U.S.Department
of Transportation
Federal Aviation
Administration

Policy Statement

Subject: Installation Guidance for Approved Inertial Navigation Systems	**Date:** (mm/dd/yy) **Initiated By:** AIR-626B	Policy No: PS-20-INS-DRAFT

1 SUMMARY

This policy statement establishes the Federal Aviation Administration (FAA) installation guidance for approved Inertial Navigation Systems.

2 CURRENT REGULATORY AND ADVISORY MATERIAL

- Title 14 Code of Federal Regulations (14 CFR) part 121 Appendix G.
- Advisory Circular 20-138D, Change 2, *Airworthiness Approval of Positioning and Navigation Systems*.
- Advisory Circular 20-181, *Airworthiness Approval of Attitude Heading Reference System (AHRS) Equipment*.
- Technical Standard Order TSO-C201, *Attitude and Heading Reference System (AHRS)*.
- Technical Standard Order TSO-C206, *Circuit Card Assembly Functional Sensors using Aircraft-Based Augmentation for Navigation and Non-Navigation Position/Velocity/Time Output*.
- Technical Standard Order TSO-C220*, GNSS-Aided Inertial System*.

3 RELEVANT PAST PRACTICE

3.1 Advisory Circular (AC) 20-138D, *Airworthiness Approval of Positioning and Navigation Systems* addresses the following avionics: Global positioning system (GPS) equipment including those using GPS augmentations, area navigation (RNAV) equipment integrating data from multiple navigation sensors, Required Navigation Performance (RNP) equipment intended for RNP operations and (barometric vertical navigation) baro-VNAV capabilities.

3.2 *Advisory Circular (AC) 20-181, Airworthiness Approval of Attitude Heading Reference System (AHRS) Equipment* supplements existing airworthiness approval guidance for

attitude heading reference system (AHRS) articles approved under technical standard order (TSO)-C201, *Attitude Heading Reference System* (AHRS), or later revisions.

3.3 *TSO-C201, Attitude and Heading Reference System (AHRS)* includes performance standards for non-gimbaled attitude, heading, and turn and slip systems.

3.4 *TSO-C206, Circuit Card Assembly Functional Sensors using Aircraft-Based Augmentation for Navigation and Non-Navigation Position/Velocity/Time Output* includes performance standards for GPS circuit card assembly (CCA) functional sensor equipment. TSO-C206 is intended as a means for end-use equipment manufacturers incorporating the GPS CCA to streamline their TSO-C196b application for a GPS position/velocity/time (PVT) sensor by using the TSO'd GPS CCA for partial certification credit.

3.5 *TSO-C220, GNSS-Aided Inertial System,* includes performance standards for (Global Navigation Satellite System) GNSS-aided inertial systems. Some GNSS-aided inertial systems have approval under TSO-C201, Attitude and Heading Reference Systems (AHRS), with the navigation capability of the product incorporated as a non-TSO function (e.g., the position outputs of the GNSS-aided inertial system making up the AHRS).

4 POLICY

4.1 This policy statement provides additional guidance and supersedes the guidance in AC 20-138D, Change 2 and AC 20-181 relating to the installation of approved inertial navigation systems. This policy statement provides relief from the current FAA acceptable means of compliance requiring an aircraft's approved inertial navigation system to show compliance with 14 CFR part 121 Appendix G.

4.2 TSO-C201 requirements for AHRS attitude function remain valid and are a prerequisite for GNSS-aided inertial systems incorporating multiple required functions. However, the FAA will no longer accept any new applications for TSO-C201 seeking additional approval of the AHRS aircraft position output as a non-TSO function.

4.3 In contrast, airworthiness applicants seeking to gain acceptance of the aircraft navigation capabilities (e.g., aircraft position outputs) of GNSS-aided inertial systems should use TSO-C220. Also, airworthiness applicants should also install a GNSS-aided inertial system approved to TSO-C220 in accordance with the means of compliance in this policy statement or a later version of AC 20-138D, Change 2.

4.4 Some FAA-approved GNSS-aided inertial systems used RTCA/DO-229() or RTCA/DO-316(), Appendix R, to meet the requirements and test procedures for installation of an integrated GNSS-aided inertial system. However, in accordance with TSO-C220, the FAA has stopped accepting any new applications using these criteria after June 22, 2024.

Note: Minor changes to existing, approved GNSS-aided inertial systems (e.g., updates to the magnetic variation database or software modifications for anomaly resolution) may continue to use the means of compliance established by the initial design approval.

4.5 In addition to the applicable guidance in AC 20-138D, Change 2, the following guidance supports an airworthiness applicant's use of TSO-C220 when seeking design and production approval for a GNSS-aided inertial system:

Insert the following as a new paragraph 3-6 to AC 20-138D, change 2, and move the existing paragraph *3.6 Multiple TSO Authorizations* and renumber the paragraph to *3-7 Multiple TSO Authorizations*

3-6. TSO-C220.

a. TSO-C220, *GNSS-Aided Inertial Systems* defines RTCA/DO-384 as an acceptable standard for obtaining design and production approval for GNSS-aided inertial systems. The GNSS-aided inertial system manufacturers define their equipment's intended function and performance when applying for a TSO authorization (TSOA). RTCA/DO-384 assumes the manufacturer's GNSS-aided inertial system relies on a GNSS receiver meeting the requirements of TSO-C196(), TSO-C145() or TSO-C146(). RTCA/DO-384 also assumes a GNSS-aided inertial system relies on external navigation performance monitor and alerting functions (e.g., RNP systems compliant with RTCA/DO-236() and RNP equipment compliant with TSO-C115()).

(1) The GNSS-aided inertial system, whose performance is classified by Equipment Category (A, B, or C) in RTCA/DO-384, can help derive the aircraft position estimation when GNSS is lost for any reason. TSO-C220 requires GNSS-aided inertial systems manufacturers to demonstrate performance claims on the following RTCA/DO-384 subcategories:

i. Subcategory 0 Horizontal Figure Of Merit (HFOM): A subcategory 0 GNSS-aided inertial system integration cannot support RNP performance monitoring and alerting after loss of GNSS. However, the subcategory 0 GNSS-aided inertial system may support RNAV operations' 95 % accuracy performance requirements per the GNSS-aided inertial system manufacturer's claims.

ii. Subcategory 1 (HFOM & Horizontal Protection Level (HPL)) and subcategory 2 (HFOM, HPL and Horizontal Exclusion Level (HEL)): Subcategory 1 and 2 GNSS-aided inertial system integration may support RNP performance monitoring and alerting. The manufacturer's performance claims for a subcategory 1 or 2 GNSS-aided inertial system integration may provide HPL integrity at either a 1×10^{-5} or 1×10^{-7} per hour, as required by the RNP approval sought.

b. Aircraft integration of a GNSS-aided inertial system with a TSOA requires level B design assurance levels to support RNP AR aircraft eligibility for use of RNP less than RNP 0.30 (RNP<0.30) during an RNP AR Approach (APCH) or less than RNP

1.0 (RNP<1.0) during the RNP AR missed approach procedure (reference AC 20-138D, change 2, Appendix 2).

c. Manufacturers may combine TSO-C220 with TSO-C206 for a circuit card assembly (CCA) design as a means to incorporate a GNSS-aided inertial system on a CCA. This combination can streamline an RNP equipment manufacturer's TSO-C115 application should the manufacturer use TSOA-C206 for partial certification credit.

---------- end of changes

Replace AC 20-138D, change 2, paragraph 6-6. *INS/IRU* and 6-7. *INS/IRU – GNSS Integration* with the following:

6-6. Approved Inertial Navigation Systems.

a. An approved inertial navigation system is an acceptable means for an aircraft's lateral positioning during flight under IFR. This is possible when the installed system either meets the requirements described in 14 CFR Appendix G to part 121 while in an inertial navigation mode or when the approved inertial navigation system manufacturer holds a TSOA in accordance with TSO-C220 (see paragraph 6-7 of this AC).

b. Applicants seeking approval of an inertial navigation system providing aircraft position output shall identify their equipment as an "approved inertial navigation system" when showing compliance with 14 CFR Appendix G to part 121 while in an inertial navigation mode or when seeking TSOA through TSO-C220 (see paragraph 6-7 of this AC).

Note: Paragraph 6-6 applies to both "stand-alone" inertial navigation systems and inertial navigation systems supporting multi-sensor navigation under IFR.

c. When an aircraft installation uses a unique acronym to describe the capabilities of an installed, approved inertial navigation system (e.g., INS, IRU, Air Data Inertial Reference Units (ADIRU), etc.), then the aircraft flight manual (AFM) or its supplement (AFM(S)) shall include a direct statement of compliance identifying the system as an "approved inertial navigation system", along with the means of compliance.

d. An AHRS is not acceptable as an approved inertial navigation system for operational use under IFR.

6-7. INS – GNSS Integration.

a. The guidance in paragraph 6-7 applies to integration of a GNSS-aided inertial system in an aircraft.

b. Applicants seeking installation approval of a new GNSS-aided inertial system as an "approved inertial navigation system" shall meet the minimum performance requirements in RTCA/DO-384 and should acquire a TSOA in accordance with TSO-C220.

c. Applicants seeking aircraft installation approval of a GNSS-aided inertial system may integrate a system compliant with RTCA/DO-384 Category A, B, or C, with RNP

equipment or other aircraft-level performance monitoring and alerting solutions. This is essential for operational use of an approved inertial navigation system under IFR. When the installed, demonstrated performance of a GNSS-aided inertial system validates the equipment manufacturer's performance claims (reference RTCA/DO-384, Appendix P) then the system may serve as an approved inertial navigation system and can support RNAV or RNP instrument routes or procedures.

(1) Previous airworthiness approvals of GNSS-aided inertial systems installed and serving as approved inertial navigation systems which met the requirements of RTCA/DO-229() or RTCA DO-316(), Appendix R, remain valid. New installations of this equipment with new airworthiness applications may use this policy statement. However, these new installations should characterize the performance of the system, e.g., accuracy and integrity of the aircraft position, in accordance with RTCA/DO-384 test methods.

(2) Once the aircraft installation of an existing GNSS-aided inertial system demonstrates inertial system performance consistent with the equipment manufacturer's claim tables (see RTCA/DO-384, Appendix P), the applicant may document the equipment's inertial performance as an "approved inertial navigation system." The applicant should document the operations under IFR the equipment supports, and how the equipment provides that support, (e.g., "inertial coasting" for safe extraction from an RNP APCH, RNP AR APCH or any other instrument approach operation requiring use of RNP or RNAV to perform the missed approach procedure).

The applicant must ensure the installation of Category A, B, or C GNSS-aided inertial equipment (and associated subcategory as defined in RTCA/DO-384, section 1.3) is consistent with and supports the alerting algorithms for the aircraft, e.g., RNP alerting.

Note: RTCA/DO-236D, Appendix C.2.3.3 provides further guidance in associating an equipment category and subcategory with performance monitoring and alerting functions.

d. US RNP AR APCH aircraft eligibility requires carriage of an approved inertial navigation system integrated with the aircraft's RNP system. For an approved inertial navigation system to be eligible for RNP AR APCH operations, the aircraft manufacturer or type certificate or supplemental type certificate (TC/STC) holder must demonstrate the ability of the installed, approved inertial navigation system to support a safe extraction from the RNP AR APCH operation. The FAA considers the safe extraction to occur during a contingency scenario where GNSS is lost (for any reason) after the flight crew begins an RNP AR APCH. Since the FAA also considers the loss of GNSS unlikely after a flight crew begins an RNP AR APCH, the navigation performance of the aircraft's approved inertial navigation system must meet the following contingency probabilities:

(1) The aircraft's lateral positioning performance when using the approved inertial navigation system must show the conditional probability the aircraft may exit the lateral obstacle clearance volume is less than 0.001, i.e., less than one in a thousand. The aircraft must meet this performance assuming the aircraft loses GNSS anywhere along the procedure-defined path up to the procedure's decision altitude (DA). The aircraft manufacturer or TC/STC holder may assume the flight crew immediately

abandons the approach, stops descending, respects speed restrictions, and continues to follow the procedural path to the missed approach point and then flies the missed approach upon loss of GNSS. This helps ensure that 999 times out of 1,000 the flight crew can safely follow the aircraft's lateral navigation guidance based on the approved inertial navigation system. This contingency probability requirement assumes a prudent flight crew that stops descending upon loss of GNSS will also contact ATC as soon as practical.

(2) To support safe extraction from an RNP AR APCH along the RNP AR APCH missed approach procedure path, the aircraft must demonstrate navigation performance showing the conditional probability the aircraft exits the missed approach procedure's obstacle clearance volume is less than 0.01; e.g., less than one in a hundred. This ensures that 99 times out of 100 the aircraft can complete the entirety of an RNP AR APCH missed approach procedure from the lowest DA following loss of GNSS through use of the approved inertial navigation system's lateral guidance up to the termination fix of the missed approach procedure. This contingency performance requirement assumes the flight crew will advise ATC they are "missed approach" as soon as practical and assumes they will conduct an expeditious climb in accordance with the missed approach procedure climb requirements or a higher climb rate.

Note 1: The FAA assumes executing a missed approach is unlikely given the weather conditions the flight crew requires to begin an RNP AR APCH procedure and the actual probability the weather conditions at the time of the operation are above the weather minima on the approach chart. Therefore, the conditional probability requirement for the RNP AR APCH missed approach procedure is less stringent than the performance requirement for the RNP AR APCH.

Note 2: The aircraft manufacturer or TC/STC holder may conduct the aircraft's contingency performance demonstration through laboratory and simulation analysis. This need not be a new flight test data collection effort when the aircraft includes an installed, approved inertial navigation system where the aircraft demonstrated a multi-sensor performance-based navigation (PBN) capability as part of existing airworthiness approval. The aircraft manufacturer's or TC/STC holders' analysis should use the approved inertial navigation system manufacturer's performance claims as part of the analysis.

Note 3: If the aircraft manufacturer or TC/STC holder installs an approved inertial navigation system in an aircraft for the first time to support safe extraction an RNP AR APCH, then the manufacturer should validate the approved inertial navigation system's installed performance. This validation can include laboratory and simulation analysis supported by sufficient inertial-only navigation performance data collection in the aircraft to have confidence in the approved inertial navigation system manufacturer's performance claims and ensure compliance with the contingency probability performance requirements of RNP AR APCH aircraft eligibility.

e. The aircraft manufacturer or TC/STC holder should apply the contingency probabilities in paragraph 6-7. d. to support safe extraction from an RNP APCH or another instrument approach requiring use of RNP or RNAV to perform the missed approach procedure.

Note: Many of the United States Instrument Landing System (ILS) approach procedures require RNAV performance in the missed approach procedure. This criterion can support safe extraction from these procedures.

Note: These contingency probabilities can also support a safe extraction from an RNP APCH using Advanced RNP to define a 2×RNP lateral obstacle evaluation area.

f. GNSS-aided inertial systems outputting PVT may demonstrate equivalence to either TSO-C145e, TSO-C146e, or TSO-C196b and receive a GNSS TSOA/LODA. The TSO approval process shall identify and resolve any discrepancies and RTCA/DO-384 will take precedence during the process.

(1) Applicants requesting a TSO-145e, TSO-C146e, or TSO-C196b TSOA/LODA for their GNSS aided inertial system will need to include part number differentiation and installation instructions limiting integration to GNSS sensors approved to the same TSO.

Note: The GNSS sensor integration in a specific aircraft may require additional interface requirements beyond those the applicable TSO requires.

g. All attitude and heading data output by the GNSS-aided inertial system must comply with the relevant regulations under all foreseeable operating conditions. This includes during GPS signal-in-space failures (including prior to detection and after exclusion) and SBAS signal-in-space failures when the GNSS sensor is an SBAS sensor.

(1) In the absence of any GNSS input, the attitude and heading data output by the GNSS-aided inertial system integrated in the aircraft must comply with the relevant regulations, including those conditions identified in the aircraft functional hazard assessment (FHA).

Note: An applicant may need to revise the FHA to address failure conditions unique to the GNSS-aided inertial system integration.

(2) The applicant's FHA must ensure that incorrect or misleading GNSS data does not affect attitude and heading reference data.

(3) The GNSS-inertial system architecture and its installation must segregate flight critical data/functions from less critical functions.

---------- end of revised paragraphs 6-6 and 6-7

Replace AC 20-138D, Change 2, Appendix 2, paragraph A2-3.b.(2) *IRS* with the following:

Appendix 2. RNP AR Operations.

A2-3. RNP AR General Requirements.

b. Position Estimation.

(2) Approved Inertial Navigation System.

An approved inertial navigation system supporting RNP AR operations must satisfy the criteria of either 14 CFR Appendix G to part 121 or TSO-C220 (see paragraph 6-7 of this AC). While 14 CFR Appendix G to part 121 defines a requirement for a 2 NM per hour drift rate (95%) for flights up to 10 hours in remote oceanic airspace, this performance requirement does not apply to an RNP system after loss of GNSS position updating. Applicants may assume an approved inertial navigation system demonstrating compliance with 14 CFR Appendix G to part 121 experiences an initial drift rate of 4 NM for the first 30 minutes (95%) without further substantiation. However, aircraft manufacturers and applicants can choose to demonstrate better short-term inertial navigation performance in support of RNP AR operations.

In contrast to an approved inertial navigation system demonstrating compliance to 14 CFR Appendix G to part 121, an aircraft may instead take advantage of an approved inertial navigation system demonstrating compliance to the standards in RTCA/DO-384 for GNSS-aided inertial navigation systems. These systems compliant with TSO-C220 can support safe extraction from RNP AR operations after loss of GNSS position updating and need not show compliance to 14 CFR Appendix G to part 121.

---------- end of revised paragraph A2-3.b.(2)

5 EFFECT OF POLICY

5.1 The contents of this policy statement do not have the force and effect of law and are not meant to bind the public in any way. This policy statement is intended only to provide clarity to the public regarding existing requirements under the law or agency policies.

5.2 This policy statement does not constitute a new regulation. Agency employees and their designees and delegations should not depart from this policy statement without the concurrence of the policy issuing office. The authority for FAA employees and designees to deviate from this policy is delegated to the Director of the Policy and Innovation Division.

5.3 Additional information on the effect of FAA policy statements may be found in FAA Order IR 8100.16, *Aircraft Certification Service Policy Statement, Policy Memorandum, and Deviation Memorandum Systems* (May 13, 2011).

6 CONCLUSION

The FAA has concluded that this policy statement provides relief from current FAA acceptable means of compliance requiring an aircraft's approved inertial navigation system to show compliance with 14 CFR Appendix G to part 121, and supersedes the guidance in 20-138D, Change 2 and AC 20-181 relating to the installation of approved inertial navigation systems.

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