessoa | /s/ | 03.01.2020 |
| EASA | Colin Hancock<br>Mathilde Labatut | /s/ | 09.12.2019 |
| FAA | Tom Groves | /s/ | 04.12.2019 |
| TCCA | Canh Nham | /s/ | 04.12.2019 |

## Final CATA Position:

(Explain agreement, dissent or conclusion on this CWI)

OPEN

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## Navigation

| Enabler | Description | Guidance | | Notes |
|---|---|---|---|---|
| **RVSM** | Ability to fly more fuel efficient flight levels and on more user preferred routings | ANAC | IS Nº 91-005, IAC-3508-91-0895 and FAA AC 91-85A | |
| | | EASA | CS-ACNS — BOOK 1 — Subpart E, Section 2 | |
| | | FAA | AC 91-85A (operational) | |
| | | TCCA | AC 700-039 (operational) | |
| **Required Navigation Performance (RNP) 10 (also called RNAV 10 in ICAO PBN Manual)** | Reduced oceanic separation | ANAC | FAA AC 20-138D Chg. 2 / ANAC IS Nº 91-001 (operational) | |
| | | EASA | CS-ACNS issue 2 Subpart C (Note: AMC 20-12 is obsolete with publication of CS-ACNS issue 2) | |
| | | FAA | AC 20-138D Chg 2 / AC 90-105A & "RNP 10 Through Data Collection" (operational) | Order 8400.12C cancelled May 2016. Guidance incorporated into AC 90-105A and Online Booklet, *RNP 10 through Data Collection* . |
| | | TCCA | FAA Order 8400.12C | |
| **Basic Area Navigation (B-RNAV) (RNAV 5)** | Implementation of Basic RNAV operations within European designated Airspace | ANAC | FAA AC 20-138D Chg. 2 / ANAC IS Nº 91-001 (operational) | |
| | | EASA | CS-ACNS issue 2 Subpart C (Note: AMC 20-4A is obsolete with publication of CS-ACNS issue 2) | |
| | | FAA | AC 20-138D Chg 2 / AC 90-96A (operational) | European operations only, but addressed in AC 20-138D Chg 2 / AC 90-96A. |
| | | TCCA | AC 700-015 (operational) / FAA AC 90-96A (operational) / EASA AMC 20-4A | |
| **RNAV 1, RNAV 2** | Enables more efficient routes and procedures | ANAC | FAA AC 20-138D Chg. 2 / ANAC IS Nº 91-001 (operational) | |
| | | EASA | CS-ACNS issue 2 Subpart C | |
| | | FAA | AC 20-138D Chg 2 / AC 90-100A (operational) | |
| | | TCCA | AC 700-019 (operational) | |
| **RNP 4** | Further reduced oceanic separation (in conjunction with Future Air Navigation System (FANS 1/A) | ANAC | FAA AC 20-138D Chg. 2 / ANAC IS Nº 91-001 (operational) | |
| | | EASA | CS-ACNS issue 2 Subpart C | |
| | | FAA | AC 20-138D Chg 2 / AC 90-105A (operational) | Order 8400.33 cancelled May 2016. Guidance incorporated into AC 90-105A. |
| | | TCCA | AC 700-006 (operational) | |
| **RNP 2** | Reduced continental separation | ANAC | FAA AC 20-138D Chg. 2 / ANAC IS Nº 91-001 (operational) | |
| | | EASA | CS-ACNS issue 2 Subpart C | |
| | | FAA | FAA AC 20-138D Chg. 2 / AC 90-105A (operational) | |
| | | TCCA | AC 700-038 (operational) | Enroute Continental |
| **RNP 1** | RNP routes for connectivity between the en route structure and terminal airspace | ANAC | FAA AC 20-138D Chg. 2 / ANAC IS Nº 91-001 (operational) | |
| | | EASA | CS-ACNS issue 2 Subpart C (Note: JAA TGL-10 is obsolete with publication of CS-ACNS issue 2) | |
| | | FAA | AC 20-138D Chg 2 / AC 90-105A & AC 90-96A (operational) | P-RNAV for European operations (addressed in AC 90-96A). RNP 1 addressed in AC 20-138D Chg 2 / AC 90-105A. RNP 1 aircraft with P-RNAV approval based on GPS capability meet the functional requirements for RNP 1 operations. |
| | | TCCA | AC 700-025 (operational) / FAA AC 90-96A | |
| **RNP-APCH** | Better access to runways that are not equipped with precision approach and landing systems | ANAC | FAA AC 20-138D Chg. 2 / ANAC IS Nº 91-001 (operational) | |
| | | EASA | CS-ACNS issue 2 Subpart C (Note: AMC 20-27A is obsolete with publication of CS-ACNS issue 2) | |
| | | FAA | FAA AC 20-138D Chg. 2 / AC 90-105A (operational) | |
| | | TCCA | AC 700-023 (operational) / EASA AMC 20-27 | |
| **RNP Authorization Required (AR) Approaches** | Improves access to airports in reduced visibility with an approach that can curve to the runway; improves procedures to separate traffic flows | ANAC | FAA AC 20-138D Chg. 2 / ANAC IS Nº 91-001 (operational) | |
| | | EASA | CS-ACNS issue 2 Subpart C (Note: AMC 20-26 is obsolete with publication of CS-ACNS issue 2) | |
| | | FAA | AC 20-138D Chg 2 / AC 90-101A (operational) | |
| | | TCCA | AC 700-024 (operational) | |
| **Advanced RNP** | Enables more accurate and predictable flight paths for enhanced safety and efficiency | ANAC | FAA AC 20-138D Chg. 2 / ANAC IS Nº 91-001 (operational) | |
| | | EASA | CS-ACNS issue 2 Subpart C | |
| | | FAA | AC 20-138D Chg 2, TSO-C115d / AC 90-105A (operational) | Includes RF Legs |
| | | TCCA | ICAO Document 9613 PBN Manual | |
| **Vertical Path Conrol for Non-Precision Approaches** | Stabilized approach to help eliminate CFIT | ANAC | | |
| | | EASA | | |
| | | FAA | AC 120-108 (operational) | |
| | | TCCA | AC 700-028 (operational) | |
| | | ANAC | | |
| | | EASA | | |

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## Navigation

| Enabler | Description | Guidance | | Notes |
|---|---|---|---|---|
| **FMS Baro-VNAV Temperature Compensation (below 0 deg C or below ISA)** | Ensures obstacle and terrain clearance during approach with temperatures below 0 deg C or below ISA | FAA | | |
| | | TCCA | AC 500-020, RTCA DO-236 / AC 700-028 (operational) | AC 500-020 - 4.1 New/Updated FMS Designs Incorporating Barometric VNAV Approach Capability<br>(1) New or updated FMS designs shall provide a means for an aircraft to fly the true vertical path angle for final approach segment, as defined in the resident navigation database, in below ISA temperature conditions. The FMS equipment shall also provide the capability to temperature compensate all waypoints from the Initial Approach Fix to the Missed Approach Holding Point (known as the Missed Approach Holding Waypoint for RNAV procedures) inclusive, as coded in the navigation database. The FMS shall also provide a means for determining a temperature compensated MDA/DA, when the MDA/DA is entered by the pilot.<br>(2) Temperature compensation may be applied for airport temperatures “below ISA” or “below 0°C”. The latter has been included to be consistent with the existing Nav Canada operational procedures as described in CAP GEN. |
| **Vertical Navigation (VNAV)** | Enables defined climb and descent paths | ANAC | FAA AC 20-138D Chg. 2 / ANAC IS Nº 91-001 (operational) | |
| | | EASA | CS-ACNS issue 2 Subpart C (Note: AMC 20-27A is obsolete with publication of CS-ACNS issue 2) | CS-ACNS Subpart C resulting from NPA 2018-02 |
| | | FAA | AC 20-138D Chg 2 / AC 90-105A (operational) | AC 20-138D, paragraph 11-1.b, provides guidance for newly installed Baro-VNAV systems incorporating automated temperature compensation for all segments in the approach procedure, including the missed approach holding waypoint. Newly installed Baro-VNAV systems not incorporating automated temperature compensation require an evaluation of procedures for manual altitude corrections, effect on crew workload and protections from erroneous altitude entries to show compliance with §§ 25.1301, 25.1302 and 25.1523. |
| | | TCCA | | |
| **Localizer Performance with Vertical Guidance (LPV)** | Improved access to many airports in reduced visibility with an approach aligned to the runway | ANAC | FAA AC 20-138D Chg 2 | |
| | | EASA | CS-ACNS issue 2 Subpart C (Note: AMC 20-28 is obsolete with publication of CS-ACNS issue 2) | CS-ACNS Subpart C resulting from NPA 2018-02 |
| | | FAA | AC 20-138D Chg 2 / AC 90-107 (operational) | FAA should be notified about any project related to applicants requesting to use DO-178C Level C flight management system (FMS) software for hazardous operations (e.g., localizer performance with vertical guidance (LPV) capability). |
| | | TCCA | EASA AMC 20-28 | |
| **Trajectory Operations** | Enhances PBN capabilities | ANAC | FAA AC 20-138D Chg 2 | |
| | | EASA | TBD | |
| | | FAA | AC 20-138D Chg 2, TSO-C115d | |
| | | TCCA | | |
| **Alternative Position, Navigation, and Timing (APNT)** | Provides GNSS-independent APNT capability | ANAC | TBD | |
| | | EASA | TBD | |
| | | FAA | TBD | |
| | | TCCA | | |

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## Surveillance

| Enabler | Description | Guidance | | Notes | Enveloped Requirements to Comply with all Authorities |
|---|---|---|---|---|---|
| **Mode S - Elementary Surveillance (ELS) (European Mandate)** | Enables improved air traffic surveillance | ANAC | FAA AC 20-151C | | Follow CS-ACNS - Subpart D - Section 2<br>NOTE: The FAA will remove from AC 20-151C reference to JAA TGL 13 (addressed in CS-ACNS) at the next opportunity. The FAA accepts the guidance noted above. |
| | | EASA | CS-ACNS - Subpart D - Section 2, ETSO-C112d | Mandated by EU No 1207/2011, 1028/2014 (amendment), & 2017/386 (amendment). | |
| | | FAA | AC 20-151C | AC references JAA TGL 13 Rev. 1/CS-ACNS | |
| | | TCCA | | | |
| **Mode S - Enhanced Surveillance (EHS) (European Mandate)** | Enables improved air traffic surveillance | ANAC | FAA AC 20-151C | | Follow CS-ACNS - Subpart D - Section 3 supplemented with AC 20-151C Section 2.3.10 & Appendix F (for populating) and B.21 (for testing) Vertical Intention Register.<br>NOTE: The FAA will remove from AC 20-151C reference to AMC 20-13 (addressed in CS-ACNS) at the next opportunity. The FAA accepts the guidance noted above. |
| | | EASA | CS-ACNS - Subpart D – Section 3, ETSO-C112d | Mandated by EU No 1207/2011, 1028/2014 (amendment), & 2017/386 (amendment). | |
| | | FAA | AC 20-151C | AC references AMC 20-13/CS-ACNS | |
| | | TCCA | | | |
| **Automatic Dependent Surveillance Broadcast (ADS-B) in Non-Radar Areas (NRA)** | Enhanced ATS in Non-Radar Areas using ADS-B Surveillance | ANAC | | | Follow AMC 20-24<br>-Does not provide the means to comply with EASA EU No. 1207/2011, 1028/2014 (amendment), & 2017/386 (amendment) or FAA 14 CFR 91.225 & 91.227. |
| | | EASA | AMC 20-24, ETSO-2C112b (ED-73B) | Does not provide the means to comply with the rules set forth in the EU No 1207/2011, 1028/2014 (amendment), & 2017/386 (amendment). | |
| | | FAA | | | |
| | | TCCA | | | |
| **ADS-B Out** | Enables improved air traffic surveillance and automation processing | ANAC | FAA AC 20-165B | An IP is no longer required with release of FAA AC 20-165B. ADS-B Out is not mandatory in Brazilian airspace yet. There is an offshore region (Rio de Janeiro) where there is a implemented ground infrastructure to allow the ADS-B use for space control purposes. After November 08th 2018 only aircrafts equipped with ADS-B out will be allowed to fly within such airspace. | To comply with all authorities:<br>-Install 1090 ES ADS-B Out data link.<br>-GNSS based position source with ETSO/TSO-129a (SA-aware) as a minimum (for FAA operations, TSO-C129/C196 GPS units covered by FAA exemption 12555 with AFM limitation if SA-unaware).<br>-The same position source for navigation, should be used for ADS-B or standalone ETSO/TSO-C145c/C146c (or later), RTCA DO-229D (or later) operational class 1, 2, or 3 GNSS receiver connected to the transponder.<br>-Installation should include antenna diversity.<br>-Include all parameters and meet all minumum values as specified in "Values to Comply with All Authorities," ref. the App. A-ADS-B Out Parameters Tab.<br>-Continuity with probability of remote or Ref. EASA Deviation to CS ACNS.D.ADSB.105 to not meet a 'remote' quantitative probability requirement (1E-5/FH) if the installation meets the requirements of EU No 1207/2011 by having a continuity equal to or less than 2E-4/FH and the equipment supporting the ADS-B functionality is DAL C (meets remote qualitative probability).<br>-Meet test and evaluation criteria inc. flight test (as required) per AC 20-165B Chapter 4.<br>-Meet continuing airworthiness requirements per AC 20-165B Chapter 2.3.<br>-Meet the more demanding criteria (either CS-ACNS or AC 20-165B) ref. red requirements in App. B-ADS-B Out Guidance Comp. Tab which includes a comparison of the two guidance documents |
| | | EASA | CS-ACNS - Subpart D - Section 4, ETSO-C166b/ETSO-C112d | Mandated by EU No 1207/2011, 1028/2014 (amendment), & 2017/386 (amendment). Reference CS-ACNS Appendix J for significant differences between EASA CS-ACNS and FAA AC 20-165A guidance. | |
| | | FAA | AC 20-165B / AC 90-114A Chg 1 (operational), TSO-C166b/TSO-C154c, Policy Memos AIR100-15-140-DM30 & AIR100-15-140-DM37, Policy Memo AFS-360_2016-03-02 & Order N 8900.362, Policy Memo AIR100-15-130-PM10, & Policy Memo, AIR-100-14-130-GM27 | Mandated by 14 CFR 91.225 & 91.227.<br><br>Reference: https://www.faa.gov/nextgen/equipadsb/installation/equipment/ for FAA approved v2 ADS-B Out avionics.<br><br>For FAA operations only: TSO-C129 and TSO-C196 GPS receivers are covered by FAA Exemption 12555. For the use of Selective Availability (SA) unaware (unaware of the current status of SA (deactivated)) GPS units in ADS-B Out installations, which requires use of the ADS-B Service Availability Prediction Tool (pre-flight availability verification tool that predicts the ability of an aircraft to meet the requirements of 14 CFR 91.227(c)(1)(i) and (iii) along a given route of flight), this would require an update to the AFM limitations to ensure that ADS-B operations are not commenced or continued unless satellite availability for the route has been confirmed using the FAA SAPT tool. | |
| | | TCCA | AC 700-009 (operational) / FAA AC 20-165B / EASA AMC 20-24 & CS-ACNS / AIP CANADA (ICAO) Part 2 Enroute (ENR) Section 1.6.3 | ADS-B is not being mandated in Canada in the near term. It is acknowledged that ADS-B technology will supplement the current ground-based radar surveillance system and may eventually replace it to some extent, however, the intent of not mandating the ADS-B system is to allow owners and operators to volunteer their participation in a surveillance system where NAV CANADA will offer ADS-B and to benefit from its advantages.<br><br>All aircraft that emit position information using a 1090 MHz extended squitter (1090ES) may be provided surveillance separation services, provided they meet the airworthiness compliance requirements defined in:<br>1. EASA AMC 20-24; or<br>2. EASA CS ACNS; or<br>3. FAA 14 CFR 91.227 or AC 20-165A (or replacement); or<br>4. Configuration standards reflected in Appendix XI of Civil Aviation Order 20.18 of the Civil Aviation Safety Authority of Australia.<br><br>ADS-B Out systems that are unable to meet the above requirements must disable ADS-B transmission unless:<br>1. the aircraft always transmits a value of 0 (zero) for one or more of the position quality indicators (NUCp, NIC, NAC or SIL); or<br>2. the operator has received an exemption from NAV CANADA.<br><br>This is essentially what TCCA will certify to and depends somewhat on how extensively the applicant wants the system certified. For strictly North American operations it will likely just be FAA and follow AC 20-165B. If the aircraft will be operated in Europe as well then it will probably be a combination of FAA and EASA. | |

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## Surveillance

| Enabler | Description | Guidance | | Notes | Enveloped Requirements to Comply with all Authorities |
|---|---|---|---|---|---|
| **Space-based ADS-B Out** | Enables global air traffic surveillance and automation processing | ANAC | | | TBD - Designed to function with the following avionics:<br>-RTCA DO-260B (EUROCAE ED-102A) MOPS for 1090 MHz Extended Squitter ADS-B, Class A1: 125 W with two antennas (top antenna required for satellite coverage).<br>Note – Almost all commercial aircraft equipage is ≥ 200 W.<br>- System accommodates other existing and future ADS-B message standards: DO-260 (Link Version 0), DO-260A (Link Version 1), and DO-260C (under development).<br>-Not designed to support 978 MHz Universal Access Transceiver (UAT).<br>-(Proposal in Canada) Include all parameters as specified in "Values to Comply with All Authorities," ref. the App. A-ADS-B Out Parameters Tab. |
| | | EASA | | | |
| | | FAA | | | |
| | | TCCA | TBD | Nav Canada is a partner on the Aerion Space Based ADS-B system using ADS-B receivers on Iridium satellites to provide global ADS-B coverage.. | |
| **ADS-B In - Airborne/Ground Cockpit Display of Traffic Information (CDTI)** | Improves awareness of other traffic | ANAC | FAA AC 20-172B | | Follow AC 20-172B |
| | | EASA | TBD, ETSO-C195b | ADS-B In isn't covered by EPAS 2018-2022. | |
| | | FAA | AC 20-172B, TSO-C195b / 90-114A Chg 1 (operational) | If an aircraft installation includes ADS-B In without ADS-B Out, the airplane won't be able to receive ADS-R or TIS-B data. The airplane will only be able to get direct ADS-B traffic (air-to air) via 1090 MHz link and FIS-B data, because they won't be able to broadcast (via ADS-B Out) their ADS-B In capability (FAA only provides TIS-B and ADS-R to aircraft that indicate they are ADS-B In capable). The only time the aircraft may receive TIS-B and ADS-R is if they are close to an ADS-B Out aircraft and can "borrow" their ADS-R/TIS-B data. | |
| | | TCCA | FAA AC 20-172B | | |
| **ADS-B In - In-Trail Procedure (ITP)** | Improves oceanic in-trail climb/descent | ANAC | FAA AC 20-172B | | Follow AC 20-172B |
| | | EASA | TBD, ETSO-C195b | ADS-B In isn't covered by EPAS 2018-2022. | |
| | | FAA | AC 20-172B, TSO-C195b / 90-114A Chg 1 (operational) | | |
| | | TCCA | FAA AC 20-172B | | |
| **ADS-B In - ADS-B Traffic Advisory System (ATAS)** | Displays and alerts crew to airborne conflicts independent of Traffic Alert and Collision Avoidance System (TCAS) | ANAC | FAA AC 20-172B | Where alerts are integrated, the recommendations from FAA AC 20-172B have been followed. | Follow AC 20-172B |
| | | EASA | TBD, ETSO-C195b | ADS-B In isn't covered by EPAS 2018-2022. | |
| | | FAA | AC 20-172B, TSO-C195b / 90-114A Chg 1 (operational) | | |
| | | TCCA | FAA AC 20-172B | | |
| **ADS-B In – Flight-deck Interval Management (FIM)** | Provides higher performance along-track guidance, control, indications, and alerts for enroute and terminal operations (single runway/coincident routes) | ANAC | TBD | | Follow Future AC 20-172C (TBD) |
| | | EASA | TBD | ADS-B In isn't covered by EPAS 2018-2022. | |
| | | FAA | AC 20-172C (TBD) | For ADS-B In – Interval Management applications, an issue paper should be initiated to establish the method of compliance. | |
| | | TCCA | | | |
| **ADS-B In – Advanced-Interval Management (A-IM)** | Provides guidance information for aircraft participating in paired approaches to closely spaced parallel runways and crossing and converging runways (non-coincident routes). Incorporates | ANAC | TBD | | Follow Future AC 20-172C (TBD) |
| | | EASA | TBD | ADS-B In isn't covered by EPAS 2018-2022. | |
| | | FAA | AC 20-172C (TBD) | For ADS-B In – Interval Management applications, an issue paper should be initiated to establish the method of compliance. | |
| | | TCCA | | | |

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## Communication

| Enabler | Description | Guidance | | Notes |
|---|---|---|---|---|
| **Voice Channel Spacing (VCS) (8.33 KHZ) (European Mandate)** | Increase to the number of available communication channels by splitting the VHF band from 25 kHz to 8.33 kHz spacing | ANAC | | |
| | | EASA | CS-ACNS – Subpart B – Section 1 | ICAO Annex 10, Volume III, Part 2 (up to Amendment No 85). Mandated by IR (EU) 1079/2012. |
| | | FAA | | |
| | | TCCA | CS-ACNS – Subpart B – Section 1 | |
| **Satellite Voice Communications** | Provides voice communication for oceanic and remote operations | ANAC | FAA AC 20-150B | |
| | | EASA | ETSO-C132a, ETSO-C159c | |
| | | FAA | AC 20-150B | |
| | | TCCA | FAA AC 20-150B | |
| **ATN B1 with VDL Mode 2 (European Mandate)** | Provides for domestic data link clearances in European airspace | ANAC | FAA AC 20-140C | |
| | | EASA | CS-ACNS – Subpart B – Section 2, ETSO-C160a | Mandated by IR (EU) No 29/2009 and 2015/310. Ref. EPAS 2018-2022 - RMT.0524 |
| | | FAA | AC 20-140C, TSO-C160a, Policy Memo AIR-6B0-17-6B0-DM281 / AC 90-117 (operational) | For the VDL M2 sub-network designator, equipment approved under a previous TSOA (i.e., TSO-C160a (or TSO-C160 with TSO-C160a multi-frequency capabilities) may receive the associated designator. |
| | | TCCA | FAA AC 20-140B | |
| **FANS 1/A+** | Provides for domestic and oceanic data link clearances and surveillance transfer of communications in North Atlantic airspace | ANAC | FAA AC 20-140C | An IP is no longer required with release of FAA AC 20-140C. |
| | | EASA | FAA AC 20-140C | |
| | | FAA | AC 20-140C, TSO-C132a, TSO-C159c, TSO-C160a, Policy Memo AIR-6B0-17-6B0-DM281 / AC 90-117 (operational) | For the SATCOM (Classic Aero & SBD) and VDL M2 sub-network designators, equipment approved under a previous TSOA (i.e., TSO-C132a or earlier revision, TSO-C159c or earlier revision, TSO-C160a (or TSO-C160 with TSO-C160a multi-frequency capabilities), as applicable) may receive the associated designator.<br><br>TSO-C132a, TSO-C159c, and TSO-C160a for the SATCOM and VDR equipment classify the failure of the function as a minor failure condition. However, AC 20-140C specifies that the integrated data comm. system must detect the corruption of a data message and mitigate the undetected corruption of a data message with a DAL commensurate to a major hazard (i.e. Level C).<br><br>Per AC 20-140C no automation for flight plan modification is still acceptable, however, if the aircraft does not include automation (i.e. functional integration) then the applicant will need to demonstrate compliance with both 14 CFR 25.771(a) and 14 CFR 25.1523. However, note that the US intends to allow only FANS 1/A+ (with automation) to operate in the US NAS (Reference AC 90-117 Data Link Communications). |
| | | TCCA | | |
| **Multiple Data Link Capabilities (Multiple Stack)** | Data link system meeting various performance criteria to support ATS (i.e., ATN B1 & FANS 1/A+, ATN B1 & B2, ATN B1 & B2 & FANS 1/A+, B2 & FANS 1/A+) | ANAC | FAA AC 20-140C | |
| | | EASA | CS-ACNS – Subpart B – Section 2 (ACNS.B.DLS.B1.015) covers ATN B1 & FANS 1/A+ | |
| | | FAA | AC 20-140C | |
| | | TCCA | | |
| **Baseline 2** | Provides clearances, terminal information, and Initial Trajectory Operations | ANAC | FAA AC 20-140C | |
| | | EASA | EUROCAE standards ED-228A and ED-229A | RMT.0524 is developing material for CS-ACNS |
| | | FAA | AC 20-140C, TSO-C160a, Policy Memo AIR-6B0-17-6B0-DM281 / AC 90-117 (operational) | For the VDL M2 sub-network designator, equipment approved under a previous TSOA (i.e., TSO-C160a (or TSO-C160 with TSO-C160a multi-frequency capabilities) may receive the associated designator.<br><br>For B2 data link communication systems that do not support Dynamic RNP or Interval Management services, an issue paper should be initiated to establish the method of compliance. |
| | | TCCA | | |
| | | ANAC | FAA AC 20-160A | |
| | | EASA | | |

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## Communication

| Enabler | Description | Guidance | | Notes |
|---|---|---|---|---|
| **Data Link Recording** | Provides guidance for compliance with airworthiness standards for onboard recording of CPDLC | FAA | AC 20-160A | A CVR update for recording of data link communications is required for any newly installed data link system (AC 20-160A/TSO-C177a (or earlier revision)/14 CFR 25.1457 at Amdt. 25-124) unless the date of manufacture for the aircraft and the date of CPDLC design approval (e.g., FANS 1/A) for the make, model, and series of that aircraft is before the effective date of the data link recording rule then data link recording is not required for the life of the aircraft. |
| | | TCCA | | |
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## Low Visibility Operations

| Enabler | Description | Guidance | | Notes |
|---|---|---|---|---|
| **Head-Up Display (HUD)/Instrument Landing System (ILS)** | Reduces minimums at qualifying runways | ANAC | AC 25-11B | ANAC IP has been issued to provide a harmonized guidance for ILS approach CAT II considering FAA AC 20-129A and EASA CS-AWO. |
| | | EASA | CS-AWO, AMC 25-11 (CS-25 Amdt 17) / Future CS-AWO Issue 2 | Ref. NPA 2018-06 |
| | | FAA | AC 25-11B Apdx F, AC 20-191 (TBD), TSO-C210 / AC 120-118, Order 8400.13E (operational) | AC 20-191/120-118 will replace AC 120-28D/120-29A which currently includes guidance for CAT I/II/III and low visibility T/O airworthiness and operational criteria. |
| | | TCCA | FAA AC 25-11B / EASA AMC 25-11 | |
| **Enhanced Flight Vision System (EFVS)** | Uses enhanced flight visibility to continue approach below minimums | ANAC | FAA AC 20-167A | |
| | | EASA | TBD (CRI) / Future CS-AWO Issue 2 | AMC 25-11 (CS-25 Amdt 17) does not provide operational credit. Ref. NPA 2018-06 |
| | Expand operational use of EFVS (for landing) | FAA | AC 20-167A / AC 90-106A (operational) | AC 20-167A includes guidance for EVS, CVS, SVS, EFVS (EVS does not require a HUD and does not provide operational credit; EFVS requires a HUD and provides operational credit).<br><br>With the amendment (25-144) to 14 CFR 25.773 (adding paragraph (e)) effective 3/21/2017, the special conditions for EVS/EFVS are no longer necessary.<br><br>EFVS using a head worn display (HWD) would require a MOC IP. |
| | | TCCA | AC 20-167A / AC 90-106A | |
| **Synthetic Vision Guidance System (SVGS)** | Installation guidance for use of SVGS for decision altitudes as low as 150 ft | ANAC | FAA AC 20-185 | |
| | | EASA | TBD / Future CS-AWO Issue 2 | Ref. NPA 2018-06 |
| | | FAA | AC 20-185A (TBD) | With the amendment (25-144) to 14 CFR 25.773 (adding paragraph (e)) effective 3/21/2017, the special conditions for SVS/SVGS are no longer necessary. |
| | | TCCA | TBD (In progress) | |
| **Ground-Based Augmentation System (GBAS) Landing System (GLS) II/III** | Provides autoland in very low visibility | ANAC | AC 20-138D, TBD | DECEA, that is responsible for the Bazilian airspace control, has been developing and implementing a GBAS station at Galeao Airport in Rio de Janeiro. The GBAS station is working, however, some challenges (ionospheric threat) prevents full use for approach purposes.This is the only GBAS facility in Brazil. |
| | | EASA | TBD / Future CS-AWO Issue 2 | Development of the requirements for the use of GBAS augmented GNSS to support CAT I/II/III operations (EPAS 2018-2022 - RMT.0682 - Implementation of the regulatory needs of the SESAR common projects).<br>CS-AWO Issue 2 resulting from NPA 2018-06 |
| | | FAA | AC 20-138D, AC 20-138E (TBD), AC 20-191 (TBD) / AC 120-118 (operational) | For CAT I/II/III GLS autoland, rollout and/or takeoff an issue paper should be initiated to establish the method of compliance (MOC). AC 20-138D Change 2 provides the guidance for CAT I GLS approach. An issue paper is needed to establish the MOC for CAT II/III GLS approaches. Guidance for CAT II/III will be incorporated into AC 20-191 & 120-118. Guidance for CAT I will be in AC 20-138E. |
| | | TCCA | | |
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**Flight Deck Enhancements**

| Enabler | Description | Guidance | | Notes |
|---|---|---|---|---|
| **Electronic Flight Bag** | Allows electronic access to paper products and other applications. Inclusion is based on intended function. | ANAC | FAA AC 20-173 (Airworthiness) IS 91-002 (Operational) | |
| | | EASA | AMC 20-25 | Opinion 10/2017 - Transposition of provisions on electronic flight bag from ICAO Annex 6 |
| | | FAA | AC 20-173 / AC 120-76D (TBD) (operational) | An IP for Class 3 EFB projects is no longer required. The guidance is covered in AC 20-173/120-76D. Note that an IP for Class 2 EFB provision projects is no longer required if the power disconnect switch is located away from the EFB/PED or cradle. |
| | | TCCA | AC 700-020 (operational) | |
| **FIS-B** | Provides weather and aeronautical information in the cockpit for enhanced situation awareness of flight conditions | ANAC | FAA AC 20-149B, FAA AC 25-11B Apdx G | |
| | | EASA | AMC 25-11 Chapter 7, ETSO-C157b, ETSO-C154c | |
| | | FAA | AC 20-149B, AC 25-11B Apdx G, TSO-C157b, TSO-C154c | |
| | | TCCA | FAA AC 20-149B | |
| **Synthetic Vision Systems** | Displays a synthetic vision image of the external scene topography to the flight crew | ANAC | FAA AC 20-167A | |
| | | EASA | Future CS-AWO Issue 2 | Ref. NPA 2018-06 |
| | | FAA | AC 20-167A / Future AC 20-185A (TBD - will contain all SVS/SVGS guidance. SVS guidance currently published in AC 20-167A will be moved to AC 20-185A) | With the amendment (25-144) to 14 CFR 25.773 (adding paragraph (e)) effective 3/21/2017, the special conditions for SVS/SVGS are no longer necessary. |
| | | TCCA | FAA AC 20-167 | |
| **Airborne Access to System Wide Information Management (AAtS)** | Provide flight crews with access to the System Wide Information Management (SWIM) over non aeronautical frequency band. | ANAC | AC 20-177 | |
| | | EASA | N/A | |
| | | FAA | AC 20-177, TSO-C207a | |
| | | TCCA | | |
| **Airborne Collision Avoidance System (ACAS-X)** | Improves airborne collision avoidance performance with fewer nuisance alerts | ANAC | TBD | |
| | | EASA | TBD | |
| | | FAA | TBD | |
| | | TCCA | | |
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| Parameter | Values to Comply with All Authorities | To Comply with EASA Only | To Comply with TCCA Only* | To Comply with FAA or ANAC Only |
|---|---|---|---|---|
| Length and width of the aircraft | R | R | O | R |
| Latitude and longitude | R | R | R | R |
| Barometric pressure altitude | R | R | R | R |
| Velocity | R | R | O | R |
| TCAS II or ACAS is installed & operating in a mode that can generate resolution advisories | R | R | O | R |
| If a resolution advisory is in effect when an operable TCAS II or ACAS is installed | R | R | O | R |
| Mode 3/A transponder code | R | R | O | R |
| Aircraft Identification (the aircraft's call sign) | R | R | R | R |
| An emergency, radio, communication failure, or unlawful interference indication | R | R | R | R |
| ''IDENT'' indication (SPI) | R | R | R | R |
| Assigned ICAO 24-bit address | R | R | R | R |
| Emitter category | R | R | O | R |
| ADS–B In capability | R | O | O | R |
| Geometric altitude | R | R | O | R |
| Navigation Accuracy Category for Position ($NAC_P$) | R ≥ 8 | R ≥ 7 | R | R ≥ 8 |
| Navigation Accuracy Category for Velocity ($NAC_V$) | R ≥ 1 | R ≥ 1 | O | R ≥ 1 |
| Navigation Integrity Category (NIC) | R ≥ 7 | R ≥ 6 | R | R ≥ 7 |
| System Design Assurance (SDA) | R ≥ 2 | R ≥ 2 | O | R ≥ 2 |
| Source Integrity Level (SIL) | R = 3 | R = 3 | R | R = 3 |
| Version number | R =2 | R =2 | R | R =2 |
| Geometric Vertical Accuracy (GVA) | R | R | O | O |
| Vertical rate | R (if available) | R (if available) | O | O |
| GNSS antenna offset | R | R | O | O |
| Selected altitude | R (if available) | R (if available) | O | O |
| Barometric pressure setting | R (if available) | R (if available) | O | O |
| Selected heading | O | O | O | O |
| | | | | |
| R=Required/O=Optional | | | | |
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*Nav Canada accepts EASA AMC 20-24 non-radar area ADS-B minimum requirements. ADS-B Out is not mandated, but those aircraft so equipped can be better served in the current, ground-based ADS-B coverage area (Hudson Bay, Northeast and Oceanic near Greenland).

ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets.

| **CS-ACNS - BOOK 2 - Subpart D - Section 4 - 1090 MHz Extended Squitter ADS-B Out** | **AC 20-165B - Airworthiness Approval of Automatic Dependent Surveillance - Broadcast Out Systems** |
|---|---|
| **GM1 ACNS.D.ADSB.001 Applicability**<br>With respect to 1090 MHz ES ADS-B Out installations, the material in this section is to a large degree in line with the corresponding FAA AC 20-165A ***[also applies to AC 20-165B]*** material. Differences between the two documents are listed in Appendix J . This guidance may be of use when showing of compliance with both documents is required.<br>The requirements of CS ACNS.D.ADSB fully cover (and exceed) the requirements of AMC 20-24 (Certification Considerations for the Enhanced ATS in Non-Radar Areas using ADS-B Surveillance (ADS-B-NRA) Application via 1090 MHz Extended Squitter). Therefore, aircraft that comply with CS ACNS.D.ADSB also comply with AMC 20-24 but not vice versa.<br>The approval of on-board systems receiving and processing ADS-B messages in support of air-to-air applications is outside the scope of Subpart D section 4.<br>Note: In accordance with EU Regulation No 1207/2011, aircraft having a maximum take off mass greater than 5 700 kg or a maximum cruising true airspeed greater than 128.6 m/s (250 knots) and operating flights as general air traffic in accordance with instrument flight rules in the airspace within the ICAO EUR and AFI regions where EU Member States are responsible for the provision of air traffic services are to be compliant with CS ACNS Book 1 Subpart D section 4. | 1.1.2 Intent of This AC.<br>This AC is primarily intended for installations compliant with the aircraft requirements of Title 14 of the Code of Federal Regulations 14 CFR 91.225 and § 91.227. Airworthiness compliance will be evaluated based on the applicable intended function rule (such as §§ 23.1301, 25.1301, 27.1301, or 29.1301) recognizing that the intended function is to meet the equipment requirements in §§ 91.225 and 91.227. It is possible to receive airworthiness approval for your ADS-B OUT system with a different intended function; however, we strongly discourage this type of installation unless it is in accordance with the criteria for ADS-B OUT in foreign non-radar airspace (for example, Approved Means of Compliance (AMC) 20-24, Certification Considerations for the Enhanced ATS in Non-Radar Areas using ADS-B Surveillance (ADS-B-NRA) Application via 1090 MHZ Extended Squitter). Applicants using this AC to install ADS-B systems that are not compliant with §§ 91.225 and 91.227 must follow all aspects of this AC or propose alternate means, as appropriate, to the Federal Aviation Administration (FAA).<br>1.5.1 (Scope) This AC only addresses the installation of ADS-B OUT systems. Installation guidance for ADS-B IN can be found in the latest version of AC 20-172, Airworthiness Approval for ADS-B In Systems and Applications. Installation guidance for Flight Information Services - Broadcast (FIS-B) can be found in the latest version of AC 20-149, Installation Guidance for Domestic Flight Information Services - Broadcast... |
| AMC1 ACNS.D.ADSB.010 ADS-B Out system approval<br>Equipment Qualification<br>For equipment qualification, refer to AMC1 ACNS.D.ADSB.030 through to AMC1 ACNS.D.ADSB.090.<br>The ADS-B Out functionality should be demonstrated by ground testing, using ramp test equipment where appropriate, that verifies during nominal system operation, the correctness of the aircraft derived surveillance data contained in the ADS-B messages, and the functioning of system monitoring tools/fault detectors including any ADS-B self-test features. | 4.1.1 (Ground Test) System Interface Testing.<br>Verify the installed ADS-B equipment meets its intended function and transmits the appropriate information from each of the interfaced systems (including the position source, barometric altitude source, heading source, TCAS II, pilot interface, etc). Coordinate with local ATC before broadcasting over the air to prevent being a source of interference to ATC or ADS-B IN equipped aircraft in the area. For example, transmitting airborne position reports with simulated airborne altitudes while on the surface will produce false targets for the ATC surveillance systems or airborne ADS-B IN equipped aircraft.<br>4.1.3 (Ground Test) Rule Compliance.<br>Ensure the ADS-B system meets the requirements of § 91.227.<br>4.1.8 (Ground Test) Self Test.<br>Evaluate the ADS-B self-test features (if provided) and failure mode annunciations to ensure the pilot is able to determine whether the system is functioning properly. |
| AMC1 ACNS.D.ADSB.020(a-b) ADS-B Out data parameters<br>During ADS-B Out system installation testing, all the parameters that are broadcast should be demonstrated to be correct for each installed ADS-B transmit unit, i.e. the transmitted data should be in line with the respective source data. | 4.1.3.2 (Ground Test) Parameters.<br>Per § 91.227(d), ensure the following parameters are properly populated and transmitted.<br>4.1.3.2.1 The length and width of the aircraft;<br>4.1.3.2.2 An indication of the aircraft's latitude and longitude;<br>4.1.3.2.3 An indication of the aircraft's barometric pressure altitude;<br>4.1.3.2.4 An indication of the aircraft's velocity;<br>4.1.3.2.5 An indication if TCAS II or ACAS is installed and operating in a mode that can generate resolution advisory alerts;<br>4.1.3.2.6 If an operable TCAS II or ACAS is installed, an indication if a resolution advisory is in effect;<br>4.1.3.2.7 An indication of the Mode 3/A transponder code specified by ATC;<br>4.1.3.2.8 An indication of the aircraft's call sign that is submitted on the flight plan, or the aircraft's registration number, except when the pilot has not filed a flight plan, has not requested ATC services, and is using a TSO-C154c self-assigned temporary 24-bit address ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** ;<br>4.1.3.2.9 An indication if the flightcrew has identified an emergency, radio communication failure, or unlawful interference;<br>4.1.3.2.10 An indication of the aircraft's "IDENT" to ATC;<br>4.1.3.2.11 An indication of the aircraft assigned ICAO 24-bit address, except when the pilot has not filed a flight plan, has not requested ATC services, and is using a TSO-C154c self-assigned temporary 24-bit address ***[CS only recognizes 1090 ES for the ADS-B Out data link]*** ;<br>4.1.3.2.12 An indication of the aircraft's emitter category;<br>4.1.3.2.13 An indication of whether an ADS-B In capability is installed ***[Not required by CS]*** ;<br>4.1.3.2.14 An indication of the aircraft's geometric altitude;<br>4.1.3.2.15 An indication of the Navigation Accuracy Category for Position ($NAC_P$);<br>4.1.3.2.16 An indication of the Navigation Accuracy Category for Velocity ($NAC_V$);<br>4.1.3.2.17 An indication of the Navigation Integrity Category (NIC);<br>4.1.3.2.18 An indication of the System Design Assurance (SDA); and<br>4.1.3.2.19 An indication of the Source Integrity Level (SIL). |

ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets.

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| AMC1 ACNS.D.ADSB.020(a-b) ADS-B Out data parameters (cont.)<br>The Emitter Category, Aircraft Length and Width and GPS Antenna Offset parameters might be either configured as a fixed value during ADS-B Out system installation, or provided via a variable data interface. In both cases ***[AC 20-165B specifies that these parameters be set at installation]*** , during installation, the respective settings should be verified to be correctly set. | 3.2.3.2 (Installation)Aircraft Length and Width.<br>This parameter must be configured during installation...<br>3.2.3.4 (Installation) Emitter Category.<br>Set emitter category per manufacturer instructions...<br>3.8.4.1 (Installation) GNSS Antenna Offset and Position Offset Applied (POA).<br>Although not required to comply with § 91.227 ***[Required by CS]*** , it is highly encouraged for ADS-B equipment manufacturers to provide instructions to installers for setting this parameter and for installers to configure the offset during installation. |
| | |
| | ***Additional Guidance not Addressed in CS-ACNS*** |
| | 4.1.3.4 (Ground Test) Barometric Altitude Accuracy.<br>Validate that the barometric altitude transmitted from the ADS-B system is accurate to within 125 feet. If the aircraft has a transponder installed, you must also validate that the ADS-B barometric altitude matches the transponder barometric altitude. |
| | |
| AMC1 ACNS.D.ADSB.020(a-b) ADS-B Out data parameters (cont.)<br>The ADS-B Horizontal Position System Design Assurance (SDA) parameter indicates the probability of an ADS-B Out system malfunction causing false or misleading position information or position quality metrics to be transmitted. SDA may be pre-set at installation for systems that do not utilise multiple position sources with different design assurance levels, otherwise the system should be capable of adjusting the SDA broadcast parameter to match the position source being employed at the time of transmission. ADS-B transmit equipment that is compliant with AMC1 ACNS.D.ADSB.030 and that is directly connected to a position source compliant with AMC1 ACNS.D.ADSB.070 may set the SDA to 'two' without further analysis. | 3.1.2 (Installation) System Safety Assessment.<br>The ADS-B System Design Assurance (SDA) parameter indicates the probability of an ADS-B system malfunction causing false or misleading position information or position quality metrics to be transmitted. SDA may be preset at installation for systems that do not use multiple position sources with different design assurance levels; otherwise the system must be capable of adjusting the SDA broadcast parameter to match the position source being employed at the time of transmission.<br>3.1.2.1 (Installation)Compliant Architecture.<br>3.1.2.1.1 (Installation) ADS-B equipment that meets the minimum performance requirements of TSO-C166b or TSO-C154c ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** and is directly connected to a position source meeting the minimum performance requirements of any revision of the following TSOs may set the SDA = 2 without further analysis:<br>- TSO-C129 ***[TSO-C129a is the minimum in CS-ACNS]*** , Airborne Supplemental Navigation Equipment Using the Global Positioning System (GPS);<br>- TSO-C145, Airborne Navigation Sensors Using The Global Positioning System (GPS) Augmented By The Satellite Based Augmentation System (SBAS);<br>- TSO-C146, Stand-Alone Airborne Navigation Equipment Using the Global Positioning System (GPS) Augmented By the Satellite Based Augmentation System (SBAS); or<br>- TSO-C196, Airborne Supplemental Navigation Sensors for Global Positioning System Equipment using Aircraft-Based Augmentation. |
| AMC1 ACNS.D.ADSB.020(a-b) ADS-B Out data parameters (cont.)<br>For more complex ADS-B installations, a system safety assessment is required to set the SDA. Basically, the lowest design assurance level of one system in the horizontal position data transmission chain should define the SDA value.<br>Additional guidance material on the required surveillance data parameters are provided in Appendix H Part 1 and Part 2.<br>Appendix H Part 6 provides matrices of the so-called BDS register fields as used by the 1090 ES ADS-B transmit unit to broadcast the ADS-B Out parameters. These matrices detail the ADS-B Out data requirements at data field level for general understanding and in support of integration testing, as appropriate.<br>If installations transmit ADS-B Out data that do not meet some requirements of the Subpart D Section 4, the respective data should only be transmitted with a 'zero' quality indication (if a quality indication is defined in the ADS-B Out transmit system). | 3.1.2.1.2 (Installation) For installations in aircraft with more complex system architectures, a system safety assessment, as described below, is required to set the SDA. Installations of uncertified ADS-B systems must set SDA = 0 with the following exception: experimental category aircraft, including experimental light-sport aircraft (E-LSA) (Part 91 aircraft), may install unapproved equipment and set the SDA in accordance with the equipment manufacturer's installation manual, provided the equipment has a statement of compliance to the performance requirements of § 91.227), from the equipment manufacturer(s).<br>3.1.2.2.1 (Installation) ADS-B systems using position sources not listed in section 3.1.2.1 or systems with intermediary devices such as data concentrators must accomplish a system safety assessment and set the SDA according to the results of the assessment. Systems integrated through a highly integrated data bus architecture must complete the system safety assessment. The system safety assessment must demonstrate that the installed system meets all TSO-C166b or TSO-C154c ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** requirements to set the SDA = 2 or 3. This can be accomplished using the methods, for example, as described in—<br>- AC 25.1309-1(), System Design and Analysis;<br>- AC 23.1309-1(), System Safety Analysis and Assessment for Part 23 Airplanes;<br>- SAE International (SAE) Aerospace Recommended Practice (ARP) 4761, Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment; or<br>- SAE ARP 4754A, Guidelines for Development of Civil Aircraft and Systems.<br>3.1.2.2.2 (Installation) If the system contains different design assurance levels for hardware and software, the worst-case design assurance level should be used. For example, if the hardware assurance level is C, and the software assurance level is B, the SDA would indicate the system has been qualified commensurate with a Major failure condition. If the ADS-B system is integrated with a noncompliant GPS, (for example, a GPS not compliant with §3.1.2.1), the SDA must be set to "0". |
| | |
| | ***Additional Guidance not Addressed in CS-ACNS*** |

ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets.

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| | 3.1.2.3 (Installation) Existing Equipment Design Assurance.<br>The aircraft installation may make use of some equipment certified for use with an existing transponder system. There is no intent for this safety assessment to drive the replacement of existing altimetry, flightcrew controls, heading instruments, or antennas. In contrast, the position source installation must be compliant with the guidance in this AC, including design assurance considerations. |
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| AMC1 ACNS.D.ADSB.025(a) Provision of data — Approved sources<br>(a) See AMC1 ACNS.D.ADSB.070-090 for details on the approval of the respective data sources.<br>(b) For transmission of optional data items, the following provisions should be considered:<br>(1) Airspeed<br>In case of a loss of GNSS horizontal velocity data, the ADS-B transmit unit normally switches to broadcast airspeed information (using subtypes 3 and 4 of register $09_{16}$).<br>Therefore, if airspeed data is provided to the ADS-B transmit unit, it should be provided by an approved airspeed source that is providing data intended for use by the flight crew. An air data computer meeting the minimum performance requirements of holding an EASA equipment authorisation in accordance with ETSO-C106 (JTSO-C106) is an acceptable source.<br>(2) Heading<br>In case of a loss GNSS ground track and if heading is provided to the ADS-B transmit unit, the heading source should hold an EASA equipment authorisation in accordance with ETSO-C5e (JTSO-C5e) or any revision of ETSO-C6d (JTSO-C6d).<br>(3) Other Data Parameters<br>The Intent Change Flag should be set as appropriate to indicate the availability of information in the Mode S registers $40_{16}$ to $42_{16}$.<br>If available, Selected Heading information should come from approved data sources.<br>The 1090 ES IN capability field should be set correctly. | A.2.2 (Parameters) Airspeed.<br>Optionally, true airspeed or indicated airspeed may be transmitted. The airspeed source should be approved to output airspeed data. An air data computer meeting the minimum performance requirements of TSO-C106 is one acceptable source. Do not interface an airspeed source to the ADS-B that has not been approved for cockpit display.<br>3.5 (Installation) Heading Source.<br>3.5.1 (Installation) Equipment Eligibility.<br>For installations that integrate heading on the airport surface, the heading source must meet the minimum performance requirements of any revision of TSO-C5, Direction Instrument, Non-Magnetic (Gyroscopically Stabilized), or any revision of TSO-C6, Direction Instrument, Magnetic (Gyroscopically Stabilized). The equipment must have the appropriate installation and airworthiness approval.<br>3.11.1 (Installation - Foreign Airspace Requirements) Optional Parameters ***[Required by CS if available and in a suitable format]*** .<br>If operations are planned in a country that requires parameters not mandated in the United States, such as selected heading and selected altitude, follow the ADS-B equipment manufacturer's installation guidance to interface those parameters.<br>3.2.3.3 (Installation) ADS-B IN Capability.<br>This parameter must ***[Not required by CS]*** be configured to indicate if the aircraft has an ADS-B IN system installed, and can process ADS-B messages to support at least one ADS-B IN application. For ease of installation, the parameter does not have to indicate the operational status of the ADS-B IN system. If the aircraft has both 1090ES ADS-B IN and UAT ADS-B IN systems installed, both the 1090ES ADS-B IN and UAT ADS-B IN capability should be set accordingly.<br>A.2.1 (Parameters) ADS-B IN Capability.<br>Two messages indicate the ADS-B IN status of the aircraft. The 1090 ADS-B IN message indicates if the aircraft has the ability to receive 1090ES ADS-B messages installed. The UAT ADS-B IN message indicates if the aircraft has the ability to receive UAT ADS-B messages installed. An indication of ADS-B IN capability is important because TIS-B and ADS-R services are provided specific to an aircraft's position relative to other aircraft. The FAA may only provide complete TIS-B and ADS-R services to aircraft that indicate they are ADS-B IN capable.<br>ADS-B IN capability is required to be transmitted by § 91.227 ***[Not required by CS]*** . |
| AMC1 ACNS.D.ADSB.025(c) Provision of data – Data quality indication and associated data<br>Data quality indications for the horizontal position containment bound (NIC) and horizontal position accuracy bound (NACp) should be provided to the ADS-B transmit unit together with the corresponding horizontal position information within the same data set.<br>Data quality indications for the horizontal position source integrity level (SIL) and system design assurance level (SDA) may be preset at installation. Systems that utilise multiple GNSS-based position sources with different design assurance levels or source integrity levels, should be capable of adjusting the SDA and SIL quality indications to match the position source that is employed at the time of transmission.<br>The horizontal velocity accuracy bound (NACv) and vertical geometric altitude accuracy bound (GVA) should be dynamically provided to the ADS-B transmit unit together with the corresponding velocity and geometric altitude information within the same data set. However, NACv and GVA may be also preset at installation.<br>For further guidance on the ADS-B data quality indicators, refer to AMC1 ACNS.D.ADSB.070(a). | 3.1.2 (Installation) System Safety Assessment.<br>…SDA may be preset at installation for systems that do not use multiple position sources with different design assurance levels; otherwise the system must be capable of adjusting the SDA broadcast parameter to match the position source being employed at the time of transmission.<br>3.3.3.3 (Installation) Source Integrity Level (SIL).<br>SIL is typically a static (unchanging) value and may be set at the time of installation if a single type of position source is integrated with the ADS-B system.<br>3.3.3.7 (Installation) Navigation Accuracy Category for Velocity ($NAC_V$).<br>Set the $NAC_V$ based on design data provided by the position source manufacturer. The $NAC_V$ may be updated dynamically from the position source, or set statically based on qualification of the position source.<br>3.3.3.9 (Installation) Geometric Vertical Accuracy (GVA).<br>Set the GVA based on design data provided by the position source manufacturer… |
| AMC1 ACNS.D.ADSB.030 ADS-B Transmit unit installation<br>To be approved, the ADS-B transmit unit should hold an EASA equipment authorisation in accordance with ETSO-C166b and ETSO-C112d, including any additional requirements as required to comply with the provision of the AMC's to Subpart D section 4 (e.g. On-the-ground status determination and maximum NIC encoding). Where such additional requirements apply, it is expected that the ADS-B transmit unit manufacturer supplies compliance information through a Declaration of Design and Performance (DDP), or an equivalent document<br>The broadcast of Selected Altitude and Barometric Pressure Setting are optional for equipment meeting ETSO-C166b and equipment should implement this optional functionality if available and in a suitable format ***[Not required by § 91.227]*** .<br>If using earlier versions of ETSO-C112( ), it should to be demonstrated that all applicable requirements from EUROCAE ED-102A have been implemented. This can be achieved by a positive deviation of compliance to previous versions of EUROCAE ED-73 that have been documented in the Declaration of Design and Performance (DDP). | 3.2.1 (Installation - ADS-B Equipment) Equipment Eligibility.<br>ADS-B equipment must meet the performance requirements specified in TSO-C166b or TSO-C154c ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** . A compliant installation must meet the requirements in § 91.227. To deviate from any rule requirements, you must obtain a deviation approval from the FAA, in accordance with § 91.225(c) and § 91.227(f). Under those provisions, as specified in 14 CFR 21.618, this requires showing that factors or design features provide an equivalent level of safety that compensates for the standards from which a deviation is requested.<br>3.11.1 (Installation - Foreign Airspace Requirements) Optional Parameters ***[Required by CS if available and in a suitable format]*** .<br>If operations are planned in a country that requires parameters not mandated in the United States, such as selected heading and selected altitude ***[incl. Barometric Pressure Setting]*** , follow the ADS-B equipment manufacturer's installation guidance to interface those parameters. |
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| | ***Additional Guidance not Addressed in CS-ACNS*** |

| ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets. | |
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| | 3.2.2.1 UAT Systems With Mode S Transponders ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** .<br>Do not install a UAT ADS-B OUT system with the capability to transmit a random 24-bit address in an aircraft that also has a Mode S transponder unless the random 24-bit feature is disabled. The ATC automation system would interpret the different 24-bit addresses as two separate aircraft, and alert controllers to a conflict that does not actually exist. |
| | 3.2.2.2. Mixed Transmit/Receive Classifications.<br>TSO-C166b and TSO-C154c ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** allow Class A transmit-only and Class A receive-only equipment configurations. There are no restrictions for installing a certain class of receive equipment with a different class of transmit equipment. For example, a Class A3 transmit-only unit can be used in the same aircraft with a Class A1 receive-only unit. It is also acceptable to have a TSO-C166b transmitter and a TSO-C154c receiver and vice versa ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** . |
| | 3.2.2.3. Stand-Alone 1090ES Transmitters.<br>RTCA/DO-260B, section 2.2.2.2, only allows Class A0 and B0 1090ES stand-alone (not integrated with a transponder) transmitters. This AC does not cover installation approval for class A0 or B0 1090ES transmitters because they are not compliant with § 91.227. |
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| AMC1 ACNS.D.ADSB.040 Antenna Diversity ***[CS requires antenna diversity, AC 20-165 allows single bottom-mounted antenna]*** .<br>The 1090 ES data protocol includes a bit to indicate, at any time, if only one or both antennas (if installed) are functional. The corresponding parameter for the Single Antenna bit is contained in register $65_{16}$ (message element bit '30') and should be set to the appropriate value.<br>Note 1: For detailed guidance on the required antenna diversity as a function of aircraft maximum cruising true airspeed capability, refer to AMC1 ACNS.D.ELS.065 ***[CS requires antenna diversity, AC 20-165 allows single bottom-mounted antenna]*** .<br>Note 2: For further guidance on antenna installations, see CS ACNS.D.ELS.060, CS ACNS.D.ELS.065, AMC1 ACNS.D.ELS.060 and AMC1 ACNS.D.ELS.065. | ***[CS requires antenna diversity, AC 20-165 allows single bottom-mounted antenna]***<br>3.8.4.5 (Installation) Single Antenna Bit.<br>For aircraft using a single antenna, this parameter should be set to one, "True".<br>A.2.26 (Parameters) Single Antenna Bit.<br>This parameter indicates if the ADS-B equipment is transmitting through a single antenna. |
| AMC1 ACNS.D.ADSB.055 Simultaneous operation of ADS-B transmit units<br>Manual switching between transmitters is considered acceptable.<br>Note: The requirement applies to ADS-B transmit units broadcasting on the same data link. It does not preclude simultaneous operation of dual link installations. | 3.2.2.4 (Installation) Multiple ADS-B OUT Systems.<br>If the aircraft has the ability to operate a 1090ES and a UAT ADS-B OUT system at the same time, the systems must have a single point of entry for the emergency code, IDENT, and Mode 3/A code. Neither system may use the anonymity (random address) feature. If dual ADS-B OUT systems of the same link are installed (for example, to increase dispatch reliability), the installation must preclude operation of both systems simultaneously...Note: Installation of dual 1090ES and UAT ADS-B IN capability is acceptable and encouraged. Also, dual systems must be the same version level;<br>that is, if the 1090ES system meets the requirements of RTCA/DO-260B (version 2), the UAT system must meet the requirements of RTCA/DO-282B (version 2).<br>Note: Installation of dual 1090ES and UAT ADS-B IN capability is acceptable and encouraged. Refer to AC 20-172() for ADS-B IN installation guidance. |
| AMC1 ACNS.D.ADSB.060 On-the-ground status Determination<br>For aircraft with retractable landing gear, the on-the-ground status determination is typically provided through a landing gear weight-on-wheels switch. For aircraft that have fixed-gear, the ADS-B Out system should be able to determine the air-ground status of the aircraft using other means.<br>Installations that provide a means to automatically determine on-the-ground status based on input from other aircraft sensors are acceptable if they are demonstrated to accurately detect the status. Otherwise, ground status validation algorithms should be implemented, using speed thresholds that match the typical aircraft's rotation speed as closely as possible.<br>It is noted that for the validation of a directly determined on-the-ground status that is not validated outside the ADS-B transmit function, validation against the aircraft's typical rotation speed (rather than a fixed value of 50 m/s (100 knots)) might not have been tested in accordance with ETSO-C166b. If that is the case, it is expected that the ADS-B transmit unit manufacturer supplies compliance information through a Declaration of Design and Performance (DDP), or an equivalent document.<br>Detailed guidance material is provided in Appendix I. | 3.10.2 (Installation) Air-Ground Status.<br>For aircraft with retractable landing gear, the air-ground status determination is typically provided through a landing gear weight-on-wheels (WOW) switch. For aircraft that have fixed gear, the ADS-B system must still be able to determine the air-ground status of the aircraft. Installations that provide a means to automatically determine air-ground status based on inputs from other aircraft sensors may be acceptable if they can be demonstrated to accurately detect the status. For example, air-ground status may be derived from WOW switch and GPS velocity; or GPS velocity, an airport database, and geometric altitude; or GPS velocity and airspeed. These algorithms should be tested and validated during the installation approval. |
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| | ***Additional Guidance not Addressed in CS-ACNS*** |

ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets.

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| | 3.10.3 (Installation) Mode S Transponder Inhibit.<br>TSO-C112d and TSO-C112e, Air Traffic Control Radar Beacon System/Mode Select (ATCRBS/Mode S) Airborne Equipment, requires Mode S transponders to inhibit the reply to Mode A/C/S all-call and Mode S-only all-call interrogations on the surface. Mode S transponders with ADS-B functionality will now remain "ON" during surface operations; thus it is imperative that you ensure the transponder interface to the air-ground status is installed correctly and that the transponder does not reply to Mode A/C/S all-call or Mode S-only all-call interrogations on the surface.<br>Note: In deploying Airport Surface Detection Equipment version X (ASDE-X) at various airports, we have found transponder installations that have been improperly wired and therefore inappropriately respond to ATC and TCAS interrogations while on the airport surface. |
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| AMC1 ACNS.D.ADSB.070 Horizontal Position and Velocity Data Sources<br>(a) GNSS Standards<br>(1) Basic GNSS System Approval<br>To be approved, the horizontal position and velocity data source should hold an EASA equipment authorisation in accordance with either ETSO-C129a, or ETSO-C196, or ETSO-C145/ETSO-C146, including the additional qualification requirements as specified in paragraph (2) below.<br>(2) Additional GNSS Receiver Qualification Requirements<br>In order to fully address the standard associated with ADS-B Out, an ETSO authorisation alone may not be sufficient to ensure ADS-B compatibility. The position and velocity source should also comply with the following requirements (i) to (vi).<br>It is expected that compliance with these requirements is demonstrated by the equipment manufacturer and documented in the Declaration of Design and Performance (DDP), or an equivalent document. Detailed guidance material on the qualification requirements is provided in Appendix H Part 5. | 3.3.1 (Installation - Position Source) Equipment Eligibility.<br>§ 91.227 is performance based and does not require any specific position source ***[CS requires GNSS position source with TSO-C129a, or TSO-C196, or TSO-C145/ETSO-C146 approval]*** . The existing navigation equipment and airworthiness standards should be used; however, they must be augmented to address the unique issues associated with ADS-B. A TSO authorization alone is not sufficient to ensure ADS-B compatibility. The position source must also comply with the performance requirements in 4.5.6 Appendix B of this AC. Compliance with the 4.5.6 Appendix B requirements may be documented in the position source manufacturer's installation instructions.<br>Note: Not all GNSS position sources will provide the same availability. Refer to 4.5.6 Appendix B for more information on GNSS availability. The FAA recommends TSO-C145 or TSO-C146 position sources that meet the 4.5.6 Appendix B requirements to maximize availability and ensure access to the airspace identified in § 91.225 after January 1, 2020. |
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| | ***Additional Guidance not Addressed in CS-ACNS*** |
| | 3.3.2.6 (Installation) GPS/UAT Time Mark Synchronization ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** .<br>When integrating a UAT with an external GPS, the design of the hardware time mark must be interoperable. Some GPS synchronize the leading edge of the time mark to the UTC second. Other GPS allow the time mark pulse to be asynchronous to the UTC second, then record the time of the leading edge in the digital data along with the position solution. The UAT equipment must support the GPS time mark design. If the UAT equipment and GPS do not share a common time mark design, the UAT equipment will not be properly synchronized with the ground system and other aircraft. |
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| AMC1 ACNS.D.ADSB.070 Horizontal Position and Velocity Data Sources (cont.)<br>(i) GNSS system must provide a latitude and longitude output.<br>Note: ETSO-C129a does not cater for full compliance with this requirement.<br>(ii) The horizontal position integrity containment should have been qualified as per Appendix H Part 5 paragraph 1;<br>Note: Horizontal Uncertainty Level (HUL) information does not fulfil CS ACNS.D.ADSB.070.<br>(iii) The maximum time to alert for the indication of a signal-in-space data integrity failure should be 10 seconds as per Appendix H in Part 5 paragraph 1;<br>(iv) Navigation modes that would force the NIC value temporarily to 'zero' whilst the actual horizontal position integrity containment bound would meet the NIC requirements in Appendix H Part 3 Table 20, should not be installed.<br>(v) The horizontal position source accuracy output should have been qualified as per Appendix H Part 5 paragraph 2;<br>(vi) The horizontal position source latency and timing characteristics should have been documented (see Appendix H Part 5 paragraph 3); | 3.3.3.1 (Installation) Latitude and Longitude.<br>The ADS-B equipment must set the latitude and longitude based on the real-time position information provided by the position source.<br>B.3.1 (Position Source Qualification - General) Position.<br>The position source must provide a latitude and longitude output. Requirements and test procedures in TSO-C129/145/146/196 are sufficient and GNSS equipment with Technical Standard Order Authorization (TSOA) for the aforementioned TSOs require no additional qualification for the position output.<br>B.3.4 (Position Source Qualification - General) Position Accuracy (Horizontal).<br>The position source must have a horizontal position accuracy output, and the output must have been qualified during the system's TSOA or design approval...<br>B.3.5 (Position Source Qualification - General) Position Integrity (Horizontal).<br>The position source must have a horizontal position integrity output qualified during the system's TSOA or design approval.<br>B.3.5.3 (Position Source Qualification - General) Integrity Fault.<br>The position source must be able to identify, and output, an indication of an integrity fault. This indication should occur within 8 seconds ***[10 sec. requirement, but AC recommends 8 sec.]*** of output of an erroneous position. The position source manufacturer must provide information on how this integrity fault is output.<br>B.3.12 (Position Source Qualification - General) Position Source Latency.<br>The position source manufacturer must provide position source latency information... |

ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets.

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| AMC1 ACNS.D.ADSB.070 Horizontal Position and Velocity Data Sources (cont.) | B.4.1 (Position Source Qualification - GNSS) Position.<br>GNSS position sources must provide a latitude and longitude output...<br>B.4.1.2 (Position Source Qualification - GNSS) TSO-C129a.<br>...Additional means of compliance for this TSO require GNSS manufacturers to substantiate that the latitude/longitude is output and referenced to WGS-84 coordinate system.<br>B.4.2 (Position Source Qualification - GNSS) Position Source Latency.<br>GNSS position source manufacturers must provide position source latency information.<br>B.4.4 (Position Source Qualification - GNSS) Horizontal Position Integrity.<br>GNSS position sources must have a horizontal position integrity (such as HIL or HPL) output qualified during the system's TSOA or design approval to determine NIC.<br>B.4.6 (Position Source Qualification - GNSS) Integrity Fault Alerts.<br>GNSS position source manufacturers must provide design data on the maximum time the position source can take to indicate an integrity fault. If the fault indication is mode specific, data on all modes must be included. It is recommended that the indication of an integrity fault be provided within 8 seconds ***[10 sec. requirement, but AC recommends 8 sec.]*** across all modes.<br>B.4.8. (Position Source Qualification - GNSS) Horizontal Position Accuracy.<br>GNSS position sources should provide an HFOM output that was demonstrated during the position source's design approval or during an installation approval. |
| AMC1 ACNS.D.ADSB.070 (cont.)<br>(vii) The horizontal velocity accuracy output should have been qualified. If a dynamic horizontal velocity accuracy output is not provided, the transmitted horizontal velocity accuracy should be based on a worst case accuracy. If a dynamic horizontal velocity accuracy output is provided, the source should have been qualified for this quality indication accordingly as per Appendix H Part 5 paragraph 4.<br>In addition, a means should be provided to establish the condition when the horizontal velocity track angle accuracy exceeds plus/minus 'eight' degrees as per Appendix H Part 5 paragraph 4.<br>(3) Interface Interoperability Aspects<br>It should be verified that the position and velocity information (including their respective quality indicators) received from the source are correctly interpreted by the ADS-B equipment.<br>(i) Horizontal Position Integrity Containment Bound<br>Some approved horizontal position sources may incorrectly output horizontal position integrity containment bounds of less than 75 meters. In such cases, it is accepted that the transmit unit limits the NIC value to 'eight'.<br>It is expected that the ADS-B transmit unit manufacturer supplies compliance information through a Declaration of Design and Performance (DDP), or an equivalent document.<br>(ii) Horizontal Velocity Format<br>The position and velocity source manufacturer should provide information describing how the horizontal velocity information is output (i.e. in a ground speed/track angle format versus north/east velocity format) and the protocols used.<br>(4) Data Quality Indicator Testing<br>By design and under nominal GNSS satellite constellation conditions, an ADS-B Out system that is compliant with CS ACNS.D.ADSB.070 should meet the required values of the horizontal position NIC, NACp, SIL and horizontal velocity NACv quality indicators (refer to Appendix H Part 3 Table 20). | B.3.8 (Position Source Qualification - General) Velocity Accuracy.<br>The position source should have a velocity accuracy output that was qualified in conjunction with the system's TSOA or design approval. Instead of a dynamic output, the position source manufacturer may demonstrate a worst case velocity accuracy that can be assumed based on testing. A test for GNSS position sources is contained in the latest revision of AC 20-138, appendix 4. The position source manufacturer may propose a test method for non-GNSS sources ***[CS requires GNSS-based position sources (GNSS/IRS systems are recognized as acceptable)]*** or an alternate test for GNSS sources during the TSOA or design approval.<br>3.3.2.2 (Installation) Position Source and ADS-B Equipment Interface.<br>Unless the ADS-B equipment manufacturer has analyzed the interface between the position source and the ADS-B equipment you are installing, and specifically listed the position source in the ADS-B equipment's installation manual, you must provide an analysis of the interface between the position source and the ADS-B equipment that demonstrates the position, velocity, position accuracy, position integrity, and velocity accuracy information taken from the position source is properly interpreted by the ADS-B equipment. When installing modifications to a position source, the installer must determine and test those portions of the ADS-B system that are impacted by the modification and ensure the ADS-B system is not adversely impacted.<br>Note: This analysis will require engineering design data from the ADS-B equipment manufacturer and/or the position source manufacturer.<br>B.3.2 (Position Source Qualification - General) Horizontal Velocity.<br>The position source must output north/south and east/west velocities. We recommend the position source also output the velocity in a ground speed and track angle format.<br>B.4.11 (Position Source Qualification - GNSS) Horizontal Velocity.<br>The position source must output north/south and east/west velocities. It is recommended the position source also output the velocity in a ground speed and track angle format. |

| ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets. | |
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| AMC1 ACNS.D.ADSB.070 (cont.)<br>(b) Installation Guidance<br>The GNSS based position sources should be installed in accordance with FAA AC 20-138B (or later).<br>Note: EASA is developing GNSS installation guidance, once published, should be used instead of the FAA material ***[Update to CS-ACNS Subpart C upon release]*** .<br>(c) Multiple Position and Velocity Data Sources<br>(1) Multiple Source Approval<br>Any position and velocity source that is interfaced to the ADS-B transmit unit, should meet the requirements of CS ACNS.D.ADSB.070.<br>(2) Source Priority<br>If multiple horizontal position data sources are interfaced with the ADS-B transmit unit, priority should be given to the source that provides the best ADS-B performance with respect to the horizontal position integrity containment bound (NIC).<br>A change of the selection between sources should only take place when the not selected source has exceeded the NIC performance of the selected source for several seconds.<br>(d) Interconnecting Avionics<br>Interconnecting avionics between a horizontal position and velocity data source and the ADS-B transmit unit are not recommended.<br>If installed, interconnecting avionics should:<br>(1) not output horizontal position and velocity data that has been blended with data from other sources;<br>(2) use GNSS horizontal velocity data to extrapolate the horizontal position data if extrapolation is deployed; and<br>(3) maintain full source resolution of the horizontal position and velocity data.<br>Interconnecting avionics that do not comply with the above may dilute the horizontal position accuracy achieved with GNSS-based sources, with detrimental effects on the usability of the ADS-B Out system.<br>Note: closely coupled GPS/IRS systems are not considered as interconnecting avionics | 3.3.2.1 (Installation) Installation Guidance.<br>The position source must be installed in accordance with the applicable guidance. New GNSS position sources must be installed in accordance with AC 20-138(), Airworthiness Approval of Positioning and Navigation Systems.<br>3.3.2.3 Secondary Position Source.<br>There is no requirement to have a secondary position source input. However, if you interface a secondary position source to the ADS-B system, it must meet the requirements in 4.5.6 Appendix B of this AC.<br>Note: If a position source is unable to provide § 91.227 accuracy and integrity values, it will not qualify the aircraft to operate in airspace defined by § 91.225 after January 1, 2020.<br>3.3.2.4 Position Source Selection.<br>If multiple position sources (such as MMR/GPS, IRS/INS/ADIRU ***[CS requires GNSS-based position sources (GNSS/IRS systems are recognized as acceptable)]*** or GPS1 & GPS2) are interfaced to the ADS-B equipment, source selection can be accomplished manually by the pilot, automatically by the aircraft's navigation system, or by the ADS-B equipment. We discourage automatic selection of the ADS-B position source based solely on the navigation source in use because operational requirements sometimes dictate a navigation source that may not provide the best ADS-B performance. If the ADS-B equipment accomplishes the position source selection, it should do so in accordance with TSO-C166b or TSO-C154c. If multiple sources are interfaced to the ADS-B system, there should be a means for the flightcrew to readily determine which source is selected. Describing how this selection is performed in the AFM is one acceptable means of compliance.<br>Note: TSO-C166b and TSO-C154c require the ADS-B equipment to use a single position source for the latitude, longitude, horizontal velocity, accuracy metrics, and integrity.<br>C.3.1 (Latency Analysis) Position Source to ADS-B Interface.<br>Directly connecting the position source to the ADS-B equipment is the preferred method of installation.<br>C.4.1 (Latency Analysis) Recommendations for Reducing Latency.<br>Directly connect the position source to the ADS-B equipment. |
| AMC1 ACNS.D.ADSB.080 Data Sources as defined by Mode S Elementary and Enhanced Surveillance<br>(a) General Requirements<br>For the requirements and general guidance on the data sources providing the Mode S Elementary and Enhanced surveillance parameters, the following references to CS ACNS.D.ELS and CS ACNS.D.EHS apply:<br>(1) Aircraft Identification: CS ACNS.D.ELS.(a)(3);<br>(2) Mode A Code: CS ACNS.D.ELS.(a)(1);<br>(3) SPI: CS ACNS.D.ELS.(a)(2);<br>(4) Emergency Mode/Status: CS ACNS.D.ELS.(a)(1);<br>(5) Pressure Altitude: CS ACNS.D.ELS.025;<br>(6) MCP/FCU Selected Altitude: : AMC1 ACNS.D.EHS. (c)(1);<br>(7) Barometric Pressure Setting:AMC1 ACNS.D.EHS.;<br>(8) ACAS Operational/Resolution Advisory: AMC1 ACNS.D.ELS.015; and<br>(9) ICAO 24 bit Address: CS ACNS.D.ELS.050.<br>(b) Emergency Status<br>When transmitting the Mode A emergency status codes, the additional specific bits should be set (see Appendix H , Part 1, Definition 10).<br>(c) Pressure Altitude — NICbaro<br>For aircraft with an approved, non-Gillham altitude source, the Barometric Altitude Integrity Code 'NICbaro' should be set to 'one'.<br>For aircraft where the pressure altitude that is based on a Gillham coded input that has not been cross-checked against another source of pressure altitude, the 'NICbaro' should be set to 'zero'. Otherwise, the 'NICbaro' should be set to 'one'.<br>For general guidance on the ADS-B 'NICbaro' indicator that is associated with Pressure Altitude information, refer to Appendix H , Part 1, Definition 9. | ***Mandated by EU No 1207/2011, 1028/2014 (amendment), & 2017/386 (amendment) in European Airspace. For ELS, follow CS-ACNS - Subpart D - Section 2. For EHS, follow CS-ACNS - Subpart D - Section 3 supplemented with AC 20-151C Section 2.3.10 & Appendix F (for populating) and B.21 (for testing) Vertical Intention Register.***<br>***Parameters common to ADS-B mandates are addressed in Appendix H below.*** |

ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets.

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| AMC1 ACNS.D.ADSB.080 (cont.)<br>(d) Vertical Rate<br>The Vertical Rate information should come from the most accurate and steady source. In order to ensure that minimum performance requirements are met for Vertical Rate information, the following source prioritisation should be applied:<br>- Hybrid Vertical Rate Source: the information may be taken from a hybrid system which filters barometric vertical rate with an inertial reference unit (IRU) vertical rate and GNSS vertical rate, provided the accuracy of the vertical rate output is at least as good as barometric vertical rate sources (e.g. ETSO-C106).<br>- Blended Vertical Rate Source: the information may be taken from a blended system which filters IRU vertical rate and barometric vertical rate, provided the accuracy of the vertical rate output t is at least as good as barometric vertical rate sources (e.g. ETSO-C106).<br>- Barometric Vertical Rate Source: the information may be taken from an air data computer (ADC) holding an EASA equipment authorisation in accordance with ETSO-C106 or a vertical velocity instrument holding an EASA equipment authorisation in accordance with applicable revisions of ETSO-C8() .<br>- GNSS Vertical Rate Source: GNSS vertical velocity equipment which have not been qualified in accordance with CS-ACNS.D.ADSB.070 should not be interfaced with the ADS-B transmit unit. | ***[Vertical rate is not required by § 91.227 (optional)].***<br>3.9.1 (Installation) Equipment Eligibility.<br>Unlike position accuracy, vertical velocity accuracy is not transmitted in ADS-B messages. Thus it is important that vertical velocity sources integrated into the ADS-B system meet minimum performance requirements at installation. Use the following guidance:<br>3.9.1.1 (Installation) Hybrid Vertical Rate Source.<br>Vertical rate may be taken from a hybrid system that filters barometric vertical rate with an Inertial Reference Unit (IRU) vertical rate and GNSS vertical rate, provided the hybrid system was tested and approved to provide a vertical rate output with an accuracy that is at least as good as barometric vertical rate sources (such as TSO-C106). Hybrid vertical rate could come from a Flight Management System (FMS), Air Data and Inertial Reference System (ADIRS), or IRU. ADS-B equipment should transmit hybrid vertical rate solutions as barometric vertical rates.<br>3.9.1.2 (Installation) Blended Vertical Rate Source.<br>Vertical rate may be taken from a blended system that filters IRU vertical rate and barometric vertical rate, provided the blended system was tested and approved to provide a vertical rate output with an accuracy that is at least as good as barometric vertical rate sources (such as TSO-C106). Blended vertical rate could come from an FMS, ADIRS, or IRU. ADS-B equipment should transmit blended vertical rate solutions as barometric vertical rates.<br>3.9.1.3 (Installation) Barometric Vertical Rate Source.<br>Barometric vertical rate may be taken from an air data computer meeting the minimum performance requirements of any revision of TSO-C106 or a vertical velocity instrument meeting the minimum performance requirements of applicable revisions of TSO-C8, Vertical Velocity Instruments (Rate-of-Climb). We recommend you use any revision of a TSO-C106 compliant air data computer if you interface barometric vertical rate to the ADS-B OUT equipment.<br>GNSS Vertical Rate Source.<br>3.9.1.4 (Installation) Geometric vertical rate may be taken from any revision of TSO-C129 ***[TSO-C129a is the minimum in CS-ACNS]*** , TSO-C145, TSO-C146, or TSO-C196 GNSS equipment if the position source has been qualified to provide vertical rate in accordance with 4.5.6 Appendix B of this AC. Do not interface GNSS vertical velocity if the equipment has not been qualified in accordance with 4.5.6 Appendix B. |
| Vertical Rate from an inertial sensor that is not blended with barometric altitude should not be transmitted. Neither should ADS-B transmit units derive a barometric altitude rate by sampling barometric altitude measurements.<br>The source bit for vertical rate (1090 ES register 0916, message bit '36') should be coded as barometric when utilising barometric rate from an air data computer, or when using a blended or hybrid vertical rate. The source bit for vertical rate should only be coded as geometric when using vertical rate from a GNSS source.<br>Note: due to differences in the respective transmit formats, the above source prioritisation differs in some parts with the guidance applicable to Mode S Enhanced Surveillance as provided in AMC1 ACNS.D.EHS.015.<br>For general guidance on Vertical Rate data sources, refer to Appendix H , Part 1, Definition 14. | 3.9.1.5 (Installation) Inertial Vertical Rate Source.<br>Vertical velocity from an inertial sensor that is not blended with barometric altitude should not be transmitted from the ADS-B system.<br>3.9.1.6 (Installation) Barometric Altitude Source.<br>ADS-B systems should not derive a barometric altitude rate by sampling barometric altitude measurements. This could lead to misleading vertical velocity information. If barometric vertical rate is not available, use geometric vertical rate.<br>3.9.2 (Installation) Installation Guidance.<br>The vertical rate field can be populated with either barometric vertical rate or geometric vertical rate. There is no requirement to interface multiple vertical velocity sources. We recommend that you use the following priority scheme when selecting or interfacing multiple vertical rate sources:<br>1. Hybrid vertical rate or blended vertical rate.<br>2. Barometric vertical rate.<br>3. GNSS vertical rate.<br>3.9.3.2 (Installation) Vertical Rate Source.<br>The source bit for vertical rate should be coded as barometric when using barometric rate from an air data computer, or when using a blended or hybrid vertical rate. The source bit for vertical rate should only be coded as geometric when using vertical rate from a GNSS source. |
| AMC1 ACNS.D.ADSB.080 (cont.)<br>(e) Selected Altitude (and related Modes)<br>With respect to the various status and mode fields contained in register $62_{16}$ (subtype 1), the respective provisions of AMC1 ACNS.D.EHS.(c)(1) apply to the Selected Altitude Type, Status of MCP/FCU Mode Bits, VNAV Mode Engaged, Altitude Hold Mode, and Approach Mode information.<br>The population of the additional Autopilot Engaged and LNAV Mode Engaged fields status bits are optional but should be populated where the data is available. | ***[Selected altitude is not required by § 91.227 (optional)]***<br>3.11.1 (Installation - Foreign Airspace Requirements) Optional Parameters.<br>If operations are planned in a country that requires parameters not mandated in the United States, such as selected heading and selected altitude, follow the ADS-B equipment manufacturer's installation guidance to interface those parameters |

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| AMC1 ACNS.D.ADSB.085 Geometric Altitude<br>(a) Geometric Altitude data source<br>The position source should output a vertical position accuracy metric to support the encoding of the Geometric Altitude GVA quality indicator.<br>GNSS position sources should provide the geometric altitude accuracy through the vertical figure of merit (VFOM). If that is the case, the vertical position source accuracy output by a GNSS receiver should have been qualified as per Appendix H Part 5 paragraph 5.<br>If the position source does not output a qualified vertical accuracy metric, the GVA parameter should be set to 'zero'.<br>For general guidance on the GVA encoding, refer to Definition 20 in Appendix H of Subpart D.<br>(b) Geometric Altitude Reference<br>A GNSS position source compliant with CS ACNS.D.ADSB.070 provides Geometric Altitude, in its native format, as geocentric height above the earth's ellipsoid shape. Height Above Ellipsoid (HAE) is described by the WGS-84 format.<br>Another altitude reference is described by the earth's geoid, a surface on which the gravitational potential is constant and which approximates the (local) mean levels of all the earth's seas. The difference between the mathematically idealised smooth ellipsoid and irregular geoid surfaces varies between +106m to -85m across the earth. The related Mean Sea Level (MSL) altitude is then established as the sum of the HAE altitude and those local differences (using look-up tables). MSL is sometimes also referred to as Height-Above-Geoid (HAG).<br>A position source that only provides HAG or MSL altitude (ARINC label 076) but not HAE (ARINC label 370) should not be interfaced to the ADS-B transmit unit unless the ADS-B transmit unit can properly convert HAG/MSL to HAE, using the same HAG/MSL model as the position source (typically NATO STANAG Appendix 6). This should be based on position source installation instructions that specify a deterministic method to perform conversion to HAE, and be demonstrated during ADS-B transmit unit design approval. It is expected that the respective compliance information is supplied by the position and velocity source, and ADS-B transmit unit manufacturers through a Declaration of Design and Performance (DDP) or an equivalent document. | ***[GVA is not required by § 91.227 (optional)]***<br>B.4.15 (Position Source Qualification - GNSS)<br>The GNSS should output vertical position accuracy...if vertical position accuracy is output, it must have been qualified during design approval of the position source.<br>3.3.3.9 (Installation) Geometric Vertical Accuracy (GVA).<br>Set the GVA based on design data provided by the position source manufacturer. GNSS position sources may provide the geometric altitude accuracy through the Vertical Figure of Merit (VFOM). If the position source does not output a qualified vertical accuracy metric, the GVA parameter should be set to "0".<br>3.3.3.8 (Installation) Geometric Altitude.<br>Ensure the geometric altitude provided by the position source is based on Height-Above-Ellipsoid (HAE) instead of Height-Above-Geoid (HAG). Do not interface a position source that provides HAG or Mean Sea Level (MSL) altitude to the ADS-B equipment unless the ADS-B equipment has the ability to determine the difference between an HAG and HAE input, and the ADS-B equipment has demonstrated during design approval that it can properly convert HAG to HAE using the same model as the position source. It would also be acceptable to demonstrate that the error due to conversion of HAG to HAE does not cause the GVA to be exceeded.<br>B.3.10 (Position Source Qualification - General) Geometric Altitude.<br>The position source must have a geometric altitude output. The geometric altitude must be referenced to the WGS-84 ellipsoid.<br>B.4.9 (Position Source Qualification - GNSS) Geometric Altitude.<br>All GNSS position sources must output a geometric altitude. Geometric altitude for ADS-B purposes is the height above the WGS-84 ellipsoid (that is, it is not MSL). We recommend that the GNSS position source output geometric altitude as Height-Above-Ellipsoid (HAE). Some GNSS position sources provide Height-Above-Geoid (HAG) instead of HAE. The position source manufacturer must provide data on whether the position source outputs HAE or HAG. |
| AMC1 ACNS.D.ADSB.085 (cont.)<br>Note: Horizontal position sources compliant with Class 3 equipment approved under ETSO-C145c/C146c are required to output HAE altitude. The requirement has been implemented from revision C of RTCA/DO-229 onwards.<br>(c) Geometric Altitude Accuracy Quality Indicator Testing<br>If a qualified vertical accuracy metric is available, under nominal GNSS satellite constellation and visibility conditions, the transmitted GVA value should be a minimum of 'one'. | |
| AMC1 ACNS.D.ADSB.090(a) Flight Deck Interface<br>(a) Installations<br>(1) Data Transmission and Display Consistency<br>The data transmitted by the active ADS-B transmit unit with the data displayed to the flight crew should be consistent ***[AC 20-165B allows the position source for ADS-B to be different than the position source used for navigation]*** .<br>Note: The horizontal position data displayed to the flight crew might be based on data from more than the position source than that used for ADS-B transmissions. | 3.3.2.5 (Installation) Position Source.<br>The ADS-B position source does not need to be the same position source used for navigation. It is acceptable for a GNSS position source to be embedded in the ADS-B equipment and provide position information to the ADS-B system without providing any navigation information to other onboard systems. ***[CS requires using a compliant GNSS sensor connected to the transponder and the navigation equipment (i.e. transponder and navigation equipment receive the same data from the GNSS source) or installation of a standalone GNSS receiver connected (only) to the transponder provided the GNSS receiver is approved to ETSO-C145c or C146c (or later ETSO amendments). Note: Operational Class 1, 2, or 3 of RTCA DO-229D (or later), satisfy the criteria.]*** As addressed in 4.5.6 Appendix B of this AC, an integrated GNSS position source should still meet the requirements of TSO-C145(), TSO-C146(), or TSO-C196(). |

| ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets. | |
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| AMC1 ACNS.D.ADSB.090(a) (cont.)<br>(2) Single Point of Flight Crew Entry<br>Installations that do not provide a single point of flight crew entry for the transponder and the ADS-B transmit unit should be evaluated to ensure that dual entry of the Mode A code, SPI, and emergency status does not lead to the transmission by the active ADS-B transmit unit of inconsistent data, particularly when communicating an aircraft emergency. | 3.7.3.2 (Installation) Emergency Status.<br>Refer to section 3.7.3.5 of this AC for information on single point of entry of the emergency status.<br>3.7.3.3 (Installation) IDENT.<br>Refer to section 3.7.3.5 of this AC for information on single point of entry of the IDENT.<br>3.7.3.4 (Installation) Mode 3/A Code.<br>Refer to section 3.7.3.5 of this AC for information on single point of entry of the Mode 3/A code.<br>3.7.3.5 (Installation) Single Point of Entry.<br>Aircraft equipped with a separate transponder and ADS-B system should provide the pilot a single point of entry into both systems for the Mode 3/A code, IDENT, and emergency status. If ADS-B equipment sets the emergency status, IDENT, or Mode 3/A code based on entry of these parameters into a separate transponder, the STC/TC needs to identify the appropriate transponder interfaces. Experience in the FAA's Alaska CAPSTONE program demonstrated that operator mitigations to prevent differing codes from being entered in the transponder and ADS-B system were ineffective and resulted in numerous false and misleading proximity alerts for ATC. Additionally, there are workload and safety concerns of requiring the pilot to enter the Mode 3/A code, IDENT, and emergency codes multiple times. Thus, if you do not provide a single point of entry for the mode 3/A code, IDENT, and emergency code, you must accomplish a human factors evaluation and an additional system safety assessment as follows:<br>3.7.3.5.1 (Installation) Human Factors Evaluation.<br>Installations not providing a single point of entry must accomplish an evaluation of the pilot interface controls to ensure the design minimizes the potential for entry errors by the flightcrew, and enables the flightcrew to detect and correct errors that do occur. Evaluate the system interface design to ensure dual entry of the emergency status, IDENT, and Mode 3/A code does not introduce significant additional workload, particularly when communicating an aircraft emergency. Refer to section 4.1.5.4 of this AC for additional information on the human factors evaluation. |
| AMC1 ACNS.D.ADSB.090 (cont.) | 3.7.3.5.2 (Installation) System Safety Assessment.<br>Transmission of false or misleading information is considered to be a major failure effect and may not occur at a rate greater than 1x10-5 per flight hour for ADS-B systems. Installations not providing a single point of entry must accomplish a safety assessment that demonstrates that the probability of the transponder and ADS-B system ever transmitting differing Mode 3/A codes is less than 1x10-5 per flight hour. The analysis must consider the potential of all pilot errors.<br>4.1.5.4 (Ground Test) Pilot Interface Errors.<br>Installations not providing a single point of entry for the ADS-B and transponder for the Mode 3/A code, IDENT, and emergency status must accomplish an evaluation of the pilot interface controls to determine that they are designed to minimize entry errors by the flightcrew, and enable the flightcrew to detect and correct errors that do occur. System interface design must also be evaluated to ensure dual entry of the Mode 3/A code, IDENT, and emergency status does not introduce significant additional workload, and that the controls are acceptable for data entry, accuracy, and error rates, particularly when communicating an aircraft emergency. Evaluations should consider pilot-detected and undetected error rates, pilot workload, and training times. Refer to section 3.7.3.5 of this AC for additional information on transponder and ADS-B system single point of entry. |
| AMC1 ACNS.D.ADSB.090(a) (cont.)<br>(b) ADS-B Off Switch<br>If control is provided to enable or disable the ADS-B transmit unit, then the status of the active ADS-B transmit unit should clearly be indicated to the flight crew from their normal seated position.<br>The respective controls should be located such that inadvertent disabling is prevented. | 3.7.2.2. (Installation) Turning Off ADS-B.<br>14 CFR 91.225 and § 91.227 requires that all aircraft equipped with ADS-B OUT operate with the equipment turned on at all times. There are no requirements to disable ADS-B broadcasts at the request of ATC. When ADS-B functionality resides in the Mode S transponder, it is acceptable to disable the ADS-B transmissions by disabling the transponder (that is, "Standby" or "Off"). If this architecture is used, specify the impact in the flight manual or pilot's guide (for example, loss of ADS-B, transponder, and TCAS functionality). Locate the ADS-B on/off controls to prevent inadvertent actuation. |

| ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets. | |
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| AMC1 ACNS.D.ADSB.090(b) Flight Deck Interface<br>ADS-B device or function failures, should be indicated in amber or in accordance with the flight deck annunciation philosophy, without undue delay, i.e. a response time within the order of one second.<br>ADS-B device or function failures may be indicated independently of each other; however, detailed operating instructions should be developed to describe the means to interpret indications.<br>The ADS-B device or function failure indication should not be confused with an ACAS or Mode S system failure annunciations.<br>In case of an ADS-B function failure, it is expected that the transponder should continue to support the ACAS, Mode A/C and Mode S functions.<br>The proper indications of the ADS-B Out system failures should be tested. | 3.7.2.1 (Installation) System Status.<br>The installation must have a method to display system operational status to the flightcrew...The following two failure annunciations must be included in the initial airworthiness certification (that is, STC or TC) type design data for the ADS-B OUT equipment, and should be consistent with the overall flightdeck design philosophy for surveillance equipment. These failure conditions are advisory only and do not constitute a caution or warning condition. For legacy Mode C installations that are adding a UAT device, the following two failure annunciations are optional ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** .<br>3.7.2.1.1 (Installation) ADS-B Device Failure.<br>If the ADS-B equipment is unable to transmit ADS-B messages, the system should provide an appropriate annunciation to the flightcrew.<br>3.7.2.1.2 (Installation) ADS-B Function Failure.<br>The ADS-B system depends on a position source to provide the data to populate the ADS-B messages and reports. If the position source or its interface with the ADS-B equipment fails, the ADS-B system will not be able to broadcast the required ADS-B data. In this case, the ADS-B equipment has not failed, but it cannot perform its function due to a failure to receive the position source data. The ADS-B system should distinguish between a position source or interface failure and an ADS-B equipment failure. The installer must provide documentation, in the applicable flight manual, or flight manual supplement, that explains how to differentiate between annunciation of an equipment failure and a function failure if the failure annunciations are not independent. The ADS-B function failure must not cause a TCAS II system failure.<br>Note: Certain advanced ADS-B IN applications may require flightcrew knowledge of own-ship ADS-B OUT operational status. Refer to AC 20-172() for guidance regarding ADS-B IN installations ***[ADS-B In isn't covered by EPAS 2018]*** . |
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| | ***Additional Guidance not Addressed in CS-ACNS*** |
| | 3.7.2.3 (Installation) Anonymity Feature ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** .<br>§ 91.227 contains specific provisions allowing operators with TSO-C154c equipment to transmit a self-assigned (randomized) temporary 24-bit address and no call sign. No such provision is provided for TSO-C166b equipment. After January 1, 2020, and in the airspace identified in § 91.225, the UAT anonymous 24-bit address feature may only be used when the operator has not filed a flight plan and is not requesting ATC services. The UAT call sign may also be omitted, but only when the anonymous 24-bit address is chosen. We do not recommend integrating the anonymity features, as the operator will not be eligible to receive ATC services, may not be able to benefit from enhanced ADS-B search and rescue capabilities, and may impact ADS-B IN situational awareness benefits. The following considerations must be included in the ADS-B system design when installing equipment capable of using the anonymity feature: |
| | 3.7.2.3.1 (Installation) ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** When the ADS-B equipment is initially powered-on, the 24-bit address must default to the aircraft's assigned ICAO 24-bit address. |
| | 3.7.2.3.2 (Installation) ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** When the ADS-B equipment is initially powered-on, the call sign may not be blank (Not Available per RTCA/DO-282()). At initial power-on, it is acceptable for the call sign to revert to a non-blank call sign that existed before the ADS-B equipment being powered off, or to the aircraft registration number. |
| | 3.7.2.3.3 (Installation) ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** The ADS-B equipment can only allow an anonymous 24-bit address selection if the Mode 3/A code is set to "1200". |
| | 3.7.2.3.4 (Installation) ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** The ADS-B equipment may only allow selection of the anonymous 24-bit address via a dedicated pilot interface. The ADS-B OUT equipment may not automatically set an anonymous 24-bit address or set a blank (Not Available per RTCA/DO-282()) call sign based solely on pilot selection of the 1200 Mode 3/A code. |
| | 3.7.2.3.5 (Installation) ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** The ADS-B OUT equipment must automatically disable the anonymity feature if any Mode 3/A code other than 1200 is selected. The 24-bit address must automatically revert to the aircraft's assigned ICAO 24-bit address. If the call sign was blank, the call sign must automatically revert to the aircraft registration number. |
| | 3.7.2.3.6 (Installation) ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** Describe the effects of selecting the anonymity features in the flight manual or pilot's guide. Effects include the inability to receive Instrument Flight Rule (IFR) or Visual Flight Rule (VFR) separation services, potential loss of enhanced search and rescue benefits, and potential negative impacts to ADS-B IN applications. |
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| ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets. | |
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| AMC1 ACNS.D.ADSB.110 Horizontal Position and Velocity Data Refresh<br>For systems with a 1 Hertz computation rate, the output of position and velocity data can vary between 0.8 seconds and 1.2 seconds.<br>Note Faster position update rates reduce the latency of the transmitted position and velocity information and are therefore encouraged. | B.3.11 (Position Source Qualification - General) Update Rate.<br>The position source must output a new position at least once per second. Faster position update rates reduce latency of the transmitted position and are encouraged.<br>B.4.10 (Position Source Qualification - GNSS) Update Rate.<br>The position source must output a new position at a minimum of once per second. Faster position update rates reduce latency of the transmitted position and are encouraged.<br>C.4.1.3 (Recommendations for Reducing Latency) Use a position source that provides position updates at greater than 1 Hz. |
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| | ***Additional Guidance not Addressed in CS-ACNS*** |
| | B.4.10.1 (Position Source Qualification - GNSS) TSO-C129 ***[TSO-C129a is the minimum in CS-ACNS]*** .<br>Means of compliance for TSO-C129 are described in RTCA/DO-208 change 1, section 2.1.11 for displays. This requirement is modified by TSO-C129 section (a)(3)(vi) for navigation data used for display in Class A equipment. Class B and Class C equipment are modified by sections (a)(4)(v) and section (a)(5)(v) respectively. |
| | B.4.10.2 (Position Source Qualification - GNSS) TSO-C129a.<br>Means of compliance for TSO-C129a are described in RTCA/DO-208 change 1, section 2.1.11 for displays. This requirement is modified by TSO-C129a, section (a)(3)(vi) for navigation data used for display in Class A equipment. Class B and Class C equipment are modified by sections (a)(4)(v) and (a)(5)(v) respectively. |
| | B.4.10.3 (Position Source Qualification - GNSS) TSO-C145/146 Rev a Class 1.<br>Means of compliance for this TSO are defined in RTCA/DO-229C, section 2.1.2.6.1. |
| | B.4.10.4 (Position Source Qualification - GNSS) TSO-C145/146 Rev a Class 2.<br>Means of compliance for this TSO are defined in RTCA/DO-229C, sections 2.1.2.6.1 and 2.1.5.8.1. |
| | B.4.10.5 (Position Source Qualification - GNSS) TSO-C145/146 Rev b/c/d Class 1.<br>Means of compliance for this TSO are defined in RTCA/DO-229D, section 2.1.2.6.1. |
| | B.4.10.6 (Position Source Qualification - GNSS) TSO-C145/146 Rev b/c/d Class 2/3.<br>Means of compliance for this TSO are defined in RTCA/DO-229D, sections 2.1.2.6.1 and 2.1.5.8.1. |
| | B.4.10.7 (Position Source Qualification - GNSS) TSO-C196/196a.<br>Means of compliance for this TSO are defined in RTCA/DO-316, section 2.1.2.6.1 |
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| AMC1 ACNS.D.ADSB.115 and 120 Horizontal Position and Velocity Total and Uncompensated Latency<br>(a) Time of Applicability<br>With respect to the latency requirements in CS ACNS.D.ADSB.115 and CS ACNS.D.ADSB.120, the initial time of applicability (ITOA) is the time of validity of the position or velocity solution. Hence, the latency between the time of signal in space measurement (TOM) and this time of validity is excluded from the total latency budget ***[CS TL measurement is from the TOA, whereas, § 91.227 TL measurement is from the TOM (adds an additional 0.5 seconds not excluded from AC 20-165 TL budget)]*** .<br>The transmit time of applicability (TTOA) equals the initial time of applicability plus the amount of compensated latency (CL), as valid at the time at which the ADS-B transmit unit broadcasts the position (or velocity) information (TOT).<br>(b) Compliance Demonstration<br>Total latency (TL) is the difference between time of transmission (TOT) and initial time of applicability (ITOA) ***[CS TL measurement is from the TOA, whereas, § 91.227 TL measurement is from the TOM (adds an additional 0.5 seconds)]*** . The analysis of total latency includes the maximum asynchronous delay caused by the time difference of position (or velocity) updates arriving at the ADS-B transmit unit and of transmitting the information. It is noted that for ADS-B transmit units compliant with AMC1 ACNS.D.ADSB.030, this asynchronous delay can be up to 1.1 second ***[includes 0.1 seconds UL of ADS-B equipment]*** . | D.1.31 (Definition) Total Latency.<br>The total time between when the position is measured by the position source (GNSS TOM for GNSS systems) and when the position is transmitted from the aircraft (ADS-B time of transmission) ***[CS TL measurement is from the TOA, whereas, § 91.227 TL measurement is from the TOM (adds an additional 0.5 seconds)].***<br>C.4.8 (Latency Analysis) Latency Points of Measurement.<br>Latency is defined as the time between when the position is measured by the position source to when it is transmitted by the ADS-B equipment ***[CS TL measurement is from the TOA, whereas, § 91.227 TL measurement is from the TOM (adds an additional 0.5 seconds)]*** .<br>C.4.8.1 (Latency Analysis) Time of Measurement (TOM).<br>The latency analysis starts at the position source TOM ***[CS TL measurement is from the TOA, whereas, § 91.227 TL measurement is from the TOM (adds an additional 0.5 seconds)]*** . The position source TOM for GNSS sources is the time when the last GNSS signal used to determine the position arrives at the aircraft GNSS antenna. TOM for an inertial position source or a GNSS-aided inertial position source is the time of the last accelerometer measurement. TOM for an RNAV system using multiple DME signals would be the time the last DME signal arrives at the aircraft's DME antenna ***[CS requires GNSS-based position sources (GNSS/IRS systems are recognized as acceptable)]*** .<br>Note: To demonstrate compliance with § 91.227, you must calculate latency from the position source TOM. Do not calculate latency from the position source time of applicability, as defined in RTCA/DO-260B with corrigendum 1 and RTCA/DO-282B with corrigendum 1 ***[CS TL measurement is from the TOA, whereas, § 91.227 TL measurement is from the TOM (adds an additional 0.5 seconds)]*** .<br>C.4.8.2 (Latency Analysis) Transmit Time of Applicability.<br>The transmit time is the time when the ADS-B system broadcasts the position. The transmitted position's time of applicability for synchronized systems is the appropriate UTC epoch. The transmitted position's time of applicability for unsynchronized systems is the actual time the ADS-B equipment begins transmission of the message that contains the position.<br>Note: Synchronized ADS-B systems randomly vary the position transmission around the UTC epoch to avoid interference with other ADS-B transmitters. This randomization should not be included in the latency analysis. |

ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets.

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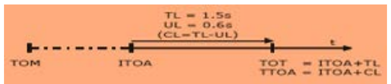
| AMC1 ACNS.D.ADSB.115 and 120 Horizontal Position and Velocity Total and Uncompensated Latency (cont.) | C.2.4 (Latency Analysis) Asynchronous Delay.<br>Total latency analysis must include the maximum asynchronous delay caused by position updates arriving at the ADS-B equipment out-of-synch with when the ADS-B system transmits the position. This delay is a factor of the position source update rate rather than the ADS-B equipment transmission rate. For example, a 1 Hz position source could provide a position update immediately after an ADS-B position transmission. This position would be extrapolated, up to 1 second, until the next position update arrives from the position source. Thus, a 1 Hz position source can introduce 1 second of total latency. This 1 second must be included in the total latency calculation.<br>C.4.3 (Latency Analysis) Mean Latency vs. Maximum Latency.<br>In instances where the latency is variable, use the worst-case latency under fault-free conditions in the analysis. Variable latency, for example, can occur due to variance in loading of a data concentrator or the asynchronous nature of a GNSS to ADS-B interface. As the applicant, you must propose to the FAA how to deal with variable latencies introduced by intermediary devices such as data concentrators. |
| AMC1 ACNS.D.ADSB.115 and 120 Horizontal Position and Velocity Total and Uncompensated Latency (cont).<br>Uncompensated latency (UL, or more generically a latency compensation error) is the difference between total latency (TL) and amount of compensated latency (CL) thereof. Therefore, uncompensated latency determines the transmit time of applicability (TTOA). The GNSS time mark if provided to the transmit system, can be used by the ADS-B transmit unit to reduce uncompensated latency. It is possible for compensation algorithms to overcompensate for the effects of latency, also as a result of the desired attempt to account for latency external to the ADS-B transmit unit. This might lead to transmitting a position that is out in front of the actual aircraft position rather than behind the actual aircraft position. This is acceptable as long as the transmitted position is not further ahead than 0.2 s (200 ms).<br>The various latency related parameters are summarised in Figure 1<br><br><br>Figure 1: Latency Parameters | D.1.32 (Definition) Uncompensated Latency.<br>Any latency in the ADS-B system that is not compensated through extrapolation. Uncompensated latency can be represented as the difference between the time of applicability of the broadcast position and the actual time of transmission.<br>C.4.7 (Latency Analysis) UTC Epoch Synchronization.<br>The position transmitted from the ADS-B equipment may be aligned with a UTC epoch. TSO-C154c requires UAT systems to extrapolate the position to the 1.0 second or 0.2 second UTC epoch. TSO-C166b allows 1090ES systems to extrapolate to the 0.2 second UTC epoch or transmit asynchronously. To synchronize the position output with the UTC epoch, the position source needs to provide a time mark. The ADS-B equipment uses this time mark to extrapolate the position to the UTC epoch. Typically the time mark will be from a GNSS position source. Implementation of the time synchronization in the 1090ES systems will help minimize uncompensated latency.<br>C.4.5 (Latency Analysis) Overcompensating.<br>It is possible for compensation algorithms to "overcompensate" for the effects of latency, essentially transmitting a position that is out in front of the actual aircraft position rather than behind the actual aircraft position. This type of system is acceptable as long as the transmitted position is no further ahead than 200 ms, (refer to RTCA/DO-260B, appendix U). |
| AMC1 ACNS.D.ADSB.115 and 120 (cont.)<br>Latency should be addressed through analysis rather than testing. Total and uncompensated latency information should be generated by the respective manufacturers of the position source, ADS-B transmit unit and any interconnecting avionics and should be included as part of the latency analysis.<br>The latency analysis should determine the latency applicable to each component of the ADS-B Out system. The total of all of the individual component latencies should be established as the sum of their maximum latencies.<br>ADS-B Out systems whereby the transmit equipment compliant with AMC1 ACNS.D.ADSB.030 is directly connected to a position source compliant with AMC1 ACNS.D.ADSB.070, should meet the total latency and uncompensated latency requirements without further analysis.<br>For other ADS-B Out systems, the applicant should perform a detailed position and velocity latency analysis. This includes systems where ADS-B Out system components are interfaced through a highly integrated architecture.<br>For detailed guidance on horizontal position and velocity source latency qualification, refer to Appendix H Part 5.<br>It is expected that this compliance information is supplied by the position and velocity source manufacturer through a Declaration of Design and Performance (DDP) or an equivalent document. | 4.1.2 (Ground Test) System Latency.<br>Latency is addressed through analysis rather than testing. Refer to section 3.1.3 and 4.5.6 Appendix C of this AC.<br>C.2 (Latency Analysis) Analysis.<br>Accomplish the analysis by determining the applicable latencies for each component and totaling all of the individual component latencies. You must include all sources of position latency, including but not limited to: the position source, intermediary devices between the position source and ADS-B equipment, and ADS-B equipment. Use the following guidelines to determine latency for each component.<br>C.2.2 (Latency Analysis) Intermediary Device.<br>Intermediary devices are typically data concentrators. The latency information should be generated by the intermediary device manufacturer and presented as part of the latency analysis. If the intermediary device latency is variable, use the worst-case latency.<br>C.2.3 (Latency Analysis) ADS-B Equipment.<br>Use the TSO-C166b and TSO-C154c ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** latency standards for the latency analysis or use the actual latency information generated by the ADS-B equipment manufacturer. TSO-C166b and TSO-C154c require the uncompensated latency of the ADS-B equipment to be less than 100 ms.<br>C.3.2 (Latency Analysis) Position Source to ADS-B Interface.<br>Directly connecting the position source to the ADS-B equipment is the preferred method of installation. Alternately, if this architecture is not used, we recommend that any latency introduced between the position source output and the ADS-B equipment input be less than 100 ms (refer to RTCA/DO-260B, appendix U).<br>C.3.3 (Latency Analysis) ADS-B Equipment<br>The latency requirements for the ADS-B equipment are included in TSO-C166b and TSO-C154c and allow for the ADS-B equipment to introduce no more than 100 ms of uncompensated latency. TSO-C166b or TSO-C154c ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** are required by § 91.225 and § 91.227.<br>C.4.1.1 (Recommendations for Reducing Latency) Directly connect the position source to the ADS-B equipment. |

| ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets. | |
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| AMC1 ACNS.D.ADSB.115 and 120 (cont.) | 3.1.3 (Installation) Position Latency.<br>Latency is the difference between the time when a measurement is taken to determine the aircraft's geometric position and the time when the aircraft's ADS-B equipment transmits that position measurement ***[CS TL measurement is from the TOA, whereas, § 91.227 TL measurement is from the TOM (adds an additional 0.5 seconds)]*** . Limiting the latency in ADS-B systems minimizes the errors in the reported position. TSO-C166b and TSO-C154c ADS-B equipment compensate for latency by extrapolating the position based on velocity information. All applicants must demonstrate compliance with the latency requirements in section 3.1.3.1. This can be done by equipping with a compliant architecture such as the one listed in section 3.1.3.2 or performing an analysis such as the one detailed in section 3.1.3.3. Latency terms are further defined in 4.5.6 Appendix C of this AC.<br>Note 1: To demonstrate compliance with § 91.227, you must calculate latency from the position source time of measurement (TOM). Do not calculate latency from the position source time of applicability, as defined in RTCA, Inc. (RTCA) document (DO)-260B, Minimum Operational Performance Standards for 1090 MHz Extended Squitter Automatic Dependent Surveillance – Broadcast (ADS-B) and Traffic Information Services – Broadcast (TIS-B), with corrigendum 1, and RTCA/DO-282B, Minimum Operational Performance Standards for Universal Access Transceiver (UAT) Automatic Dependent Surveillance – Broadcast, with corrigendum 1 ***[CS TL measurement is from the TOA, whereas, § 91.227 TL measurement is from the TOM (adds an additional 0.5 seconds)]*** . |
| AMC1 ACNS.D.ADSB.115 and 120 (cont.) | 3.1.3.1 (Installation) Position Latency Requirements.<br>There are two position latency requirements associated with ADS-B OUT:<br>1. Total latency. Total latency is defined as the difference between the time when the position is measured and when the position is transmitted from the aircraft. To meet § 91.227, the total latency must be less than or equal to 2.0 seconds ***[CS latency measurement is from the TOA (total 1.5 sec. requirement), whereas, § 91.227 latency measurement is from the TOM (adds an additional 0.5 seconds - total 2 sec. requirement)].***<br>2. Uncompensated latency. Uncompensated latency is the difference between the time of applicability for the transmitted position and the actual time the position is transmitted from the ADS-B system. To meet § 91.227, the uncompensated latency must be less than or equal to 0.6 seconds. The aircraft must compensate for any latency greater than 0.6 seconds but must not overcompensate (that is, lead the aircraft position) by more than 0.2 seconds.<br>Note: RTCA Special Committee 186, which developed the ADS-B OUT minimum operational performance standards, recommends ADS-B OUT systems transmit position information with an uncompensated latency of less than or equal to 0.4 seconds. This recommendation is to support future ADS-B IN applications. The § 91.227 latency requirements support ATC separation services and the initial basic ADS-B IN applications. However, we encourage you to minimize uncompensated latency as much as possible in your installation. Recommendations for minimizing latency are included in 4.5.6 Appendix C of this AC.<br>3.1.3.2 (Installation) Compliant Architecture.<br>ADS-B systems that directly connect a position source meeting the minimum performance requirements of any revision of TSO-C145, TSO-C146, or TSO-C196 with ADS-B equipment meeting the minimum performance requirements of TSO-C166b or TSO-C154c satisfy the total latency and uncompensated latency requirements. Systems with a compliant architecture do not need to accomplish a position and velocity latency analysis.<br>3.1.3.3 (Installation) Position Latency Analysis.<br>If you are installing an ADS-B system that does not have a compliant architecture described in section 3.1.3.2, you must accomplish a latency analysis to demonstrate that the installed ADS-B system meets the total latency and uncompensated latency requirements. Systems integrated through a highly integrated data bus architecture must complete the latency analysis. 4.5.6 Appendix C of this AC provides for an acceptable method to complete the latency analysis. |

ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets.

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| AMC1 ACNS.D.ADSB.115 and 120 (cont.)<br>(c) ADS-B Quality Indicator Change Latency<br>The ADS-B Quality Indicator change latency requirements are driven by the maximum time to alert for the indication of a data integrity failure with respect to exceeding integrity containment bound (CS ACNS.D.ADSB.070 and related AMC guidance).<br>For detailed guidance on time to alert qualification, refer to Appendix H Part 5. | 3.1.4 (Installation) Integrity Metric Latency.<br>There is an allowance for Global Navigation Satellite System (GNSS) position sources to delay the update of the integrity containment radius while attempting to detect and exclude faulted satellites. § 91.227 allows up to 12 seconds for the ADS-B system to transmit a change in the Navigation Integrity Category (NIC). This 12-second allowance is available for any position source, not just GNSS position sources. The 12 seconds includes both the time for the position source to detect the fault and time for the ADS-B system to transmit the fault indication. The requirement to indicate a change in NIC applies to the time between when a faulted position is first transmitted and when the updated NIC is transmitted indicating the fault. The total time to update the NIC is based on the cumulative effect of (1) the position source fault detection and exclusion time, and (2) the worst-case asynchronous transmission difference between when the faulted position is transmitted and when the NIC indicating the fault is transmitted.<br>3.1.4.1 (Installation) Compliant Architecture.<br>ADS-B equipment meeting the minimum performance requirements of TSO-C166b or TSO-C154c that is directly connected to a position source meeting the minimum performance requirements of any revision of TSO-C145, TSO-C146, or TSO-C196 will typically meet the integrity latency requirements. For these systems you only need to demonstrate, through analysis, that a non-isolated GNSS satellite fault detected by the position source is properly passed to the ADS-B equipment and that the ADS-B equipment indicates an invalid position by transmitting the position integrity and accuracy metrics equal to zero.<br>Note: ARINC Characteristic 743A-5, GNSS Sensor, allows flexibility in how information is transferred during a GNSS satellite fault; thus, it is necessary to ensure a non-isolated satellite failure results in the ADS-B indicating an invalid position.<br>Integrity Metric Latency Analysis.<br>3.1.4.2 (Installation) If you are installing an ADS-B system without a compliant architecture, like the one described above, you must accomplish a latency analysis to demonstrate the ADS-B system meets the integrity metric latency requirements. The latency analysis should include the maximum time for a position source to indicate an integrity fault, any delay added by an intermediary device such as a data concentrator, and the delay added by the ADS-B equipment. |
| AMC1 ACNS.D.ADSB.115 and 120 (cont.)<br>(d) Horizontal Position Latency Compensation<br>The ADS-B transmit unit may compensate for horizontal position latency incurred outside the ADS-B transmit unit (see sub-paragraph 2 above). If such is implemented, a verifiable estimation of the delay between the time of applicability of the position measurement, and the provision of that measurement to the ADS-B transmit unit data interface should be performed. | C.4.4 (Latency Analysis) Compensating for Interface Latency in Unsynchronized Systems.<br>It is acceptable to install ADS-B equipment that compensates for latency that occurs outside of the ADS-B equipment, even if the position source and ADS-B equipment are not time synchronized. Establishing the proper corrections for external latency is problematic because the TSO-C166b equipment may be interfaced to numerous different aircraft architectures. These architectures could include different position sources, with different latencies, as well as different data concentrators with different delays. To interface unsynchronized ADS-B equipment that compensates for external latencies, the ADS-B equipment manufacturer must provide a list of the acceptable equipment and the acceptable architectures. Typically this type of ADS-B equipment will only be installed in closely-integrated architectures. You may not attempt to integrate ADS-B equipment that compensates for external latencies unless the ADS-B equipment manufacturer has expressly documented the installation architecture and design data is available for each component. The total amount of time that can be used for compensation is still limited by the requirement to limit total latency to within<br>2.0 seconds. |
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| | ***Additional Guidance not Addressed in CS-ACNS*** |
| | 3.1.5 (Installation) System Design Assurance (SDA) and Source Integrity Level (SIL) Latency.<br>§ 91.227 requires broadcasting changes in the SDA or SIL within 10 seconds. Changes in the SDA or SIL will typically occur when all position sources are lost, or when a secondary position source is integrated into an ADS-B system and that secondary position source has a different SDA or SIL than the primary position source. If you integrate multiple position sources with different SDAs or SILs, demonstrate during ground testing that a change in position source results in an updated SDA and SIL within 10 seconds. If integrating an ADS-B transmitter with a noncompliant GPS, the SDA and SIL must be set to "0". |
| | C.4.6 (Latency Analysis) Extrapolation During Loss of Position Data.<br>TSO-C166b equipment compliant with RTCA/DO-260B, sections 2.2.3.2.3.7.4 and 2.2.3.2.3.8.4, allows extrapolation of the position for up to 2 seconds when the position data is not available from the position source. This allowance is in case position data is lost for a single sample, and it does not have to be considered in the total latency calculation, provided it is a non-normal condition. If the position data is lost, several position updates could exceed the latency requirement, but the position would then be invalidated within 2 seconds, pursuant to TSO-C166b. |
| | C.4.9 (Latency Analysis) Minor Changes to Position Source Type Design.<br>If the ADS-B installation relies on position source latency performance, versus a TSO latency standard, the ADS-B system installer must update the ICA for the position source with a process that ensures continued airworthiness of the ADS-B system following design changes to the position source. |

ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets.

C.5 (Latency Analysis) Latency Analysis Example.

This example uses a GNSS meeting the minimum performance requirements of TSO-C145 (any revision) directly connected to TSO-C166b ADS-B equipment. This installation is a T = 0 installation; thus it is unsynchronized. The example in Table C-1 is considered a compliant architecture.

Note 1: ADS-B equipment compensated latency is bounded by the asynchronous nature of the position source delivery and ADS-B system transmission. Thus ADS-B equipment compensated latency is included in the asynchronous delay row.

Note 2: The latency between the position source TOM and the position source time of applicability is required to be compensated by all revisions of TSO-C145, TSO-C146, and TSO-C196.

**Table C-1. Latency Analysis Example**

| Item | Uncompensated Latency | Compensated Latency | Total Latency | Notes |
|---|---|---|---|---|
| Position Source | ≤ 200 ms | ≤ 500 ms | ≤ 700 ms | |
| Position Source to ADS-B Interface | 0 | 0 | 0 | Directly connected |
| ADS-B Equipment | ≤ 100 ms | Note 1 | ≤ 100 ms | |
| Asynchronous Delay | 0 | ≤ 1.0 second | ≤ 1.0 second | 1 Hz position source |
| Total | ≤ 300 ms | ≤ 1.5 second | ≤ 1.8 second | |

7

## Appendix G - Example of Flight Manual Supplement for ADS-B Out

GENERAL

The installed ADS-B out system is fully compliant with the requirements of CS ACNS.D.ADSB (1090 MHz Extended Squitter ADS-B Out). A detailed description of the system operation can be found in the ____________________, P/N __________________, Rev. ____ or subsequent revisions.

LIMITATIONS

None

EMERGENCY PROCEDURES

No change to Approved Aircraft Flight Manual

NORMAL/ ABNORMAL PROCEDURES

Normal/Abnormal operating procedures are described in the ________________, P/N ____________________, Rev. _____ or subsequent revisions.

The procedure to change Aircraft Identification in flight is described in _________________________.

PERFORMANCE

No change to Approved Aircraft Flight Manual

2.2 (AFM) Aircraft Flight Manual.

Include ADS-B OUT operating limitations, normal operating procedures, and a system description in the Airplane Flight Manual (AFM), Rotorcraft Flight Manual (RFM), AFM Supplement (AFMS), or RFM Supplement (RFMS). The flight manual must also state that the installation meets the requirements of § 91.227. This can be accomplished by adding the following statement to the General or Normal Procedures section of the flight manual:

The installed ADS-B OUT system has been shown to meet the equipment requirements of 14 CFR 91.227.

2.2.1 (AFM) Operating Limitations.

The flight manual should describe any operating limitations necessary for safe operation because of design, installation, or operating characteristics.

2.2.2 (AFM)Operating Procedures.

Describe normal and non-normal operating procedures for the system in the flight manual.

2.2.3 (AFM) System Description.

Describe the ADS-B OUT system and the interface with other systems on the aircraft in the flight manual...

***Additional Guidance not Addressed in CS-ACNS***

2.2.2.1 (AFM) Describe any actions expected of the pilot.

2.2.2.2 Describe how to enter the Mode 3/A code, Flight ID, operate the IDENT function, and activate or deactivate emergency status. If the ADS-B system and transponder do not have a single point of entry for the Mode 3/A code, IDENT, and emergency status, the flight manual procedures must ensure conflicting information is not transmitted from the ADS-B system and transponder.

2.2.2.3 (AFM) Describe any ADS-B OUT displays and provide instructions to the pilot on how to respond to any error conditions.

2.2.2.4 (AFM) Describe how the ADS-B OUT system can be disabled, if there is an ability to disable the ADS-B OUT system. Also, describe the means through which the pilot can detect that the system has been disabled. The flight manual must address the effects of turning off the ADS-B OUT system, including the effects on the transponder and TCAS II if disabling the ADS-B OUT system also disables the transponder or the TCAS II.

ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets.

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| | 2.2.2.5 (AFM) Include guidance in the flight manual on when to enable the ADS-B OUT system. The ADS-B OUT system must be enabled (turned ON) during all phases of flight operation including airport surface movement operations. ADS-B IN surface applications and ATC surface surveillance will use ADS-B OUT broadcasts; thus, it is important for aircraft ADS-B OUT systems to continue to transmit on the airport surface. If the ADS-B OUT function is embedded in a Mode S transponder, the flight manual, checklists, and any operator procedures manuals must be updated accordingly with ADS-B OUT operations guidance.<br>Note: Historically, transponders have been turned on by the flightcrew when entering the runway for takeoff and turned off or to standby when exiting the runway after landing. When ADS-B is integrated into a Mode S transponder, the existing guidance for transponder operation must be updated to ensure the ADS-B system is operating during airport surface movement operations. |
| | 2.2.3 (AFM) System Description.<br>...If multiple position sources are interfaced to the ADS-B transmitter, describe the source selection mechanism and any related indications. |
| | |
| **Appendix H - Part 1 – ADS-B Out Data Parameters (AMC ACNS.D.ADSB.020(a))** | |
| Part 1 of this Appendix provides guidance to the aircraft integrator on the minimum ADS-B Out surveillance data requirements (Table 5 and associated Definitions).<br>In addition, guidance is given for the overall understanding of the ADS-B Out system, in support of equipment configuration and ADS-B Out data parameter testing, as appropriate. This includes the presentation of data encodings related to the so-called BDS registers (Table 4), as extracted from ED-102A. The content of the various BDS registers are loaded into the 56-bit ADS-B message (ME) field of the Mode S Downlink Format 17 (DF17, bits 33-88), in line with their respective transmission rates.<br>Table 5 below makes reference to the BDS registers that contain the various ADS-B Out data parameters. When Table 5 states Same source as for Mode S replies, reference is made to the requirement that the content of ADS-B broadcasts and Mode S replies that carry the same information need to come from the same source (CS ACNS.D.ADSB.025(b)).<br>The reference to the BDS registers is provided in order to facilitate a detailed understanding and traceability of ADS-B Out requirements at ADS-B transmit unit level, also in support of integration testing, as appropriate.<br>The relationship between the BDS registers and the ADS-B message Type Codes (first 5 bits in the 56-bit ADS-B message field) is thereby as shown in Table 4. The Type Code is used to differentiate between ADS-B message types (i.e. BDS registers). In addition, for Airborne and Surface Position Messages, the Type Code is used to encode the horizontal position integrity containment bounds (NIC). The Subtype Code is used to further differentiate between ADS-B messages of a certain type (e.g. Operational Status Message). A number of service bulletins have been issued to rectify some observed deficiencies and have already been addressed by the equipment manufacturers. Therefore, the installed transponders should have all published corrective transponder equipment service bulletins (SB) relating to the correct operation of the ADS-B functionality embodied. | 3.1.6 (Installation) Populating Message Elements.<br>§ 91.227 lists parameters that must be populated (that is, not a null value) for operation in airspace defined by § 91.225. All parameters transmitted by the ADS-B system must conform to the standards in TSO-C166b or TSO-C154c ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** and may not contain false or misleading information.<br>A.1 (Parameters) Purpose.<br>This appendix provides a description of the message elements that may be contained in an ADS-B OUT message. |
| (Table 4, below) | 3.1.6 (Installation) Populating Message Elements.<br>§ 91.227 lists parameters that must be populated (that is, not a null value) for operation in airspace defined by § 91.225. All parameters transmitted by the ADS-B system must conform to the standards in TSO-C166b or TSO-C154c and may not contain false or misleading information. |

**Table 4: BDS Register Overview**

| BDS Register | Type Code(s) | Subtype Code |
|---|---|---|
| $05_{16}$ – Airborne Position Message | 0, 9-18, 20-22 | n/a |
| $06_{16}$ – Surface Position Message | 0, 5-8 | n/a |
| $08_{16}$ - Aircraft Identification and Category Message | 1, 2, 3 or 4 | n/a |
| $09_{16}$ - Airborne Velocity Message<br>Velocity over Ground (Normal/Supersonic) | 19 | 1+2 |
| $61_{16}$ - Aircraft Status Message<br>Emergency Status and Mode A Code | 28 | 1 |
| $61_{16}$ - Aircraft Status Message<br>ACAS RA Broadcast | 28 | 2 |
| $62_{16}$ - Target State and Status Message | 29 | 1 |
| $65_{16}$ – Aircraft Operational Status Message<br>While Airborne | 31 | 0 |
| $65_{16}$ – Aircraft Operational Status Message<br>On the Surface | 31 | 1 |

*Note: Although BDS registers $07_{16}$ and $0A_{16}$ are not conveying ADS-B data items their implementation is needed to complement the ADS-B protocol.*

Table 5: Minimum ADS-B Out Surveillance Data Transmission Requirements (Parameter/Requirements/BDS Register/Remarks)

| ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets. | |
|---|---|
| 1. Aircraft Identification/See Definition 1/$08_{16}$/Same source as for Mode S replies<br>Definition 1: Aircraft Identification Data Sources<br>Aircraft Identification is provided to the ADS-B transmit unit so that the information is identical to the filed ICAO flight plan. This information may be provided from, amongst others:<br>A flight management system; or<br>A pilot control panel; or<br>For aircraft, which always operate with the same aircraft identification (e.g. using registration as the aircraft identification), it may be programmed into equipment at installation.<br>In case no ICAO flight plan is filed, the Aircraft Registration is provided to the ADS-B transmit unit. | 3.7.3.1 (Installation) Call Sign/Flight ID.<br>The assigned aircraft registration number must ***[change to should]*** be set as the call sign/flight ID during installation. Procedures for dynamically selecting a call sign must be included in the flight manual or pilot's guide if the ADS-B equipment provides a means to input a radio telephony call sign. If pilot-selectable, the call sign/flight ID should be readily apparent to the flightcrew. When the aircraft system is powered on, the call sign/flight ID must be filled. At initial power-on it is acceptable for the call sign/flight ID to revert to a previously set call sign that existed before the system being powered off, or to the aircraft registration number. Refer to section 3.7.2.3 of this AC for information on use of the anonymity feature.<br>Note: The preset call sign/flight ID will have to be updated if the aircraft's registration number changes.<br>A.2.4 (Parameters) Call Sign/Flight ID.<br>The term "aircraft call sign" is the radiotelephony call sign assigned to an aircraft for voice communications purposes. (This term is sometimes used interchangeably with "flight identification" or "flight ID"). For general aviation aircraft, the aircraft call sign is normally the national registration number; for airline and commuter aircraft, the call sign is usually comprised of the company identification and flight number (and therefore not linked to a particular airframe) and, for the military, it usually consists of numbers and code words with special significance for the operation conducted. The call sign or aircraft registration number is required to be transmitted by § 91.227 except when using the TSO-C154c anonymity feature ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** . |
| 2. Mode A Code/See Definition 2/$61_{16}$/Same source as for Mode S replies Broadcast suppressed for conspicuity code '1000'<br>Definition 2: Mode A Code<br>Refer to AMC1 ACNS.D.ELS.015 for general guidance.<br>When the ADS-B transmit unit receives a Mode A Code containing the Mode S conspicuity code (1000), the broadcast of Mode A code information is stopped.<br>Note: The broadcast of the Mode A Code is provided as a transitional feature, e.g. to aid operation of legacy ATC automation systems that use Mode A Code for Flight Plan correlation. Entry of the Mode A Code of 1000 will disable the transmission of the Mode A Code, and, hence, reduce the overall 1090 ES transmission rate. | 3.7.3.4 (Installation) Mode 3/A Code.<br>The installation must provide a means for the pilot to enter the Mode 3/A code.<br>A.2.19 (Parameters) Mode 3/A Code.<br>Currently ATC automation relies on the Mode 3/A code to identify aircraft under radar surveillance and correlate the target to a flight plan. The mode 3/A code is a four digit number ranging from 0000 to 7777. Secondary Surveillance Radars (SSR) and ADS-B will concurrently provide surveillance, so the Mode 3/A code is included in the ADS-B OUT message and is required to be transmitted by § 91.227.<br>Note: ADS-B systems will not transmit the Mode 3/A code if the Mode 3/A code is set to 1000. |
| 3. ICAO 24-bit aircraft address/Transmit ICAO 24-bit aircraft address/All BDS (AA field of DF17, bits 9-32)/Unique ICAO 24 bit aircraft address needs to be assigned by the responsible authority | 3.2.3.1 (Installation) International Civil Aviation Organization (ICAO) 24-Bit Address.<br>You must set the ICAO 24-bit address during installation in accordance with the ADS-B equipment manufacturer's instructions. For U.S. civil aircraft, the ICAO 24-bit address is currently established as a function of the aircraft's registration or "N" number. You can determine the appropriate address for U.S. registered aircraft on the following FAA website: http://registry.faa.gov/aircraftinquiry/. Use of a random 24-bit address is discussed further in section 3.7.2.3 of this AC.<br>Note 1: The ICAO 24-bit address is also used by the Mode S transponder. For the addition of ADS-B (1090ES) in an existing Mode S transponder installation, verify that the ICAO 24-bit address decodes to the current aircraft registration number.<br>Note 2: The ICAO 24-bit address will have to be updated if the aircraft's registration number changes.<br>Note 3: Installation instructions may require inputting the 24-bit address as an Octal, Decimal, or Hexadecimal number (that is, 50604331Octal = 10684633Decimal = A308D9Hex). Ensure you use the correct base number when configuring the ADS-B system.<br>4.1.7 (Ground Test) ICAO 24-Bit Address.<br>For U.S. civil aircraft, demonstrate that the 24-bit address transmitted by the system correlates to the aircraft registration number. If the system has a separate Mode S transponder and UAT ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** . ADS-B system installed, ensure both the transponder and ADS-B system transmit the same correct ICAO 24-bit address. For non-U.S. registered aircraft, verify that the ICAO 24-bit address is the address assigned to the aircraft by the responsible State authority.<br>A.2.14 (Parameters) ICAO 24-bit Address<br>The ICAO 24-bit address is a unique address assigned to an aircraft during the registration process. ICAO 24-bit addresses are defined blocks of addresses assigned for participating countries or states worldwide. In the United States, civil aircraft are assigned an address from an encoding scheme based on the aircraft registration number ("N" number). Additional information regarding the 24-bit address can be found in ICAO Annex 10, Part I, Volume III, appendix to Chapter 9, A World-Wide Scheme for the Allocation, Assignment and Application of Aircraft Addresses. The ICAO 24-bit address is required to be transmitted by § 91.227 except when using the TSO-C154c anonymity feature ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** . |

ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets.

| | |
|---|---|
| 4.a. Airborne Horizontal Position – Latitude and Longitude/See Definition 3/$05_{16}$<br>Definition 3: Horizontal Position Information<br>The Mode S Extended Squitter position format uses the Compact Position Reporting (CPR) algorithm to encode latitude and longitude efficiently into messages. The resulting messages are compact in the sense that several higher order bits which are normally constant for long periods of time, are not transmitted in every message.<br>The CPR technique enables a receiving system to unambiguously determine the location of the aircraft, and, hence, reconstruct the original information provided by the source. If required for integration testing purposes, detailed guidance on the CPR algorithm is provided in ED-102A/DO-260B.<br>A horizontal position data source provides position information for both the airborne and surface horizontal position data formats (i.e. registers $05_{16}$ or $06_{16}$, respectively), accordingly encoded by the ADS-B transmit unit depending on the aircraft airborne/surface state. | 3.3.3.1 (Installation) Latitude and Longitude.<br>The ADS-B equipment must set the latitude and longitude based on the real-time position information provided by the position source.<br>A.2.17 (Parameters) Latitude and Longitude.<br>These parameters are derived from the position source and provide a geometric based position. Reference all geometric position elements broadcast from the ADS-B unit to the WGS-84 ellipsoid. Latitude and longitude are required to be transmitted by § 91.227.<br>A.2.24 (Parameters) Position.<br>These parameters are derived from the position source and provide a geometric based position. Reference all geometric position elements broadcast from the ADS-B unit to the WGS-84 ellipsoid. Latitude and longitude is required to be transmitted by § 91.227. |
| 4.b. Airborne Horizontal Position Quality: NIC/See Definition 4 and 5/$05_{16}$ Type Codes/Incl. NIC Supplements A ($65_{16}$) and B ($05_{16}$)<br>4.c. Horizontal Position Quality: NACp/See Definition 4 and 6/$62_{16}$ and $65_{16}$/<br>4.d. Horizontal Position Quality: SIL/See Definition 4 and 7/$62_{16}$ and $65_{16}$/Incl. SIL Supplement.<br>4.e. Horizontal Position Quality: SDA/See Definition 4 and 8/$65_{16}$<br>Definition 4: Horizontal Position Quality – NIC and NACp<br>The encoding of the NIC and NACp horizontal position quality indicators should be directly derived from the corresponding integrity and accuracy information as being reported by the selected horizontal position source (refer also to CS ACNS.D.ADSB.025(c)).<br>In case a measurement integrity failure has been indicated by the selected horizontal position source (e.g. bit 11 of ARINC label 130 for ARINC 743A compliant sources), both the NIC and NACp quality indicators will be set to invalid (zero), regardless of the indicated integrity containment bound (e.g. HPL). | |
| 4.b. Airborne Horizontal Position Quality: NIC/See Definition 4 and 5/$05_{16}$ Type Codes/Incl. NIC Supplements A ($65_{16}$) and B ($05_{16}$)Definition 5: Airborne NIC Value<br>NIC is reported so that surveillance applications, such as by ATC or other aircraft, may determine whether the reported horizontal position has an acceptable level of measurement integrity for the intended use. (Note that the NIC parameter is closely associated with the SIL quality metric.)<br>The NIC (and SIL) values are associated with a possible failure condition of the position measurement function and the detection thereof. For most ADS-B applications, the NIC (and SIL) values are the key horizontal position quality metrics on which the horizontal position data is determined to be of sufficient quality for its intended use. The NIC value is encoded on the respective horizontal position integrity containment radius as provided by the source.<br>The NIC values, including the NIC Supplements values, are encoded for airborne position messages as follows (Rc is the horizontal position integrity containment bound, typically HPL/HIL for GNSS systems): | 3.3.3.5 (Installation) Navigation Integrity Category (NIC).<br>The ADS-B equipment must set the NIC based on the real-time integrity metric provided by the position source. When interfacing GNSS position sources, the NIC should be based on the HPL or HIL. However, although HPL values significantly smaller than 0.1 nautical mile (nm) can be output from single-frequency GNSS sources, the HPL may not actually achieve the reported level of protection as there are error contributions that are no longer considered negligible. You should review the position source design data to determine if all error sources are taken into consideration, or if the position source limits the HPL output, when computing an unaugmented Receiver Autonomous Integrity Monitoring (RAIM) based HPL. This applies to all TSO-C129() and TSO-C196() position sources, and to TSO-C145() and TSO-C146() position sources when operating in unaugmented modes where the HPL is based on RAIM. This may apply to some position sources even when operating in an augmented mode.<br>If the position source does not account for all errors or accomplish the appropriate HPL limiting, you must ensure you interface the position source to ADS-B equipment that limits the NIC ≤ 8. Refer to section 4.5.6Appendix B, of this AC for additional information regarding HPL considerations.<br>A.2.22 (Parameters) Navigation Integrity Category (NIC).<br>The NIC parameter specifies a position integrity containment radius. NIC is reported so surveillance applications, such as ATC or other aircraft, may determine whether the reported geometric position has an acceptable level of integrity for the intended use. The NIC parameter is closely associated with the SIL. While NIC specifies the integrity containment radius, SIL specifies the probability of the actual position lying outside that containment radius without indication. ADS-B systems should derive the NIC from an approved position source's integrity output, such as the HPL from the GNSS. A minimum NIC value of "7" must be transmitted **[CS requires a minimum NIC of "6"]** to operate in airspace defined in § 91.225. Table A-3 provides the applicable NIC values.<br>D.1.20 (Definition) Navigation Integrity Category (NIC).<br>A parameter that specifies an integrity containment radius. Table D-3 provides a list of possible NIC values. A NIC of 7 or greater is required ***[CS requires a minimum NIC of "6"]*** by § 91.227. |

ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets.

**Table 6: Airborne NIC Encoding**

| NIC Value | Radius of Containment ($R_C$) | Airborne: Airborne Position TYPE Code | Airborne: NIC Supplement Codes A | Airborne: NIC Supplement Codes B |
|---|---|---|---|---|
| 0 | $R_C$ unknown or $R_C \geq$ 37 040 m (20 NM) | 0, 18 or 22 | 0 | 0 |
| 1 | $R_C$ < 37 040 m (20 NM) | 17 | 0 | 0 |
| 2 | $R_C$ < 14 816 m (8 NM) | 16 | 0 | 0 |
| 3 | $R_C$ < 7 408 m (4 NM) | 16 | 1 | 1 |
| 4 | $R_C$ < 3 704 m (2 NM) | 15 | 0 | 0 |
| 5 | $R_C$ < 1 852 m (1 NM) | 14 | 0 | 0 |
| 6 | $R_C$ < 1 111.2 m (0.6 NM) | 13 | 1 | 1 |
| | $R_C$ < 926 m (0.5 NM) | 13 | 0 | 0 |
| | $R_C$ < 555.6 m (0.3 NM) | 13 | 0 | 1 |
| 7 | $R_C$ < 370.4 m (0.2 NM) | 12 | 0 | 0 |
| 8 | $R_C$ < 185.2 m (0.1 NM) | 11 | 0 | 0 |
| 9 | $R_C$ < 75 m | 11 | 1 | 1 |
| 10 | $R_C$ < 25 m | 10 or 21 | 0 | 0 |
| 11 | $R_C$ < 7.5 m | 9 or 20 | 0 | 0 |

**Table A-3. NIC Values**

| NIC | Containment Radius |
|---|---|
| 0 | Unknown |
| 1 | RC < 37.04 km (20.0 nm) |
| 2 | RC < 14.816 km ( 8.0 nm) |
| 3 | RC < 7.408 km ( 4.0 nm) |
| 4 | RC < 3.704 km ( 2.0 nm) |
| 5 | RC < 1.852 km ( 1.0 nm) |
| 6 Sup A=1 Sup B=1 | RC < 1111.2 m ( 0.6 nm) |
| 6 Sup A=0 Sup B=0 | RC < 926 m ( 0.5 nm) |
| 6 Sup A=0 Sup B=1 | RC < 555.6 m ( 0.3 nm) |
| 7 | RC 370.4 m ( 0.2 nm) |
| 8 | RC < 185.2 m ( 0.1 nm) |
| 9 | RC < 75 m |
| 10 | RC < 25 m |
| 11 | RC < 7.5 m |

**Table D-3. NIC Encoding**

| Value | Radius of Containment |
|---|---|
| 0 | Unknown |
| 1 | $R_C$ < 37.04 km (20.0 nm) |
| 2 | $R_C$ < 14.816 km (8.0 nm) |
| 3 | $R_C$ < 7.408 km (4.0 nm) |
| 4 | $R_C$ < 3.704 km (2.0 nm) |
| 5 | $R_C$ < 1.852 km (1.0 nm) |
| 6 | $R_C$ < 1.111 km (0.6 nm) |
| 6 | $R_C$ < 926 m (0.5 nm) |
| 6 | $R_C$ < 555.6m (0.3 nm) |
| 7 | $R_C$ < 370.4 m (0.2 nm) |
| 8 | $R_C$ < 185.2 m (0.1 nm) |
| 9 | $R_C$ < 75 m |
| 10 | $R_C$ < 25 m |
| 11 | $R_C$ < 7.5 m |

Note: The minimum NIC values required for the ADS-B-RAD application can be found in Table 20, in Part 3 of Appendix A. They are met through the horizontal position source requirements defined in CS ACNS.D.ADSB.070.

4.c. Horizontal Position Quality: NACp/See Definition 4 and 6/$62_{16}$ and $65_{16}$/

Definition 6: NACp

NACp specifies the 95 % radial accuracy of the aircraft's horizontal position information (latitude and longitude) derived from the position source's accuracy output, typically the HFOM metric from GNSS based sources. Whereas the NIC value is associated with a possible failure condition of the position measurement function, the NACp value describes the nominal performance of the measurement function in terms of horizontal position accuracy as provided by the source.

The NACp value is encoded as follows:

3.3.3.6 (Installation) Navigation Accuracy Category for Position ($NAC_P$).

The ADS-B equipment must set the $NAC_P$ based on the real-time 95-percent accuracy metric provided by the position source. When interfacing GNSS sources, the $NAC_P$ should be based on a qualified Horizontal Figure of Merit (HFOM).

A.2.20 (Parameters) Navigation Accuracy Category for Position ($NAC_P$).

The NACP specifies the accuracy of the aircraft's horizontal position information (latitude and longitude) transmitted from the aircraft's avionics. The ADS-B equipment derives a $NAC_P$ value from the position source's accuracy output, such as the HFOM from the GNSS. The $NAC_P$ specifies with 95 percent probability that the reported information is correct within an associated allowance. A minimum $NAC_P$ value of "8" must be transmitted to operate in airspace defined in § 91.227 ***[CS requires a minimum NAC $_P$ of "7"]***. Table A-1 provides the applicable $NAC_P$ values.

D.1.18 (Definition) Navigation Accuracy Category for Position ($NAC_P$).

Used to indicate, with 95 percent certainty, the accuracy of the aircraft reported horizontal position. Table D-1 provides a list of possible $NAC_P$ values. A $NAC_P$ of 8 or greater is required ***[CS requires a minimum NAC $_P$ of "7"]*** by § 91.227.

ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets.

**Table 7: NACp Encoding**

| Coding | 95% Horizontal Accuracy Bound |
|---|---|
| 0 | EPU ≥ 18 520 m (≥10 NM) |
| 1 | EPU < 18 520 m (10 NM) |
| 2 | EPU < 7 408 m (4 NM) |
| 3 | EPU < 3 704 m (2 NM) |
| 4 | EPU < 1852 m (1 NM) |
| 5 | EPU < 926 m (0.5 NM) |
| 6 | EPU < 555.6 m (0.3 NM) |
| 7 | EPU < 185.2 m (0.1 NM) |
| 8 | EPU < 92.6 m (0.05 NM) |
| 9 | EPU < 30 m |
| 10 | EPU < 10 m |
| 11 | EPU < 3 m |

4.d. Horizontal Position Quality: SIL/See Definition 4 and 7/$62_{16}$ and $65_{16}$/Incl. SIL Supplement.

Definition 7: SIL

The encoding of the horizontal position source integrity level (SIL) is based on the probability of the reported horizontal position exceeding the radius of containment defined by the NIC, without alerting, assuming no avionics faults. The SIL value is set as follows:

**Table A-1. $NAC_P$ Values**

| $NAC_P$ | Horizontal Accuracy Bound |
|---|---|
| 0 | EPU ≥ 18.52 km (10nm) |
| 1 | EPU < 18.52 km (10nm) |
| 2 | EPU < 7.408 km (4nm) |
| 3 | EPU < 3.704 km (2nm) |
| 4 | EPU < 1852 m (1nm) |
| 5 | EPU < 926 m (0.5nm) |
| 6 | EPU < 555.6 m (0.3nm) |
| 7 | EPU < 185.2 m (0.1nm) |
| 8 | EPU < 92.6 m (0.05nm) |
| 9 | EPU < 30 m |
| 10 | EPU < 10 m |
| 11 | EPU < 3 m |

**Table D-1. $NAC_P$ Encoding**

| Value | Horizontal Accuracy Bound (Estimated Position Uncertainty) |
|---|---|
| 0 | EPU ≥ 18.52 km (10.0 nm) |
| 1 | EPU < 18.52 km (10.0 nm) |
| 2 | EPU < 7.408 km (4.0 nm) |
| 3 | EPU < 3.704 km (2.0 nm) |
| 4 | EPU < 1.852 m (1.0 nm) |
| 5 | EPU < 926 m (0.5 nm) |
| 6 | EPU < 555.6 m (0.3 nm) |
| 7 | EPU < 185.2 m (0.1 nm) |
| 8 | EPU < 92.6 m (0.05 nm) |
| 9 | EPU < 30 m |
| 10 | EPU < 10 m |
| 11 | EPU < 3 m |

3.3.3.3 ) (InstallationSource Integrity Level (SIL).

...SIL is based solely on the position source's probability of exceeding the reported integrity value and should be set based on design data from the position source equipment manufacturer...

A.2.27 (Parameter) Source Integrity Level (SIL).

The SIL field defines the probability of the reported horizontal position exceeding the radius of containment defined by the NIC, without alerting, assuming no avionics faults... A SIL value of "3" must be transmitted to operate in airspace defined in § 91.225. Table A-4 outlines the SIL values.

Note 1: The probability of an avionics fault causing the reported horizontal position to exceed the radius of containment defined by the NIC, without alerting, is covered by the SDA parameter.

Note 2: The SIL probability can be defined as either per sample or per-hour as defined in the SIL supplement (SILSUPP).

D.1.25 (Definition) Source Integrity Level (SIL).

The probability of the reported horizontal position exceeding the radius of containment defined by the NIC without alerting, assuming the avionics has no faults. Table D-4 provides a list of possible SIL values. A SIL of 3 is required by § 91.227.

ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets.

**Table 8: SIL Encoding**

| SIL value | Probability of Exceeding the NIC Containment Radius |
|---|---|
| 0 | Unknown or > $1 \times 10^{-3}$ per flight hour or per sample |
| 1 | ≤ $1 \times 10^{-3}$ per flight hour or per sample |
| 2 | ≤ $1 \times 10^{-5}$ per flight hour or per sample |
| 3 | ≤ $1 \times 10^{-7}$ per flight hour or per sample |

Note: The minimum SIL value required for the ADS-B-RAD application can be found in Table 20, in Part 3 of Appendix A. This value is met through the horizontal position source requirements defined in CS ACNS.D.ADSB.070 (see also related AMC guidance).

Whereas SIL assumes that there are no system integrity failures, the SIL should consider the effects of a faulted signal-in-space.

For horizontal position sources compliant with CS ACNS.D.ADSB.070, the probability of exceeding a NIC radius of containment without alerting is based on a per hour rate. Hence, the SIL Supplement should be set to 'zero'. If based on per sample, the SIL Supplement would be set to 'one'.

The SIL encoding is the same for airborne position messages and surface position messages.

**Table A-4. SIL Values, Probability of Exceeding the NIC Containment Radius**

| SIL Value | Probability of exceeding the NIC containment radius |
|---|---|
| 0 | > $1x10^{-3}$ Per-hour or Sample or Unknown |
| 1 | ≤ $1x10^{-3}$ Per-hour or Sample |
| 2 | ≤ $1x10^{-5}$ Per-hour or Sample |
| 3 | ≤ $1x10^{-7}$ Per-hour or Sample |

**Table D-4. SIL Encoding**

| Value | Probability |
|---|---|
| 0 | > $1x10^{-3}$ or unknown |
| 1 | ≤ $1x10^{-3}$ |
| 2 | ≤ $1x10^{-5}$ |
| 3 | ≤ $1x10^{-7}$ |

A.2.27 (Parameters) Source Integrity Level (SIL).

Although the SIL assumes there are no unannunciated faults in the avionics system, the SIL must consider the effects of a faulted Signal-In-Space (SIS), if a SIS is used by the position source.

Note 2: The SIL probability can be defined as either per sample or per-hour as defined in the SIL supplement (SILSUPP).

3.3.3.4 (Installation) Source Integrity Level Supplement (SILSUPP).

SILSUPP is based on whether the position source probability of exceeding the reported integrity value is calculated on a per-hour or per-sample basis and should be set based on design data from the position source equipment manufacturer. ADS-B systems interfaced with a GNSS position source compliant with any revision of TSO-C129 ***[TSO-C129a is the minimum in CS-ACNS]*** , TSO-C145, TSO-C146, or TSO-C196 may preset SILSUPP to "ZERO," as GNSS position sources use a per-hour basis for integrity.

A.2.28 (Parameters) Source Integrity Level Supplement (SILSUPP).

The SILSUPP defines whether the reported SIL probability is based on a per-hour probability or a per-sample probability as defined in Table A-5.

**Table A-5. Source Integrity Level Supplement**

| SIL Supplement | Basis for SIL Probability |
|---|---|
| 0 | Probability of exceeding NIC containment radius is based on per-hour. |
| 1 | Probability of exceeding NIC containment radius is based on per-sample. |

ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets.

4.e. Horizontal Position Quality: SDA/See Definition 4 and $8/65_{16}$

Definition 8: SDA

The encoding of the system design assurance level (SDA) is based on the failure condition that the entire ADS-B Out system, with respect to the horizontal position data and associated quality indicators, is designed to support.

The SDA value is encoded as follows:

**Table 9: SDA Encoding**

| SDA value | Software & Hardware Design Assurance Level (see Note 1) | Corresponding System Integrity Level (see Note 2) |
|---|---|---|
| 0 | N/A | > $1X10^{-3}$ per flight hour or unknown (No Safety Effect) |
| 1 | D | ≤ $1X10^{-3}$ per flight hour (Probable) |
| 2 | C | ≤ $1X10^{-5}$ per flight hour (Remote) |
| 3 | B | ≤ $1X10^{-7}$ per flight hour (Extremely Remote) |

Note 1: Software Design Assurance per EUROCAE ED-12C (RTCA DO-178C). Airborne Electronic Hardware Design Assurance per EUROCAE ED-80 (RTCA DO-254).

Note 2: In line with the ADS-B-RAD requirements, the minimum value required for the horizontal position source is SDA=2 ().

The SDA encoding is the same for airborne position messages and surface position messages.

A.2.29 (Parameters) System Design Assurance (SDA).

The SDA parameter defines the failure condition that the ADS-B system is designed to support as defined in Table A-5. The supported failure condition will indicate the probability of an ADS-B system malfunction causing false or misleading position information or position quality metrics to be transmitted. This should include the probability of exceeding the containment radius without annunciation. Because the installer of ADS-B OUT equipment does not know how the broadcast data will be used, the installer cannot complete a Functional Hazard Assessment (FHA) evaluating the use of the broadcast data. The SDA provides a surrogate for such a FHA by identifying the potential impact of an erroneous position report caused by an equipment malfunction. The definitions and probabilities associated with the supported failure effect are defined in AC 25.1309-1, AC 23.1309-1(),and AC 29-2 (Changes 1-3 incorporated). The SDA includes the position source, ADS-B equipment, and any intermediary devices that process the position data. § 91.227 requires an SDA of 2 or 3 as defined in Table A-6.

D.1.26 (Definition) System Design Assurance (SDA).

The failure condition that the position transmission chain is designed to support. Table D-5 provides a list of possible SDA values. An SDA of 2 or greater is required by § 91.227. Refer to A.2.29 for more information

**Table A-6. System Design Assurance**

| SDA Value | Supported Failure Condition Note 2 | Probability of Failure Causing Transmission of False or Misleading Information Note 3,4 | Software & Hardware Design Assurance Level Note 1,3 |
|---|---|---|---|
| 0 | Unknown/ No safety effect | > $1x10^{-3}$ Per-hour or Unknown | N/A |
| 1 | Minor | ≤ $1x10^{-3}$ Per-hour | D |
| 2 | Major | ≤ $1x10^{-5}$ Per-hour | C |
| 3 | Hazardous | ≤ $1x10^{-7}$ Per-hour | B |

**Table D-5. SDA Encoding**

| Value | Probability of Undetected Fault Causing the Transmission of False or Misleading Information |
|---|---|
| 0 | > $1x10^{-3}$ or unknown |
| 1 | ≤ $1x10^{-3}$ |
| 2 | ≤ $1x10^{-5}$ |
| 3 | ≤ $1x10^{-7}$ |

Note 1: Software design assurance pursuant to RTCA/DO-178C, Software Considerations in Airborne Systems and Equipment Certification, or equivalent. Airborne electronic hardware design assurance pursuant to RTCA/DO-254, Design Assurance Guidance for Airborne Electronic Hardware, or equivalent.

Note 2: Supported failure classification defined in AC 25.1309-1(), AC 23.1309-1(), and AC 29-2().

Note 3: Because the broadcast position can be used by any ADS-B IN equipped aircraft or by ATC, the provisions in AC 23.1309-1() that allow reduction in failure probabilities and design assurance level for aircraft under 6,000 pounds do not apply for the ADS-B OUT system.

Note 4: Includes probability of transmitting false or misleading latitude, longitude, or associated position accuracy and integrity metrics.

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5. Pressure Altitude/See Definition 9/$05_{16}$/Same source as for Mode S replies. Data associated with 'NICbaro' integrity indicator .
Definition 9: Pressure Altitude Data Sources
Refer to AMC1 ACNS.D.ELS.015 for guidance.
The ADS-B NICbaro quality indicator is encoded as follows:

**Table 10: NICbaro Encoding**

| Coding | Meaning |
|---|---|
| 0 | The barometric altitude is based on a Gillham coded input that has not been cross-checked against another source of pressure altitude. |
| 1 | The barometric altitude is either based on a Gillham code input that has been cross-checked against another source of pressure altitude and verified as being consistent, or is based on a non-Gillham coded source. |

3.4.3.2 (Installation) Barometric Altitude Integrity Code ($NIC_{BARO}$).
You should verify the type of altitude source installed in the aircraft and interface the altitude system per the ADS-B equipment manufacturer's instructions. For aircraft with an approved, non-Gillham altitude source, $NIC_{BARO}$ should be preset at installation to "ONE". For aircraft with a Gillham altitude source without an automatic cross-check, $NIC_{BARO}$ must be preset at installation to "ZERO". For aircraft that dynamically cross-check a Gillham altitude source with a second altitude source, the $NIC_{BARO}$ must be set based on the result of this cross-check. We recommend that ADS-B installations use non-Gillham altitude encoders to reduce the potential for altitude errors.
A.2.3 (Parameters) Barometric Pressure Altitude.
This parameter indicates the aircraft's barometric pressure altitude referenced to standard sea level pressure of 29.92 inches of mercury or 1013.2 hectopascals. The barometric pressure altitude is required to be transmitted by § 91.227.
A.2.23 (Parmeters) $NIC_{BARO}$
$NIC_{BARO}$ indicates if pressure altitude is provided by a single Gillham encoder or another more robust altitude source. Because of the potential for an undetected error in a Gillham encoding, many Gillham installations are cross-checked against a second altitude source. $NIC_{BARO}$ annotates the status of this cross-check.
D.1.6 (Definition) Barometric Altitude Integrity Code ($NIC_{BARO}$).
Indicates if pressure altitude is provided by a single Gillham encoder or another, more robust altitude source. Because of the potential for an undetected error in a Gillham encoding, many Gillham installations are cross-checked against a second altitude source. $NIC_{BARO}$ annotates the status of this cross-check.

6 Special Position Identification/Setting as per ED-73E §2.5/$05_{16}$/Same source as for Mode S replies

3.7.3.3 (Installation) IDENT.
The installation must provide a means for the pilot ot enter the IDENT feature.
A.2.16 (Parameters) IDENT.
IDENT is a flag manually set by the pilot at the request of ATC in ATCRBS, Mode S, and ADS-B messages. The pilot manually enables the IDENT state, which highlights their aircraft on the controller's screen. IDENT is required to be transmitted by § 91.227.

7.a. Emergency Status/See Definition 10/$61_{16}$ (subtype 1)/Same source as for Mode S replies (where defined for SSR)
Definition 10: Emergency Status
The provision of the Emergency Status values that do not have a corresponding Mode A Code value (see CS ACNS.D.ELS.) denoting the other emergency conditions defined in $61_{16}$, is optional. This applies to the decimal values 2, 3, 6 and 7 in Table 11.

**Table 11: Emergency Status Encoding**

| Coding (Binary) | Coding (Decimal) | Meaning |
|---|---|---|
| 000 | 0 | No Emergency |
| 001 | 1 | General Emergency |
| 010 | 2 | Lifeguard/medical Emergency |
| 011 | 3 | Minimum Fuel |
| 100 | 4 | No Communications |
| 101 | 5 | Unlawful Interference |
| 110 | 6 | Downed Aircraft |
| 111 | 7 | Reserved |

3.7.3.2 (Installation) Emergency Status.
The installation must provide a means for the pilot to enter the emergency status of the aircraft. Although TSO-C166b and TSO-C154c ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** identify multiple emergency codes, only the codes for general emergency, no communications, and unlawful interference are required to be available for broadcast. It is acceptable to base the ADS-B emergency status on the emergency status code input into the transponder (that is, Mode 3/A codes 7500, 7600, and 7700).
A.2.5 (Parameters) Emergency Status.
This parameter alerts ATC that the aircraft is experiencing emergency conditions and indicates the type of emergency. Applicable emergency codes are found in ICAO Annex 10 Volume 4, Surveillance Radar and Collision Avoidance Systems. This information alerts ATC to potential danger to the aircraft so it can take appropriate action. Emergency status is required to be transmitted by § 91.227.

7.b. Emergency Indication/Setting as per ED-73E §2.5/$05_{16}$/Same source as for Mode S replies

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| | |
|---|---|
| 8. 1090 ES Version Number/To be set to 2 for ED-102A/DO-260B systems/$65_{16}$/Value is fixed at the time the ADS-B transmit unit is manufactured | A.2.34 Version Number.<br>The applicable TSO Minimum Operational Performance Standard (MOPS) level is communicated through the version number, which is fixed at the time the ADS-B equipment is manufactured. Version 2 applies to ADS-B equipment that meets MOPS documents RTCA/DO-260B with corrigendum 1 or RTCA/DO-282B with corrigendum 1 ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** . ADS-B equipment outputting version 2 or higher is required by § 91.227. |
| 9.a. Airborne Horizontal Velocity (Ground Speed) - east/west and north/south/See Definition 11/$09_{16}$ (subtypes 1 and 2)/Same source as for SSR EHS replies<br>14. Movement (surface ground speed)/See Definitions 11 and 12/$06_{16}$/NACv: same as for airborne ground velocity (see 9b)<br>Definition 11: Horizontal Velocity (Ground Velocity)<br>The horizontal velocity provides the rate at which an aircraft changes its horizontal position with a clearly stated direction.<br>Velocity data sources provide ground velocity vector information for both the airborne and surface velocity data transmit formats, allowing for the transmission of east/west and north/south velocity information ($09_{16}$), or velocity scalar ($06_{16}$, movement) and possibly ground track information2 ($06_{16}$), respectively. In case of a failure of the provision of ground velocity data, the ADS-B transmit unit will broadcast airspeed (and heading) information instead (using subtypes 3 or 4 of register $09_{16}$. | B.3.2 (Position Source Qualification - General) Horizontal Velocity.<br>The position source must output north/south and east/west velocities. We recommend the position source also output the velocity in a ground speed and track angle format.<br>3.3.3.2 (Installation) Horizontal Velocity.<br>The ADS-B equipment must set the horizontal velocity based on the real-time velocity information provided by the position source. The ADS-B equipment must transmit a north/south and an east/west velocity while airborne, and a combination of ground speed and ground track or heading while on the surface. Ensure the position source provides horizontal velocity in both formats or ensure the ADS-B equipment can properly convert between formats. We recommend transmitting heading instead of ground track while on the surface. Refer to section 3.5.3 of this AC for additional information on interfacing heading.<br>A.2.13 (Parameters) Horizontal Velocity.<br>The horizontal velocity provides the rate at which an aircraft changes its horizontal position with a clearly stated direction. Horizontal velocity is provided with the north/south velocity and the east/west velocity parameters while airborne. Horizontal velocity is provided by a combination of the ground speed and heading or ground track while on the surface. TSO-C166b and TSO-C154c ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** require that the north/south velocity, east/west velocity, ground speed, and ground track come from the same source as the position. Heading information may come from a separate source. Horizontal velocity is required to be transmitted by § 91.227.<br>A.2.10 (Parameters) Ground Speed.<br>This parameter is also derived from the position sensor and provides ATC with the aircraft's speed over the ground. This parameter is reported in the surface position message. |
| 9.b. Horizontal Velocity Quality: NACv/See Definition 12/$09_{16}$ (airborne) and $65_{16}$ (subtype 1 surface)<br>14. Movement (surface ground speed)/See Definitions 11 and 12/$06_{16}$/NACv: same as for airborne ground velocity (see 9b)<br>Definition 12: Horizontal Velocity Quality Indicator NACv<br>The NACv is an estimate of the accuracy of the horizontal geometric velocity data.<br>The NACv value is encoded as follows:<br>The NACv encoding is the same for airborne position messages and surface position messages. | 3.3.3.7 (Installation) Navigation Accuracy Category for Velocity (NACv).<br>Set the NACv based on design data provided by the position source manufacturer. The NACV may be updated dynamically from the position source, or set statically based on qualification of the position source.<br>A.2.21 (Parameters) Navigation Accuracy Category for Velocity ($NAC_V$).<br>The $NAC_V$ is an estimate of the accuracy of the horizontal geometric velocity output. The coding of "ZERO," indicating that the accuracy is unknown or either equal to or worse than 10 meters per second (m/s), is of little value to ADS-B applications. There is no vertical rate accuracy metric. A $NAC_V$ of greater than or equal to "1" is required by § 91.227. Table A-2 provides the applicable NIC ***[typo]*** values.<br>D.1.19 (Definition) Navigational Accuracy Category for Velocity (NACV).<br>Used to indicate, with 95 percent certainty, the accuracy of the aircraft reported horizontal velocity. Table D-2 provides a list of possible NACV values. A NACV of 1 or greater is required by § 91.227. |

**Table 12: NACv Encoding**

| Navigation Accuracy Category for Velocity NACv | | |
|---|---|---|
| Coding | | Horizontal Velocity Error (95%) |
| (Binary) | (Decimal) | |
| 000 | 0 | Unknown or ≥ 10 m/s |
| 001 | 1 | < 10 m/s |
| 010 | 2 | < 3 m/s |
| 011 | 3 | < 1 m/s |
| 100 | 4 | < 0.3 m/s |

**Table A-2. $NAC_V$**

| Value | Velocity Accuracy Bound (Estimated Velocity Uncertainty) |
|---|---|
| 0 | ≥ 10 m/s or unknown |
| 1 | < 10 m/s |
| 2 | < 3 m/s |
| 3 | < 1 m/s |
| 4 | < 0.3 m/s |

**Table D-2. $NAC_V$**

| Value | Velocity Accuracy Bound (Estimated Velocity Uncertainty) |
|---|---|
| 0 | ≥ 10 m/s or unknown |
| 1 | < 10 m/s |
| 2 | < 3 m/s |
| 3 | < 1 m/s |
| 4 | < 0.3 m/s |

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10. Emitter Category/See Definition 13/$08_{16}$

Definition 13: Emitter Category

Emitter Category settings describe the size and performance of an aircraft, primarily expressed with respect to its maximum take-off weight.

The Emitter Category value is encoded as follows:

The ADS-B Emitter Category Sets A, B, C or D are identified by the Message Format TYPE Codes 4, 3, 2, and 1 respectively.

Note 1: A coding of '0' within an Emitter Category Set is not allowed.

Note 2: The Emitter Category codes 1 to 5 in category set A are intended to advise other aircraft of the transmitting aircraft's wake vortex characteristics, and not necessarily the transmitting aircraft's actual maximum take-off weight. In case of doubt, the next higher aircraft category code should be used.

**Table 13: Emitter Category Encoding**

| ADS-B Emitter Category Set "A" | |
|---|---|
| **Coding** | **Meaning** |
| 0 | No ADS-B Emitter Category Information |
| 1 | Light (< 7 031 kg (15 500 lbs)) |
| 2 | Small (7 031 to 34 019 kg (15 500 to 75 000 lbs)) |
| 3 | Large (34 019 to 136 078 kg (75 000 to 300 000 lbs)) |
| 4 | High-Vortex Large (aircraft such as B-757) |
| 5 | Heavy (> 136 078 kg (300 000 lbs)) |
| 6 | High Performance (> 49 m/s² (5g) acceleration and > 205 m/s (400 knots)) |
| 7 | Rotorcraft |

| ADS-B Emitter Category Set "B" | |
|---|---|
| **Coding** | **Meaning** |
| 0 | No ADS-B Emitter Category Information |
| 1 | Glider / Sailplane |
| 2 | Lighter-than-Air |
| 3 | Parachutist / Skydiver |
| 4 | Ultralight / hang-glider / paraglider |
| 5 | Reserved |
| 6 | Unmanned Aerial Vehicle |
| 7 | Space / Trans-atmospheric vehicle |

| ADS-B Emitter Category Set "C" | |
|---|---|
| **Coding** | **Meaning** |
| 0 | No ADS-B Emitter Category Information |
| 1 | Surface Vehicle - Emergency Vehicle |
| 2 | Surface Vehicle - Service Vehicle |
| 3 | Point Obstacle (includes tethered balloons) |
| 4 | Cluster Obstacle |
| 5 | Line Obstacle |
| 6 - 7 | Reserved |

| ADS-B Emitter Category Set "D" | |
|---|---|
| **Coding** | **Meaning** |
| 0 | No ADS-B Emitter Category Information |
| 1 - 7 | Reserved |

3.2.3.4 (Installation) Emitter Category.

Set emitter category per manufacturer instructions. Table 1 below provides guidance on setting the emitter category that is appropriate for the type of aircraft it is being install on.

A.2.6 (Parameters) Emitter Category.

The emitter category provides an indication of the aircraft's size and performance capabilities. Emitter categories are defined in TSO-C166b and TSO-C154c ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** . Emitter category is designed primarily to provide information on the wake turbulence that an aircraft produces. Emitter category is required to be transmitted by § 91.227.

**Table 1. Emitter Category**

| Emitter Category | Description |
|---|---|
| No Emitter Category | Do not use this emitter category. If no emitter category fits your installation, seek guidance from the FAA as appropriate. |
| Light Airplane < 15,500 lbs | Any airplane with a maximum takeoff weight less than 15,500 pounds. This includes very light aircraft (light-sport aircraft) that do not meet the requirements of 14 CFR 103.1. |
| Small Airplane ≥ 15,500 to < 75,000 lbs | Any airplane with a maximum takeoff weight greater than or equal to15,500 pounds but less than 75,000 pounds. |
| Large Airplane ≥ 75,000 to < 300,000 lbs | Any airplane with a maximum takeoff weight greater than or equal to 75,000 pounds but less than 300,000 pounds that does not qualify for the high vortex category. |
| Large Airplane With High Vortex | Any airplane with a maximum takeoff weight greater than or equal to 75,000 pounds but less than 300,000 pounds that has been determined to generate a high wake vortex. Currently, the Boeing 757 is the only example. |
| Heavy ≥ 300,000 lbs | Any airplane with a maximum takeoff weight equal to or above 300,000 pounds. |
| High Performance > 5 G and > 400 TAS | Any airplane, regardless of weight, that can maneuver in excess of 5 G's and maintain true airspeed above 400 knots. |
| Rotorcraft | Any rotorcraft, regardless of weight. |
| Glider / Sailplane | Any glider or sailplane, regardless of weight. |
| Lighter Than Air | Any lighter-than-air (airship or balloon), regardless of weight. |
| Parachute / Sky Diver | For use by parachute / sky divers. |
| Ultralight Vehicle | A vehicle that meets the requirements of 14 CFR 103.1.Light sport aircraft should not use the ultralight emitter category unless they meet 14 CFR 103.1. |
| UAV | Any unmanned aerial vehicle or system regardless of weight. |
| Space/Trans-atmospheric Vehicle | For use by space/trans-atmospheric vehicles. |
| No ADS-B Emitter Category Information | Do not use this emitter category. Refer to category 0 above. |
| Surface Vehicle—Emergency Vehicle | For use by surface emergency vehicles. |
| Surface Vehicle—Service Vehicle | For use by surface vehicles. |
| Point Obstacle (Includes Tethered Balloons) | For use by point obstacles to include tethered Balloons. |
| Cluster Obstacle | For use by cluster obstacles. |
| Line Obstacle | For use by line obstacles. |

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| | |
|---|---|
| 11. Vertical Rate/See Definition 14/0916 (subtypes 1 and 2)/Selected source is indicated in 0916 source indication)<br>Definition 14: Vertical Rate<br>Vertical Rate is either the barometric or geometric rate at which the aircraft is climbing or descending, measured in feet per minute. The vertical rate is typically generated by an air data computer or GNSS position source, or equipment which blends barometric vertical rate with inertial vertical rate and/or GNSS vertical rate.<br>As the geometric vertical rate can be readily derived from the ADS-B Out position source, it is classified as a minimum requirement rather than an (effectively Mode S Enhanced Surveillance) conditional requirement ***[CS requires Vertical Rate parameter].*** | 3.9 (Installation) Vertical Rate Source.<br>We recommend that the ADS-B system output the vertical rate field when available ***[Vertical Rate is not required by § 91.227 (optional)]*** .<br>The vertical rate may come from a barometric air data computer, a GNSS source, or a system that filters barometric and geometric vertical rates. Vertical rate will typically come from a position source or an air-data computer. This section addresses this unique parameter, and augments section 3.3 and 3.4 of this AC, as applicable.<br>3.9.3.1 (Installation) Vertical Rate.<br>Interface vertical rate from one or more of the sources listed in section 3.9.1 above. Ensure the source provides vertical rate in feet per minute, or ensure the ADS-B equipment can recognize the vertical rate basis and convert the vertical rate to feet per minute.<br>A.2.33 (Parameters) Vertical Rate.<br>The vertical rate is the barometric or geometric rate at which the aircraft is climbing or descending, measured in feet per minute. The vertical rate is typically generated by an air data computer or GNSS position source, or equipment that blends barometric vertical rate with inertial vertical rate and/or GNSS vertical rate. |
| 12.a. Surface Horizontal Position - Latitude and Longitude/Source see AMC ACNS.D.ADSB.070 See Definition 3/$06_{16}$/Quality indicators NACp, SIL, SDA: same encodings as for airborne horizontal position. | |
| 12.a. Surface Horizontal Position - Latitude and Longitude/Source see AMC ACNS.D.ADSB.070 See Definition 3/0616/Quality indicators NACp, SIL, SDA: same encodings as for airborne horizontal position.<br>Definition 15: Surface NIC Value<br>The Surface NIC value, including the NIC Supplement A and C values, is encoded as follows: | |

**Table 14: Surface NIC Encoding**

| NIC Value | Radius of Containment ($R_C$) | Surface | | |
|---|---|---|---|---|
| | | Surface Position TYPE Code | NIC Supplement Codes | |
| | | | A | C |
| 0 | $R_C$ unknown | 0, 8 | 0 | 0 |
| 6 | $R_C$ < 1 111.2 m (0.6 NM) | 8 | 0 | 1 |
| | $R_C$ < 555.6 m (0.3 NM) | 8 | 1 | 0 |
| 7 | $R_C$ < 370.4 m (0.2 NM) | 8 | 1 | 1 |
| 8 | $R_C$ < 185.2 m (0.1 NM) | 7 | 0 | 0 |
| 9 | $R_C$ < 75m | 7 | 1 | 0 |
| 10 | $R_C$ < 25m | 6 | 0 | 0 |
| 11 | $R_C$ < 7.5m | 5 | 0 | 0 |

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| | |
|---|---|
| 13. Heading, Ground Track/See Definition 16/$06_{16}$/Heading preferred source<br>Definition 16: Surface Heading/Ground Track<br>Aircraft Heading indicates the direction in which the nose of the aircraft is pointing. It should be used as the primary source and be expressed (in ME bit 54 in $65_{16}$) as either true north ('0', preferred) or magnetic north ('1').<br>If an approved heading source is not available (or failed during operation), the Ground Track angle information from the selected ground velocity data source will be used instead by the ADS-B transmit unit for the determination of the direction of the horizontal velocity vector. If the position source ground track is used and inaccurate below a certain ground speed, and the position source does not inhibit output of the ground track at these slower speeds, the installer should ensure that the ADS-B transmit unit has the capability to invalidate the ground track when the GNSS ground speed falls below a threshold specified by the position source manufacturer (e.g. 3.6 m/s (7 knots)). | 3.3.3.2 (Installation) Horizontal Velocity.<br>...The ADS-B equipment must set...a combination of ground speed and ground track or heading while on the surface. We recommend transmitting heading instead of ground track while on the surface. Refer to section 3.5.3 of this AC for additional information on interfacing heading.<br>3.3.3.10 (Installation) Ground Track Angle.<br>For installations that do not have heading information available, ground track from the position source must be transmitted while on the surface. Many position sources will provide accurate ground track information, but the ground track may only be accurate above certain ground speeds. If the position source ground track is inaccurate below a certain ground speed and the position source does not inhibit output of the ground track at these slower speeds, the installer should ensure the ADS-B equipment has the capability to invalidate the ground track when the GNSS ground speed falls below 7 knots. Erroneous ground track readings could be misleading for ATC surface operations and ADS-B IN applications. If the position source itself inhibits output of ground track at slower speeds where the ground track would be inaccurate, the installer may interface the position source ground track to the ADS-B equipment without any restrictions.<br>3.5.2.2 (Installation) Interfacing heading is not required, but is highly encouraged if the aircraft has an approved heading source.<br>3.5.3 Configuration of Associated Parameters.<br>When the aircraft is on the surface, the ADS-B system is required to transmit either heading or ground track; however, we recommend transmitting heading if a source of heading information is available and valid. True heading is preferred, but magnetic heading is acceptable. Ensure the heading type (true or magnetic) interfaced to the ADS-B equipment matches the heading type transmitted from the ADS-B equipment.<br>3.5.2.1 The heading does not need to come from the same source as the position and velocity. |
| 13. Heading, Ground Track/See Definition 16/$06_{16}$/Heading preferred source<br>Definition 16: Surface Heading/Ground Track (cont.) | A.2.11 (Parameters) Ground Track Angle.<br>The ground track angle is the direction of the horizontal velocity vector over the ground. Ground track or heading is required to be transmitted while on the ground to transmit complete velocity information.<br>A.2.12 (Parameters) Heading.<br>Heading indicates the direction in which the nose of the aircraft is pointing. There is no heading accuracy metric. Heading or ground track is required to be transmitted while on the ground to transmit complete velocity information.<br>A.2.13 (Parameters) Horizontal Velocity.<br>...Horizontal velocity is provided by a combination of the ground speed and heading or ground track while on the surface. |
| 15. Length & width of aircraft/See Definition 17/6516 (subtype 1)<br>Definition 17: Aircraft Length and Width<br>Aircraft Length and Width settings describe the aircraft dimensions by the width and length of a rectangle that is aligned parallel to the aircraft's heading. The aircraft's length is to be measured along its axis of symmetry (i.e. from nose to tail). The aircraft's width is to be measured from wing-tip to wing-tip.<br>The Aircraft Length and Width values are encoded as shown in Table 15 to be less than or equal to a respective upper bound length and width as expressed in the two right-side columns. The Length and Width Codes are based on a combined encoding of the actual length and width whereby the largest respective upper bound prevails. If the Aircraft or Vehicle is longer than 85 meters, or wider than 90 meters, then decimal Aircraft/Vehicle Length/Width Code 15 is used.<br>Example: a powered glider with an overall length of 24 meters and wingspan of 50 meters would, normally, have a length code of '001'. HoweveA142:A143r, since the wingspan exceeds 34 meters, it does not qualify for either Width subcategory of length category '001'. In line with its actual width, such an aircraft would be assigned a length code of '100' and width code of '1', meaning length less than 55 meters and width less than 52 meters. | 3.2.3.2 (Installation) Aircraft Length and Width.<br>This parameter must be configured during installation. Do not set the length and width parameter to a value of "0," as the length and width code is required by § 91.227. The length and width code chosen should be the smallest value that encompasses the entire aircraft and any fixed objects. For fixed-wing aircraft, this may be the nose, or other fixed object forward of the nose, such as a pitot probe. For rotorcraft, this may be the most forward, aft and lateral point the rotor blades sweep or some other fixed object such as a refueling boom. See (refer to figure 2 below).<br>A.2.18 (Parameters) Length and Width of Aircraft.<br>This parameter provides ATC and other aircraft with quick reference to the aircraft's dimensions while on the surface. Aircraft length and width is required to be transmitted by § 91.227. |

ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets.

**Figure 2. Example of Aircraft Length and Width Code Determination**

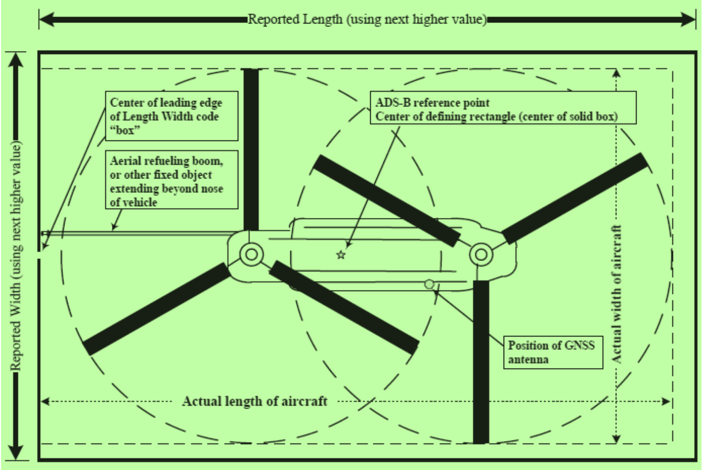


**Table 15: Aircraft Length/Width Encoding**

| A/V - L/W Code (Decimal) | Length Code 'ME' Bit 21 | Length Code 'ME' Bit 22 | Length Code 'ME' Bit 23 | Width Code 'ME' Bit 24 | Upper-Bound Length (meters) | Upper-Bound Width (meters) |
|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | No Data or Unknown | |
| 1 | 0 | 0 | 0 | 1 | 15 | 23 |
| 2 | 0 | 0 | 1 | 0 | 25 | 28.5 |
| 3 | | | | 1 | | 34 |
| 4 | 0 | 1 | 0 | 0 | 35 | 33 |
| 5 | | | | 1 | | 38 |
| 6 | 0 | 1 | 1 | 0 | 45 | 39.5 |
| 7 | | | | 1 | | 45 |
| 8 | 1 | 0 | 0 | 0 | 55 | 45 |
| 9 | | | | 1 | | 52 |
| 10 | 1 | 0 | 1 | 0 | 65 | 59.5 |
| 11 | | | | 1 | | 67 |
| 12 | 1 | 1 | 0 | 0 | 75 | 72.5 |
| 13 | | | | 1 | | 80 |
| 14 | 1 | 1 | 1 | 0 | 85 | 80 |
| 15 | | | | 1 | | 90 |

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16. GPS Antenna Offset/See Definition 18/$65_{16}$ (subtype 1) /Lateral and longitudinal
Definition 18: GPS Antenna Offset (lateral and longitudinal)
GPS Antenna Offset information provides the position offset of the GNSS antenna used for the provision of horizontal position information. Both a lateral distance of the GPS Antenna (from the longitudinal axis of the aircraft) and a longitudinal distance of the GPS Antenna (from the nose of the aircraft) are provided.
The accuracy of the information should be better than 2 meters, consistent with the data resolution.
The lateral and longitudinal GPS Antenna Offset values are encoded as follows:

**Table 16: Lateral Axis GPS Antenna Offset Encoding**

| 'ME' Bit (Message Bit) 33 (65) | 34 (66) | 35 (67) | Upper Bound of the GPS Antenna Offset Along Lateral (Pitch) Axis Left or Right of Longitudinal (Roll) Axis | |
|---|---|---|---|---|
| 0 = left<br>1 = right | Encoding Bit 1 | Encoding Bit 0 | Direction | (meters) |
| 0 | 0 | 0 | LEFT | NO DATA |
| | 0 | 1 | | 2 |
| | 1 | 0 | | 4 |
| | 1 | 1 | | 6 |
| 1 | 0 | 0 | RIGHT | 0 |
| | 0 | 1 | | 2 |
| | 1 | 0 | | 4 |
| | 1 | 1 | | 6 |

*Supplementary Notes*

*Maximum distance left or right of aircraft longitudinal (roll) axis is 6 meters or 19.685 feet. If the distance is greater than 6 meters, then the encoding should be set to 6 meters.*

*The No Data case is indicated by encoding of 000 as above, while the ZERO offset case is represented by encoding of 100 as above.*

*The rounding should be performed to half of the resolution of the GPS antenna offset information, i.e. +/- 1 meter.*

A.2.9.1 (Parameters) The GNSS antenna offset indicates the longitudinal distance between the most forward part of the aircraft and the GNSS antenna, and the lateral distance between the longitudinal center line of the aircraft and the GNSS antenna. Also, refer to section 3.8.4.1 – 3.8.4.3 and Figure 3 of this AC.
GNSS Antenna Offset and Position Offset Applied (POA).
3.8.4.1 (Installation) Although not required to comply with § 91.227 ***[CS requires GPS Antenna Offset parameter]*** , it is highly encouraged for ADS-B equipment manufacturers to provide instructions to installers for setting this parameter and for installers to configure the offset during installation. The GNSS antenna offset information will be extremely valuable for surface ATC surveillance and future ADS-B IN surface situational awareness and surface collision alerting applications.
3.8.4.2 (Installation) If the ADS-B equipment is interfaced to multiple GNSS position sources that use GNSS antennas in different locations on the aircraft, the installation must have provisions to ensure the appropriate GNSS antenna offset is being transmitted when the ADS-B equipment switches from one position source to another.

**Table 17: Longitudinal Axis GPS Antenna Offset Encoding**

| 'ME' Bit (Message Bit) | | | | | Upper Bound of the GPS Antenna Offset Along Longitudinal (Roll) Axis Aft From Aircraft Nose |
|---|---|---|---|---|---|
| 36 (68) | 37 (69) | 38 (70) | 39 (71) | 40 (72) | |
| Encoding | | | | | |
| Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 | (meters) |
| 0 | 0 | 0 | 0 | 0 | NO DATA |
| 0 | 0 | 0 | 0 | 1 | Position Offset Applied by Sensor *(see also Notes)* |
| 0 | 0 | 0 | 1 | 0 | 2 |
| 0 | 0 | 0 | 1 | 1 | 4 |
| 0 | 0 | 1 | 0 | 0 | 6 |
| * | * | * | * | * | *** |
| 1 | 1 | 1 | 1 | 1 | 60 |

*Supplementary Notes:*

*If the distance is greater than 60 meters, the encoding should be set to 60 meters.*

*Position Offset Applied by the Sensor applies to future cases where the antenna offset is compensated by the horizontal position source to the centre of the rectangle describing the aircraft's length and width (refer to Definition 17).*

*The encoding of the values from decimal '2' (only bit 1 one set to '1') to '31' (all five bits set to '1') is as follows: encoded binary value = offset [m]) / 2 + 1 (e.g. an offset of 4 meters leads to a binary value of (4/2 + 1 = 3), i.e. Bits 0-1 equal '1' and Bits 2-4 equal '0').*

| | |
|---|---|
| | ***Additional Guidance not Addressed in CS-ACNS*** |
| | 3.8.4.3 (Installation) The POA setting of the GNSS antenna indicates if the broadcast position of the vehicle is referenced to either a) the aircraft's ADS-B position reference point, or b) the lateral distance from centerline and longitudinal distance from the most forward part of the aircraft, (reference 4.5.6 B.4.1).<br>Note: Either the transmitted position should be adjusted to the reference point described in paragraph 3.8.4.4 OR the GNSS antenna offsets should be provided. It is not required to do both. |
| | 3.8.4.4 (Installation) The ADS-B position reference point is the center of the rectangle used to describe the length and width of the aircraft in the length and width code. Refer to section 3.2.3.2 and figure 2 of this AC. For a more detailed description of POA, refer to RTCA/DO-338, Minimum Aviation System Performance Standards (MASPS) for ADS-B Traffic Surveillance Systems and Applications (ATSSA), section 3.2.4.1. |
| | A.2.9.2 (Installation) The POA setting of the GNSS antenna offset indicates that the broadcast position is referenced to the aircraft's ADS-B position reference point versus the GNSS antenna location. Also, refer to section 3.8.4.1 - 3.8.4.3and Figure 3 of this AC. For further details about POA, refer to RTCA/DO-338, section 3.2.4.1. |

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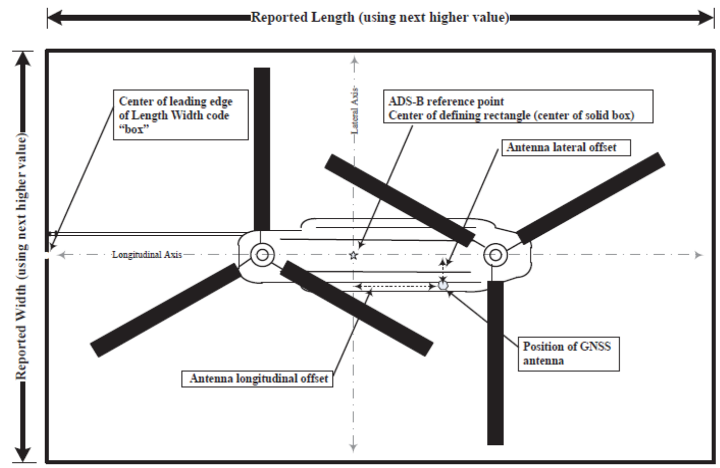
**Figure 3. Position Offset**




17.a. Geometric Altitude/See Definition 19/$09_{16}$ ($05_{16}$)

Definiton 19: Geometric Altitude

The geometric altitude is a measure of the aircraft's height above a geometric reference and is provided by a GNSS-based position source. Both within $05_{16}$ and $09_{16}$, Geometric Altitude is provided as height above ellipsoid (HAE) in accordance with the WGS 84 coordinate system (AMC1 ACNS.D.ADSB.085(b)).

3.3.3.8 (Installation) Geometric Altitude.

Ensure the geometric altitude provided by the position source is based on Height-Above-Ellipsoid (HAE) instead of Height-Above-Geoid (HAG). Do not interface a position source that provides HAG or Mean Sea Level (MSL) altitude to the ADS-B equipment unless the ADS-B equipment has the ability to determine the difference between an HAG and HAE input, and the ADS-B equipment has demonstrated during design approval that it can properly convert HAG to HAE using the same model as the position source. It would also be acceptable to demonstrate that the error due to conversion of HAG to HAE does not cause the GVA to be exceeded.

A.2.7 (Parameters) Geometric Altitude.

The geometric altitude is a measure of altitude provided by a satellite-based position service and is not affected by atmospheric pressure. Geometric altitude is only available with a GNSS position source. Geometric altitude for ADS-B purposes is the height above the World Geodetic System 1984 (WGS-84) ellipsoid (HAE). Geometric altitude is required to be transmitted by § 91.227.

17.b. Geometric Altitude Quality: GVA/See Definition 20/6516 (subtype 0)

Definition 20: Geometric altitude quality indicator information (GVA)

The GVA parameter expresses the actual performance of the geometric altitude data source as valid at the time of applicability of the measurement.

The GVA value is encoded as follows:

**Table 18: GVA Encoding**

| GVA Encoding (decimal) | 95% Accuracy (meters) |
|---|---|
| 0 | Unknown or > 150 meters |
| 1 | ≤ 150 meters |
| 2 | ≤ 45 meters |
| 3 | Reserved |

***[GVA is not required by § 91.227 (optional)]***

3.3.3.9 (Installation) Geometric Vertical Accuracy (GVA).

Set the GVA based on design data provided by the position source manufacturer. GNSS position sources may provide the geometric altitude accuracy through the Vertical Figure of Merit (VFOM). If the position source does not output a qualified vertical accuracy metric, the GVA parameter should be set to "0".

A.2.8 (Parameters) Geometric Vertical Accuracy (GVA).

The GVA indicates the 95-percent accuracy of the reported vertical position (geometric altitude) within an associated allowance.

***Additional Guidance not Addressed in CS-ACNS***

<table>
<tr><td colspan="2">ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets.</td></tr>
<tr><td></td><td>A.2.15 (Parameters) IFR Capability.<br>This parameter existed in TSO-C166a and TSO-C154b compliant equipment, but was removed from TSO-C166b and TSO-C154c equipment [Remove from AC 20-165B] .</td></tr>
<tr><td></td><td>A.2.25 (Parameters) Receiving ATC Services.<br>This parameter is a bit set in the ADS-B system of an aircraft indicating that the Mode A code is not set to “1200”.  This parameter existed in TSO-C166a and TSO-C154b compliant equipment, but was removed from TSO-C166b and TSO-C154c equipment [Remove from AC 20-165B] .</td></tr>
<tr><td></td><td>A.2.32 (Parameters) Trajectory Change Report Capability.<br>This information is permanently set to “zero” in TSO-C166b or TSO-C154c [CS only recongnizes 1090 ES for the ADS-B Out data link] equipment.  No installation interface is required.  Trajectory change reports are reserved for future use.</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Appendix H - Part 2 – ADS-B Out Surveillance Data Parameters (AMC1 ACNS.D.ADSB.020(b))</td><td></td></tr>
<tr><td>Table 19 below makes reference to the BDS register(s) that contain the various ADS-B Out surveillance data parameters. When Table 19 states Same source as for Mode S replies, reference is made to the requirement that the content of ADS-B broadcasts and Mode S replies that carry the same information and need to come from the same source (CS ACNS.D.ADSB.025(b)).<br>Guidance on the content of the various BDS registers and their relationship with the ADS-B message Type Codes is provided in Table 4 in part 1 of Appendix A.<br><br>Table 19: ADS-B-ADD Surveillance Data Transmission Requirements
<table>
<tr><th>Item</th><th>Parameter</th><th>Requirements</th><th>BDS Register</th><th>Remarks</th></tr>
<tr><td>1</td><td>Selected Altitude</td><td rowspan="2">See Definition 21.</td><td>$62_{16}$</td><td rowspan="4">Same source as for Mode S replies</td></tr>
<tr><td>2</td><td>Barometric Pressure Setting</td><td>$62_{16}$</td></tr>
<tr><td>3a</td><td>ACAS Operational</td><td rowspan="2">See Definition 22.</td><td>$62_{16}$ and $65_{16}$</td></tr>
<tr><td>3b</td><td>Resolution Advisory (RA)</td><td>$61_{16}$ (subtype 2)</td></tr>
</table></td><td>3.1.6 (Installation) Populating Message Elements.<br>§ 91.227 lists parameters that must be populated (that is, not a null value) for operation in airspace defined by § 91.225.  All parameters transmitted by the ADS-B system must conform to the standards in TSO-C166b or TSO-C154c [CS only recongnizes 1090 ES for the ADS-B Out data link]  and may not contain false or misleading information.<br>A.1 (Parameters) Purpose.<br>This appendix provides a description of the message elements that may be contained in an ADS-B OUT message.</td></tr>
<tr><td>Definition 21: Selected Altitude/Barometric Pressure Setting<br>Refer to AMC1 ACNS.D.EHS. (c) (1 and (c) (3) for detailed guidance.</td><td>[Selected Altitude/Barometric Pressure Setting is not required by § 91.227 (optional)]<br>3.11.1 (Installation - Foreign Airspace Requirements) Optional Parameters [CS requires Selected Altitude/Barometric Pressure Setting parameters when available and in a suitable format].<br>If operations are planned in a country that requires parameters not mandated in the United States, such as selected heading and selected altitude, follow the ADS-B equipment manufacturer’s installation guidance to interface those parameters.</td></tr>
<tr><td>Definition 22: ACAS Operational /Resolution Advisory (RA) Refer to AMC1 ACNS.D.ELS.015 (f) for detailed guidance.<br>The data is populated from ACAS II systems if installed on the aircraft. Both parameters should be preset to ‘zero’ if an ACAS II system is not installed (refer to ADS-B transmit unit manufacturer instructions).</td><td>3.6.1 (Installation) Equipment Eligibility.<br>TCAS II systems should comply with TSO-C119a, Traffic Alert and Collision Avoidance System (TCAS) Airborne Equipment, TCAS II, or subsequent version, and be installed in accordance with AC 20-131A, Airworthiness Approval of Traffic Alert and Collision Avoidance Systems (TCAS II) and Mode S Transponders, or any revision of AC 20-151, Airworthiness Approval of Traffic Alert and Collision Avoidance Systems (TCAS II), Versions 7.0 and 7.1 and Associated Mode S Transponders, as applicable.  No ADS-B interface is available or required for TCAS I systems.<br>Note: Many aircraft will be equipped with a Mode S transponder with ADS-B functionality and a TCAS II.  The Mode S transponder is considered to be a component of the TCAS II system and also a component of the ADS-B system.<br>3.6.2.1 (Installation) TCAS II Interface.<br>TCAS II is not a required part of the ADS-B system; however, if TCAS II is installed on your aircraft, the equipment must be integrated so the “TCAS installed and operational” and the “TCAS traffic status” parameters indicate the real-time status of the TCAS II.<br>3.6.3.1 (Installation) TCAS Installed and Operational.<br>This parameter must interface with the TCAS II system if a TCAS II system is installed on your aircraft.  This parameter should be preset to “ZERO” if a TCAS II is not installed in your aircraft or if a TCAS I is installed in your aircraft.  Typically, this parameter will already be provided to the Mode S transponder from the TCAS II.  TCAS II systems compliant with TSO-C119() indicate they are operational and able to issue an RA when they transmit Reply Information (RI) = 3 or 4 to the transponder.<br>TCAS Traffic Status.<br>3.6.3.2 (Installation) This parameter must be interfaced with the TCAS II system if a TCAS II system is installed on your aircraft.  The TCAS traffic status parameter can be preset to “ZERO” in accordance with the ADS-B equipment manufacturer’s instructions if a TCAS II is not installed.</td></tr>
</table>

<table>
<tr><td colspan="2">ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets.</td></tr>
<tr><td>Definition 22 (cont.)</td><td>A.2.30 (Parameters) TCAS Installed and Operational.<br>This parameter indicates whether the aircraft is fitted with a TCAS II and if the TCAS II is turned on and operating in a mode that can generate resolution advisory alerts. The TCAS installed and operational parameter is required to be transmitted by § 91.227.<br>A.2.31 (Parameters) TCAS Traffic Status.<br>This parameter indicates if a TCAS II equipped aircraft is currently generating a TCAS resolution advisory. The TCAS traffic status parameter is required to be transmitted by § 91.227 if the aircraft is TCAS II equipped.</td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td>Additional Guidance not Addressed in CS-ACNS</td></tr>
<tr><td></td><td>3.6.2.2 (Installation) TCAS II Hybrid Surveillance.<br>If an ADS-B IN system is installed in an aircraft equipped with a TCAS II hybrid surveillance system compliant with RTCA/DO-300(), Minimum Operational Performance Standards (MOPS) for Traffic Alert and Collision Avoidance System II (TCAS II) Hybrid Surveillance, the TCAS II will use ADS-B IN position data to reduce the interrogation rates of low-threat intruders. The information transmitted by ADS-B OUT systems installed in accordance with the guidance in this AC is suitable for use by TCAS II hybrid surveillance. Refer to AC 20-151() for more information on hybrid surveillance.</td></tr>
<tr><td></td><td>3.6.2.3 (Installation) TCAS Messages.<br>The ADS-B transmission of the “TCAS operational” or “TCAS Resolution Advisory (RA) active” messages does not increase the hazard level of the ADS-B equipment defined in TSO-C166b or TSO-C154c [CS only recongnizes 1090 ES for the ADS-B Out data link].</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Appendix H - Part 3 – ADS-B Out Minimum Horizontal Position and Velocity Data Requirements</td><td></td></tr>
<tr><td>Table 20 provides a summary of the minimum horizontal position data requirements as specified in the defining ADS-B-RAD Safety and Performance Requirements/Interoperability document (ED-161).<br>Note 1: The requirement of NACp<=0.1NM in support of 3NM separation is based on the arguments produced in Annex B to ED-161 (ADS-B-RAD Safety and Performance Requirements/Interoperability Requirements Document).<br>Note 2: The SDA encoding of ‘2’ (10-5/fight-hour) applies to individual components of the ADS-B Out system, i.e. 10-5/flight-hour for the ADS-B transmit unit and 10-5/flight-hour for the horizontal position and velocity source.<br>Note 3: ADS-B transmit units interfaced with a GNSS position source that is compliant with CS ACNS.D.ADSB.070 (and the related AMC guidance) should preset the SIL Supplement to ‘zero’.<br><br>Table 20: Minimum Horizontal Position and Velocity Data Quality Requirements
<table>
<tr><th>Quality Parameter</th><th>Requirement</th></tr>
<tr><td>Position Accuracy (NACp)</td><td>NACp<=185.2 m (0.1NM) (i.e. NACp>=7) for both 3 NM and 5 NM separation</td></tr>
<tr><td>Position Integrity Containment Radius (NIC)</td><td>3 NM Sep: NIC<=1 111.2 m (0.6 NM) (i.e. NIC>=6)<br>5 NM Sep: NIC<=1 852 m (1 NM) (i.e. NIC>=5)</td></tr>
<tr><td>Source Integrity Level (SIL)</td><td>SIL=3: $10^{-7}$/flight-hour</td></tr>
<tr><td>System Design Assurance (SDA)</td><td>SDA=2: $10^{-5}$/flight-hour - allowable probability level REMOTE<br>(MAJOR failure condition, LEVEL C software and design assurance level)</td></tr>
<tr><td>Velocity Accuracy (NACv)</td><td>NACv<=10 m/s (i.e. NACv>=1)</td></tr>
</table></td><td>D.1.18 (Definitions) Navigation Accuracy Category for Position ($NAC_P$).<br>...A $NAC_P$ of 8 or greater is required by § 91.227 [CS requires $NAC_P$ of 7 or greater] .<br>A.2.20 (Parameters) Navigation Accuracy Category for Position ($NAC_P$).<br>...A minimum $NAC_P$ value of “8” must be transmitted to operate in airspace defined in § 91.227 [CS requires a minimum $NAC_P$ value of 7].<br>A.2.22 (Parameters) Navigation Integrity Category (NIC).<br>...A minimum NIC value of “7” must be transmitted to operate in airspace defined in § 91.225 [CS requires a minimum NIC value of 6] .<br>D.1.20 (Definition) Navigation Integrity Category (NIC).<br>... A NIC of 7 or greater is required by § 91.227 [CS requires NIC of 6 or greater] .<br>A.2.27 (Parameters) Source Integrity Level (SIL)<br>...A SIL value of “3” must be transmitted to operate in airspace defined in § 91.225.<br>D.1.2.5 (Definition) Source Integrity Level (SIL)<br>...A SIL of 3 is required by § 91.227.<br>A.2.29 (Parameters) System Design Assurance (SDA).<br>The SDA parameter defines the failure condition that the ADS-B system is designed to support as defined in Table A-5...The SDA includes the position source, ADS-B equipment, and any intermediary devices that process the position data...§ 91.227 requires an SDA of 2 or 3 as defined in Table A-6<br>D.1.26 (Definition) System Design Assurance (SDA).<br>...An SDA of 2 or greater is required by § 91.227.<br>A.2.21 (Parameters) Navigation Accuracy Category for Velocity ($NAC_V$).<br>...A $NAC_V$ of greater than or equal to “1” is required by § 91.227.<br>D.1.19 (Defintion) Navigational Accuracy Category for Velocity ($NAC_V$).<br>...A $NAC_V$ of 1 or greater is required by § 91.227.</td></tr>
</table>

| ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets. | |
|---|---|
| Note 4: If set as fixed value, NACv should be always 'one'. For quality indications that are dynamically provided by the velocity source, NACv should be 'one' or 'two'. There is currently no established guidance on establishing a NACv performance of 'three' or better. | 3.3.3.4 (Installation) Source Integrity Level Supplement (SILSUPP).<br>...ADS-B systems interfaced with a GNSS position source compliant with any revision of TSO-C129 ***[TSO-C129a is the minimum in CS-ACNS]*** , TSO-C145, TSO-C146, or TSO-C196 may preset SILSUPP to "ZERO," as GNSS position sources use a per-hour basis for integrity.<br>3.3.3.7.1 (Installation) A $NAC_V$ = 1 (< 10 m/s) may be permanently set at installation for GNSS equipment passing the tests identified in 4.5.6 Appendix B of this AC, or may be set dynamically from velocity accuracy output of a position source qualified in accordance with the guidance in 4.5.6 Appendix B.<br>3.3.3.7.2 (Installation) A $NAC_V$ = 2 (< 3 m/s) must be set dynamically from velocity accuracy output of a position source qualified in accordance with the 4.5.6 Appendix B guidance. Do not permanently pre-set a NACV = 2 at installation, even if the position source has passed the tests identified in 4.5.6 Appendix B.<br>3.3.3.7.3 (Installation) A $NAC_V$ = 3 or NACV = 4 should not be set based on GNSS velocity accuracy unless you can demonstrate to the FAA that the velocity accuracy actually meets the requirement. |
| This should be verified through appropriate tests, as follows. With respect to NIC and NACp testing, the ADS-B Out system installer should check for satellite shielding and masking effects if the stated performance is not achieved.<br>(a) Airborne & Surface NIC:<br>During testing under nominal GNSS satellite constellation and visibility conditions, the transmitted NIC value should be a minimum of 'six' ***[§ 91.227 requires a minimum NIC value of 7]*** .<br>(b) NACp:<br>During testing under nominal GNSS satellite constellation and visibility conditions, the transmitted NACp value should be a minimum of 'eight' ***[The CS minimum operational requirement is a $NAC_P$ of 7, however, during testing under nominal GNSS satellite constellation and visibility conditions, a $NAC_P$ of 8 is expected. Tests which produce a $NAC_P$ of 7 indicate an issue with the test environment]*** . In order to validate the correctness of the transmitted horizontal position, the aircraft should be positioned on a known location.<br>(c) SIL:<br>SIL is typically a static (unchanging) value and may be set at the time of installation if a single type of position source is integrated with the ADS-B transmit unit. SIL should be set based on design data from the position source equipment manufacturer. Installations which derive SIL from GNSS position sources compliant with CS ACNS.D.ADSB.070 should set the SIL to 'three'.<br>ADS-B transmit units interfaced with a GNSS position source that is compliant with CS ACNS.D.ADSB.070 (and the related AMC guidance) should pre-set the SIL Supplement to 'zero'. | 4.1.3.1 Accuracy and Integrity Performance.<br>Ensure the installed system meets its stated accuracy and integrity performance under expected operating conditions. We recommend that you accomplish a GNSS performance prediction for the applicable time of your test to ensure the ADS-B system meets the predicted performance. In absence of predicted GNSS performance, demonstrate that you meet all § 91.227(c)(1) requirements as listed in Table 2.<br>4.1.3.2.17 An indication of the Navigation Integrity Category<br>4.1.3.2.15 An indication of the Navigation Accuracy Category for Position ($NAC_P$);<br>4.1.3.3 Position Accuracy.<br>Position the aircraft on a surveyed location and validate the position transmitted from the ADS-B system. Ensure the position transmitted is within the allotted $NAC_P$ accuracy limit. For example, if the aircraft reports a NACP = 8, the ADS-B position should be within 92.6 meters, 0.05 nm. If the aircraft reports a NACP = 10, the ADS-B position should be within 10 meters. Refer to 4.5.6 Appendix A of this AC for a complete list of NACP values. If the transmitted position accuracy is smaller or equal to the resolution of the test equipment, it is acceptable to use plus or minus one Least Significant Bit as the pass/fail criteria.<br>Source Integrity Level (SIL).<br>3.3.3.3 SIL is typically a static (unchanging) value and may be set at the time of installation if a single type of position source is integrated with the ADS-B system. SIL is based solely on the position source's probability of exceeding the reported integrity value and should be set based on design data from the position source equipment manufacturer. Installations that derive SIL from GNSS position sources that are compliant with any revision of TSO-C129 ***[TSO-C129a is the minimum in CS-ACNS]*** , TSO-C145, TSO-C146, or TSO-C196 and output Horizontal Protection Level (HPL) or Horizontal Integrity Level (HIL) should set the SIL = 3 because HPL and HIL are based on a probability of 1x10-7 per-hour. Do not base NIC or SIL on Horizontal Uncertainty Level (HUL) information. If integrating with a noncompliant GPS, SIL must be set to "0".<br>3.3.3.4 Source Integrity Level Supplement (SILSUPP).<br>...ADS-B systems interfaced with a GNSS position source compliant with any revision of TSO-C129 ***[TSO-C129a is the minimum in CS-ACNS]*** , TSO-C145, TSO-C146, or TSO-C196 may preset SILSUPP to "ZERO," as GNSS position sources use a per-hour basis for integrity.<br>4.1.3.2.19 An indication of the Source Integrity Level (SIL). |

ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets.

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<td>(d) NACv:<br>If set as fixed value, NACv should be always 'one'. For quality indications that are dynamically provided by the velocity source, NACv should be 'one' or 'two'.<br>It is noted that there is currently no established guidance on establishing a NACv performance of 'three' or better.</td>
<td>3.3.3.7.1 A $NAC_V$ = 1 (< 10 m/s) may be permanently set at installation for GNSS equipment passing the tests identified in 4.5.6 Appendix B of this AC, or may be set dynamically from velocity accuracy output of a position source qualified in accordance with the guidance in 4.5.6 Appendix B.<br>3.3.3.7.2 A $NAC_V$ = 2 (< 3 m/s) must be set dynamically from velocity accuracy output of a position source qualified in accordance with the 4.5.6 Appendix B guidance. Do not permanently pre-set a NACV = 2 at installation, even if the position source has passed the tests identified in 4.5.6 Appendix B.<br>3.3.3.7.3 A $NAC_V$ = 3 or NACV = 4 should not be set based on GNSS velocity accuracy unless you can demonstrate to the FAA that the velocity accuracy actually meets the requirement.<br>4.1.3.2.16 An indication of the Navigation Accuracy Category for Velocity ($NAC_V$);<br><br>Table 2. Accuracy and Integrity Requirements
<table>
<tr><td>NIC ≥ 7</td><td>Rc < 370.4 m (0.2 nm)</td></tr>
<tr><td>$NAC_P \geq 8$</td><td>EPU < 92.6 m (0.05 nm)</td></tr>
<tr><td>$NAC_V \geq 1$</td><td>< 10 m/s</td></tr>
<tr><td>SIL ≥ 3</td><td>$\leq 1x10^{-7}$ per-hour or per sample</td></tr>
<tr><td>SDA ≥ 2</td><td>$\leq 1x10^{-5}$ per-hour</td></tr>
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<tr><td></td><td></td></tr>
<tr><td>Appendix H - Part 4 – ADS-B Out Integrity and Continuity Requirements</td><td></td></tr>
<tr>
<td>CS ACNS.D.ADSB.100 and CS ACNS.D.ADSB.105 summarise, per data parameter, the integrity and continuity probability levels applicable to the ADS-B Out system.<br>In the first place, the ADS-B Out System installed in the aircraft needs to deliver data that satisfy the ADS-B-RAD airborne domain system safety and performance requirements in line with Section 3.4 of the ADS-B-RAD Safety and Performance Requirements/Interoperability standard ED-161.<br>As, for the purpose of framing the ADS-B-RAD operational safety assessment, the ADS-B-RAD airborne domain only comprises the horizontal position data source and the ADS-B transmit unit, including the interconnecting avionics, the data sources providing surveillance information other than horizontal position and velocity are assumed to operate as within today's SSR environment. Hence, in line with CS ACNS.D.ADSB.080, the related Mode S Elementary and Enhanced Surveillance requirements apply.<br>It is noted that the respective Mode S Elementary and Enhanced Surveillance requirements have to be understood within their given context, in particular taking into account applicable procedural mitigation means (e.g. as currently performed by means of the ICAO required controller-pilot verification procedure for pressure altitude reporting).<br>The ADS-B Out data parameters other than the ones addressed in the preceding paragraphs, need to satisfy comparable ADS-B-RAD requirements.<br>The specified integrity levels are required to adequately protect against the corruption of ADS-B Out surveillance data causing false or misleading information to be transmitted.<br>Although the direct effects to an aircraft of an ADS-B Out failure may be minor, the ADS-B Out information will be used by ATC and other ADS-B equipped aircraft, thus provisions that would allow for a reduction in failure probabilities and design assurance level, do not apply to the ADS-B Out system.</td>
<td>3.1.2.2.2 (Installation) Note: Although the direct effects to your aircraft of an ADS-B failure may be minor, the ADS-B OUT information will be used by other ADS-B IN equipped aircraft and by ATC.Thus, the provisions in AC 23.1309-1() [typo 25.1309-1 (add other part guidance)] that allow reduction in failure probabilities and design assurance level for aircraft under 6,000 pounds do not apply to the ADS-B OUT system.<br>B.3.9 (Installation) Design Assurance.<br>...Because the broadcast position can be used by any ADS-B IN equipped aircraft or by ATC, the provisions in AC 23.1309-1() [typo 25.1309-1 (add other part guidance)] that allow reduction in failure probabilities and design assurance level for aircraft under 6,000 pounds do not apply for the ADS-B OUT system. The overall probability of a position source malfunction causing a position to be output that exceeds the output integrity radius must be less than 1x10-5 per-hour.</td>
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<tr><td></td><td></td></tr>
<tr><td></td><td>Additional Guidance not Addressed in CS-ACNS</td></tr>
</table>

B.3.15 (Position Source Qualification - General) Availability.
§ 91.225 and § 91.227 do not define an availability requirement; however, it is a significant operational factor when selecting the position source (refer to Table B-2, Estimated GNSS Availabilities (Minimum Threshold Constellation), below).
B.4.3.1 (Position Source Qualification - GNSS - Availability) Analysis has shown the following estimated availability for TSO GPS receivers using a 2-degree antenna mask angle (refer to Table B-2), assuming the minimum threshold GPS satellite constellation. The Minimum Threshold Constellation is the probability of slots filled with healthy satellites. For Table B-1, the FAA uses the modified interagency forum on operational requirements (IFOR) constellation probabilities that provides a conservative estimate of predicted GNSS availability. The modified IFOR probabilities are not guaranteed by the U.S. Air Force, but are intended to be consistent with the Global Positioning System Standard Positioning Service Performance Standard, revision 4, dated September 2008. Modified IFOR threshold constellation state probabilities based on this performance standard (a 0.99999-percent probability of 20 healthy satellites or satellite pairs in expanded slot configuration) are shown in Table B-1.

**Table B-1. Modified IFOR Threshold Constellation State Probabilities**

| Number of Healthy Satellites | Probability That Exactly a Given Number of Satellites Are Healthy | Probability That at Least a Given Number of Satellites Are Healthy |
|---|---|---|
| 24 | 0.72% | 0.72% |
| 23 | 0.17% | 0.89% |
| 22 | 0.064% | 0.954% |
| 21 | 0.026% | 0.98% |
| 20 | 0.01999% | 0.99999% |
| 19 | 0.000005% | 0.999995% |
| 18 | 0.000005% | 1.0000% |

B.4.3.2 (Position Source Qualification - GNSS - Availability) The FAA plans to integrate the availability of backup surveillance systems with ADS-B, including SSR and Wide Area Multilateration, to mitigate the impact of loss of GNSS performance due to current limitations of operator GNSS receivers and the health of the constellation. Backup surveillance will not be available in all airspace, and operators should select an ADS-B positioning source that provides the necessary availability for their route of flight. The FAA plans to implement a preflight GPS service availability determination system to assist operators in determining surveillance availability for ADS-B before flight. This tool will consider the operator's GNSS equipage and the GPS constellation that is predicted to be available at the planned flight time. The tool will also consider the status of existing backup surveillance capability along with the required positioning performance for the separation standard ATC is authorized to apply along the operator's defined route of flight.

**Table B-2. Estimated GNSS Availabilities (Minimum Threshold Constellation)**

| Positioning Service (Receiver Standard) | Predicted Availability (ADS-B Compliance) |
|---|---|
| GPS (TSO-C129) (SA On) | ≥ 89.0% |
| GPS (TSO-C196) (SA Off) | ≥ 99.0% |
| GPS/SBAS (TSO-C145/TSO-C146) | ≥ 99.9% |

| Appendix H - Part 5 – GNSS Position and Velocity Source Qualification | APPENDIX B. IDENTIFYING AND QUALIFYING ADS-B POSITION SOURCES |
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| ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets. | |
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| This part 5 of Appendix H provides guidance to GNSS equipment manufacturers on how to establish a qualification for these ADS-B specific requirements, i.e. beyond the demonstration of compliance to ETSO requirements. In the following, as appropriate, reference is made to the respective:<br>ETSO material: ETSO-C129a (JTSO-C129a), ETSO-C196a, ETSO-C145()/146()<br>EUROCAE/RTCA MOPS material: ED-72A, DO-208, DO-229D, DO-316 as well as DO-235B; and<br>FAA AC material (AC 20-138C).<br>Note: ETSO-C145 refers to RTCA DO-229A, ETSO-C146 refers to RTCA DO-229B, ETSO-C145c/146c refers to RTCA DO-229D, and ETSO-C145()/146() refers to any of those revisions.<br>In addition to the ETSO minimum requirements, the requirements of this part need to be demonstrated unless this has been demonstrated as a declared non-ETSO function. It is expected that the required compliance demonstration is supplied by the position and velocity source manufacturer through a Declaration of Design and Performance (DDP), or an equivalent document. | B.1 (Position Source Qualification) Purpose.<br>This appendix defines the minimum requirements for position sources interfaced to ADS-B systems. The appendix also defines appropriate position source qualification methods when the existing GNSS TSOs do not contain specific requirements or test procedures. The position source manufacturer should provide design data where appropriate, preferably in the GNSS equipment installation manual, so the installer can properly interface the position source to the ADS-B system. Position source suppliers must ensure any supplied data is incorporated into the article design, and changes to any documented characteristics result in a change to the part number.<br>B.2 (Position Source Qualification) Organization.<br>This appendix includes general guidance that applies to all position sources, as well as GNSS-specific guidance. The appendix also provides high-level requirements for tightly-coupled GNSS/IRU position sources and non-GNSS position sources ***[CS requires GNSS-based position sources (GNSS/IRS systems are recognized as acceptable)]*** . Unless otherwise specified, all references in this AC to TSO-C129 ***[TSO-C129a is the minimum in CS-ACNS]*** , TSO-C145, TSO-C146, and TSO-C196 refer to any revision of the TSO.<br>B.4. (Position Source Qualification - GNSS) GNSS Position Sources.<br>Compliance to the applicable TSOs for GNSS position sources does not guarantee that the unit is suitable as an ADS-B position source. The information in this section describes an acceptable means to demonstrate compliance with ADS-B requirements not addressed by GNSS TSOs when using GNSS position sources for ADS-B. |
| (a) Horizontal Position Integrity (HPL)<br>Horizontal Position Integrity — AMC1 ACNS.D.ADSB.070(a).1.2(a)<br>Applicability: ETSO-C129a (JTSO-C129a)<br>GNSS equipment manufacturers should provide substantiation data showing that the equipment outputs latitude and longitude information that is referenced to the WGS-84 coordinate system.<br>GNSS equipment manufacturers should provide substantiation data showing that the equipment outputs a 10-7/hr Horizontal Protection Limit (HPL, or equivalent) based on the RAIM algorithm meeting the ETSO-C129a (JTSO-C129a) Class A1, A2, B1, B2, C1, or C2 RAIM requirements. | B.4.1 (Position Source Qualification - GNSS) Position.<br>GNSS position sources must provide a latitude and longitude output. Requirements and test procedures in TSO-C129 ***[TSO-C129a is the minimum in CS-ACNS]*** /145/146/196 are sufficient and GNSS equipment with TSOA for the aforementioned TSOs require no additional qualification for the position output. Some GNSS position outputs are referenced to the center of navigation of the aircraft. Manufacturers should document under what conditions the position is output in this manner. Installers must configure the ADS-B installation to account for any position offset from the surveillance reference point or GNSS antenna position as applicable.<br>Note: The intent is to output position, velocity, and HFOM in a consistent manner for time of applicability (refer to RTCA/DO-229D, Minimum Operational Performance Standards for Global Positioning System/Wide Area Augmentation System Airborne Equipment, sections 2.1.2.6 and 2.1.2.6.2).<br>B.4.1.2 (Position Source Qualification - GNSS - Position) TSO-C129a.<br>The requirements outlined for 2D accuracy in section (a)(3)(xvi) of TSO-C129a do not ensure full compliance for the GNSS unit. Additional means of compliance for this TSO require GNSS manufacturers to substantiate that the latitude/longitude is output and referenced to WGS-84 coordinate system. |
| | |
| | ***Additional Guidance not Addressed in CS-ACNS*** |
| | B.4.1.1 (Position Source Qualification - GNSS - Position) TSO-C129 ***[TSO-C129a is the minimum in CS-ACNS]*** .<br>The requirements outlined for 2D accuracy in section (a)(3)(xvi) of TSO-C129 do not ensure full compliance for the GNSS unit. Additional means of compliance for this TSO require GNSS manufacturers to substantiate that the latitude/longitude is output and referenced to WGS-84 coordinate system. |
| | B.4.1.3 (Position Source Qualification - GNSS - Position) TSO-C145/146 Rev a Class 1.<br>Means of compliance for this TSO are defined in RTCA/DO-229C, section 2.1.2.6. |
| | B.4.1.4 (Position Source Qualification - GNSS - Position) TSO-C145/146 Rev a Class 2/3.<br>Means of compliance for this TSO are defined in RTCA/DO-229C, sections 2.1.4.8 and 2.1.5.8. |
| | B.4.1.5 (Position Source Qualification - GNSS - Position) TSO-C145/146 Rev b/c/d Class 1.<br>Means of compliance for this TSO are defined in RTCA/DO-229D, section 2.1.2.6. |
| | B.4.1.6 (Position Source Qualification - GNSS - Position) TSO-C145/146 Rev b/c/d Class 2/3.<br>Means of compliance for this TSO are defined in RTCA/DO-229D, sections 2.1.4.8 and 2.1.5.8. |
| | B.4.1.7 (Position Source Qualification - GNSS - Position) TSO-C196/196a.<br>Means of compliance for this TSO are defined in RTCA/DO-316, Minimum Operational Performance Standards for Global Positioning System/Aircraft Based Augmentation System, section 2.1.2.6. |
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| ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets. | |
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| (a) Horizontal Position Integrity (HPL) (cont.) | B.3.5. (Position Source Qualification - General) Position Integrity (Horizontal)<br>The position source must have a horizontal position integrity output qualified during the system's TSOA or design approval. This integrity output should describe the radius of a circle in the horizontal plane, with its center being at the true position that describes the region assured to contain the indicated horizontal position with at least 99.99999 percent probability under fault-free avionics conditions. Position sources that degrade from a 99.99999 percent probability to a 99.999 percent probability (such as a tightly-coupled inertial/GNSS system after the loss of GNSS) can still be installed; however, they will not meet § 91.227 following the degradation. In this case, the position source must have a way of indicating the change to the ADS-B equipment ***[CS requires GNSS-based position sources (GNSS/IRS systems are recognized as acceptable)]*** . Additionally, if the change of probability is due to a change in position source, the new position source must meet all of the requirements in this appendix.<br>B.4.4 (Position Source Qualification - GNSS) Horizontal Position Integrity.<br>GNSS position sources must have a horizontal position integrity (such as HIL or HPL) output qualified during the system's TSOA or design approval to determine NIC. |
| (a) Horizontal Position Integrity (HPL) (cont.) | B.4.4.2 (Position Source Qualification - GNSS - Horizontal Position Integrity) TSO-C129a.<br>The requirements outlined for Class A, B, and C equipment provide horizontal integrity through RAIM algorithms under RTCA/DO-208 change 1, section 2.2.1.13. However, there is no requirement to compute or output HPL. To properly comply with the ADS-B requirements, additional means of compliance for this TSO require GNSS manufacturers to provide substantiation data showing that the equipment outputs a 1x10-7/hr HPL based on the RAIM algorithm at least once per second that meets a 10-second time to alert. This AC recommends an 8-second time to alert. The protection level value is acceptable as an HPL if the equipment performs the test in RTCA/DO-208 change 1, section 2.5.2.5 using this protection level value for comparison against the alarm limit. Equipment using the least-squares residual RAIM method recommended in RTCA/DO-208 change 1, appendix F provides an acceptable HPL.<br>B.3.6 (Position Source Qualification - General) Position Integrity (Probability).<br>The position source manufacturer must provide information describing the basis for the probability of exceeding the horizontal integrity containment radius. This basis must indicate the probability of exceeding the integrity containment radius as well as the sampling duration (per-hour or per-sample).<br>B.4.5 (Position Source Qualification - GNSS) Position Integrity (Probability).<br>GNSS position source manufacturers must provide information describing the basis for the probability of exceeding the horizontal integrity containment radius. |
| | |
| | ***Additional Guidance not Addressed in CS-ACNS*** |
| | B.4.4.1 (Position Source Qualification - GNSS - Horizontal Position Integrity) TSO-C129 **[TSO-C129a is the minimum in CS-ACNS]**.<br>The requirements outlined for Class A, B, and C equipment provide horizontal integrity through RAIM algorithms under RTCA/DO-208 change 1, Minimum Operational Performance Standards for Airborne Supplemental Navigation Equipment Using Global Positioning System (GPS), section 2.2.1.13. However, there is no requirement to compute or output HPL. To properly comply with the ADS-B requirements, additional means of compliance for this TSO require GNSS manufacturers to provide substantiation data showing that the equipment outputs a 1x10-7/hr HPL based on the RAIM algorithm at least once per second that meets a 10-second time to alert. This AC recommends an 8-second time to alert. The protection level value is acceptable as an HPL if the equipment performs the test in RTCA/DO-208 change 1, section 2.5.2.5 using this protection level value for comparison against the alarm limit. Equipment using the least-squares residual RAIM method recommended in RTCA/DO-208 change 1, appendix F provides an acceptable HPL. |
| | B.4.4.3 (Position Source Qualification - GNSS - Horizontal Position Integrity) TSO-C145/146 Rev a Class 1.<br>Means of compliance for this TSO are defined in RTCA/DO-229C, sections 2.1.2.6, 2.1.2.2.2, and 2.1.3.2.2. A summary of the latter requirements can be found in RTCA/DO-229C, section 2.1.1.13.1. |
| | B.4.4.4 (Position Source Qualification - GNSS - Horizontal Position Integrity) TSO-C145/146 Rev a Class 2/3.<br>Means of compliance for this TSO are defined in RTCA/DO-229C sections 2.1.2.6, 2.1.2.2.2, 2.1.3.2.2, 2.1.4.2.2, and 2.1.5.2.2. A summary of the latter requirements can be found in RTCA/DO-229C,<br>section 2.1.1.13.1. |
| | B.4.4.5 (Position Source Qualification - GNSS - Horizontal Position Integrity) TSO-C145/146 Rev b/c/d Class 1.<br>Means of compliance for this TSO are defined in RTCA/DO-229D, sections 2.1.2.6, 2.1.2.2.2, and 2.1.3.2.2. Related requirements can be found in RTCA/DO-229D, sections 2.1.1.4 and 2.1.4.9. |
| | B.4.4.6 (Position Source Qualification - GNSS - Horizontal Position Integrity) TSO-C145/146 Rev b/c/d Class 2/3.<br>Means of compliance for this TSO are defined in RTCA/DO-229D, sections 2.1.2.6, 2.1.2.2.2, 2.1.3.2.2, 2.1.4.2.2, and 2.1.5.2.2. Related requirements can be found in RTCA/DO-229D, sections 2.1.1.4<br>and 2.1.4.9. |
| | B.4.4.7 (Position Source Qualification - GNSS - Horizontal Position Integrity) TSO-C196/196a.<br>Means of compliance for this TSO are defined in RTCA/DO-316, sections 2.1.2.6, 2.1.2.2.2, and 2.1.3.2. |

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| | B.4.5.1 (Position Source Qualification - GNSS - Position Integrity Probability) TSO-C129 ***[TSO-C129a is the minimum in CS-ACNS]*** .<br>Means of compliance for TSO-C129 are defined in RTCA/DO-208 change 1, section 2.2.1.13.1, referring to table 2-1. |
| | B.4.5.2 (Position Source Qualification - GNSS - Position Integrity Probability) TSO-C129a.<br>Means of compliance for TSO-C129a are defined in RTCA/DO-208 change 1, section 2.2.1.13.1, referring to table 2-1. |
| | B.4.5.7 (Position Source Qualification - GNSS - Position Integrity Probability) TSO-C196/196a.<br>Means of compliance for this TSO are defined in RTCA/DO-316, section 2.1.2.2.2.2. For additional guidance on an acceptable scaling method, GNSS manufacturers can refer to RTCA/DO-316, appendix U, section 4. |
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| (a) Horizontal Position Integrity (HPL) (cont.)<br>Applicability: ETSO-C145()/146()<br>SBAS equipment certified under any revision of ETSO-C145 or ETSO-C146 is required to have several modes of operation depending on the availability of augmentation. For example, when operating in an augmented mode intended for LPV approach guidance, the position source may determine HPL based on a lateral error versus a horizontal error and an exposure time based on the duration of the approach versus flight hour (refer to Appendix J to RTCA DO229D for details).<br>If the position source outputs the HPL on lateral error and approach exposure time, it is possible that the ADS-B transmit function would need to inflate the HPL by 3% in approach modes to ensure the integrity is appropriately bounded.<br>GNSS equipment manufacturers should provide information data to determine if the integrity output needs to be scaled (i.e., by applying an inflation factor). The same considerations apply to GBAS differentially-corrected position sources when in approach mode. | B.4.5.3 (Position Source Qualification - GNSS - Position Integrity Probability) TSO-C145/146 Rev a Class 1.<br>Means of compliance for this TSO are defined in RTCA/DO-229C, section 2.1.2.2.2.1 for Satellite-Based Augmentation System (SBAS) based integrity. This requirement references appendix J, section J.2.1, defining position integrity. (Integrity probability is for HPLSBAS only). For additional guidance on an acceptable scaling method, GNSS manufacturers can refer to RTCA/DO-229C, appendix U, section 4. FDE requirements can be found in section 2.1.2.2.2.2.2.<br>B.4.5.4 (Position Source Qualification - GNSS - Position Integrity Probability) TSO-C145/146 Rev a Class 2/3.<br>Means of compliance for this TSO are defined in RTCA/DO-229C, section 2.1.2.2.2.1 for SBAS-based integrity. This requirement references appendix J, section J.2.1, defining position integrity. (Integrity probability is for HPLSBAS only). For additional guidance on an acceptable scaling method, GNSS manufacturers can refer to RTCA/DO-229C, appendix U, section 4. FDE requirements can be found in section 2.1.2.2.2.2.2.<br>B.4.5.5 (Position Source Qualification - GNSS - Position Integrity Probability) TSO-C145/146 Rev b/c/d Class 1.<br>Means of compliance for this TSO are defined in RTCA/DO-229D, section 2.1.2.2.2.1 for SBAS-based integrity. This requirement references to appendix J, section J.3.1, defining position integrity. (Integrity probability is for HPLSBAS only). For additional guidance on an acceptable scaling method, GNSS manufacturers can refer to<br>RTCA/DO-229D appendix U, section 4. FDE requirements can be found in section 2.1.2.2.2.2.2.<br>B.4.5.6 (Position Source Qualification - GNSS - Position Integrity Probability) TSO-C145/146 Rev b/c/d Class 2/3.<br>Means of compliance for this TSO are defined in RTCA/DO-229D, section 2.1.2.2.2.1 for SBAS-based integrity. Appendix J, section J.3.1 provides a background definition for position integrity. (Integrity probability is for HPLSBAS only). For additional guidance on an acceptable scaling method, GNSS manufacturers can refer to<br>RTCA/DO-229D, appendix U, section 4. FDE requirements can be found in section 2.1.2.2.2.2.2. |
| (a) Horizontal Position Integrity (HPL) (cont.) | B.4.17 (Position Source Qualification - GNSS) Approach Mode Integrity.<br>SBAS equipment certified under any revision of TSO-C145 or TSO-C146 is required to have several modes of operation depending on the availability of augmentation. For example, when operating in an augmented mode intended for LPV approach guidance, the position source may determine HPL based on a lateral error versus a horizontal error and an exposure time based on the duration of the approach versus flight hour (refer to RTCA/DO-229D, appendix J). If the position source outputs the HPL on lateral error and approach exposure time, it is possible that the ADS-B transmitter would need to inflate the HPL by 3 percent in approach modes to ensure the integrity is appropriately bounded. GBAS equipment is required to comply with the GNSS or SBAS requirements for the output of position data. This is an integration issue between the GPS and ADS-B transmitter. The position source manufacturer must provide information to the system integrator to determine if the integrity output needs to be scaled (that is, by applying an inflation factor). Although we do not address the interface of a GBAS differentially-corrected position source in this AC, it will have similar considerations in approach modes as SBAS. |
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| | ***Additional Guidance not Addressed in CS-ACNS*** |
| | B.4.17.1 (Position Source Qualification - GNSS - Approach Mode Integrity) TSO-C129 ***[TSO-C129a is the minimum in CS-ACNS]*** .<br>This is not applicable to this TSO as no HPL scaling is applied. |
| | B.4.17.2 (Position Source Qualification - GNSS - Approach Mode Integrity) TSO-C129a.<br>This is not applicable to this TSO as no HPL scaling is applied. |
| | B.4.17.3 (Position Source Qualification - GNSS - Approach Mode Integrity) TSO-C145/146 Rev a Class 1.<br>Means of compliance for this TSO are defined in RTCA/DO-229C, sections 2.1.1.13.1 and 2.1.3.2.2. |
| | B.4.17.4 (Position Source Qualification - GNSS - Approach Mode Integrity) TSO-C145/146 Rev a Class 2/3.<br>Means of compliance for this TSO are defined in RTCA/DO-229C, sections 2.1.1.13.1, 2.1.3.2.2, 2.1.4.2.2, and 2.1.5.2.2. |
| | B.4.17.5 (Position Source Qualification - GNSS - Approach Mode Integrity) TSO-C145/146 Rev b/c/d Class 1.<br>Means of compliance for this TSO are defined in RTCA/DO-229D, sections 2.1.1.13.1 and 2.1.3.2.2. |
| | B.4.17.6 (Position Source Qualification - GNSS - Approach Mode Integrity) TSO-C145/146 Rev b/c/d Class 2/3.<br>Means of compliance for this TSO are defined in RTCA/DO-229D, sections 2.1.1.13.1, 2.1.3.2.2, 2.1.4.2.2, and 2.1.5.2.2. |

ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets.

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| | B.4.17.7 (Position Source Qualification - GNSS - Approach Mode Integrity) TSO-C196/196a.<br>This is not applicable to this TSO as no HPL scaling is applied. |
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| Integrity Fault – Time to Alert — AMC ACNS.D.ADSB.070(a).1.2(b)<br>Applicability: ETSO-C129a (JTSO-C129a)<br>For the horizontal position sources compliant with AMC ACNS.D.ADSB.070, it should to be demonstrated, that a non-isolated GNSS satellite fault detected by the position source is properly passed to the ADS-B transmit unit within the allowable time to alert of 10 seconds, at any time.<br>With reference to the mode dependent time to alert in Table 3-5 of EUROCAE ED-72A section 3.2.1 (Table 2-1 of RTCA DO-208 Section 2.2.1.13.1), GNSS equipment manufacturers should provide information describing the equipment integrity fault output latency, along with interface instructions and/or any limitations for meeting the 10-second latency requirement of AMC1 ACNS.D.ADSB.070(a).1.2(b).<br>Note 1: The latency of reporting nominal ADS-B Quality Indicator changes, such as in response to changing GNSS satellite constellations or due to switching between position sources, is bounded by CS ACNS.D.ADSB.070(a).1.2(c) as well.<br>Note 2: ED-72A allows a provision to extend the Time to Alarm up to 30 seconds during en route phases of flight while for terminal and Non-Precision Approach the 10-second limit is applicable. For ADS-B Out, a time to alert of 10 seconds applies to any phases of flight. | B.3.5.2 (Position Source Qualification - General - Horizontal Position Integrity) Validity Limit.<br>If the integrity value of the output cannot be trusted beyond a certain limit, indicate this limitation in the design documentation.<br>B.3.5.3 (Position Source Qualification - General - Horizontal Position Integrity) Integrity Fault.<br>The position source must be able to identify, and output, an indication of an integrity fault. This indication should occur within 8 seconds of output of an erroneous position. The position source manufacturer must provide information on how this integrity fault is output.<br>B.4.4.2 (Position Source Qualification - GNSS - Position Source Latency) TSO-C129a.<br>...To properly comply with the ADS-B requirements, additional means of compliance for this TSO require GNSS manufacturers to provide substantiation data showing that the equipment outputs a 1x10-7/hr HPL based on the RAIM algorithm at least once per second that meets a 10-second time to alert. This AC recommends an 8-second time to alert.<br>B.4.6 (Position Source Qualification - GNSS) Integrity Fault Alerts.<br>GNSS position source manufacturers must provide design data on the maximum time the position source can take to indicate an integrity fault. If the fault indication is mode specific, data on all modes must be included. It is recommended that the indication of an integrity fault be provided within 8 seconds across all modes. All revisions of TSO-C145, TSO-C146, and TSO-C196 GNSS equipment meet this requirement. No revisions of TSO-C129 GNSS equipment meet this requirement without meeting further qualifications outlined below.<br>TSO-C129a. Receivers compliant with ARINC Characteristic 743A-5, GNSS Sensor, dated May 2009, represent the condition where a satellite fault has been detected but the receiver was unable to exclude the faulted satellite by setting bit 11 of label 130. This bit must be interpreted to set the position invalid regardless of the indicated HIL or HPL.<br>B.3.5. (Position Source Qualification - General) Position Integrity (Horizontal).<br>...Additionally, if the change of probability is due to a change in position source, the new position source must meet all of the requirements in this appendix. |
| Integrity Fault – Time to Alert — AMC ACNS.D.ADSB.070(a).1.2(b) (cont.)<br>Applicability: ETSO-C129a (JTSO-C129a) | B.4.6.2 (Position Source Qualification - GNSS - Integrity Fault Alerts) TSO-C129a.<br>The requirements in RTCA/DO-208 change 1, section 2.2.1.13.1 cover the time to alarm for different phases of flight. To properly comply with the overall 12-second integrity fault output for ADS-B ***[includes both the time for the position source to detect the fault and time for the ADS-B system to transmit the fault indication]*** , additional means of compliance for TSO-C129a require GNSS manufacturers to provide information in the installation instructions describing the equipment integrity fault latency output with interface instructions and/or limitations for meeting the 12-second allocation set by this AC ***[includes both the time for the position source to detect the fault and time for the ADS-B system to transmit the fault indication]*** . |
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| | ***Additional Guidance not Addressed in CS-ACNS*** |
| | B.4.6.1 (Position Source Qualification - GNSS - Integrity Fault Alerts) TSO-C129 ***[TSO-C129a is the minimum in CS-ACNS]*** .<br>The requirements in RTCA/DO-208 change 1, section 2.2.1.13.1 cover the time to alarm for different phases of flight. To properly comply with the overall 12-second integrity fault output for ADS-B, additional means of compliance for TSO-C129 require GNSS manufacturers to provide information in the installation instructions describing the equipment integrity fault latency output with interface instructions and/or limitations for meeting the 12-second allocation set by § 91.227. |
| | B.4.6.3 (Position Source Qualification - GNSS - Integrity Fault Alerts) TSO-C145/146 Rev a Class 1.<br>Means of compliance for this TSO are defined in RTCA/DO-229C, sections 2.1.1.13 and 2.1.2.2.2.1 through 2.1.2.2.2.4. |
| | B.4.6.4 (Position Source Qualification - GNSS - Integrity Fault Alerts) TSO-C145/146 Rev a Class 2/3.<br>Means of compliance for this TSO are defined in RTCA/DO-229C, sections 2.1.1.13, 2.1.2.2.2.1 through 2.1.2.2.2.4, and 2.1.4.2.2.1 through 2.1.4.2.2.3. |
| | B.4.6.5 (Position Source Qualification - GNSS - Integrity Fault Alerts) TSO-C145/146 Rev b/c/d Class 1.<br>Means of compliance for this TSO are defined in RTCA/DO-229D, sections 2.1.1.13 and 2.1.2.2.2.1 through 2.1.2.2.2.4. |
| | B.4.6.6 (Position Source Qualification - GNSS - Integrity Fault Alerts) TSO-C145/146 Rev b/c/d Class 2/3.<br>Means of compliance for this TSO are defined in RTCA/DO-229D, sections 2.1.1.13, 2.1.2.2.2.1 through 2.1.2.2.2.4, and 2.1.4.2.2.1 through 2.1.4.2.2.3. |
| | B.4.6.7 (Position Source Qualification - GNSS - Integrity Fault Alerts) TSO-C196/196a.<br>Means of compliance for this TSO are defined in RTCA/DO-316, sections 2.1.1.11 and 2.1.2.2.2.1 through 2.1.2.2.2.4. |
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ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets.

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| Mode Output — AMC1 ACNS.D.ADSB.070(a).1.3<br>Applicability: ETSO-C129a (JTSO-C129a), ETSO-C196a, ETSO-C145()/146()<br>GNSS equipment manufacturers should provide instructions describing any equipment modes affecting the interpretation of horizontal position integrity output and how the position source outputs the mode indication.<br>As the minimum horizontal position integrity containment bound provided by non-augmented, as well as some specific augmented GNSS source, equipment is limited to 0.1 NM by design, the GNSS equipment manufacturer should present substantiation data whether the HPL output is limited or not, and provide proper instructions for the ADS-B Out system integration. If the GNSS source equipment does not limit the HPL, although it should do so by design, the ADS-B transmit unit limits the encoded NIC value to be equal to or less than 'eight'. | B.3.5.1 (Position Source Qualification - General - Horizontal Position Integrity) Mode.<br>If interpretation of the integrity output of the position source can change due to a change in the position source mode, the position source must have a way of communicating that change of mode to the ADS-B equipment. Additionally, the position source manufacturer should provide a description of the modes and a description of how the position source outputs the mode indication.<br>B.4.16 (Position Source Qualification - GNSS) Mode Output<br>If interpretation of the integrity output of the position source can change due to a change in the position source mode, the position source must have a way of communicating that change of mode to the ADS-B equipment. Additionally, the position source manufacturer should provide a description of the modes and a description of how the position source outputs the mode indication.<br>B.4.16.1 (Position Source Qualification - GNSS - Mode Output) TSO-C129 ***[TSO-C129a is the minimum in CS-ACNS]*** .<br>Means of compliance for this TSO require GNSS manufacturers to provide installation instructions describing the modes available (if affecting interpretation of integrity output) and how the position source outputs the mode indication (refer to Position Integrity Limits, section paragraph B.4.7, of this appendix).<br>B.4.16.2 (Position Source Qualification - GNSS - Mode Output) TSO-C129a.<br>Means of compliance for this TSO require GNSS manufacturers to provide installation instructions describing the modes available (if affecting interpretation of integrity output) and how the position source outputs the mode indication (refer to Position Integrity Limits, paragraph B.4.7, of this appendix).<br>B.4.16.3 (Position Source Qualification - GNSS - Mode Output) TSO-C145/146 Rev a Class 1.<br>Means of compliance for this TSO require GNSS manufacturers to provide installation instructions describing the modes available (if affecting interpretation of integrity output) and how the position source outputs the mode indication (refer to Position Integrity Limits, paragraph B.4.7, of this appendix).<br>B.4.16.4 (Position Source Qualification - GNSS - Mode Output)TSO-C145/146 Rev a Class 2.<br>Means of compliance for this TSO require GNSS manufacturers to provide installation instructions describing the modes available (if affecting interpretation of integrity output) and how the position source outputs the mode indication (refer to Position Integrity Limits, paragraph B.4.7, of this appendix). |
| Mode Output — AMC1 ACNS.D.ADSB.070(a).1.3 (cont.) | B.4.16.5 (Position Source Qualification - GNSS - Mode Output) TSO-C145/146 Rev b/c/d Class 1.<br>Means of compliance for this TSO require GNSS manufacturers to provide installation instructions describing the modes available (if affecting interpretation of integrity output) and how the position source outputs the mode indication (refer to Position Integrity Limits, paragraph B.4.7, of this appendix).<br>B.4.16.6 (Position Source Qualification - GNSS - Mode Output) TSO-C145/146 Rev b/c/d Class 2/3.<br>Means of compliance for this TSO require GNSS manufacturers to provide installation instructions describing the modes available (if affecting interpretation of integrity output) and how the position source outputs the mode indication (refer to Position Integrity Limits, paragraph B.4.7, of this appendix).<br>B.4.16.7 (Position Source Qualification - GNSS - Mode Output) TSO-C196/196a.<br>Means of compliance for this TSO require GNSS manufacturers to provide installation instructions describing the modes available (if affecting interpretation of integrity output) and how the position source outputs the mode indication (refer to Position Integrity Limits, paragraph B.4.7, of this appendix).<br>B.4.7 (Position Source Qualification - GNSS ) Position Integrity Limits.<br>This requirement was previously called Integrity Validity Limit. Single-frequency RAIM-based HPL computations have been designed to support navigation applications and provide an appropriate error bound down to approximately 0.1 nm. Although HPL values significantly smaller than 0.1 nm can be output from single-frequency GNSS sources, if the HPL value was computed using RAIM, it may not actually achieve the reported level of protection as there are error contributions that are no longer negligible and should be taken into consideration. Such error sources specifically include correlation of ionospheric errors across satellites, tropospheric delay compensation errors, multipath, and receiver noise errors. This issue is not unique to unaugmented GPS position sources, as all revisions of TSO-C145 and TSO-C146 GNSS position sources also calculate integrity based on RAIM when Satellite-Based Augmentation System (SBAS) integrity is not used. Even when using SBAS augmentation, the integrity calculation is not required to account for these error sources except when in LNAV/VNAV or LPV/LP approach modes. ADS-B capable position sources must provide design information to the installer that identifies the following: |

| ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets. | |
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| Mode Output — AMC1 ACNS.D.ADSB.070(a).1.3 (cont.) | B.4.7.1 (Position Source Qualification - GNSS - Position Integrity Limits) Whether a TSO-C129 or TSO-C196 position source limits the HPL output to greater than 75 meters. If the position source does not limit its HPL output, the position source manufacturer should provide guidance to the ADS-B system installer to ensure the ADS-B equipment limits the NIC to ≤ 8. Although single-frequency RAIM-based HPL values are only accurate down to approximately 0.1 nm, for ADS-B purposes, the position source only need limit the HPL to greater than 75 meters, because an HPL greater than 75 meters ensures the ADS-B equipment will only set a NIC of ≤ 8.<br>B.4.7.1.1 (Position Source Qualification - GNSS - Position Integrity Limits) TSO-C129 ***[TSO-C129a is the minimum in CS-ACNS]*** .<br>Means of compliance for this TSO require GNSS manufacturers to present substantiation data whether HPL is limited or not, and provide proper installation instructions for the ADS-B integration.<br>B.4.7.1.2 (Position Source Qualification - GNSS - Position Integrity Limits) TSO-C129a.<br>Means of compliance for this TSO require GNSS manufacturers to present substantiation data whether HPL is limited or not, and provide proper installation instructions for the ADS-B integration.<br>B.4.7.1.3 (Position Source Qualification - GNSS - Position Integrity Limits) TSO-C196/196a.<br>Means of compliance for this TSO require GNSS manufacturers to present substantiation data whether HPL is limited or not, and provide proper installation instructions for the ADS-B integration.<br>B.4.7.2 (Position Source Qualification - GNSS - Position Integrity Limits) Whether a TSO-C145 or TSO-C146 position source limits the HPL in non-SBAS augmented modes to greater than 75 meters. If the position source does not limit the HPL output in non-augmented modes, the position source manufacturer should provide guidance to the ADS-B system installer to ensure the ADS-B equipment limits the NIC to ≤ 8 in non-augmented modes. The position source manufacturer should also provide instructions on how to determine the position source mode if appropriate.<br>B.4.7.2.1 (Position Source Qualification - GNSS - Position Integrity Limits) TSO-C145/146 Rev a Class 1.<br>Means of compliance for this TSO require GNSS manufacturers to present substantiation data whether HPL is limited or not, and provide proper installation instructions for the ADS-B integration. |
| Mode Output — AMC1 ACNS.D.ADSB.070(a).1.3 (cont.) | B.4.7.2.2 (Position Source Qualification - GNSS - Position Integrity Limits) TSO-C145/146 Rev a Class 2/3.<br>Means of compliance for this TSO require GNSS manufacturers to present substantiation data whether HPL is limited or not, and provide proper installation instructions for the ADS-B integration. Installations intending to support NIC ≥ 9 must use LNAV/VNAV or LPV/LP approach requirements (RTCA/DO-229C, section 2.1) at the time of HPL output, in accordance with TSO-C145/C146 Rev a, but the enroute through LNAV K-Factor (6.18 vs. 6) must be applied (refer to RTCA/DO-229C, appendix J, section 2.1 and appendix U, section 4). Either the GNSS source equipment sets the K-Factor for HPL, or the ADS-B equipment applies proper scaling. The GNSS manufacturer must present substantiation data on which K-Factor is used and provide proper installation instructions for the ADS-B integration.<br>B.4.7.2.3 (Position Source Qualification - GNSS - Position Integrity Limits) TSO-C145/146 Rev b/c/d Class 1.<br>Means of compliance for this TSO require GNSS manufacturers to present substantiation data whether HPL is limited or not, and provide proper installation instructions for the ADS-B integration.<br>B.4.7.2.4 (Position Source Qualification - GNSS - Position Integrity Limits) TSO-C145/146 Rev b/c/d Class 2/3.<br>Means of compliance for this TSO require GNSS manufacturers to provide substantiation data whether HPL is limited or not, and provide proper installation instructions for the ADS-B integration. Installations intending to support NIC ≥ 9 must use LNAV/VNAV or LPV/LP approach requirements (RTCA/DO-229D, section 2.1) at the time of HPL output, in accordance with TSO-C145/C146 Rev b/c, but the enroute through LNAV K-Factor (6.18 vs. 6) must be applied (refer to RTCA/DO-229D appendix J, section 3.1 and appendix U, section 4). Either the GNSS source equipment sets the K-Factor for HPL, or the ADS-B equipment applies proper scaling. The GNSS manufacturer must present substantiation data on which K-Factor is used and provide proper installation instructions for the ADS-B integration. |

ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets.

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| (b) Horizontal Position Accuracy (HFOM) — AMC ACNS.D.ADSB.070(a).1.2(d)<br>Applicability: ETSO-C129a, ETSO-C145, and ETSO-C146<br>Note 1: Compliance with RTCA/DO-229D is required by ETSO-C145c-C146c. ETSO-C145/-C146 may be acceptable by applications of a positive deviation.<br>Note 2: If in the following, reference is made in the qualification tests described in DO-229D, the equivalent material in DO-316 applies as well.<br>GNSS equipment manufacturers should provide substantiation data showing the equipment computes and outputs HFOM. The following criteria for an acceptable horizontal position output and its associated HFOM accuracy metric are recommended to be applied:<br>(1) The horizontal position output should be calculated using the general least squares position solution of DO-229D Appendix J.1 (or any mathematically equivalent linear combination of range measurements). There is no restriction on the choice of the weight matrix W including non-weighted solutions; the use of the LNAV/VNAV, LP, LPV approach weight ($w_i = 1/\sigma_i^2$) is optional.<br>(2) The horizontal position accuracy should be tested using the procedure of DO-229D Section 2.5.8.3. The $\sigma_i^2$ used to compute the variance $d^2_{major}$ should be greater or equal to the ones listed in DO-229D Appendix J when the equipment uses SBAS-provided integrity and greater or equal to the ones listed as an acceptable means for FDE-provided integrity in section DO-229D 2.1.2.2.2.2 when the equipment does not use SBAS-provided integrity. A fixed sigma of 33.3 m is considered a sufficient over-bound when using FDE-provided integrity. For equipment that uses SBAS-provided integrity, testing only in the highest mode attainable for its declared Operational Class as specified in the test itself is acceptable. | B.3.4 (Position Source Qualification - General) Position Accuracy (Horizontal).<br>The position source must have a horizontal position accuracy output, and the output must have been qualified during the system's TSOA or design approval. This output must describe the radius of a circle in the horizontal plane, with its center being at the true position that describes the region assured to contain the indicated horizontal position with at least 95 percent probability under fault-free conditions.<br>B.4.8 (Position Source Qualification - GNSS) Horizontal Position Accuracy.<br>GNSS position sources should provide an HFOM output that was demonstrated during the position source's design approval or during an installation approval. GNSS certified under TSO-C145b/c, TSO-C146b/c/d, or all revisions of TSO-C196 are required to provide the HFOM output. TSO-C129, TSO-C145a, and TSO-C146a do not contain a horizontal position accuracy output requirement; however, all equipment must provide a HFOM output to be considered an ADS-B compliant position source.<br>Note: The intent is to output position, velocity, and HFOM in a consistent manner for time of applicability (refer to RTCA/DO-229D, sections 2.1.2.6 and 2.1.2.6.2).<br>B.4.8.1 (Position Source Qualification - GNSS - Horizontal Position Accuracy) TSO-C129 ***[TSO-C129a is the minimum in CS-ACNS]*** .<br>Means of compliance for this TSO require GNSS manufacturers to provide substantiation data showing the equipment computes and outputs HFOM. Refer to the test described in AC 20-138(), appendix 4, section A4-11 for an acceptable HFOM test.<br>B.4.8.2 (Position Source Qualification - GNSS - Horizontal Position Accuracy) TSO-C129a.<br>Means of compliance for this TSO require GNSS manufacturers to provide substantiation data showing the equipment computes and outputs HFOM. Refer to the test described in AC 20-138(), appendix 4, section A4-11 for an acceptable HFOM test. |
| (b) Horizontal Position Accuracy (HFOM) — AMC ACNS.D.ADSB.070(a).1.2(d) (cont.)<br>(3) The accuracy metric should be greater or equal to 1.96 $\sqrt{d^2_{east} + d^2_{north}}$ or 2.45 $d_{major}$ where $d_{major}$, $d_{east}$, and $d_{north}$ are computed using the same $\sigma_i$ employed during the horizontal accuracy test procedure. General certification substantiation data that the equipment meets this requirement is sufficient; no specific test is required. Note 1: The scaling factors for the horizontal position accuracy metrics were rounded to 2 decimal places; there is no intention to prohibit the use of a more accurate number.<br>Note 2: The horizontal position accuracy metrics listed above are the standard metrics used to provide a minimum of 95 % containment (varying from 95 % to approximately 98.5 % for the horizontal metrics) under the assumption that a Gaussian distribution with a sigma of $\sigma_i$ over- bounds the error of the range measurements. The use of a general least squares position solution (or mathematically equivalent) results in a joint Gaussian distribution for the components (North, East, Up) of the position error. Any accuracy metric that can be mathematically demonstrated to provide a minimum 95 % containment in the position domain under the Gaussian assumption is also acceptable. | B.4.8.3 (Position Source Qualification - GNSS - Horizontal Position Accuracy) TSO-C145/146 Rev a Class 1. Means of compliance for this TSO require GNSS manufacturers to provide substantiation data based on the test described in AC 20-138(), appendix 4, section A4-11 for an acceptable HFOM test.<br>B.4.8.4 (Position Source Qualification - GNSS - Horizontal Position Accuracy) TSO-C145/146 Rev a Class 2/3.<br>Means of compliance for this TSO require GNSS manufacturers to provide substantiation data based on the test described in AC 20-138(), appendix 4, section A4-11 for an acceptable HFOM test.<br>B.4.8.5 (Position Source Qualification - GNSS - Horizontal Position Accuracy) TSO-C145/146 Rev b/c/d Class 1.<br>Means of compliance for this TSO are defined in RTCA/DO-229D, section 2.1.2.6 (also refer to section 1.7.1 and appendix H of RTCA/DO-229D).<br>B.4.8.6 (Position Source Qualification - GNSS - Horizontal Position Accuracy) TSO-C145/146 Rev b/c/d Class 2/3.<br>Means of compliance for this TSO are defined in RTCA/DO-229D, section 2.1.2.6 (also refer to section 1.7.1 and appendix H of RTCA/DO-229D).<br>B.4.8.7 (Position Source Qualification - GNSS - Horizontal Position Accuracy) TSO-C196/196a.<br>Means of compliance for this TSO are defined in RTCA/DO-316, section 2.1.2.6 (also refer to section 1.7.1 and appendix H of RTCA/DO-316). |

| ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets. | |
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| Horizontal Position Latency — AMC1 ACNS.D.ADSB.070(a).1.2(e)<br>Time of Measurement to Time of Applicability<br>Applicability: ETSO-C129a (JTSO-C129a)<br>The intent of this qualification is to ensure that position and related quality indicator information are related to the same time of applicability in a consistent manner.<br>Based on the particular receiver design, GNSS equipment manufacturers should use a manufacturer-defined test, and/or analysis to determine the latency between the time satellite measurements are collated for processing and the time the equipment calculates a filtered (impulse response) position solution. The equipment should meet a 500-millisecond time of measurement to time of applicability requirement and account for the impulse response of the position solution.<br>Note: Whilst CS ACNS.D.ADSB does not establish requirements on the time of measurement, the above qualification has been incorporated to ensure consistency with FAA AC 20-165A ***[CS latency measurement is from the TOA, whereas, § 91.227 latency measurement is from the TOM (adds an additional 0.5 seconds)]*** . | D.1.12 (Definition) GNSS Time of Applicability.<br>The time when the position output from the GNSS sensor is applicable.<br>D.1.13 (Definition) GNSS Time of Measurement (TOM).<br>The time when the last GNSS signal used to determine the position arrives at the aircraft GNSS antenna.<br>B.3.13 (Position Source Qualification - General) Positon, Velocity, and Accuracy Time of Applicability.<br>For each position output by the source, a velocity, horizontal position accuracy metric, and horizontal velocity accuracy metric must also be output. All measurements and metrics must have the same time of applicability. A horizontal position integrity metric must also be output, but its time of applicability may lag the position. Refer to TSO-C145, TSO-C146, or TSO-C196 for additional information on the integrity time to alert.<br>B.4.13 (Position Source Qualification - GNSS) Time of Applicability.<br>The GNSS equipment must output a time of applicability.<br>Note: The intent is to output position, velocity, and HFOM with a consistent time of applicability (refer to RTCA/DO-229D, sections 2.1.2.6 and 2.1.2.6.2).<br>B.4.13.2 (Position Source Qualification - GNSS - TOA) TSO-C129a.<br>Means of compliance for this TSO require GNSS manufacturers to use a manufacturer-defined test and/or analysis to determine the latency between the time satellite measurements are collated for processing and the time the equipment calculates a filtered (impulse response) position solution. The equipment must meet a 500-millisecond TOM-to-time-of-applicability requirement and account for the impulse response of the position solution.<br>C.3.1 (Latency Analysis) Position Source.<br>We recommend using position sources where the latency of the position, velocity, and position accuracy metrics are less than or equal to 500 ms between the position TOM and the position time of applicability ***[CS latency measurement is from the TOA, whereas, § 91.227 latency measurement is from the TOM (adds an additional 0.5 seconds)]*** , and that the position is output in less than 200 ms after the position time of applicability ***[consistent with the TSO with an additional 200ms to get the information to the transponder consistent with 0.9 second guidance/CS-ACNS]*** .<br>Note: All revisions of TSO-C145, TSO-C146, and TSO-C196 equipment meet these recommendations.<br>C.4.1.2 (Latency Analysis - Recommendations for Reducing Latency) Use a TSO-C145, TSO-C146, or TSO-C196 position source (any revision). |
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| | ***Additional Guidance not Addressed in CS-ACNS*** |
| | B.4.13.1 (Position Source Qualification - GNSS - TOA) TSO-C129 ***[TSO-C129a is the minimum in CS-ACNS]*** .<br>Means of compliance for this TSO require GNSS manufacturers to use a manufacturer-defined test and/or analysis to determine the latency between the time satellite measurements are collated for processing and the time the equipment calculates a filtered (impulse response) position solution. For example; the receiver does not make observations at a single moment in time but instead staggers them, perhaps to reduce throughput. In that case, the observations would need to be extrapolated to a common moment. There are many extrapolation methods but some use filtering that may induce latency. This would need to be addressed in the latency analysis. Since there are filters involved, measuring the impulse response may be one way of observing this delay. Furthermore, as another example; a receiver uses a Costas filter that has a specific bandwidth as part of the tracking loop. That bandwidth constrains the speed at which a dynamic maneuver will propagate through the tracking loop and thus to the resulting position. Again, measuring the impulse response of the Costas loop would provide insight into delay that would be observed when installed. Bearing this in mind, the equipment must meet a 500-millisecond TOM-to-time-of-applicability requirement and account for the impulse response of the position solution. |
| | B.4.13.3 (Position Source Qualification - GNSS - TOA) TSO-C145/146 Rev a Class 1.<br>Means of compliance for this TSO are defined in RTCA/DO-229C sections 2.1.2.6 and 2.1.2.6.2. |
| | B.4.13.4 (Position Source Qualification - GNSS - TOA) TSO-C145/146 Rev a Class 2/3.<br>Means of compliance for this TSO are defined in RTCA/DO-229C, sections 2.1.2.6, 2.1.2.6.2, and 2.1.5.8.2. |
| | B.4.13.5 (Position Source Qualification - GNSS - TOA) TSO-C145/146 Rev b/c/d Class 1.<br>Means of compliance for this TSO are defined in RTCA/DO-229D, sections 2.1.2.6 and 2.1.2.6.2. |
| | B.4.13.6 (Position Source Qualification - GNSS - TOA) TSO-C145/146 Rev b/c/d Class 2/3.<br>Means of compliance for this TSO are defined in RTCA/DO-229D, sections 2.1.2.6, 2.1.2.6.2, and 2.1.5.8.2 |
| | B.4.13.7 (Position Source Qualification - GNSS - TOA) TSO-C196/196a.<br>Means of compliance for this TSO are defined in RTCA/DO-316, sections 2.1.2.6 and 2.1.2.6.2. |
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| ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets. | |
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| Time of Applicability to Time of Output<br>Applicability: ETSO-C129a (JTSO-C129a)<br>The GNSS equipment manufacturer should document the position source latency from time of applicability to time of position output ***[CS latency measurement is from the TOA, whereas, § 91.227 latency measurement is from the TOM (adds an additional 0.5 seconds)]*** . If this latency exceeds 0.4 seconds ***[Clarification - 200ms for the GNSS receiver output and 200ms for getting the information to the transponder interface consistent with AC 20-165]*** , it may not support the 1.5-second total ADS-B transmission latency at the aircraft level (refer also to AMC1 ACNS.D.ADSB.115) ***[CS latency measurement is from the TOA (total 1.5 sec. requirement), whereas, § 91.227 latency measurement is from the TOM (adds an additional 0.5 seconds - total 2 sec. requirement)].*** | C.2.1 (Latency Analysis) Position Source Latency Considerations.<br>In general, the latency information should be generated by the position source manufacturer and presented as part of the latency analysis. The latency measurement should begin at the TOM ***[CS latency measurement is from the TOA, whereas, § 91.227 latency measurement is from the TOM (adds an additional 0.5 seconds)]*** and end when the position is output from the position source.<br>B.3.12 (Position Source Qualification - General) Position Source Latency.<br>The position source manufacturer must provide position source latency information. Specifically, the manufacturer must provide the amount of position source total latency and uncompensated latency. Because the latency requirements are based on the entire ADS-B OUT system, and not just the position source, the following position source latency targets are only guidelines. Position source uncompensated latency should be less than 200 ms, compensated latency should be less than 500 ms, and total latency should be less than 700 ms ***[consistent with the TSO with an additional 200ms to get the information to the transponder consistent with 0.9 second guidance/CS-ACNS]*** .<br>Note 1: System latency requirements are described in section 3.1.3 and Appendix C of this AC.<br>Note 2: This section addresses position latency only.<br>B.4.2 (Position Source Qualification - GNSS) Position Source Latency.<br>GNSS position source manufacturers must provide position source latency information.<br>B.4.2.1 (Position Source Qualification - GNSS - Position Source Latency) TSO-C129 ***[TSO-C129a is the minimum in CS-ACNS]*** .<br>Means of compliance for this TSO require GNSS manufacturers to document the position source latency from time of measurement (TOM) to time of position output. If this latency exceeds 0.9 seconds ***[Clarification - includes 200ms to get the information to the transponder]*** , it may not support the 2-second ADS-B transmission latency at the aircraft level.<br>B.4.2.2 (Position Source Qualification - GNSS - Position Source Latency) TSO-C129a.<br>Means of compliance for this TSO require GNSS manufacturers to document the position source latency from TOM to time of position output ***[CS latency measurement is from the TOA, whereas, § 91.227 latency measurement is from the TOM (adds an additional 0.5 seconds)]*** . If this latency exceeds 0.9 seconds ***[Clarification - includes 200ms to get the information to the transponder]*** , it may not support the 2-second ADS-B transmission latency ***[CS latency measurement is from the TOA (total 1.5 sec. requirement), whereas, § 91.227 latency measurement is from the TOM (adds an additional 0.5 seconds - total 2 sec. requirement)]*** at the aircraft level. |
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| | ***Additional Guidance not Addressed in CS-ACNS*** |
| | B.4.2.3 (Position Source Qualification - GNSS - Position Source Latency) TSO-C145/146 Rev a Class 1.<br>Means of compliance for this TSO are defined in RTCA/DO-229C, section 2.1.2.6.2. |
| | B.4.2.4 (Position Source Qualification - GNSS - Position Source Latency) TSO-C145/146 Rev a Class 2/3.<br>Means of compliance for this TSO are defined in RTCA/DO-229C, sections 2.1.2.6.2 and 2.1.5.8.2. |
| | B.4.2.5 (Position Source Qualification - GNSS - Position Source Latency) TSO-C145/146 Rev b/c/d Class 1.<br>Means of compliance for this TSO are defined in RTCA/DO-229D, section 2.1.2.6.2. |
| | B.4.2.6 (Position Source Qualification - GNSS - Position Source Latency) TSO-C145/146 Rev b/c/d Class 2/3.<br>Means of compliance for this TSO are defined in RTCA/DO-229D, sections 2.1.2.6.2 and 2.1.5.8.2. |
| | B.4.2.7 (Position Source Qualification - GNSS - Position Source Latency) TSO-C196/196a.<br>Means of compliance for this TSO are defined in RTCA/DO-316, section 2.1.2.6.2. |
| | C.2.1.1 (Latency Analysis) TSO-C145, TSO-C146, and TSO-C196 GNSS.<br>Use the TSO latency standards in the latency analysis or use actual latency information generated by the GNSS manufacturer to determine the position source maximum total latency and uncompensated latency. If the GNSS equipment is classified as Class 3 pursuant to any revision of TSO-C145, there are tighter latency standards for the LPV modes. If the Class 3 standard is implemented across all modes, the tighter latency numbers may be used; however, if the tighter latency standards are only met when in approach mode, use the worst-case latency across all modes. |
| | C.2.1.2 (Latency Analysis) TSO-C129 GNSS.<br>There are no latency standards for any revision of TSO-C129 GNSS equipment. Latency information must be generated by the GNSS manufacturer and included as part of the latency analysis. |
| | C.2.1.3 (Latency Analysis) Tightly-Coupled GNSS/Inertial ***[CS requires GNSS-based position sources (GNSS/IRS systems are recognized as acceptable)]*** .<br>There are no latency standards for tightly-coupled GNSS/Inertial equipment. Total and uncompensated latency information should be generated by the position source manufacturer and presented as part of the latency analysis. Base the latency analysis on the update rate of the inertial sensor, as 10-second or 20-second GNSS updates to the inertial sensor are not impacting the latency of the position output. However, the GNSS update latency does affect the position accuracy and should be appropriately reflected in the position source accuracy output. |

ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets.

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| | C.2.1.4 Other Position Sources ***[CS requires GNSS-based position sources (GNSS/IRS systems are recognized as acceptable)].***<br>Total and uncompensated latency information should be generated by the position source manufacturer and included as part of the latency analysis. |
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| Time Mark<br>Applicability: ETSO-C129a (JTSO-C129a), ETSO-C196a, ETSO-C145()/C146()<br>If the use of the time mark to reduce latency is implemented in the ADS-B Out system, GNSS equipment manufacturers should provide installation instructions describing how the time mark relates to the time of applicability of the position, velocity, and related quality indicator information. | B.3.14 (Position Source Qualification - General) Time Mark.<br>Position sources should output a time mark identifying the Coordinated Universal Time (UTC) time of applicability of the position. The time mark can be used by the ADS-B equipment to reduce uncompensated latency.<br>B.4.19 (Position Source Qualification - GNSS) Time Mark.<br>GNSS position sources should output a UTC time mark identifying time of applicability with the successive position output...The time mark can be used by the ADS-B equipment to reduce uncompensated latency.<br>C.4.1.4 (Latency Analysis - Recommendations for Reducing Latency) Use the GNSS time mark in TSO-C166b systems to reduce position source and intermediary device uncompensated latency. (Use of the GNSS time mark is required by TSO-C154c ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** )<br>B.4.19.2 (Position Source Qualification - GNSS - Time Mark) TSO-C129a.<br>Means of compliance for this TSO require GNSS manufacturers to provide installation instructions describing how the time mark relates to the position, velocity, FOM, and time of applicability.<br>B.4.19.3 (Position Source Qualification - GNSS - Time Mark) TSO-C145/146 Rev a Class 1.<br>Means of compliance for this TSO require GNSS manufacturers to provide installation instructions describing how the time mark relates to the position, velocity, FOM, and time of applicability.<br>B.4.19.4 (Position Source Qualification - GNSS - Time Mark) TSO-C145/146 Rev a Class 2/3.<br>Means of compliance for this TSO require GNSS manufacturers to provide installation instructions describing how the time mark relates to the position, velocity, FOM, and time of applicability.<br>B.4.19.5 (Position Source Qualification - GNSS - Time Mark) TSO-C145/146 Rev b/c/d Class 1.<br>Means of compliance for this TSO require GNSS manufacturers to provide installation instructions describing how the time mark relates to the position, velocity, FOM, and time of applicability.<br>B.4.19.6 (Position Source Qualification - GNSS - Time Mark) TSO-C145/146 Rev b/c/d Class 2/3.<br>Means of compliance for this TSO require GNSS manufacturers to provide installation instructions describing how the time mark relates to the position, velocity, FOM, and time of applicability.<br>B.4.19.7 (Position Source Qualification - GNSS - Time Mark) TSO-C196/196a.<br>Means of compliance for this TSO require GNSS manufacturers to provide installation instructions describing how the time mark relates to the position, velocity, FOM, and time of applicability. |
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| | ***Additional Guidance not Addressed in CS-ACNS*** |
| | B.4.11 (Position Source Qualification - GNSS - Horizontal Velocity) The position source must output north/south and east/west velocities. It is recommended the position source also output the velocity in a ground speed and track angle format.<br>Note: The intent is to output position, velocity, and quality metrics in a consistent manner for time of applicability (refer to RTCA/DO-229D, sections 2.1.2.6 and 2.1.2.6.2). |
| | B.4.11.1.1 (Position Source Qualification - GNSS - Horizontal Velocity) TSO-C129 ***[TSO-C129a is the minimum in CS-ACNS]*** .<br>Means of compliance for this TSO require GNSS manufacturers to perform the velocity test in AC 20-138(), appendix 4 and provide information substantiating the data is output. |
| | B.4.11.1.2 (Position Source Qualification - GNSS - Horizontal Velocity) TSO-C129a.<br>Means of compliance for this TSO require GNSS manufacturers to perform the velocity test in AC 20-138(), appendix 4 and provide information substantiating the data is output. |
| | B.4.11.1.3 (Position Source Qualification - GNSS - Horizontal Velocity) TSO-C145/146 Rev a Class 1.<br>Means of compliance for this TSO are defined in RTCA/DO-229C, section 2.1.2.6 along with the test defined in AC 20-138(), appendix 4. |
| | B.4.11.1.4 (Position Source Qualification - GNSS - Horizontal Velocity) TSO-C145/146 Rev a Class 2/3.<br>Means of compliance for this TSO are defined in RTCA/DO-229C, section 2.1.2.6 along with the test defined in AC 20-138(), appendix 4. |
| | B.4.11.1.5 (Position Source Qualification - GNSS - Horizontal Velocity) TSO-C145/146 Rev b/c/d Class 1.<br>Means of compliance for this TSO are defined in RTCA/DO-229D, section 2.1.2.6. The TSO requirement is only to output velocity, but there is no accuracy requirement. Satisfying this ADS-B requirement means the GNSS manufacturer must also comply with the horizontal velocity accuracy requirements and tests described in AC 20-138(), appendix 4. |

| ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets. | |
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| | B.4.11.1.6 (Position Source Qualification - GNSS - Horizontal Velocity) TSO-C145/146 Rev b/c/d Class 2/3.<br>Means of compliance for this TSO are defined in RTCA/DO-229D, section 2.1.2.6. The TSO requirement is only to output velocity, but there is no accuracy requirement. Satisfying this ADS-B requirement means the GNSS manufacturer must also comply with the horizontal velocity accuracy requirements and tests described in AC 20-138(), appendix 4. |
| | B.4.11.1.7 (Position Source Qualification - GNSS - Horizontal Velocity) TSO-C196/196a.<br>Means of compliance for this TSO are defined in RTCA/DO-316, section 2.1.2.6. The TSO requirement is only to output velocity, but there is no accuracy requirement. Satisfying this ADS-B requirement means the GNSS manufacturer must also comply with the horizontal velocity accuracy requirements and tests described in AC 20-138(), appendix 4.<br>Note: The velocity test found in AC 20-138() is also defined in section 2.3.6.4 of RTCA/DO-316. |
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| (d) Horizontal Velocity Accuracy — AMC1 ACNS.D.ADSB.070(a).1.2(f)<br>Environmental Noise Test Conditions:<br>Applicability: ETSO-C129a, ETSO-C145( )/C146( ) (JTSO-C145/C146)<br>For equipment that was not required to meet the environmental noise standard prescribed by DO-235B, the velocity tests in AC 20-138B, Appendix 4 use environmental noise test conditions that may cause the equipment to stop functioning, i.e. to lose satellite acquisition and tracking capability that causes the equipment to stop outputting velocity. Whilst this contributes to an ADS-B availability issue for operators, this loss of function will not prevent the equipment from being used as an ADS-B velocity input, provided:<br>(1) the equipment does not output misleading velocity information at or after the onset of the triggering interference levels; and<br>Note: A method to accomplish this is first running the test at the higher noise level to ensure there is no misleading velocity information at loss of function before running the complete test at the lower noise level<br>(2) the equipment manufacturer should state that the equipment meets the noise requirements in DO-235B.<br>If the above conditions are met, the velocity tests in Appendix 4 of AC 20-138B (see below for NACv=1 and NACv=2 cases) can be run using an interference level that does not cause the equipment to lose acquisition and tracking. | B.4.14 (Position Source Qualification - GNSS) Velocity Accuracy.<br>The GNSS position source manufacturer must provide design data to assist the installer in setting the $NAC_V$. Scaling the reported GNSS position accuracy (HFOM and VFOM) is not an acceptable means to determine $NAC_V$.<br>B.4.14.5 (Position Source Qualification - GNSS - Velocity Accuracy) TSO-C129a.<br>Means of compliance for this TSO require GNSS manufacturers to provide substantiation data based on the $NAC_V$ =1 and NACV = 2 test as appropriate and document the NACV in the installation instructions for the ADS-B integration. Refer to AC 20-138() appendix 4, section A4-2d(3) for additional guidance relative to using the noise environment in RTCA/DO-235() for the velocity tests. |
| ADS-B Out system installations intending to support NACv = 1:<br>Applicability: ETSO-C129a (JTSO-C129a), ETSO-C196a, ETSO-C145()/146()<br>The GNSS equipment manufacturer should perform the velocity tests in Appendix 4 of AC 20-138B associated with NACv = 1 to substantiate the equipment's velocity output.<br>The GNSS equipment manufacturer should indicate that the equipment satisfies the requirements for NACv =1 in the instructions for the ADS-B integration.<br>ADS-B Out system installations intending to support NACv = 2:<br>Applicability: ETSO-C129a (JTSO-C129a), ETSO-C196a, ETSO-C145()/146()<br>The GNSS equipment manufacturer should substantiate that the equipment dynamically outputs HFOMv and VFOMv and perform the velocity tests in AC 20-138C Appendix 4 associated with NACv = 1 and NACv = 2 to substantiate the equipment's velocity output.<br>The GNSS equipment manufacturer should indicate that the equipment satisfies the requirements for NACv = 2 in the instructions for ADS-B Out system integration. | B.4.14.1 (Position Source Qualification - GNSS - Velocity Accuracy) NACV = 1.<br>For installations intending to support NACV = 1, the GNSS manufacturer must perform the velocity tests in AC 20-138D, appendix 4, section A4-1 through A4-8 associated with NACV = 1. The GNSS manufacturer must indicate that the equipment satisfies the requirements for NACV =1 in the installation instructions for the ADS-B integration.<br>B.4.14.2 (Position Source Qualification - GNSS - Velocity Accuracy) NACV = 2.<br>For installations intending to support NACV = 2, the GNSS manufacturer must perform the velocity tests in AC 20-138D, appendix 4, sections A4-1 through A4-9 associated with NACV = 1 and NACV = 2. The GNSS manufacturer must present substantiation data that the equipment dynamically outputs HFOMv and VFOMv (refer to AC 20-138(), appendix 4, sections A4-5 and A4-8) and that the equipment velocity and accuracy outputs have passed the velocity tests associated with NACV = 1 and NACV = 2. The GNSS manufacturer must indicate that the equipment satisfies the requirements for NACV = 2 in the installation instructions for the ADS-B integration.<br>B.4.14.3 (Position Source Qualification - GNSS - Velocity Accuracy) $NAC_V$ = 3 or 4.<br>No standard for performance has been developed to support NACv = 3 or NACV = 4. A NACV = 3 or NACV = 4 should not be set based on GNSS velocity accuracy unless you can demonstrate to the FAA that the error contributions have been adequately modeled to meet those levels of performance.<br>B.4.14.4 (Position Source Qualification - GNSS - Velocity Accuracy) TSO-C129 ***[TSO-C129a is the minimum in CS-ACNS]*** .<br>Means of compliance for this TSO require GNSS manufacturers to provide substantiation data based on the NACV =1 and NACV = 2 test as appropriate and document the NACV in the installation instructions for the ADS-B integration. Refer to AC 20-138(), appendix 4, section A4-2d(3) for additional guidance relative to using the noise environment in RTCA/DO-235B for the velocity tests.<br>B.4.14.5 (Position Source Qualification - GNSS - Velocity Accuracy) TSO-C129a.<br>Means of compliance for this TSO require GNSS manufacturers to provide substantiation data based on the NACV =1 and NACV = 2 test as appropriate and document the NACV in the installation instructions for the ADS-B integration. Refer to AC 20-138() appendix 4, section A4-2d(3) for additional guidance relative to using the noise environment in RTCA/DO-235() for the velocity tests. |

| ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets. | |
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| ADS-B Out system installations intending to support NACv = 1: (cont.) | B.4.14.6 (Position Source Qualification - GNSS - Velocity Accuracy) TSO-C145/146 Rev a Class 1.<br>Means of compliance for this TSO require GNSS manufacturers to provide substantiation data based on the NACV =1 and NACV = 2 test as appropriate and document the NACV in the installation instructions for the ADS-B integration.<br>B.4.14.7 (Position Source Qualification - GNSS - Velocity Accuracy) TSO-C145/146 Rev a Class 2/3.<br>Means of compliance for this TSO require GNSS manufacturers to provide substantiation data based on the NACV =1 and NACV = 2 test as appropriate and document the NACV in the installation instructions for the ADS-B integration.<br>B.4.14.8 (Position Source Qualification - GNSS - Velocity Accuracy) TSO-C145/146 Rev b/c/d Class 1.<br>Means of compliance for this TSO require GNSS manufacturers to provide substantiation data based on the NACV =1 and NACV = 2 test as appropriate and document the NACV in the installation instructions for the ADS-B integration.<br>B.4.14.9 (Position Source Qualification - GNSS - Velocity Accuracy) TSO-C145/146 Rev b/c/d Class 2/3.<br>Means of compliance for this TSO require GNSS manufacturers to provide substantiation data based on the NACV =1 and NACV = 2 test as appropriate and document the NACV in the installation instructions for the ADS-B integration.<br>B.4.14.10 (Position Source Qualification - GNSS - Velocity Accuracy) TSO-C196/196a<br>Means of compliance for this TSO require GNSS manufacturers to provide substantiation data based on the NACV =1 and NACV = 2 test as appropriate and document the NACV in the installation instructions for the ADS-B integration. |
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| | ***Additional Guidance not Addressed in CS-ACNS*** |
| | B.4.12 (Position Source Qualification - GNSS) Ground Speed.<br>It is recommended that the position source output ground speed. GNSS manufacturers choosing to output ground speed may show compliance as described below for the appropriate TSO. |
| | B.4.12.1 (Position Source Qualification - GNSS - Ground Speed) TSO-C129 ***[TSO-C129a is the minimum in CS-ACNS]*** .<br>Means of compliance for this TSO require GNSS manufacturers to provide information in the installation instructions describing how the velocity is output (that is, in a ground speed format versus north/east velocity format) and the protocols used. |
| | B.4.12.2 (Position Source Qualification - GNSS - Ground Speed) TSO-C129a.<br>Means of compliance for this TSO require GNSS manufacturers to provide information in the installation instructions describing how the velocity is output (that is, in a ground speed format versus north/east velocity format) and the protocols used. |
| | B.4.12.3 (Position Source Qualification - GNSS - Ground Speed) TSO-C145/146 Rev a Class 1.<br>The Gamma equipment requirements outlined in RTCA/DO-229C, section 2.2.1.4.10 for the display resolution of ground speed are insufficient to show ADS-B compliance. A recommendation for<br>GNSS manufacturers on label 103 and label 112 can be found in RTCA/DO-229D, appendix H. Additional means of compliance for TSO-C145/146 Rev a Class 1 require GNSS manufacturers to provide information in the installation instructions describing how the velocity is output (that is, in a ground speed format versus north/east velocity format) and the protocols used. |
| | B.4.12.4 (Position Source Qualification - GNSS - Ground Speed) TSO-C145/146 Rev a Class 2/3.<br>The Gamma equipment requirements outlined in RTCA/DO-229C, section 2.2.1.4.10 for the display resolution of ground speed are insufficient to show ADS-B compliance. A recommendation for<br>GNSS manufacturers on label 103 and label 112 can be found in<br>RTCA/DO-229D, appendix H. Additional means of compliance for TSO-C145/146 Rev a Class 2/3 require GNSS manufacturers to provide information in the installation instructions describing how the velocity is output (that is, in a ground speed format versus north/east velocity format) and the protocols used. |
| | B.4.12.5 (Position Source Qualification - GNSS - Ground Speed) TSO-C145/146 Rev b/c/d Class 1.<br>Gamma-1 equipment requirements outlined in RTCA/DO-229D,<br>section 2.2.1.4.10 for the display resolution of ground speed are insufficient to show ADS-B compliance. A recommendation for GNSS manufacturers on label 103 and label 112 can be found in<br>RTCA/DO-229D, appendix H. Additional means of compliance for TSO-C145/146 Rev b/c/d Class 1 require GNSS manufacturers to provide information in the installation instructions describing how the velocity is output (that is, in a ground speed format versus north/east velocity format) and the protocols used. |
| | B.4.12.6 (Position Source Qualification - GNSS - Ground Speed) TSO-C145/146 Rev b/c/d Class 2/3.<br>Gamma-2 and Gamma-3 equipment requirements outlined in<br>RTCA/DO-229D, section 2.2.1.4.10 for the display resolution of ground speed are insufficient to show ADS-B compliance. A recommendation for GNSS manufacturers on label 103 and label 112 can be found<br>in RTCA/DO-229D, appendix H. Additional means of compliance for TSO-C145/146 Rev b/c/d Class 2/3 require GNSS manufacturers to provide information in the installation instructions describing how the velocity is output (that is, in a ground speed format versus north/east velocity format) and the protocols used. |

| ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets. | |
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| | B.4.12.7 (Position Source Qualification - GNSS - Ground Speed) TSO-C196/196a.<br>Means of compliance for this TSO require GNSS manufacturers to provide information in the installation instructions describing how the velocity is output (that is, in a ground speed format versus north/east velocity format) and the protocols used. A recommendation for GNSS manufacturers on label 103 and label 112 can be found in RTCA/DO-316, appendix H. |
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| Track Angle Validity:<br>Applicability: ETSO-C129a (JTSO-C129a), ETSO-C196a, ETSO-C145()/146()<br>Using test and/or analysis for substantiation data, GNSS manufacturers should provide instructions for the ADS-B Out system integrator indicating when the track angle 95 % accuracy, when derived from north/east velocity, exceeds plus/minus 'eight' degrees. It is acceptable for the instructions to state that the track angle does not meet the required accuracy below a specified speed.<br>Note 1: Track Angle Validity is only an issue at taxiing speeds. Thereby, only along-track acceleration (0.58g) and jerk (0.25g/sec) are assumed to apply.<br>Note 2: Use should be made of the test environment specified in Appendix 4 of AC 20-138B. The interference levels used to demonstrate velocity accuracy compliance can be used for true track angle validity testing as well. | B.4.18 (Position Source Qualification - GNSS ) Track Angle Validity.<br>GNSS position sources can provide a track angle; however, the GNSS track angle may become invalid below a certain velocity. Optimally, the position source should either invalidate or remove the track angle when it is no longer valid. If the position source does not invalidate the track angle or remove the track angle when it is potentially invalid, the position source manufacturer must provide information on velocity limitations for GNSS track angle.<br>Note: The interference levels used to demonstrate velocity accuracy compliance can be used for track angle validity as well.<br>B.4.18.1 (Position Source Qualification - GNSS - Track Angle Validity) TSO-C129 ***[TSO-C129a is the minimum in CS-ACNS]*** .<br>Means of compliance for TSO-C129 require GNSS manufacturers<br>to use the test environment and guidance defined in AC 20-138(), appendix 4, section 4-12. It is recommended that manufacturers use RTCA/DO-229D, appendix H for outputting track angle (ARINC 743 all revisions, label 103) for those using ARINC 429 characteristics.<br>B.4.18.2 (Position Source Qualification - GNSS - Track Angle Validity) TSO-C129a.<br>Means of compliance for TSO-C129a require GNSS manufacturers<br>to use the test environment and guidance defined in AC 20-138(), appendix 4, section 4-12. It is recommended that manufacturers use RTCA/DO-229D, appendix H for outputting track angle (ARINC 743 all revisions, label 103) for those using ARINC 429 characteristics.<br>B.4.18.3 (Position Source Qualification - GNSS - Track Angle Validity) TSO-C145/146 Rev a Class 1.<br>Means of compliance for TSO-C145/146 Rev a Class 1 require<br>GNSS manufacturers to use the test environment and guidance defined in AC 20-138(), appendix 4, section 4-12. It is recommended that manufacturers use RTCA/DO-229C, appendix H for outputting track angle (ARINC 743 all revisions, label 103) for those using ARINC 429 characteristics.<br>B.4.18.4 (Position Source Qualification - GNSS - Track Angle Validity) TSO-C145/146 Rev a Class 2/3.<br>Means of compliance for TSO-C145/146 Rev a Class 2/3 require GNSS manufacturers to use the test environment and guidance defined in AC 20-138(), appendix 4, section 4-12. It is recommended that manufacturers use RTCA/DO-229C, appendix H for outputting track angle (ARINC 743 all revisions, label 103) for those using ARINC 429 characteristics. |
| Track Angle Validity: (cont.)<br>Applicability: ETSO-C129a (JTSO-C129a), ETSO-C196a, ETSO-C145()/146()<br>Using test and/or analysis for substantiation data, GNSS manufacturers should provide instructions for the ADS-B Out system integrator indicating when the track angle 95 % accuracy, when derived from north/east velocity, exceeds plus/minus 'eight' degrees. It is acceptable for the instructions to state that the track angle does not meet the required accuracy below a specified speed.<br>Note 1: Track Angle Validity is only an issue at taxiing speeds. Thereby, only along-track acceleration (0.58g) and jerk (0.25g/sec) are assumed to apply.<br>Note 2: Use should be made of the test environment specified in Appendix 4 of AC 20-138B. The interference levels used to demonstrate velocity accuracy compliance can be used for true track angle validity testing as well. | B.4.18.5 (Position Source Qualification - GNSS - Track Angle Validity) TSO-C145/146 Rev b/c/d Class 1.<br>Means of compliance for TSO-C145/146 Rev b/c/d Class 1 require GNSS manufacturers to use the test environment and guidance defined in AC 20-138(), appendix 4, section 4-12. It is recommended that manufacturers use RTCA/DO-229D, appendix H for outputting track angle (ARINC 743 all revisions, label 103) for those using ARINC 429 characteristics.<br>B.4.18.6 (Position Source Qualification - GNSS - Track Angle Validity) TSO-C145/146 Rev b/c/d Class 2/3.<br>Means of compliance for this TSO require GNSS manufacturers to use the test environment and guidance defined in AC 20-138(), appendix 4, section 4-12. It is recommended that manufacturers use RTCA/DO-229D, appendix H for outputting track angle (ARINC 743 all revisions, label 103) for those using ARINC 429 characteristics.<br>B.4.18.7 (Position Source Qualification - GNSS - Track Angle Validity) TSO-C196/196a.<br>Means of compliance for this TSO require GNSS manufacturers, using test or analysis to use the test environment and guidance defined in AC 20-138(), appendix 4 section 4-12. It is recommended that manufacturers use RTCA/DO-316, appendix H for outputting track angle (ARINC 743 all revisions, label 103) for those using ARINC 429 characteristics. |
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| | ***Additional Guidance not Addressed in CS-ACNS*** |
| | B.3.10 (Position Source Qualification - General) Geometric Altitude.<br>The position source must have a geometric altitude output. The geometric altitude must be referenced to the WGS-84 ellipsoid. |
| | B.4.9 (Position Source Qualification - GNSS) Geometric Altitude.<br>All GNSS position sources must output a geometric altitude. Geometric altitude for ADS-B purposes is the height above the WGS-84 ellipsoid (that is, it is not MSL). We recommend that the GNSS position source output geometric altitude as Height-Above-Ellipsoid (HAE). Some GNSS position sources provide Height-Above-Geoid (HAG) instead of HAE. The position source manufacturer must provide data on whether the position source outputs HAE or HAG. |
| | B.4.9.1 (Position Source Qualification - GNSS - Geometric Altitude) TSO-C129 ***[TSO-C129a is the minimum in CS-ACNS]*** .<br>Means of compliance for this TSO require GNSS manufacturers to provide data to substantiate the output of HAE. The data produced to substantiate vertical position accuracy pursuant to the test described in AC 20-138(), appendix 4, section A4-10 is sufficient. For GPS equipment that outputs other altitude measures, the installation instructions must specify a deterministic method to perform conversion to HAE. |

| ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets. | |
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| | B.4.9.2 (Position Source Qualification - GNSS - Geometric Altitude) TSO-C129a.<br>Means of compliance for this TSO require GNSS manufacturers to provide data to substantiate the output of HAE. The data produced to substantiate vertical position accuracy pursuant to the test described in AC 20-138(), appendix 4, section A4-10 is sufficient. For GPS equipment that outputs other altitude measures, the installation instructions must specify a deterministic method to perform conversion to HAE. |
| | B.4.9.3 (Position Source Qualification - GNSS - Geometric Altitude) TSO-C145/146 Rev a Class 1.<br>Means of compliance for this TSO require GNSS manufacturers to provide substantiation data showing the equipment outputs HAE. The data produced to substantiate vertical position accuracy pursuant to the test described in AC 20-138(), appendix 4, section A4-10 is sufficient. |
| | B.4.9.4 (Position Source Qualification - GNSS - Geometric Altitude) TSO-C145/146 Rev a Class 2/3.<br>For Class 2 equipment, the means of compliance for this TSO require GNSS manufacturers to provide substantiation data showing the equipment outputs HAE. The data produced to substantiate vertical position accuracy pursuant to the test described in AC 20-138(), appendix 4, section A4-10 is sufficient. Class 3 equipment complies with the ADS-B geometric altitude requirement pursuant to RTCA/DO-229C, section 2.1.5.8. |
| | B.4.9.5 (Position Source Qualification - GNSS - Geometric Altitude) TSO-C145/146 Rev b/c/d Class 1.<br>Means of compliance for this TSO require GNSS manufacturers to provide substantiation data showing the equipment outputs HAE. The data produced to substantiate vertical position accuracy pursuant to the test described in AC 20-138(), appendix 4, section A4-10 is sufficient. |
| | B.4.9.6 (Position Source Qualification - GNSS - Geometric Altitude) TSO-C145/146 Rev b/c/d Class 2/3.<br>Means of compliance for this TSO require GNSS manufacturers to provide substantiation data showing the equipment outputs HAE. The data produced to substantiate vertical position accuracy pursuant to the test described in AC 20-138(), appendix 4, section A4-10 is sufficient. |
| | B.4.9.7 (Position Source Qualification - GNSS - Geometric Altitude) TSO-C196/196a.<br>Means of compliance for this TSO require GNSS manufacturers to provide substantiation data showing the equipment outputs HAE. The data produced to substantiate vertical position accuracy pursuant to the test described in AC 20-138(), appendix 4, section A4-10 is sufficient. |
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| (e) Geometric Altitude Accuracy (VFOM) — AMC ACNS.D.ADSB.085<br>Applicability: ETSO-C129a (JTSO-C129a), ETSO-C196a, ETSO-C145()/146()<br>GNSS equipment manufacturers should provide substantiation data showing if and how the equipment computes and outputs VFOM. If VFOM is output, the following criteria for an acceptable HAE-referenced geometric altitude output and its associated VFOM accuracy metric are recommended to be applied:<br>(1) The HAE output should be calculated using the general least squares position solution of DO-229D Appendix J.1 (or any mathematically equivalent linear combination of range measurements). There is no restriction on the choice of the weight matrix W including non-weighted solutions; the use of the LNAV/VNAV, LP, LPV approach weight ($w_i = 1/\sigma_i^2$) is optional.<br>(2) The HAE accuracy should be tested using the procedure of DO-229D Section 2.5.8.3. The $\sigma_i^2$ used to compute the variance $dU^2$ should be greater or equal to the ones listed in DO-229D Appendix J when the equipment uses SBAS-provided integrity and greater or equal to the ones listed as an acceptable means for FDE-provided integrity in section 2.1.2.2.2.2 when the equipment does not use SBAS-provided integrity. A fixed sigma of 33.3 m is considered a sufficient over-bound when using FDE-provided integrity. For equipment that uses SBAS-provided integrity, testing only in the highest mode attainable for its declared Operational Class as specified in the test itself is acceptable.<br>(3) The accuracy metric should be greater or equal to 1.96 dU where dU is computed using the same $\sigma_i$ employed during the HAE accuracy test procedure. General certification substantiation data that the equipment meets this requirement is sufficient; no specific test is required. | B.3.3 (Position Source Qualification - General) Position Accuracy (Vertical)<br>The position source should output a vertical position accuracy metric. The vertical position accuracy metric must have been qualified during the system's TSOA or design approval. This output must describe the vertical position accuracy with 95 percent probability under fault-free conditions.<br>B.4.15 (Position Source Qualification - GNSS) Vertical Position Accuracy.<br>The GNSS should output vertical position accuracy. The vertical accuracy should specify a 95-percent probability bound on the reported vertical position. No revisions of TSO-C129 or TSO-C196 have vertical accuracy or integrity requirements, and TSO-C145 /146 only has vertical accuracy requirements for certain approach modes. None of the GNSS TSOs have a requirement to continuously output the vertical position accuracy data. If vertical position accuracy is output, it must have been qualified during design approval of the position source.<br>B.4.15.1 (Position Source Qualification - GNSS - Vertical Position Accuracy) TSO-C129 ***[TSO-C129a is the minimum in CS-ACNS]*** .<br>Means of compliance for this TSO require GNSS manufacturers to provide substantiation data along with the VFOM output based on the test described in AC 20-138(), appendix 4, section A4-10.<br>B.4.15.2 (Position Source Qualification - GNSS - Vertical Position Accuracy) TSO-C129a.<br>Means of compliance for this TSO require GNSS manufacturers to provide substantiation data along with the VFOM output based on the test described in AC 20-138(), appendix 4, section A4-10.<br>B.4.15.2 (Position Source Qualification - GNSS - Vertical Position Accuracy) TSO-C145/146 Rev a Class 1.<br>Means of compliance for this TSO require GNSS manufacturers to provide substantiation data along with the VFOM output based on the test described in AC 20-138(), appendix 4, section A4-10.<br>B.4.15.3 (Position Source Qualification - GNSS - Vertical Position Accuracy) TSO-C145/146 Rev a Class 2.<br>Means of compliance for this TSO require GNSS manufacturers to provide substantiation data along with the VFOM output based on the test described in AC 20-138(), appendix 4, section A4-10. |

| ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets. | |
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| (e) Geometric Altitude Accuracy (VFOM) — AMC ACNS.D.ADSB.085 (cont.)<br>For GPS equipment that outputs altitude references other than HAE whilst the overall ADS-B Out System meets AMC1 ACNS.D.ADSB.085(b), an equivalent data accuracy should be demonstrated.<br>Note 1: The scaling factors for the vertical position accuracy metrics were rounded to 2 decimal places; there is no intention to prohibit the use of a more accurate number.<br>Note 2: The vertical position accuracy metrics listed above are the standard metrics used to provide a minimum of 95 % containment (varying from 95 % to approximately 98.5 % for the vertical metrics) under the assumption that a Gaussian distribution with a sigma of σi over- bounds the error of the range measurements. The use of a general least squares position solution (or mathematically equivalent) results in a single Gaussian distribution for the components (North, East, Up) of the position error. Any accuracy metric that can be mathematically demonstrated to provide a minimum 95 % containment in the position domain under the Gaussian assumption is also acceptable. | B.4.15.4 (Position Source Qualification - GNSS - Vertical Position Accuracy) TSO-C145/146 Rev b/c/d Class 1.<br>Means of compliance for this TSO require GNSS manufacturers to provide substantiation data along with the VFOM output based on the test described in AC 20-138(), appendix 4, section A4-10.<br>B.4.15.5 (Position Source Qualification - GNSS - Vertical Position Accuracy) TSO-C145/146 Rev b/c/d Class 2/3.<br>Means of compliance for this TSO require GNSS manufacturers to provide substantiation data along with the VFOM output based on the test described in AC 20-138(), appendix 4, section A4-10.<br>B.4.15.6 (Position Source Qualification - GNSS - Vertical Position Accuracy) TSO-C196/196a.<br>Means of compliance for this TSO require GNSS manufacturers to provide substantiation data along with the VFOM output based on the test described in AC 20-138(), appendix 4, section A4-10. |
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| | ***Additional Guidance not Addressed in CS-ACNS*** |
| | B.3.7 SIS Error Detection.<br>The position source should provide a means to detect a SIS error when the system uses a SIS. The probability of missed detection for a faulty SIS should be less than 1x10-3. GNSS equipment provides the appropriate SIS error detection. |
| | B.4.20 SIS Error Detection.<br>The position source should provide a means to detect a SIS error when the system uses a SIS. The probability of missed detection for a faulty SIS should be less than 1x10-3. GNSS equipment provides the appropriate SIS error detection. |
| | B.4.20.1 TSO-C129.<br>Means of compliance for this TSO are defined in RTCA/DO-208 change 1, section 2.2.1.13.1, referring to Table 2-1 (refer to Table 2-1, note D). However, TSO-C129 equipment has no requirement for pseudorange step detection. This requires GNSS manufacturers to provide substantiation data documenting that their RAIM algorithm includes pseudorange step detection pursuant to TSO-C129a, section (a)(3)(xv)5. |
| | B.4.20.2 TSO-C129a.<br>Means of compliance for this TSO are defined in RTCA/DO-208, change 1, section 2.2.1.13.1, referring to Table 2-1 (refer to Table 2-1, note D) and TSO-C129a, section (a)(3)(xv)5. |
| | B.4.20.3 TSO-C145/146 Rev a Class 1.<br>Means of compliance for this TSO are defined in RTCA/DO-229D, sections 2.1.1.3 and 2.1.1.5 for SBAS, section 2.1.1.2 for GPS health message, and section 2.1.2.2.2.2.2 for FDE.<br>Note: The SBAS SIS includes health monitoring/fault information, which is why these general signal processing requirements are included. |
| | B.4.20.4 TSO-C145/146 Rev a Class 2/3.<br>Means of compliance for this TSO are defined in RTCA/DO-229D, sections 2.1.1.3 and 2.1.1.5 for SBAS, section 2.1.1.2 for GPS health message, and section 2.1.2.2.2.2.2 for FDE.<br>Note: The SBAS SIS includes health monitoring/fault information, which is why these general signal processing requirements are included. |
| | B.4.20.5 TSO-C145/146 Rev b/c/d Class 1.<br>Means of compliance for this TSO are defined in RTCA/DO-229D, sections 2.1.1.3 and 2.1.1.5 for SBAS, section 2.1.1.2 for GPS health message, and section 2.1.2.2.2.2.2 for FDE.<br>Note: The SBAS SIS includes health monitoring/fault information, which is why these general signal processing requirements are included. |
| | B.4.20.6 TSO-C145/146 Rev b/c/d Class 2/3.<br>Means of compliance for this TSO are defined in RTCA/DO-229D, sections 2.1.1.3 and 2.1.1.5 for SBAS, section 2.1.1.2 for GPS health message, and section 2.1.2.2.2.2.2 for FDE.<br>Note: The SBAS SIS includes health monitoring/fault information, which is why these general signal processing requirements are included. |
| | B.4.20.7 TSO-C196/196a.<br>Means of compliance for this TSO are defined in RTCA/DO-316, sections 2.1.1.2, 2.1.1.3, and 2.1.2.2.2.2. |
| | B.5 Tightly-Coupled GNSS/IRS Position Sources ***[CS requires GNSS-based position sources (GNSS/IRS systems are recognized as acceptable)]***<br>This section provides high-level guidance on the issues that will need to be addressed to qualify a tightly-coupled Global Navigation Satellite System/Inertial Reference System (GNSS/IRS) for use in an ADS-B system. You must propose to the FAA the method to approve a tightly-coupled GNSS/IRS for use in an ADS-B system. |

| ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets. | |
|---|---|
| | B.5.1 Tightly-Coupled GNSS/IRS Outputs ***[CS requires GNSS-based position sources (GNSS/IRS systems are recognized as acceptable)]*** . The tightly-coupled GNSS/IRS outputs must meet the requirements, including validation, of either RTCA/DO-229(), appendix R, or RTCA/DO-316, appendix R. |
| | B.5.2 Horizontal Velocity Accuracy ***[CS requires GNSS-based position sources (GNSS/IRS systems are recognized as acceptable)]*** . The ADS-B system must address the horizontal velocity accuracy. |
| | B.5.3 GNSS Performance ***[CS requires GNSS-based position sources (GNSS/IRS systems are recognized as acceptable)]*** . The GNSS sensor should meet the minimum performance requirements for any revision of TSO-C129, TSO-C145, TSO-C146, or TSO-C196. Additionally, the GNSS sensor should meet all applicable GNSS requirements of this appendix as applicable. |
| | B.5.4 GNSS Installatation ***[CS requires GNSS-based position sources (GNSS/IRS systems are recognized as acceptable)]*** . Install the GNSS sensor(s) in accordance with AC 20-138(). |
| | B.5.5 NIC Containment Radius ***[CS requires GNSS-based position sources (GNSS/IRS systems are recognized as acceptable)].*** § 91.227 requires a SIL = 3, which means the probability of exceeding the NIC containment radius should be less than 1x10-7 per hour or per sample. The tightly-coupled GNSS/IRS system should transmit the integrity quality metric on a per-hour basis. After loss of GNSS or GNSS RAIM, the hybrid system should report the integrity containment radius of 1x10-7 probability on a per-sample basis rather than on a per-hour basis. Doing so would allow the GNSS/IRS system to transmit at a probability of 1x10-7 for a longer period of time. |
| | B.5.5.1 ***[CS requires GNSS-based position sources (GNSS/IRS systems are recognized as acceptable)]*** RTCA/DO-229D, appendix R, section 2.1 requires tightly-coupled systems to meet two integrity limits. The integrity limit for the faulted satellite case is 1x10-7. The integrity limit for fault-free (rare normal) case is 1x10-5. RTCA/DO-229D, appendix R, section 2.1.1 acknowledges that in tightly integrated systems, inertial coasting may cause the rare normal limit to be dominant over the limit for the faulted conditions in times of poor satellite coverage. If the HPL output from the tightly-coupled position source changes from the fault detection 1x10-7 basis to the fault free 1x10-5 basis, the position source needs to indicate this change to the ADS-B equipment. We recommend the position source use a 1x10-7 integrity basis in all modes. |
| | B.5.5.2 ***[CS requires GNSS-based position sources (GNSS/IRS systems are recognized as acceptable)]*** If the integrity containment probability output of the tightly-coupled GNSS/IRS position source changes from per-hour to per sample following a loss of GNSS or a loss of GNSS RAIM, the position source must indicate this change to the ADS-B equipment (that is, SILSUPP). |
| | B.5.5.3 ***[CS requires GNSS-based position sources (GNSS/IRS systems are recognized as acceptable)]*** If the tightly-coupled GNSS/IRS scales the inertial integrity from 1x10-5 to 1x10-7, the scaling must have been demonstrated during design approval of the position source. If the inertial basis is per-sample and is scaled to per-hour, this scaling must have been demonstrated during the position source design approval. |
| | B.5.6 ***[CS requires GNSS-based position sources (GNSS/IRS systems are recognized as acceptable)]*** GNSS Integrity Performance in the Flight Manual. If a tightly-coupled GNSS/IRS position source is intended to be used as an ADS-B position source after the loss of GNSS, include integrity coasting performance in the flight manual. Specifically address the following: |
| | B.5.6.1 ***[CS requires GNSS-based position sources (GNSS/IRS systems are recognized as acceptable)]*** If inertial coasting will meet § 91.227 requirements, such as NACP = 8, NIC = 7, SIL = 3, and SDA = 2. |
| | B.5.6.2 ***[CS requires GNSS-based position sources (GNSS/IRS systems are recognized as acceptable)]*** Estimated length of time following a loss of GNSS for which inertial coasting is expected to meet the § 91.227 requirements. The estimate should assume the system met minimum § 91.227 requirements just before the loss of GNSS or GNSS RAIM. This estimate will be helpful to operators in developing a means to ensure that the system can meet § 91.227 requirements during predicted GNSS degradations. |
| | B.6 ***[CS requires GNSS-based position sources (GNSS/IRS systems are recognized as acceptable)]*** Non-GNSS Position Sources. The FAA does not know of any currently available non-GNSS position sources that can meet the performance requirements of § 91.227. However, you may wish to integrate a backup ADS-B OUT capability in the event of loss of GNSS. Such a backup is not required. We do not expect any ATC operational advantages for systems that provide a non-GNSS backup unless that backup capability meets the performance requirements of § 91.227. This section provides high-level guidance on the issues that will need to be addressed to qualify a non-GNSS position source for use in an ADS-B system without regard to § 91.227 requirements. If you choose to integrate this capability, use the guidance below and propose to the FAA the method to approve a non-GNSS position source for use in an ADS-B system |
| | B.6.1.1 ***[CS requires GNSS-based position sources (GNSS/IRS systems are recognized as acceptable)]*** The DME/DME Area Navigation (RNAV) system must meet the minimum performance requirements of TSO-C66c, Distance Measuring Equipment (DME) Operating within the Radio Frequency Range of 960-1215 Megahertz. |

| ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets. | |
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| | B.6.1.2 ***[CS requires GNSS-based position sources (GNSS/IRS systems are recognized as acceptable)]*** There are no industry standards for use of a DME/DME system to determine position integrity or velocity accuracy. You must propose a method to derive these parameters. |
| | B.6.1.3 ***[CS requires GNSS-based position sources (GNSS/IRS systems are recognized as acceptable)]*** The DME/DME system must only use DME facilities listed in the Airport/Facility Directory (A/FD). |
| | B.6.1.4 ***[CS requires GNSS-based position sources (GNSS/IRS systems are recognized as acceptable)]*** The DME/DME system must only use operational DME facilities.<br>The system must exclude non-operational facilities by checking the identification. Operational mitigations, such as manually excluding (blackballing) DME stations or any action that requires pilot action or monitoring of the DME/DME system, are not permissible for ADS-B qualified position sources. |
| | B.6.1.5 ***[CS requires GNSS-based position sources (GNSS/IRS systems are recognized as acceptable)]*** Reasonableness Checks.<br>The DME/DME system must incorporate reasonableness checking. Refer to AC 90-100(), U.S. Terminal and En Route Area Navigation (RNAV) Operations, for additional information on reasonableness checks. |
| | B.6.2 ***[CS requires GNSS-based position sources (GNSS/IRS systems are recognized as acceptable)]*** VOR/DME.<br>ADS-B position sources may not use Very High Frequency Omnidirectional Range (VOR) information. Do not interface any position solution that uses VOR information as the performance of the VOR cannot be assumed throughout the region in which the signal is received. |
| | B.6.3.1 ***[CS requires GNSS-based position sources (GNSS/IRS systems are recognized as acceptable)]*** The GNSS equipment or DME equipment must meet the requirements in this appendix. |
| | B.6.3.2 ***[CS requires GNSS-based position sources (GNSS/IRS systems are recognized as acceptable)]*** Loosely coupled INS/IRU equipment must meet 14 CFR part 121, appendix G. |
| | B.6.3.3 ***[CS requires GNSS-based position sources (GNSS/IRS systems are recognized as acceptable)]*** The loosely coupled INS/IRU position source must provide all of the required position source outputs listed in this appendix. Qualify the outputs during installation approval of the ADS-B system; refer to section B.3 of this appendix. Velocity accuracy may be qualified and set statically. Update the position accuracy and position integrity metrics dynamically. |
| | B.6.3.4 ***[CS requires GNSS-based position sources (GNSS/IRS systems are recognized as acceptable)]*** § 91.227 requires a SIL = 3, which means the probability of exceeding the NIC containment radius should be less than 1x10-7 per hour or per sample. A GNSS/IRS that continues to provide the integrity containment radius based on a 1x10-7 probability after loss of GNSS or GNSS RAIM is preferred. Potential errors, caused by GNSS updating before the loss of GNSS, must continue to be bounded. |
| | B.6.3.4.1 ***[CS requires GNSS-based position sources (GNSS/IRS systems are recognized as acceptable)]*** If the integrity containment probability output of a loosely coupled<br>GNSS/IRS position source changes from 1x10-7 to 1x10-5 following a loss of GNSS or a loss of GNSS RAIM, the position source must relay this change to the ADS-B equipment. The overall system time to transmit a change in SIL must be 10 seconds or less. |
| | B.6.3.4.2 ***[CS requires GNSS-based position sources (GNSS/IRS systems are recognized as acceptable)]*** If the integrity containment probability output of a loosely coupled GNSS/IRS position source changes from per-hour to per-sample following a loss of GNSS or a loss of GNSS RAIM, the position source must relay this change to the ADS-B equipment. |
| | B.7 Future Position Sources **[CS requires GNSS-based position sources (GNSS/IRS systems are recognized as acceptable)]**.<br>It is expected that future position sources such as dual frequency GPS and GPS/Galileo sources will be acceptable position sources for ADS-B and meet the performance requirements of § 91.227. Future revisions of this AC will address new position source technology when it becomes available. |
| | |
| **Appendix H - Part 6 - Compliance Matrix BDS Register Fields** | |

| ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets. | |
|---|---|
| This part of Appendix H lists compliance matrices of the BDS register fields transmitted by the 1090 ES ADS-B transmit unit, with respect to the population of the 1090 ES data fields with data from approved sources (CS ACNS.D.ADSB.025(a) applies).<br>Omitted in the tables are fields containing the subtype codes (for these, refer to Part 1 of this Appendix) and reserved fields.<br>Reference to ADS-B Out item numbers is made in line with Part 1 of this Appendix respectively. Reference to Definitions is made in line with Part 1 of this Appendix.<br>Within the requirements (Req't) column, 'M' expresses a mandatory requirement, i.e. the respective fields are populated with data from approved sources. 'O' expresses an optional requirement, 'NA' expresses non-applicability and 'C' expresses a conditional requirement (requirement is mandatory provided that the condition expressed in the remark column is met).<br>In addition to the 1090 ES data fields (as specified by the respective 'ME' Bits conveyed within the downlink format DF 17), the 3-bit 'Capability (CA)' field, also conveyed within downlink format DF 17, should be populated for all below registers as follows:<br><br>**DF 17 – CA Field**<br><br>DF 17 bits: 6-8 — Field: Capability — Req't: M — Remark: Refer to ICAO Annex 10, Volume IV, section 3.1.2.5.2.2.1. | 3.1.6 (Installation) Populating Message Elements.<br>§ 91.227 lists parameters that must be populated (that is, not a null value) for operation in airspace defined by § 91.225. All parameters transmitted by the ADS-B system must conform to the standards in TSO-C166b or ***TSO-C154c [CS only recongnizes 1090 ES for the ADS-B Out data link]*** and may not contain false or misleading information. |
| **Register $05_{16}$ – Airborne Position Message** (table below) | 3.1.6 (Installation) Populating Message Elements.<br>§ 91.227 lists parameters that must be populated (that is, not a null value) for operation in airspace defined by § 91.225. All parameters transmitted by the ADS-B system must conform to the standards in TSO-C166b or TSO-C154c ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** and may not contain false or misleading information. |
| **Register $06_{16}$ – Surface Position Message** (table below) | 3.1.6 (Installation) Populating Message Elements.<br>§ 91.227 lists parameters that must be populated (that is, not a null value) for operation in airspace defined by § 91.225. All parameters transmitted by the ADS-B system must conform to the standards in TSO-C166b or TSO-C154c ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** and may not contain false or misleading information. |

**DF 17 – CA Field**

| DF 17 bits | Field | Req't | Remark |
|---|---|---|---|
| 6-8 | Capability | M | Refer to ICAO Annex 10, Volume IV, section 3.1.2.5.2.2.1. |

**Register $05_{16}$ – Airborne Position Message**

| ME Bits | Field | Req't | Remark |
|---|---|---|---|
| 6-7 | Surveillance Status | M | = '0', no condition information<br>= '1', Item 7a, Definition 10<br>= '2', Mode A code change<br>= '3', Item 6 |
| 8 | NIC Supplement-B | M | Item 4b, Definition 4 and 5 |
| 9-20 | Altitude | M | Item 5, Definition 9 |
| 21 | Time (T) | M | "GNSS time mark coupled" ('0' no, '1' yes), Item 4a, Definition 3 |
| 22 | CPR Format (F) | M | Compact Position Reporting (CPR) format type ('0' even, '1' odd) , Item 4a, Definition 3 |
| 23-39 | CPR Encoded Latitude | M | Item 4a, Definition 3 |
| 40-56 | CPR Encoded Longitude | M | |

**Register $06_{16}$ – Surface Position Message**

| ME Bits | Field | Req't | Remark |
|---|---|---|---|
| 6-12 | Movement | M | Item 14, Definitions 11 and 12 |
| 13 | Heading/Ground Track Status | M | Item 13, Definition 15 |
| 14-20 | Heading/Ground Track | M | |
| 21 | Time (T) | M | 'GNSS time mark coupled' ('0' no, '1' yes), Item 4a, Definition 3 |
| 22 | CPR Format (F) | M | Compact Position Reporting (CPR) format type ('0' even, '1' odd) , Item 4a, Definition 3 |
| 23-39 | CPR Encoded Latitude | M | Item 4a, Definition 3 |
| 40-56 | CPR Encoded Longitude | M | |

ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets.

**Register 08$_{16}$ - Aircraft Identification and Category Message**

| ME Bits | Field | Req't | Remark |
|---|---|---|---|
| 6-8 | ADS-B Emitter Category | M | Item 10, Definition 13 |
| 9-56 | Identification Characters #1-#8 | M | 6 bits per character, Item 1, Definition 1 |

3.1.6 (Installation) Populating Message Elements.

§ 91.227 lists parameters that must be populated (that is, not a null value) for operation in airspace defined by § 91.225. All parameters transmitted by the ADS-B system must conform to the standards in TSO-C166b or TSO-C154c ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** and may not contain false or misleading information.

**Register 09$_{16}$ - Airborne Velocity Message - Velocity over Ground (Subtypes 1and2, Normal/Supersonic)**

| ME Bits | Field | Req't | Remark |
|---|---|---|---|
| 6-8 | Subtype | M | '0' normal, '1' supersonic |
| 9 | Intent Change Flag | O | Mode S protocol support, indication of new information in GICB registers 40$_{16}$ to 42$_{16}$ |
| 11-13 | NAC$_V$ | M | Item 9b, Definition 12 |
| 14 | E/W Direction Bit | M | Item 9a, Definition 11 |
| 15-24 | E/W Velocity | M | |
| 25 | N/S Direction Bit | M | |
| 26-35 | N/S Velocity | M | |
| 36 | Vertical Rate Source | M | Item 11, Definition 14 |
| 37 | Vertical Rate Sign | M | |
| 38-46 | Vertical Rate | M | |
| 49 | Difference from Barometric Altitude Sign | M | Item 17a, Definition 19 |
| 50-56 | Difference from Barometric Altitude | M | |

3.1.6 (Installation) Populating Message Elements.

§ 91.227 lists parameters that must be populated (that is, not a null value) for operation in airspace defined by § 91.225. All parameters transmitted by the ADS-B system must conform to the standards in TSO-C166b or TSO-C154c ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** and may not contain false or misleading information.

ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets.

**Register $09_{16}$ - Airborne Velocity Message - Airspeed (Subtypes 3 and 4, Normal/Supersonic)**

| ME Bits | Field | Req't | Remark |
|---|---|---|---|
| 6-8 | Subtype | M | '0' normal, '1' supersonic |
| 9 | Intent Change Flag | O | Mode S protocol support, indication of new information in GICB registers $40_{16}$ to $42_{16}$ |
| 11-13 | $NAC_V$ | O | Item 9b, Definition 12 |
| 14 | Heading Status Bit | O | Item 9a, Definition 11 |
| 15-24 | Heading | O | |
| 25 | Airspeed Type | O | |
| 26-35 | Airspeed | O | |
| 36 | Vertical Rate Source | M | Item 11, Definition 14 |
| 37 | Vertical Rate Sign | M | |
| 38-46 | Vertical Rate | M | |
| 49 | Difference from Barometric Altitude Sign | M | Item 17a, Definition 19 |
| 50-56 | Difference from Barometric Altitude | M | |

3.1.6 (Installation) Populating Message Elements.
§ 91.227 lists parameters that must be populated (that is, not a null value) for operation in airspace defined by § 91.225. All parameters transmitted by the ADS-B system must conform to the standards in TSO-C166b or TSO-C154c ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** and may not contain false or misleading information.

**Register $61_{16}$ - Aircraft Status Message - Emergency Status and Mode A Code**

| ME Bits | Field | Req't | Remark |
|---|---|---|---|
| 6-8 | Subtype | M | ='1' |
| 9-11 | Emergency/Priority Status | M | Mandatory codes: '0', '1', '4' and '5', Item 7a, Definition 10 |
| 12-24 | Mode A Code | M | Item 2, Definition 2 |

3.1.6 (Installation) Populating Message Elements.
§ 91.227 lists parameters that must be populated (that is, not a null value) for operation in airspace defined by § 91.225. All parameters transmitted by the ADS-B system must conform to the standards in TSO-C166b or TSO-C154c ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** and may not contain false or misleading information.

**Register $61_{16}$ - Aircraft Status Message - ACAS RA Broadcast**

| ME Bits | Field | Req't | Remark |
|---|---|---|---|
| 5-8 | Subtype | M | ='2' |
| 9-22 | Active Resolution Advisories | M | Item 20b, Definition 22 |
| 23-26 | RACs Record | M | |
| 27 | RA Terminated | M | |
| 28 | Multiple Threat Encounter | M | |
| 29-30 | Threat Type Indicator | M | |
| 31-56 | Threat Identity Data | M | |

3.1.6 (Installation) Populating Message Elements.
§ 91.227 lists parameters that must be populated (that is, not a null value) for operation in airspace defined by § 91.225. All parameters transmitted by the ADS-B system must conform to the standards in TSO-C166b or TSO-C154c ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** and may not contain false or misleading information.

ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets.

**Register $62_{16}$ - Target State and Status Message**

| *ME Bits* | Field | Req't | Remark |
|---|---|---|---|
| 6-7 | Subtype | M | = '1' |
| *8* | SIL Supplement | M | Item 4d, Definition 4 and 7 |
| 9 | Selected Altitude Type | C | Where available in a suitable format Item 18, Definition 21 |
| 10-20 | MCP/FCU Selected Altitude ***or*** FMS Selected Altitude | C | |
| 21-29 | Barometric Pressure Setting | C | Where available in a suitable format Minus 800 millibars. |
| 30 | Selected Heading Status | O | not required by Commission Regulation (EU) No 1207/2011 |
| 31 | Selected Heading Sign | O | |
| 32-39 | Selected Heading | O | |
| 40-43 | Navigation Accuracy Category Position ($NAC_P$) | M | Item 4c, Definition 4 and 6 |
| 44 | Navigation Integrity Category Baro | M | Item 5, Definition 9 |
| 45-46 | Source Integrity Level | M | Item 4d, Definition 4 and 7 |
| 47 | Status of MCP/FCU Mode Bits | M | Item 18, Definition 21 |
| 48 | Autopilot Engaged | O | |
| 49 | VNAV Mode Engaged | O | |
| 50 | Altitude Hold Mode | O | |
| 52 | Approach Mode | O | |
| 53 | TCAS Operational | M | Item 20a, Definition 22 |
| 54 | LNAV Mode Engaged | O | Item 18, Definition 21 |

3.1.6 (Installation) Populating Message Elements.

§ 91.227 lists parameters that must be populated (that is, not a null value) for operation in airspace defined by § 91.225. All parameters transmitted by the ADS-B system must conform to the standards in TSO-C166b or TSO-C154c ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** and may not contain false or misleading information.

ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets.

**Register $65_{16}$ – Aircraft Operational Status Message - While Airborne**

| ME Bits | Field | Req't | Remark |
|---|---|---|---|
| 6-8 | Subtype | M | = '0' (Airborne) |
| 9-10 | Airborne Capability Class Subtype | M | = '0,0' |
| 11 | TCAS Operational | M | Item 20a, Definition 22 |
| 12 | 1090 ES IN | O | not required by EU Regulation No 1207/2011 |
| 15 | Air Referenced Velocity Report Capability | M | = '0', if aircraft is not capable of sending Airborne Velocity, Subtype 3 or 4<br>= '1', if yes |
| 16 | Target State Report Capability | M | = '1' |
| 17-18 | Trajectory Change Report Capability | M | = '0' |
| 19 | UAT IN | O | not required by EU Regulation No 1207/2011 |
| 25-26 | Airborne Operational Mode Subtype | M | = '0,0' |
| 27 | TCAS RA Active | M | Item 20b, Definition 22 |
| 28 | IDENT Switch Active | M | Item 6 |
| 30 | Single Antenna Flag | M | = '0', see CS-ACNS.D.ADSB.040 |
| 31-32 | System Design Assurance | M | Item 4e, Definition 4 & 8 |
| 41-43 | MOPS Version Number | M | = '2' |
| 44 | NIC Supplement-A | M | Item 4b, Definition 4 & 5 |
| 45-48 | NACP | M | Item 4c, Definition 4 & 6 |
| 49-50 | GVA | M | Item 17b, Definition 20 |
| 51-52 | Source Integrity Level | M | Item 4d, Definition 4 & 7 |
| 53 | NICBaro | M | Item 5, Definition 9 |
| 54 | Horizontal Reference Direction (HRD) | O | '0' true north, '1' magnetic north (Airborne Velocity, subtype 3 & 4) |
| 55 | SIL Supplement | M | Item 4d, Definition 4 & 7 |

3.1.6 (Installation) Populating Message Elements.

§ 91.227 lists parameters that must be populated (that is, not a null value) for operation in airspace defined by § 91.225. All parameters transmitted by the ADS-B system must conform to the standards in TSO-C166b or TSO-C154c ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** and may not contain false or misleading information.

ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets.

**Register $65_{16}$ – Aircraft Operational Status Message - On the Surface**

| ME Bits | Field | Req't | Remark |
|---|---|---|---|
| 6-8 | Subtype | M | = '1' (Surface) |
| 9-10 | Surface Capability Class Subtype | M | = '0,0' |
| 12 | 1090 ES IN | O | not required by Commission Regulation (EU) No 1207/2011 |
| 15 | B2 Low | NA | not applicable (targeting at class B2 equipment, e.g. ground vehicles) |
| 16 | UAT IN | O | not required by Commission Regulation (EU) No 1207/2011 |
| 17-19 | NACv | M | Item 9b, Definition 12 |
| 20 | NIC Supplement C | M | Item 12b, Definition 15 |
| 21-24 | Length/Width Codes | M | Item 15, Definition 17 |
| 25-26 | Surface Operational Mode Subtype | M | = '0,0' |
| 27 | TCAS RA Active | M | Item 20b, Definition 22 |
| 28 | IDENT Switch Active | M | Item 6 |
| 30 | Single Antenna Flag | M | = '0', see CS ACNS.D.ADSB.040 |
| 31-32 | System Design Assurance | M | Item 4e, Definition 4 and 8 |
| 33-40 | GPS Antenna Offset | M | Item 16, Definition 18 |
| 41-43 | MOPS Version Number | M | = '2' |
| 44 | NIC Supplement-A | M | Item 12b, Definition 15 |
| 45-48 | $NAC_P$ | M | Item 4c, Definition 4 and 6 |
| 51-52 | Source Integrity Level | M | Item 4d, Definition 4 and 7 |
| 53 | Track Angle/Heading | M | Item 9a, Definition 11 |
| 54 | Horizontal Reference Direction (HRD) | M | '0' true north, '1' magnetic north Item 13, Definition 15 |
| 55 | SIL Supplement | M | Item 4d, Definition 4 and 7 |

3.1.6 (Installation) Populating Message Elements.

§ 91.227 lists parameters that must be populated (that is, not a null value) for operation in airspace defined by § 91.225. All parameters transmitted by the ADS-B system must conform to the standards in TSO-C166b or TSO-C154c ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** and may not contain false or misleading information.

**Appendix I - On-the-ground status Test and Validation Guidance for Aeroplanes**

| ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets. | |
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| The ADS-B Out system installer should verify that the air-ground status inputs (or algorithms) are functioning properly and that the ADS-B Out system transmits the appropriate airborne messages or surface messages based on the On-the-ground status. This can be accomplished with simulated inputs to the appropriate sensors or accomplished in conjunction with the flight test.<br>The following tests provide guidance to the aircraft integrator for the verification of the ADS-B Out system installation, as appropriate. Separate cases are presented depending on the need to validate the status within the ADS-B transmit unit.<br>(a) Directly determined On-the-ground status being validated outside the ADS-B transmit function:<br>Modern aircraft with integrated avionics suites commonly contain sophisticated algorithms for determining the On-the-ground status based on multiple aircraft sensors. These algorithms are customised to the airframe and designed to overcome individual sensor failures. These algorithms are an acceptable means to determine the On-the-ground status and do not require additional validation.<br>(b) Validation of directly determined On-the-ground status not being validated outside the ADS-B transmit function:<br>If ground speed or airspeed is larger than the aeroplane's typical rotation speed, then the On-the-ground status is (changed to) airborne and the airborne position message is broadcast irrespective of the directly determined On-the-ground status (i.e. as indicated to the ADS-B transmit function).<br>(c) Indirectly determined On-the-ground status validation within the ADS-B transmit unit: If an aircraft is not equipped with a means, such as a weight-on-wheels switch, to determine whether it is airborne or on the ground, then the following tests should be performed to determine whether to broadcast the Airborne or Surface Position Messages.<br>(1) If the aircraft's radio height (RH) parameter is available, and RH is less than 15 m (50 feet), and at least ground speed (GS) or airspeed (AS) is available, and the GS or the AS are less than 51 m/s (100 knots), then that aircraft broadcasts the surface position message.<br>If all three parameters are available, the decision to broadcast the Airborne or Surface Position Messages is determined by the logical AND of all three parameters.<br>(2) If radio height (RH) is not available, and if the aircraft's ground speed (GS) and airspeed (AS) are available, and GS<26 m/s (50 knots) and AS<26 m/s (50 knots), then that aircraft broadcasts the surface position message.<br>Otherwise, the aircraft broadcasts the Airborne Position Message. | 4.1.10 (Ground Test) Air-Ground Status.<br>Verify that the air-ground inputs (or algorithms) are functioning properly and that the ADS-B system transmits the appropriate airborne messages or surface messages based on the air-ground status. This can be accomplished with simulated inputs to the appropriate sensors or accomplished in conjunction with the flight test. Rotorcraft may consider hover taxi as in the air. |
| On-the-ground status Test and Validation Guidance for Helicopters, Lighter-than-Air Vehicles and Fixed-under-Carriage Aeroplanes<br>Installations intended for this category that are unable to provide a compliant direct or indirect ground status detection function, should only broadcast the Airborne Position Message. In addition, the "CA" capability field in downlink format DF 17 should be set accordingly. | |
| | |
| **CS-ACNS - BOOK 1 - Subpart D - Section 4 — 1090 MHz Extended Squitter ADS-B** | |
| **GENERAL** | |
| CS ACNS.D.ADSB.001 Applicability<br>(See GM1 ACNS.D.ADSB.001)<br>This section provides standards for 1090 MHz Extended Squitter (ES) ADS-B Out installations. | § 91.227 Automatic Dependent Surveillance-Broadcast (ADS-B) Out equipment performance requirements. |
| **SYSTEM FUNCTIONAL REQUIREMENTS** | |
| CS ACNS.D.ADSB.010 ADS-B Out system approval<br>(See AMC1 ACNS.D.ADSB.010)<br>The equipment contributing to the ADS-B Out function is approved. | |
| **ADS-B OUT DATA** | |

ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets.

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| CS ACNS.D.ADSB.020 ADS-B Out Data Parameters (See AMC1 ACNS.D.ADSB.020(a-b))<br>(a) The ADS-B Out system provides the following minimum set of data parameters:<br>(1) Aircraft Identification;<br>(2) Mode A Code;<br>(3) ICAO 24-bit aircraft address;<br>(4a) Airborne Horizontal Position — Latitude and Longitude;<br>(4b) Airborne Navigation Integrity Category: NIC;<br>(4c) Airborne/Surface Navigation Accuracy Category for Position: NACp;<br>(4d) Airborne/Surface Source Integrity Level: SIL;<br>(4e) Airborne/Surface System Design Assurance: SDA;<br>(5) Pressure Altitude (incl. NICbaro);<br>(6) Special Position Identification (SPI);<br>(7a) Emergency Status;<br>(7b) Emergency Indication;<br>(8) 1090 ES Version Number;<br>(9a) Airborne velocity over Ground — (East/West and North/South);<br>(9b) Airborne/Surface Navigation Accuracy Category for Velocity: NACv;<br>(10) Emitter Category;<br>(11) Vertical Rate ***[not required by 91.227 (optional)]*** ;<br>(12a) Surface Horizontal Position — Latitude and Longitude;<br>(12b) Surface Navigation Integrity Category: NIC;<br>(13) Surface Ground Track;<br>(14) Movement (surface ground speed);<br>(15) Length/width of Aircraft;<br>(16) GPS Antenna Longitudinal Offset ***[not required by 91.227 (optional)]*** ;<br>(17a) Geometric Altitude; and<br>(17b) Geometric Altitude Quality: GVA ***[not required by 91.227 (optional)]*** . | § 91.227(d) Minimum Broadcast Message Element Set for ADS-B Out. Each aircraft must broadcast the following information, as defined in TSO-C166b or TSO-C154c. The pilot must enter information for message elements listed in paragraphs (d)(7) through (d)(10) of this section during the appropriate phase of flight.<br>(1) The length and width of the aircraft;<br>(2) An indication of the aircraft's latitude and longitude;<br>(3) An indication of the aircraft's barometric pressure altitude;<br>(4) An indication of the aircraft's velocity;<br>(5) An indication if TCAS II or ACAS is installed and operating in a mode that can generate resolution advisory alerts;<br>(6) If an operable TCAS II or ACAS is installed, an indication if a resolution advisory is in effect;<br>(7) An indication of the Mode 3/A transponder code specified by ATC;<br>(8) An indication of the aircraft's call sign that is submitted on the flight plan, or the aircraft's registration number, except when the pilot has not filed a flight plan, has not requested ATC services, and is using a TSO-C154c self-assigned temporary 24-bit address;<br>(9) An indication if the flightcrew has identified an emergency, radio communication failure, or unlawful interference;<br>(10) An indication of the aircraft's "IDENT" to ATC;<br>(11) An indication of the aircraft assigned ICAO 24-bit address, except when the pilot has not filed a flight plan, has not requested ATC services, and is using a TSO-C154c self-assigned temporary 24-bit address;<br>(12) An indication of the aircraft's emitter category;<br>***(13) An indication of whether an ADS-B In capability is installed [not required by CS (optional)];***<br>(14) An indication of the aircraft's geometric altitude;<br>(15) An indication of the Navigation Accuracy Category for Position (NACP);<br>(16) An indication of the Navigation Accuracy Category for Velocity (NACV);<br>(17) An indication of the Navigation Integrity Category (NIC);<br>(18) An indication of the System Design Assurance (SDA); and<br>(19) An indication of the Source Integrity Level (SIL). |
| (b) Where available in a suitable format, the ADS-B Out system provides the following data parameters:<br>(1) Selected Altitude ***[not required by 91.227 (optional)]*** ;<br>(2) Barometric Pressure Setting ***[not required by 91.227 (optional)]*** ; and<br>(3) ACAS Resolution Advisory. | |
| CS ACNS.D.ADSB.025 Provision of Data (See AMC1 ACNS.D.ADSB.025(a)(c))<br>(a) All data provided by the ADS-B Out system comes from approved sources.<br>(b) The data transmitted by the ADS-B Out system originates from the same data source as used in the transponder replies to Mode S interrogations.<br>(c) When a data quality indication is required, it is provided to the ADS-B transmit unit together with the associated data parameter and it expresses the actual quality of the respective data as valid at the time of applicability of the measurement. | |
| ADS-B TRANSMIT UNIT | |
| CS ACNS.D.ADSB.030 ADS-B Transmit Unit Approval (See AMC1 ACNS.D.ADSB. )<br>The ADS-B transmit unit is approved and it is integrated in the Mode S transponder. | |
| CS ACNS.D.ADSB.035 ICAO 24-bit Aircraft address<br>The ICAO 24 bit aircraft address is implemented as specified in CS ACNS.D.ELS.055.<br>*The ICAO 24-bit aircraft address assigned by the competent authority is correctly implemented on each transponder.* | AC 20-165, 4.1.7 ICAO 24-Bit Address.<br>...For non-U.S. registered aircraft, verify that the ICAO 24-bit address is the address assigned to the aircraft by the responsible State authority. |
| CS ACNS.D.ADSB.040 Antenna diversity (See AMC1 ACNS.D.ADSB.040) ***[CS requires antenna diversity, AC 20-165 allows single bottom-mounted antenna]***<br>The ADS-B transmit unit employs antenna diversity under the same conditions as specified in CS ACNS.D.ELS.065.<br>*Aircraft with a maximum certified take-off mass in excess of 5700 kg or a maximum cruising true airspeed capability, under International Standard Atmosphere (ISA) conditions, in excess of 130 m/s (250 knots) operates with an antenna diversity installation* ***[CS requires antenna diversity (aircraft applicability equivalent to EU No 1207/2011 for ADS-B Out equipage), AC 20-165 allows single bottom-mounted antenna]*** . | AC 20-165B, 3.8.1 Antenna Location and Number Required ***[CS requires antenna diversity, AC 20-165 allows single bottom-mounted antenna]*** .<br>The aircraft ADS-B antenna is an important part of the overall ADS-B Out system because antenna systems are major contributors to the system link performance. The location and number of antennas required for the airborne ADS-B OUT system is a function of the equipment class of the selected broadcast link (UAT or 1090ES). Single bottom-mounted antenna (TSO-C166b and TSO-C154c A1S and B1S classes) installations are allowed ***[CS requires antenna diversity, AC 20-165 allows single bottom-mounted antenna]*** . |

<table>
<tr><td colspan="2">ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets.</td></tr>
<tr><td>CS ACNS.D.ADSB.045 Antenna installation<br>The antenna is installed as specified in CS ACNS.D.ELS.060.<br>(a) The installed antenna(s) has (have) a resulting radiation pattern which is (are) vertically polarised, omnidirectional in the horizontal plane, and has (have) sufficient vertical beam width to ensure proper system operation during normal aircraft manoeuvres.<br>(b) Antenna(s) is/are located such that the effect on the far field radiation pattern(s) by the aircraft structure are minimised.</td><td></td></tr>
<tr><td>CS ACNS.D.ADSB.050 Transmit power<br>The ADS-B transmit unit has a peak transmit power as specified in CS ACNS.D.ELS.010(c);(d).<br>(c) The peak pulse power available at the antenna end of the transmission line of the transponder is more than 125 W (21 dBW) and not more than 500 W (27 dBW) for aircraft that operate at altitudes exceeding 4 570 m (15 000 ft) or with a maximum cruising speed exceeding 90 m/s (175 knots).<br>(d) The peak pulse power available at the antenna end of the transmission line of the transponder is more than 70 W (18.5 dBW) and not more than 500 W (27 dBW) for aircraft operating at or below 4 570 m (15 000 ft) with a maximum cruising airspeed of 90 m/s (175 knots) or less.</td><td>AC 20-165B, 3.8.1 Antenna Location and Number Required.<br>...For the UAT link, 16 watts minimum transmit power at the antenna output is required [CS only recongnizes 1090 ES for the ADS-B Out data link] . For the 1090ES link, 125 watts minimum transmit power at the antenna output is required.<br>§ 91.227(b) 1090 MHz ES and UAT Broadcast Links and Power Requirements--<br>(1) Aircraft operating in Class A airspace must have equipment installed that meets the antenna and power output requirements of Class A1, A1S [CS requires antenna diversity] , A2, A3, B1S [CS requires antenna diversity] , or B1 equipment as defined in TSO-C166b, Extended Squitter Automatic Dependent Surveillance-Broadcast (ADS-B) and Traffic Information Service-Broadcast (TIS-B) Equipment Operating on the Radio Frequency of 1090 Megahertz (MHz).<br>(2) Aircraft operating in airspace designated for ADS-B Out, but outside of Class A airspace, must have equipment installed that meets the antenna and output power requirements of either:<br>(i) Class A1, A1S [CS requires antenna diversity] , A2, A3, B1S [CS requires antenna diversity] , or B1 as defined in TSO-C166b; or<br>(ii) Class A1H, A1S, A2, A3, B1S, or B1 equipment as defined in TSO-C154c, Universal Access Transceiver (UAT) Automatic Dependent Surveillance-Broadcast (ADS-B) Equipment Operating on the Frequency of 978 MHz [CS only recongnizes 1090 ES for the ADS-B Out data link] .<br><br>Table 3. Minimum and Maximum Transmitted Power From TSO-C166b
<table>
<tr><th>Tested Transmitter Class</th><th>Minimum Power</th><th>Maximum Power</th></tr>
<tr><td>A1</td><td>21.0 dBW</td><td>27.0 dBW</td></tr>
<tr><td>A1S</td><td>21.0 dBW</td><td>27.0 dBW</td></tr>
<tr><td>B1</td><td>21.0 dBW</td><td>27.0 dBW</td></tr>
<tr><td>B1S</td><td>21.0 dBW</td><td>27.0 dBW</td></tr>
<tr><td>A2</td><td>21.0 dBW</td><td>27.0 dBW</td></tr>
<tr><td>A3</td><td>23.0 dBW</td><td>27.0 dBW</td></tr>
</table></td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td>Additional Guidance not Addressed in CS-ACNS</td></tr>
<tr><td></td><td>3.8.2 (Installation) Equipment Eligibility.<br>ADS-B antennas must meet requirements defined in the ADS-B equipment manufacturer's installation manual.</td></tr>
<tr><td></td><td>3.8.3.1 (Installation) Using an Existing Antenna.<br>When using an existing antenna system, if the installation does not modify the existing antenna(s), cabling, or output specifications, the antenna installation does not have to be reevaluated.</td></tr>
<tr><td></td><td>3.8.3.2 (Installation) Installing a New Shared Transponder/ADS-B Antenna.<br>Follow the transponder antenna installation guidance in AC 20-151().</td></tr>
<tr><td></td><td>3.8.3.3 (Installation) Installing a New Stand-Alone UAT ADS-B Antenna [CS only recongnizes 1090 ES for the ADS-B Out data link] .<br>If the UAT system is installed in an aircraft without a transponder or the installation will not use the existing transponder antenna, use the following guidance:</td></tr>
<tr><td></td><td>3.8.3.3.1 (Installation) Antenna Location [CS only recongnizes 1090 ES for the ADS-B Out data link] .<br>Mount antennas as near as practical to the centerline of the fuselage and locate them in a position to minimize obstruction in the horizontal plane.</td></tr>
<tr><td></td><td>3.8.3.3.2 (Installation) Antenna Distance From Other Antennas [CS only recongnizes 1090 ES for the ADS-B Out data link] .<br>The spacing between the UAT antenna and any transponder (Mode S or Air Traffic Control Radar Beacon System (ATCRBS)) antenna must provide a minimum of 20 dB of isolation between the two antennas. If both antennas are conventional omni-directional matched quarter-wave stubs, 20 dB of isolation is obtained by providing a spacing of at least 20 inches between the centers of the two antennas. If either antenna is other than a conventional stub, the minimum spacing must be determined such that 20 dB or more of isolation is achieved.</td></tr>
</table>

| ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets. | |
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| | 3.8.3.3.3 (Installation) Transmit Power ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** .<br>Transmit power will be verified during ground test. |
| | 3.8.3.3.4 (Installation) Structural Analysis ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** .<br>You may need to submit a structural analysis of new antenna installation to show compliance with the applicable regulations. |
| | 3.8.3.4 (Installation) Antenna Diplexers ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** .<br>Diplexers manufactured in accordance with TSO-C154b or TSO-C154c may be installed so UAT ADS-B equipment and a transponder may share the same antenna. The TSO-C154b and TSO-C154c diplexer installation instructions are required to have a limitation that ensures insertion of the diplexer does not exceed the maximum cable attenuation allowance between the transponder and antenna. |
| | 3.8.3.5 (Installation) Single Antenna ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** .<br>Single antenna systems must use a bottom-mounted antenna. |
| | 3.8.5 (Installation) Mutual Suppression.<br>Follow the ADS-B equipment manufacturer's guidance on interfacing the ADS-B OUT equipment to the mutual suppression bus. |
| | |
| CS ACNS.D.ADSB.055 Simultaneous operation of ADS-B transmit units (See AMC1 ACNS.D.ADSB.)<br>If more than one ADS-B transmit unit is installed, simultaneous operation of the transmit systems is prevented. | AC 20-165B, 3.2.2.4 If dual ADS-B OUT systems of the same link are installed (for example, to increase dispatch reliability), the installation must preclude operation of both systems simultaneously. |
| CS ACNS.D.ADSB.060 On-the-ground status determination (See AMC1 ACNS.D.ADSB.)<br>(a) The on-the-ground status is determined and validated by the ADS-B Out system.<br>(b) The on-the-ground status is not set by a manual action. | AC 20-165B, 3.10.2 Air-Ground Status.<br>For aircraft with retractable landing gear, the air-ground status determination is typically provided through a landing gear weight-on-wheels (WOW) switch. For aircraft that have fixed gear, the ADS-B system must still be able to determine the air-ground status of the aircraft. Installations that provide a means to automatically determine air-ground status based on inputs from other aircraft sensors may be acceptable if they can be demonstrated to accurately detect the status. For example, air-ground status may be derived from WOW switch and GPS velocity; or GPS velocity, an airport database, and geometric altitude; or GPS velocity and airspeed. These algorithms should be tested and validated during the installation approval.<br>Note 1: We recommend that any automatic air-ground determination be more robust than just a simple comparison of ground speed to a single threshold value. Field experience has shown that this method can lead to false air-ground status.<br>Note 2: Manual selection of the air-ground status is not acceptable.<br>Note 3: Rotorcraft may require unique logic for providing an accurate air-ground state. A reliable method to determine the air-ground state should consider training requirements. Rotorcraft may consider hover taxi as in the air.<br>4.1.10 Air-Ground Status.<br>Verify that the air-ground inputs (or algorithms) are functioning properly and that the ADS-B system transmits the appropriate airborne messages or surface messages based on the air-ground status. This can be accomplished with simulated inputs to the appropriate sensors or accomplished in conjunction with the flight test. Rotorcraft may consider hover taxi as in the air. |
| HORIZONTAL POSITION AND VELOCITY DATA SOURCES | |
| CS ACNS.D.ADSB.070 Horizontal Position and Velocity Data Sources (See AMC1 ACNS.D.ADSB.)<br>(a) The horizontal position is derived from GNSS data ***[AC 20-165 allows for non-GNSS position sources if requirements are met]*** .<br>(b) The GNSS receiver based horizontal position and velocity data source is approved and performs, as a minimum, horizontal position receiver autonomous integrity monitoring (RAIM) and fault detection and exclusion (FDE).<br>(c) Horizontal velocity data stems from the same source as horizontal position data. | |
| OTHER DATA SOURCES | |
| CS ACNS.D.ADSB.080 Data Sources as defined by Mode S Elementary and Enhanced Surveillance (See AMC1 ACNS.D.ADSB.080)<br>The data source requirements as defined for in section 2 and 3 of this subpart, are applicable. | ***Mandated by EU No 1207/2011, 1028/2014 (amendment), & 2017/386 (amendment) in European Airspace. For ELS, follow CS-ACNS - Subpart D - Section 2. For EHS, follow CS-ACNS - Subpart D - Section 3 supplemented with AC 20-151C Section 2.3.10 & Appendix F (for populating) and B.21 (for testing) Vertical Intention Register.*** |
| CS ACNS.D.ADSB.085 Geometric Altitude (See AMC1 ACNS.D.ADSB.)<br>(a) Geometric Altitude is provided by the horizontal position and velocity source (see CS ACNS.D.ADSB.070).<br>(b) Geometric Altitude is transmitted as height above WGS-84 ellipsoid. | AC 20-165B, B.3.10 Geometric Altitude.<br>The position source must have a geometric altitude output. The geometric altitude must be referenced to the WGS-84 ellipsoid. |
| FLIGHT DECK CONTROL AND INDICATION CAPABILITIES | |

| ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets. | |
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| CS ACNS.D.ADSB.090 Flight deck interface (See AMC1 ACNS.D.ADSB.090(a) and AMC1 ACNS.D.ADSB.090(b))<br>(a) The control and display of surveillance data items is as per CS ACNS.D.ELS.030.<br>*(a) A means is provided :*<br>*(1) to select Mode A Code, including emergency indicators;*<br>*(2) to initiate the IDENT (SPI) feature;*<br>*(3) for an aircraft identification to be inserted by the flight crew if the aircraft uses variable aircraft identification;*<br>*(4) to notify the flight crew when the transmission of pressure altitude information has been inhibited, if a means to inhibit the transmission of pressure altitude is provided;*<br>*(5) to select the transponder to the 'standby' or 'OFF' condition;*<br>*(6) to indicate the non-operational status or failure of the transponder system without undue delay and without the need for flight crew action;*<br>*(7) to display the selected Mode A code to the flight crew;*<br>*(8) to display the aircraft identification to the flight crew; and*<br>*(b) Input which is not intended to be operated in flight, is not readily accessible to the flight crew.*<br>(b) A means is provided to indicate the non-operational status or failure of the ADS-B Out system without undue delay. | AC 20-165B, 3.7.2.1 System Status.<br>The installation must have a method to display system operational status to the flightcrew, and should be consistent with the overall flightdeck design philosophy. The system must display flightcrew inputs such as Mode 3/A code, emergency codes, IDENT, and call sign. If an existing transponder is used to input Mode 3/A codes, emergency codes, and IDENT into the ADS-B system, the current transponder control interface is sufficient. The following two failure annunciations must be included in the initial airworthiness certification (that is, STC or TC) type design data for the ADS-B OUT equipment, and should be consistent with the overall flightdeck design philosophy for surveillance equipment. These failure conditions are advisory only and do not constitute a caution or warning condition. For legacy Mode C installations that are adding a UAT device, the following two failure annunciations are optional ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** .<br>3.7.2.1.1 ADS-B Device Failure.<br>If the ADS-B equipment is unable to transmit ADS-B messages, the system should provide an appropriate annunciation to the flightcrew.<br>3.7.2.1.2 ADS-B Function Failure.<br>The ADS-B system depends on a position source to provide the data to populate the ADS-B messages and reports. If the position source or its interface with the ADS-B equipment fails, the ADS-B system will not be able to broadcast the required ADS-B data. In this case, the ADS-B equipment has not failed, but it cannot perform its function due to a failure to receive the position source data. The ADS-B system should distinguish between a position source or interface failure and an ADS-B equipment failure. The installer must provide documentation, in the applicable flight manual, or flight manual supplement, that explains how to differentiate between annunciation of an equipment failure and a function failure if the failure annunciations are not independent. The ADS-B function failure must not cause a TCAS II system failure...<br>Turning Off ADS-B.<br>14 CFR 91.225 and § 91.227 requires that all aircraft equipped with ADS-B OUT operate with the equipment turned on at all times. There are no requirements to disable ADS-B broadcasts at the request of ATC. When ADS-B functionality resides in the Mode S transponder, it is acceptable to disable the ADS-B transmissions by disabling the transponder (that is, "Standby" or "Off"). If this architecture is used, specify the impact in the flight manual or pilot's guide (for example, loss of ADS-B, transponder, and TCAS functionality). Locate the ADS-B on/off controls to prevent inadvertent actuation. |
| SYSTEM PERFORMANCE REQUIREMENTS | |
| CS ACNS.D.ADSB.100 Integrity<br>(a) The ADS-B Out system integrity is designed commensurate with a 'major' failure condition for the transmission of the following parameters:<br>(1) ICAO 24-bit aircraft address;<br>(2) Airborne Horizontal Position — Latitude and Longitude;<br>(3) Airborne Navigation Integrity Category: NIC;<br>(4) Airborne/Surface Navigation Accuracy Category for Position: NACp;<br>(5) Airborne/Surface Source Integrity Level: SIL;<br>(6) Airborne/Surface System Design Assurance: SDA;<br>(7) 1090 ES Version Number;<br>(8) Airborne velocity over Ground — East/West and North/South;<br>(9) Airborne/Surface Navigation Accuracy Category for Velocity: NACv;<br>(10) Emitter Category;<br>(11) Surface Horizontal Position — Latitude and Longitude;<br>(12) Surface Navigation Integrity Category: NIC;<br>(13) Surface Ground Track;<br>(14) Movement (surface ground speed);<br>(15) Length/width of Aircraft;<br>(16) GPS Antenna Offset ***[not required by 91.227 (optional)]*** ;<br>(17) Geometric Altitude;<br>(18) Geometric Altitude Quality: GVA ***[not required by 91.227 (optional)]*** ;<br>(b) The ADS-B Out system integrity is designed commensurate with a 'minor' failure condition for the transmission of other data parameters. | AC 20-165B, 3.7.3.5.2 System Safety Assessment.<br>Transmission of false or misleading information is considered to be a major failure effect and may not occur at a rate greater than 1x10-5 per flight hour for ADS-B systems...<br>AC 20-165B, B.3.9 The position source must support a major or greater failure effect... |

| ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets. | |
|---|---|
| CS ACNS.D.ADSB.105 Continuity<br>(a) The ADS-B Out system continuity is designed to an allowable qualitative probability of 'remote' ***[§ 91.227 doesn't specify a continuity requirement]*** .<br>Ref. EASA Deviation to CS ACNS.D.ADSB.105 to not meet a 'remote' quantitative probability requirement (1E-5/FH) if the installation meets the requirements of EU No 1207/2011 by having a continuity equal to or less than 2E-4/FH and the equipment supporting the ADS-B functionality is DAL C (meets remote qualitative probability). | ***[§ 91.227 doesn't specify a continuity requirement].*** |
| HORIZONTAL POSITION AND VELOCITY DATA REFRESH RATE AND LATENCY | |
| CS ACNS.D.ADSB.110 Horizontal Position and Velocity Data Refresh Rate (See AMC1 ACNS.D.ADSB.)<br>A horizontal position and velocity source calculates position and velocity data with a rate of at least 1 Hertz. | § 91.227(e)(3) The aircraft must transmit its position and velocity at least once per second while airborne or while moving on the airport surface. |
| CS ACNS.D.ADSB.115 Horizontal Position and Velocity Total Latency (See AMC1 ACNS.D.ADSB.115 and 120)<br>Measured from the time of applicability within the source, the total latency of the horizontal position and horizontal velocity data introduced by the ADS-B Out system does not exceed 1.5 second.<br>***[Although TL requirements appear different, they are consistent with each other. CS TL measurement is from the TOA, whereas, § 91.227TL measurement is from the TOM (adds an additional 0.5 seconds)]*** | § 91.227(e)(1) The aircraft must transmit its geometric position no later than 2.0 seconds from the time of measurement of the position to the time of transmission.<br>***[Although TL requirements appear different, they are consistent with each other. CS TL measurement is from the TOA, whereas, § 91.227 TL measurement is from the TOM (adds an additional 0.5 seconds)]*** |
| CS ACNS.D.ADSB.120 Horizontal Position Uncompensated Latency (See AMC1 ACNS.D.ADSB.115 and 120)<br>The uncompensated latency of the horizontal position data introduced by the ADS-B Out System does not exceed 0.6 second. | § 91.227(e)(2) Within the 2.0 total latency allocation, a maximum of 0.6 seconds can be uncompensated latency. The aircraft must compensate for any latency above 0.6 seconds up to the maximum 2.0 seconds total by extrapolating the geometric position to the time of message transmission.<br>AC 20-165, C.4.2 Latency Applicability.<br>The 2.0 second total latency requirement ***[CS latency measurement is from the TOA (total 1.5 sec. requirement), whereas, § 91.227 latency measurement is from the TOM (adds an additional 0.5 seconds - total 2 sec. requirement)]*** applies to the aircraft position (latitude and longitude), velocity, and the velocity accuracy metric ($NAC_V$). The 0.6 second uncompensated latency requirement only applies to the aircraft position (latitude and longitude). |
| | |
| | **Additional Guidance not Addressed in CS-ACNS** |
| | **CHAPTER 2. THE APPROVAL PROCESS AND NECESSARY DOCUMENTATION** |
| | 2.1.2 The ADS-B OUT System.<br>...Applicants should list the components that make up the ADS-B system in their master drawing list. You may demonstrate interoperability with multiple components for a given function. For example, you may request approval for a secondary position source, or add multiple unique position sources to the STC. |
| | **2.3 Continuing Airworthiness Requirements.** |
| | 2.3.1 ADS-B OUT Equipment.<br>Follow the ADS-B equipment manufacturer's guidance for periodic inspection and maintenance of the ADS-B system. ICA must be provided and must address any maintenance requirements to maintain the ADS-B equipment. |
| | 2.3.2 ADS-B Functionality in a Transponder.<br>Transponders that incorporate ADS-B functionality (such as with 1090ES) must continue to meet the operational requirements of 14 CFR 91.215, §91.217, and §91.413 and comply with the transponder system tests and inspections called out in 14 CFR part 43, appendix F. Refer to AC 43-6, Altitude Reporting Equipment and Transponder System Maintenance and Inspection Practices. |
| | 2.3.3 Altimetry Systems and Altitude Reporting Equipment.<br>Altitude reporting equipment connected to the ADS-B system must comply with all applicable 14 CFR 91.217, §91.411, and part 43, appendix E test and inspection requirements. Refer to AC 43-6. If the altimetry system is compliant with the Reduced Vertical Separation Minimum (RVSM) standards, the requirements and tolerances stated in the approved RVSM maintenance program must be met. ADS-B installation does not alter these requirements. |
| | 2.3.4 Maintenance and Design Changes to Interfacing Components.<br>The ADS-B system interfaces with multiple external components, such as position sources and altimetry sources. The installer should list all interfacing components in the ICA. It is important that any future maintenance or design changes to these interfacing components be accomplished in such a way that continued satisfactory performance of the overall ADS-B system is maintained. |
| | 2.3.4.1 Maintenance of the ADS-B System.<br>The ADS-B system installation must include ICA that meet the typical requirements for a system installation, which includes how to accomplish a complete functional check of the system. |

| ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets. | |
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| | 2.3.4.2 ADS-B Source System Components.<br>Although the installer may not have access to the specific source system ICA to incorporate changes into those specific documents, the installer must do an analysis of the source systems to determine what maintenance actions on those source systems would require a functional test of the ADS-B system to verify that the system is operating properly. In particular, those systems providing a dedicated input to the ADS-B system that cannot be verified by other means should be tested as part of the ADS-B system as a whole. Once the installer identifies those actions, they must provide recommended language for the operator to include in their ICA. If the installer determines that removal and replacement of the Global Positioning System (GPS) receiver requires a full functional check of the ADS-B system because the GPS input to the ADS-B cannot be verified by other means, its instructions to the operator should indicate this. For example:<br>Modify the R&R ICA instructions in your GPS maintenance manual to include the following statement:<br>"Removal and replacement of the GPS receiver also requires a full functional check of the ADS-B system per MM XX-XX-XX, Pg xxx. Make a logbook entry for accomplishment of this test".. |
| | 2.3.4.2 Design Changes to Interfacing Components.<br>Ensuring continued airworthiness of the ADS-B system following upgrades of interfacing components could be problematic if the installer of the ADS-B system is unaware of design changes to interfacing components, or if the installer of the updated interfacing component is unaware of a potential impact to the ADS-B system. To avoid this problem, the ADS-B system installer must update the ICA for each interfacing system with a process that ensures continued airworthiness of the ADS-B system following design changes to the interfacing component. |
| | |
| | **CHAPTER 3. ADS-B OUT SYSTEM INSTALLATION GUIDANCE** |
| | **3.1 General Installation Guidance.** |
| | 3.1.1 Environmental Qualification.<br>Ensure the environmental qualification of the installed equipment is appropriate for the aircraft in accordance with AC 21-16G, RTCA Document DO-160 versions D, E, F, and G, "Environmental Conditions and Test Procedures for Airborne Equipment". |
| | |
| | **CHAPTER 4. TEST AND EVALUATION** |
| | 4.1.4 Electromagnetic Interface (EMI)/Electro Magnetic Compatibility (EMC) Testing.<br>Provide an EMI/EMC test plan that demonstrates compliance with 14 CFR 23.1431(a) and (b), 25.1353(a) and (b), 25.1431(a) and (c), 27.1301, 27.1309, 29.1353(a) and (b), and 29.1431(a) and (b) as appropriate. Accomplish EMI/EMC testing to ensure the ADS-B equipment does not provide an interference source on other installed systems on the aircraft. Additionally, ensure equipment already installed in the aircraft does not interfere with the ADS-B system. If the STC or TC only involves a software change to an existing approved Mode S transponder installation, and the software update will not affect the systems response to EMI, you do not need to accomplish EMI testing again. |
| | 4.1.5 Human Machine Interface.<br>Evaluate the flightcrew interface for the ADS-B OUT system, including the human-system interface and system behavior. The ADS-B OUT system must be compatible with the overall flightdeck design characteristics (such as access to controls, sunlight readability, night lighting, etc.) as well as the aircraft environment (such as vibrations). |
| | 4.1.5.1 Information Display.<br>Evaluate the ADS-B OUT system to ensure displayed information is easily and clearly discernible, and has enough luminance, size, and visual contrast for the pilots to see and interpret it. Ensure the pilots have a clear, unobstructed, and undistorted view of the displayed information elements. Ensure information elements are distinct and permit the pilots to determine the source of the information elements if necessary, when there are multiple sources of the same kind of information. |
| | 4.1.5.2 Controls and Labeling.<br>Evaluate the controls for the pilot interface to ensure they are plainly marked as to their intended function, provide convenient operation, and prevent confusion and inadvertent operation of both the ADS-B system, and the other systems with which they interact. Evaluate the acronyms, labels, and annunciations to ensure they are used consistently in the flightdeck, and do not cause confusion or errors. If a control performs more than one function, evaluate the labels to ensure the labels include all intended functions, unless the function of the control is obvious. During evaluation, consider line select keys, touch screens or cursor controlled devices (such as trackballs) as these can be susceptible to unintended mode selection resulting from their location in the flightdeck (for example, proximity to a footrest or temporary stowage area). |

| ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets. | |
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| | 4.1.5.3 Annunciations and Alerts.<br>Evaluate all ADS-B annunciations and alerts to ensure they are clear and unambiguous, and provide attention-getting and saliency appropriate to the type of alert. Compliance with AC 25.1322-1, Flightcrew Alerting; AC 27.1322 (in AC 27-1B, Certification of Normal Category Rotorcraft); and AC 29.1322 (in AC 29-2C, Certification of Transport Category Rotorcraft) should be considered when evaluating ADS-B annunciations and alerts. The colors yellow/amber and red should be restricted to cautions and warnings, respectively. Evaluate the annunciations and indications to ensure they are operationally relevant and limited to minimize the adverse effects on flightcrew workload. When an annunciation is provided for the status or mode of a system, it is recommended that the annunciation indicate the actual state of the system, and not just the position of a switch. |
| | 4.1.5.5 Lighting.<br>Evaluate all foreseeable conditions relative to lighting, including failure modes such as lighting and power system failure, and day and night operations. |
| | 4.1.6 Transponder Regression Testing.<br>At a minimum, use the procedures outlined in AC 43-6(), Altitude Reporting Equipment and Transponder System Maintenance and Inspection Practices, to validate that the transponder is operating normally following the ADS-B installation. Use the procedures outlined in AC 20-151() for ADS-B systems that include installation of a new or modified Mode S transponder. If you are installing a new air-ground status capability for the ADS-B system and this functionality is also interfaced to the transponder, you must ensure replies to the Mode A/C and ATCRBS/Mode S all-call interrogations are inhibited on the ground. |
| | 4.1.7 ICAO 24-Bit Address.<br>For U.S. civil aircraft, demonstrate that the 24-bit address transmitted by the system correlates to the aircraft registration number. If the system has a separate Mode S transponder and UAT ADS-B system installed, ensure both the transponder and ADS-B system transmit the same correct ICAO 24-bit address. For non-U.S. registered aircraft, verify that the ICAO 24-bit address is the address assigned to the aircraft by the responsible State authority. |
| | 4.1.9 Position Source Failure.<br>Demonstrate that a failure or loss of the position source results in an indication to the operator of an ADS-B function failure. If a secondary position source is interfaced to the ADS-B equipment, ensure it meets all guidance in this AC. If the change from the primary position source to the secondary position source requires a change in SIL or SDA, ensure these changes are accomplished within 10 seconds. |
| | 4.1.11 Transmit Power.<br>Transmit power testing must be accomplished if a new antenna has been installed, an existing antenna has been relocated, a diplexer has been installed into an existing antenna system, or the output specifications on the transponder have changed. Perform the following testing to validate transmit power:<br>Note: Upgrading a previously installed and approved TSO-C112() Mode S transponder to include ADS-B functionality does not require transmit power testing unless a new antenna has been installed, the antenna location has changed, or the output specifications on the transponder have changed. |
| | 4.1.11.1 1090ES Transmitter.<br>Verify that the peak pulse power at the antenna end of the transmission line meets the minimum and maximum power levels summarized in Table 3, considering the test equipment antenna gain and path loss. Repeat the measurement in each quadrant of the antenna pattern (forward, aft, left, right).<br>**Table 3. Minimum and Maximum Transmitted Power From TSO-C166b**<br>Tested Transmitter Class \| Minimum Power \| Maximum Power<br>A1 \| 21.0 dBW \| 27.0 dBW<br>A1S \| 21.0 dBW \| 27.0 dBW<br>B1 \| 21.0 dBW \| 27.0 dBW<br>B1S \| 21.0 dBW \| 27.0 dBW<br>A2 \| 21.0 dBW \| 27.0 dBW<br>A3 \| 23.0 dBW \| 27.0 dBW |

ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets.

4.1.11.2 UAT Transmitter ***[CS only recongnizes 1090 ES for the ADS-B Out data link]*** .
Verify that the peak pulse power at the antenna end of the transmission line meets the minimum and maximum power levels summarized in Table 4, considering the test equipment antenna gain and path loss. Repeat the measurement in each quadrant of the antenna pattern (forward, aft, left, right).

**Table 4. Minimum and Maximum Transmitted Power From TSO-C154c**

| Tested Transmitter Class | Minimum Power | Maximum Power |
|---|---|---|
| A1H | 12.0 dBW | 16.0 dBW |
| A1S | 12.0 dBW | 16.0 dBW |
| B1 | 12.0 dBW | 16.0 dBW |
| B1S | 12.0 dBW | 16.0 dBW |
| A2 | 12.0 dBW | 16.0 dBW |
| A3 | 20.0 dBW | 24.0 dBW |

4.1.12 TCAS.
If a TCAS II system is installed on the aircraft, ensure the proper messages are transmitted by the ADS-B system when the TCAS II is on and operating in a mode that can provide RAs. No TCAS II system regression testing beyond the ground interface testing covered in this section is required.

4.1.13 Transponder All-call Inhibit.
When ADS-B functionality resides in a Mode S transponder, conduct a test demonstrating that replies to Mode A/C/S all-call and Mode S-only all-call interrogations are inhibited on the ground. Also demonstrate that replies to discrete interrogations are not inhibited.

4.1.14 Mode 3/A Code and Emergency Code.
Demonstrate that the correct Mode 3/A code and IDENT is transmitted. Do not transmit the 7500, 7600, or 7700 emergency codes over the air during ground or flight testing. If testing emergency codes is desired, contact the local ATC facility and coordinate testing to prevent a nuisance emergency response.

4.2 Flight Test ***[CS-ACNS doesn't require a flight test]*** .
This section provides information on flight testing ADS-B systems.

4.2.1 Electromagnetic Interference ***[CS-ACNS doesn't require a flight test]*** .
During all phases of flight, survey the flight deck EMI to determine that the ADS-B OUT equipment is not a source of objectionable conducted or radiated interference to previously installed systems or equipment, and that operation of the ADS-B OUT equipment is not adversely affected by conducted or radiated interference from previously installed systems and equipment.

4.2.2 Other System Performance ***[CS-ACNS doesn't require a flight test].***
Demonstrate the proper performance of any previously installed aircraft systems that required changes as a result of the ADS-B installation in accordance with the applicable policy. This can be accomplished with standard regression test procedures for the other installed systems, and does not require a unique test for ADS-B.

4.2.3 User Interface ***[CS-ACNS doesn't require a flight test]*** .
Exercise all user inputs. If separate user inputs are required for the transponder and ADS-B systems, evaluate the flight manual procedures for ensuring the same Mode 3/A code, IDENT, and emergency codes are transmitted from both systems.

4.3 Flight Test With FAA Ground System ***[CS-ACNS doesn't require a flight test]*** .
Perform a flight test to show that the installed system performs properly with the FAA ground system. The test will verify that the FAA ground system properly receives the aircraft's ADS-B broadcast messages, there are no dropouts, and the information transmitted is complete and correct. Currently the only method available to accomplish the flight test is to fly within ADS-B service coverage and accomplish a post-flight analysis of the data received from the FAA. This test is intended to evaluate the design interface for the position source and the ADS-B equipment.
Note 1: This flight test is intended to complete a design approval under an STC or TC application; it is not intended for the alteration of individual aircraft.
Note 2: Follow your standard process for requesting flight test authorization; there are no unique flight test authorization requirements for ADS-B flight tests.

4.3.1 Preflight Coordination ***[CS-ACNS doesn't require a flight test]*** .

4.3.1.1 Data Retrieval ***[CS-ACNS doesn't require a flight test]*** .
Flight test data can be requested for two distinct types of flight testing, operational checkout of a previously certified system, and testing of a first-of-kind ADS-B system.

| ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets. | |
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| | 4.3.1.1.1. Previously Certified Systems ***[CS-ACNS doesn't require a flight test]*** .<br>In the context of this AC, a previously certified system is an ADS-B system that holds a Type Certificate, Supplemental Type Certificate or is listed on an Approved Model Listing. Aircraft owners may request a flight test compliance report to verify a previously approved ADS-B system has been installed and configured correctly. Interested parties can email 9-AWA-AFS-300-ADSB-AvionicsCheck@faa.gov and request an ADS-B Aircraft Operation Compliance Report (ACR). When requesting an ACR, include aircraft registration number ("N" number), location, date, and approximate local time of flight. All requests should be made after the test flight has taken place. |
| | 4.3.1.1.2 First-of-Kind Systems ***[CS-ACNS doesn't require a flight test]*** .<br>System integration teams may request flight test data for first-of-kind ADS-B systems. First-of-kind systems are those that are part of a TC, STC, or Approved Model List (AML) effort. At least 48 hours before the flight, notify the FAA by emailing 9-avs-air-130flttest@FAA.gov that you require data to support first-of-kind testing of a new ADS-B system. Contacting the FAA before a test flight will better ensure flight test data will be provided in a timely manner. Upon initial contact, the FAA will provide a flight test request sheet. When contacting the FAA for flight test data, it is recommended you carbon copy any certifying officials you may be working with within the Aircraft Certification Office, Military Certification Office, Flight Standards District Office, or Flight Inspection District Office. Flight test data can usually be provided to the requester within 48 hours. An analysis report may take up to 30 days if it is determined necessary. |
| | 4.3.1.2 ATC Coordination ***[CS-ACNS doesn't require a flight test]*** .<br>There is no ADS-B specific requirement to coordinate the flight test in advance with ATC. Follow normal flight test procedures for coordinating with ATC. |
| | 4.3.2 Flight Test Profile ***[CS-ACNS doesn't require a flight test]*** .<br>This profile is intended to be flown on all ADS-B system approvals. The profile need not be flown exactly, and variances for ATC clearances and vectors are acceptable. The flight test should be at least 1 hour long. If the profile is completed in less than 1 hour, continue the flight until enough data is collected. The flight test may not be performed using the random UAT 24-bit address feature, since the 24-bit address is a key field in retrieving the ATC flight profile data. The profile discussed in section 4.3.2.3 through 4.3.4.6 below may be flown in any order. |
| | 4.3.2.1 Location of Flight ***[CS-ACNS doesn't require a flight test]*** .<br>The flight may be accomplished in any airspace that has FAA ADS-B ground station coverage. As of December 1, 2015 the ADS-B ground network is completely deployed across the continental United States, Hawaii, Puerto Rico, and Guam. The ADS-B ground network has been installed in Alaska but does not cover the entire state. Refer to the following website for information on existing ADS-B coverage in the National Airspace System (NAS):<br>http://www.faa.gov/nextgen/programs/adsb/coverageMap |
| | 4.3.2.2 Distance From Ground Station ***[CS-ACNS doesn't require a flight test]*** .<br>This flight profile does not specify the distance the aircraft must be from an ADS-B ground station. Transmit power is evaluated through ground testing instead of demonstrating a minimum air-to-ground reception distance. |
| | 4.3.2.3 Altitude ***[CS-ACNS doesn't require a flight test]*** .<br>Fly the aircraft at multiple altitudes throughout the flight within ADS-B coverage. There is no maximum or minimum altitude required for the flight test. |
| | 4.3.2.4 Turns ***[CS-ACNS doesn't require a flight test]*** .<br>Verify the ADS-B system performs properly during turning maneuvers. During the flight, place the aircraft in various normal configurations such as takeoff, approach, landing, and cruise configuration if appropriate for the airframe. During the flight, perform at least two left and two right 360-degree turns. Table 5 below provides the suggested altitude, speed, and bank angle at which these turns should be made. The intent of this test is to ensure the ADS-B system operates properly over the normal flight regimes of the aircraft under test. Variations on altitude, speed, and bank angle are acceptable as long as the intent of the test is met. |

ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets.

**Table 5. Turns**

| Part 23 Aircraft | | | |
|---|---|---|---|
| Configuration | Altitude Range (in feet AGL) | Speed Range | Bank Angle |
| Takeoff | 3000-5000 | 1.4 $V_S$ | 30° |
| Approach or Landing | 2000-7000 | 1.4 $V_S$ | 30° |
| Cruise | 7000-10000 | 1.5 $V_S$ to 1.8 $V_S$ | 30° |
| **Part 25 Aircraft** | | | |
| Configuration | Altitude Range | Speed Range | Bank Angle |
| Takeoff | 3000-5000 | $V_2$ + 20 kts | 30° |
| Approach or Landing | 2000-7000 | $V_{APP}$ + 20 kts | 30° |
| Cruise | 7000-10000 | 1.5 $V_S$ to 1.8 $V_S$ | 30° |
| **Part 27 Rotorcraft** | | | |
| Configuration | Altitude Range | Speed Range | Bank Angle |
| Landing | 1000-3000 | $V_Y$ + 10 kts | 30° |
| Cruise | 2000-5000 | 0.8 $V_{NE}$ or 0.8 $V_H$ | 30° |
| **Part 29 Rotorcraft** | | | |
| Configuration | Altitude Range | Speed Range | Bank Angle |
| Landing | 1000-3000 | $V_Y$ + 10 kts | 30° |
| Cruise | 2000-10000 | 0.8 $V_{NE}$ or 0.8 $V_H$ | 30° |

4.3.2.5 Climbs/Descents ***[CS-ACNS doesn't require a flight test].***

Verify the ADS-B system performs properly during climbs and descents. Table 6 provides a suggested airspeed at which climbs should be made during the test flight. Table 7 provides a suggested airspeed at which descents should be made during the test flight. Climbs and descents should be at least one minute in length. The intent of this test is to ensure the ADS-B system operates properly over the flight regime of the aircraft under test. Variations on climb and descent rates are acceptable as long as the intent of the test is met.

**Table 6. Climb Speeds**

| Configuration | Part 23 Aircraft | Part 25 Aircraft | Part 27 Rotorcraft | Part 29 Rotorcraft |
|---|---|---|---|---|
| Take off | $V_Y$ | $V_{FE}$ - 10 kts | $V_Y$ | $V_Y$ |
| Cruise | $V_H$ | $V_{MO}$ - 10 kts | 0.8 $V_{NE}$ or 0.8 $V_H$ | 0.8 $V_{NE}$ or 0.8 $V_H$ |

**Table 7. Descent Speeds**

| Configuration | Part 23 Aircraft | Part 25 Aircraft | Part 27 Rotorcraft | Part 29 Rotorcraft |
|---|---|---|---|---|
| Cruise | $V_{NE}$ - 10 | $V_{MO}$ - 10 kts | 0.8 $V_{NE}$ or 0.8 $V_H$ | 0.8 $V_{NE}$ or 0.8 $V_H$ |
| Approach | $V_{FE}$ - 10 | $V_{FE}$ - 10 kts | $V_Y$ + 10 kts | $V_Y$ + 10 kts |
| Landing | $V_{FE}$ - 10 | $V_{FE}$ - 10 kts | N/A | N/A |

4.3.2.6 Position Accuracy ***[CS-ACNS doesn't require a flight test]*** .

Using a known waypoint, fly a north/south course that crosses the defined waypoint followed by an east/west course that crosses the same defined waypoint.

ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets.

4.3.3 Post-Flight Data Analysis ***[CS-ACNS doesn't require a flight test]*** .
You must accomplish a post-flight data analysis to ensure the aircraft is transmitting accurate ADS-B information. Ensure all data associated with the track is consistent, such as position, 24-bit address, velocity, flight ID, barometric altitude, Mode 3/A code, emitter category, and geometric altitude. The post-flight data analysis should also reveal if there were any unexpected data dropouts that might be caused by intermittent wiring interfaces or interface incompatibility. The flight test does not require the use of a truth source to accomplish post-flight data analysis; however, the FAA will provide radar data when available to help analyze the flight track. At a minimum, analyze the following areas:

4.3.3.1 Rule Compliance ***[CS-ACNS doesn't require a flight test]*** .
Review the data from the FAA ground system for the flight to ensure the installed system meets its stated accuracy and integrity performance under flight conditions. We recommend that you accomplish a GNSS performance prediction for the applicable time of your test and ensure the ADS-B system meets the predicted performance. Due to the design of existing GNSS receivers and typical GPS constellation configurations, there will be time periods when unaugmented GNSS solutions drop below the NIC and NACP performance required by the rule. Such outages usually do not occur for more than 20 minutes, and many are of much shorter durations. If the integrity and accuracy of an existing GNSS installation does not meet the rule requirements during the test flight, the applicant should show that poor performance was caused by the constellation during the period of time that the flight occurred. If that cannot be established as the cause of the poor performance, there may be a problem with the position sensor installation that needs to be investigated and resolved. Resolution of this type of issue will probably require the involvement of the position source manufacturer. There may also be short periods where position messages transmit NIC = 0, velocity messages transmit NACV = 0, and status messages transmit NACP = 0, SIL = 0. These can be caused by antenna shadowing and switching effects, and do not indicate an installation problem if they are infrequent and of short duration. All such outages must be less than 5 seconds in duration to avoid operational impacts. This condition may not occur more often than once every 1000 position transmissions when averaging all outages over the flight duration. If this condition occurs more often during the flight test, the applicant must establish root cause and provide a solution before granting installation approval. Demonstrate that you meet all
§ 91.227(c)(1) accuracy and integrity requirements, listed in Table 8, during flight.

**Table 8. Accuracy and Integrity Requirements During Flight**

| | |
|---|---|
| Ensure NIC ≥ 7 throughout the flight. | Rc <370.4 m (0.2 nm) |
| Ensure $NAC_P$ ≥ 8 throughout the flight. | EPU <92.6 m (0.05 nm) |
| Ensure $NAC_V$ ≥ 1 throughout the flight. | < 10 m/s |
| Ensure SIL = 3 throughout the flight | $\leq 1x10^{-7}$ |
| Ensure SDA ≥ 2 throughout the flight | $\leq 1x10^{-5}$ |

4.3.3.2 Position Accuracy/Integrity ***[CS-ACNS doesn't require a flight test]*** .
Compare the track received by the FAA ground system with the actual flight track. There is no specific tolerance for this test; rather, the applicant must show there are no gross position errors, track offsets or discontinuities, or other obvious anomalies.

4.3.3.4 Velocity Accuracy ***[CS-ACNS doesn't require a flight test]*** .
Compare the velocity received by the FAA ADS-B ground system with the actual velocities flown. There is no specific tolerance for this test; rather, you must show that they compare reasonably, and that there are no gross velocity errors.

4.3.3.4 Geometric Altitude Accuracy ***[CS-ACNS doesn't require a flight test]*** .
Compare the geometric altitude received by the FAA ground system with the geometric altitude flown. There is no specific tolerance for this test; rather, you must show that they compare reasonably, and that there are no gross geometric altitude errors.

4.3.3.5 Barometric Pressure Altitude Accuracy ***[CS-ACNS doesn't require a flight test]*** .
Compare the barometric pressure altitude received by the FAA ground system with the actual barometric pressure altitude flown. There is no specific tolerance for this test; rather, you must show that they compare reasonably, and that there are no gross barometric pressure altitude errors.

ADS-B Out Guidance Comp: Includes a comparison of EASA CS-ACNS (incl. BOOK1/BOOK 2 – Subpart D – Section 4, Appendix H (Part 1-6), and Appendix I) and AC 20-165B (incl. Appendix A-D)/ § 91.227. Guidance/requirements in green are the same or consistent, guidance/requirements in black are additional info. that does not conflict, but is not specified in the other guidance document/regulation, and guidance/requirements in red are different guidance or requirements. Clarification has been provided in brackets.

| | |
|---|---|
| | 4.3.3.6 Validity Checks ***[CS-ACNS doesn't require a flight test]*** .<br>The FAA plans to use radar, multilateration, and UAT passive ranging as independent validity checks for ADS-B. The validity check will indicate "valid" when the independent check is able to validate the ADS-B position, "invalid" when it determines the ADS-B position is out of tolerance, and "unknown" if it is unable to accomplish the validity check. If a validity or enhanced validity status is provided in the flight test data, you must show that it never indicates "invalid".<br>Note: Validity checks are planned to ensure the ADS-B position is within 0.56 nm in terminal airspace and 1.9 nm in en-route airspace. Enhanced validity checks are planned to ensure the ADS-B position is within 0.2 nm within approximately 15 nm of terminal radars and close proximity to airports with Airport Surface Detection Equipment, Model X (ASDE-X) systems. |
| | 4.4 International Flight Test Options ***[CS-ACNS doesn't require a flight test]*** .<br>If the aircraft is being flight tested outside of the United States, it is acceptable to perform the flight test against another Air Navigation Service Provider's (ANSP) ground system. Other ANSP's ground systems must be fully operational and appropriately qualified to provide ATC separation services. Other ANSP ground systems must also be able to provide all parameters required by § 91.227. You will have to work with the foreign ANSP to retrieve the necessary data. |
| | 4.5 Subsequent Flight Test Data Reuse ***[CS-ACNS doesn't require a flight test]*** .<br>The flight test guidelines in section 4.3 of this AC apply to initial TC/STC applications. Flight test data from a similar installation, covered under a previous TC/STC, may be used instead of a new flight test if the following conditions can be confirmed through the documentation of the previous STC: |
| | 4.5.1 Position Source Equipment ***[CS-ACNS doesn't require a flight test]*** .<br>The position source must be identical to that of the other Amended Type Certificate (ATC), TC, or STC documentation. Equipment families that use the same baseline design may make a case for equivalence. |
| | 4.5.2 ADS-B Equipment ***[CS-ACNS doesn't require a flight test]*** .<br>The ADS-B equipment must be identical to that of the other ATC/TC/STC documentation. Equipment families that use the same baseline design may make a case for equivalence. |
| | 4.5.3 System Interface ***[CS-ACNS doesn't require a flight test]*** .<br>A direct interface must be used between the position source and the ADS-B equipment, and that interface must be identical to that of the previous ATC/TC/STC. Aircraft with data concentrators will have to re-accomplish the flight test, even if the equipment is identical. |
| | 4.5.4 Air-Data Interface ***[CS-ACNS doesn't require a flight test]*** .<br>The air-data interface to the ADS-B equipment must be identical to that of the previous ATC/TC/STC. The actual air-data source may be different equipment; only the interface to the ADS-B equipment needs to be identical. However, if the air-data source is different, more extensive ground testing should be accomplished, to include a dynamic test where the air-data source has simulated inputs from sea level to the maximum certified operating altitude of the aircraft. Care should be taken to ensure broadcast of simulated altitude information does not cause interference with ATC or ADS-B IN applications. |
| | 4.5.5 Heading Interface ***[CS-ACNS doesn't require a flight test]*** .<br>The heading interface to the ADS-B equipment (if applicable) must be identical to that of the previous ATC/TC/STC. The heading source may be different; only the interface to the ADS-B equipment needs to be identical. If the heading source is different, testing should be accomplished, to include positioning the aircraft at multiple headings on the surface to verify heading accuracy. |
| | 4.5.6 TCAS Interface ***[CS-ACNS doesn't require a flight test]*** .<br>The TCAS interface to the ADS-B equipment must be identical to that of the previous ATC/TC/STC. The TCAS equipment may be different; only the interface to the ADS-B equipment needs to be identical. |