Clearance Record
DOCUMENT COMMENT LOG

Originating Office:	Document Description:	Project Lead:	Reviewing Office:	Date of Review:
AIR-130	**AC 20-138C Consolidated Public Comments**	Kevin Bridges		

Person and/or Company	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
Boeing	Pg 15, Para 4-2.c(2), Note 2.	Note 2 states: Baro-VNAV is subject to temperature and pressure altitude (i.e., correct altimeter setting) performance limitations that could potentially cause advisory vertical path guidance to fall below step-down fixes on LNAV approaches. While we recognize that note 2 is unchanged from the previous version of this AC, we request further clarification of the step-down fixes for baro-VNAV.	If the vertically guided path is biased down by temperature, then the step-down altitudes will be as well, such that the path will not be below the step altitudes. Additionally, the procedure design requirements for altitudes do consider temperature, and for VNAV, would preclude use of VNAV in the instance where obstacle clearance will not be assured.	Clarify Note 2.	**Partially Accepted.** The point is that baro-VNAV has anomalies. This note is intended to amplify the point that on an LNAV approach the crew cannot rely solely on advisory vertical guidance because there is no guaranteed, TERPS-protected glidepath associated with the approach. The procedure developers will strive to create step-down fixes that won't be problematic for advisory vertical guidance provided by baro-VNAV equipment, but there is no guarantee that will always be the case. It is not necessary in the note to detail all the possible reasons a baro-

Person and/or Company	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
					VNAV system might provide guidance below a step-down fix. The note is changed as follows: Note 2: *Baro-VNAV is subject to performance limitations that could...*
Boeing	Appendix 8, Pg A8-1	Appendix 8 contains a list of FAA Advisory Circulars related to the proposed AC subject. AC 20-174, *Development of Civil Aircraft and Systems*, is related to the proposed AC but is not listed as a reference in this appendix.	AC 20-174 is mentioned in appendix 2 of the proposed AC and, thus, adding to the related AC list would be appropriate.	We recommend adding AC 20-174 to the list in appendix 8.	**Accepted.**
Alessandro Gonçalves Adinolfi (Brazilian Civil Aviation Authority – ANAC)	Appendix 2, item A2-5b. (page A2-14)	The note added the possibility of using the AC 20-174 for demonstrating compliance for hazardous failure condition with DAL C independent systems, but apparently removed the possibility to use operational mitigation, as in the same Note in the AC 20-138B. Please clarify if			**Not Accepted.** AC 20-174 does not preclude operational mitigations. AC 20-138C is deferring to the guidance in AC 20-174 and the current note is more broad-based than specifying "operational mitigations." The note says: "...taking into account the overall aircraft

Person and/or Company	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
		there was an intent to remove this possibility			operating environment and the independent functions of the aircraft's systems..." This statement says to account for the "operational environment" which includes operational mitigations.
Alessandro Gonçalves Adinolfi (Brazilian Civil Aviation Authority – ANAC)	Appendix 2, item A2-6	There is no consideration about the criticality of misleading, as it is done in the item A2-5. Why do not consider hazardous failure condition for lateral or vertical guidance misleading also during missed approach with RNP less than 1.0 NM?			**Not Accepted.** The rationale on why an RNP < 1.0 missed approach does not include a failure condition for misleading information is as follows: During the missed approach phase the flight crew is already climbing at the best rate of climb to the missed approach altitude(s), which reduces the exposure to a potential hazard at each moment the aircraft continues to climb. That is, the "hazard(s)" is/are rapidly diminishing, unlike during the approach where the aircraft is continuously approaching

Person and/or Company	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
					the potential hazard(s). Additionally, we already impose the requirement on the approach side such that there must the ability to transition to an alternate means of navigation should there be a loss of GNSS, & the design assurance must be consistent with a hazardous failure condition. Thus, the likelihood misleading guidance could occur during the missed approach after none was experienced in the approach phase diminishes the design assurance requirement for the missed approach phase. Finally, since there's no vertical guidance in the missed approach procedure, there's no vertical design assurance requirement. In this phase, the only vertical performance requirement is

Person and/or Company	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
					the climb gradient required for the missed approach itself.
Alessandro Gonçalves Adinolfi (Brazilian Civil Aviation Authority – ANAC)	Appendix 2, item A2-7	It is very important to check the accuracy of the data inside the database, but I'm also concerned about the risks during the database loading processes, specially when the operation will use functions with hazardous failures conditions (at a moment we have LPV and RNP AR). I think there is the need of a more robust process to assure the correct database has been loaded.			**Not Accepted.** This comment is addressed in the RNP AR operational approval rather than an airworthiness approval. The operational approval for RNP AR includes pilot training requirements on procedures to verify the FMC database and approach procedures are current and contain the required data (see described in AC 90-101A, appendix 5)
Cessna	General			Cessna recommends that the parts of LNAV/VNAV and RNP references found in AC120-29A (CAT I/II) be incorporated into this AC.	**Not Accepted.** The information in AC 120-29A is focused on aircraft operators which is not the focus of AC 20-138C. Additionally, some of the information on RNP in AC 120-29A is obsolete and incorrect. AC 120-29A is

Person and/or Company	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
					currently being updated and will remove the RNP information in favor of referencing the current revisions of ACs 90-105 and 90-101 for information on RNP operational aspects. As stated in AC 20-138C, operational information on RNP is available in ACs 90-101A and 90-105. Though duplicated now, the airworthiness information in the 90-series RNP documents will be deleted at the next revision.
Cessna	General			Assure statement of NAV system accuracy to accepted standards are included.	**Not Accepted.** It is unclear where or what the recommendation specifically applies to. From what is stated, it seems to infer a statement of compliance normally submitted as part of a certification effort (i.e., an applicant's statement of compliance). Guidance

Person and/or Company	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
					information on certification processes is contained in ACs describing Type Certificate and TSO procedures.
Cessna	General			Assure statements of FTE (Raw Data, FD and AP) to accepted standards are included.	**Not Accepted.** It is unclear where or what the recommendation specifically applies to. From what is stated, it seems to infer a statement of compliance normally submitted as part of a certification effort (i.e., an applicant's statement of compliance). Guidance information on certification processes is contained in ACs describing Type Certificate and TSO procedures.
Cessna	General			Assure statements of altimetry systems/ADCs compliance for RNP AR VTSE analysis are included.	**Not Accepted.** It is unclear where or what the recommendation specifically applies to. From what is stated, it seems to infer a statement of compliance normally

Person and/or Company	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
					submitted as part of a certification effort (i.e., an applicant's statement of compliance). Guidance information on certification processes is contained in ACs describing Type Certificate and TSO procedures.
Cessna	Pg 1	This AC does not address new satellite constellations that are planned or currently under construction. This AC will be updated when sufficient documentation is available from the GNSS provider countries and RTCA to support service definition, service performance commitments, and minimum operational performance standards for multiconstellation equipment. It is unclear if the reference includes international SBAS systems.		Cessna requests clarification. Is this paragraph referencing international SBAS systems such as EGNOS, GAGAN, etc.?	**Not Accepted.** EGNOS and GAGAN are not satellite constellations. As noted, EGNOS and GAGAN are SBAS systems. SBAS is designed for international interoperability among SBAS systems. Therefore, AC 20-138C does address EGNOS, GAGAN, and MSAS in its SBAS sections since SBAS avionics are compatible with any SBAS system.

Person and/or Company	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
Cessna	Pg 3: a.	Cessna suggests that the requirement was clear when first presented by both the FAA, and then by EASA in their CRIs. Meaning that a mode 5 alert was needed for descent below glide path. Since then, it seems the FAA is missing a potentially life-saving, minor change in systems architecture.		Cessna suggests that for the long term, i.e. the introduction of SBAS, LAAS and lower RNP AR approaches, that the use of GPWS monitoring of vertical deviation should be done for safety's sake (as was done in the past).	**Partially Accepted.** The purpose of the answer to the frequently asked question is to indicate that GPWS or Class A TAWS Mode 5 alerting is not the only means to provide the function. That method is certainly acceptable, but it is not the FAA's intent to cause the added expense of replacing or modifying the GPWS or TAWS just to add LPV or GLS capability, particularly if it is impractical. Other methods are acceptable. This intent is further amplified in paragraphs 14-6.8 and 14-8.13. The FAA is considering an additional recommendation to include the glideslope warning function during baro LNAV/VNAV or RNP AR approaches as well. Additionally, language has been added to section 17

Person and/or Company	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
					for baro-VNAV and paragraph A2-1 for RNP AR for applicants to consider implementing a glidepath warning function but, that GPWS/TAWS Mode 5 alerting isn't the only acceptable method. The AC publication will be delayed to give the public a chance to comment on the new language. The following sentence was added to the end of paragraph 1-4.a(2): *Using the GPWS or TAWS Mode 5 alerting to provide the function is certainly acceptable, but is not required as the only acceptable method.*
Cessna	Pg 10, Para 3-4.a	Cessna notes that the FAA is using multiple methods of identifying C115 that are not found in publications directories. TSO C115c is currently not on the FAA		Cessna requests clarification, for example, what C115(AR) is referring to.	**Not Accepted.** TSO-C115c is posted on the FAA website. The paragraph uses the specific TSO revision when needed to provide guidance

Person and/or Company	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
		TSO web site – should it be referenced here?			relative to a specific revision. The (AR) acronym is used when the guidance applies to "all revisions" and is listed in the acronym appendix. This convention is used throughout the document for all TSOs.
Cessna	Pgs 113-114: 21-2 Flight Test.	1) Cessna suggests that there could be better distinction in (d) between an INS with DME updating and an IRS used as a navigation sensor for a Flight Management System. 2) Also, Cessna requests a better definition on applying the Schuler effect immediately after alignment, as opposed to applying the effect, in the case of an FMS system, at time of using the IRS as the sole nav sensor. (Table 10)	1) In the one case you have the INS NAV position, and in the other, the FMS position based on an IRS input. 2) Applying 8 kts as shown, assures that most airplanes will not be able to operate in RNP 4 airspace for more than 30 minutes on IRS.	For 2): Cessna recommends 2 kts for an IRS (Table 10).	**Not Accepted.** Table 10 is not changed because paragraph 21-2.d already contains the following sentence that provides applicants with guidance if they desire credit for better performance: "*Applicants that desire certification credit for better performance should coordinate with their ACO for the requirements to demonstrate and document the performance.*" Additionally, it is not necessary to incorporate guidance on the Schuler effect in the AC since

Person and/or Company	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
					vendors of inertial equipment are already cognizant of the Schuler effect and its implications. There is no suggested change, and it is unclear why additional material is needed, to make a distinction between INS with DME updating and an IRS used as a nav sensor for an FMS. The inertial vendors and airframe manufacturers integrating the equipment demonstrate the performance for credit during certification testing.
Cessna	Appendix 4	Regarding ADS-B on wing testing with commonly used ramp test equipment. Cessna suggests guidance in this AC should be used to verify the installation meets xx.1301(a)(d) before flight testing (or for ICAW conditions).	Installers, apart from the TSO holder and their first Part XX certification, are not so interested in how the MOPS calculations are derived or how they are applied (let the TSO holder put that data in their certification plan).	Cessna requests that the math be put in the MOPS (minimal operational performance specifications).	**Not Accepted.** There are several different TSOs for GNSS equipment and each has different capabilities defined by the MOPS requirements with regard to supporting ADS-B. Appendix 4 provides GNSS manufacturers the information needed to qualify GNSS systems for the specific ADS-B

Person and/or Company	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
					functions described. This is necessary because some equipment was built to TSO/MOPS standards that are no longer in force (such as TSO-C129/DO-208 or TSO-C145a/DO-229C) but the equipment is still produced and is still eligible for installation. Placing the material in appendix 4 provides the centralized location for the tests needed for manufacturers to qualify the older equipment's outputs as acceptable for ADS-B; and, allows the older equipment to remain in service.
Cessna	Pg 64, Note 1	Cessna suggests stating that when an aircraft is qualified for RVSM, that qualification indicates that the aircraft meets the ASE (altimetry system error) requirement and can use the numbers in Table 6 for its VTSE			**Partially Accepted.** The RVSM qualification for ASE only applies to the FL 290-FL 410 block in table 6 because that is the only block where RVSM is demonstrated. That is, the data cannot be extrapolated to other altitude blocks.

Person and/or Company	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
		(vertical total system error) analysis.			The applicant will need other data verifying ASE for the lower altitude blocks. Note 1 adds the following clarification to the existing sentence: Aircraft meeting reduced vertical separation minimums (RVSM) requirements may apply the altimetry system error data developed during the RVSM qualification toward the vertical total system error for the above 29,000 ft to 41,000 ft row in table 6. However, the altimetry system error cannot be extrapolated to the other altitude blocks.
CMC	Page 11 Para 3-4.b	Is the intent of Note 2 to state that not only are there no conflicts between DO-229D (TSO-C146c) Gamma class requirements and DO-283A (TSO-C115c) when using SBAS/GNSS but that C146c covers all DO-283A	During the development of DO-229D, the question of full compliance with DO-283A was raised and the FAA declined to provide any such statement. Par. 3-4.b(2) implies that compliance to DO-283A does not conflict with TSO-C146c;	Clarify the note to state whether C146c is sufficient to cover all DO-283A requirements when using GPS/SBAS-based inputs.	**Accepted.** The intent is that there is significant overlap among requirements in DO-229D and requirements in DO-283A so there is no need to repeat data substantiation. That is, where requirements overlap exists it is

Person and/or Company	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
		requirements?	completeness of TSO-C146c is not addressed.		acceptable to re-use compliance information from DO-229D to satisfy DO-283A compliance. Note 2 has been changed as follows: *There is significant overlap in requirements between TSO-C146c Class Gamma implementation of RTCA/DO-229D and TSO-C115c implementation of RTCA/DO-283A requirements. Where requirements overlap exists it is acceptable to re-use compliance information from RTCA/DO-229D as the method of demonstrating RTCA/DO-283A compliance.*
CMC	Page 11 Para 3-4.b(2)	Is TSO-C115c sufficient for SBAS LNAV/VNAV when combined with a GPS/SBAS TSO-C145c Beta-2 sensor?	Par. 3-4.b(2) clearly states that every navigation computer functions <u>other than</u> LP/LPV is covered under TSO-C115c. This implies that SBAS LNAV/VNAV is covered..	Clarify status of SBAS LNAV/VNAV functions with respect to TSO-C115c.	**Accepted.** DO-283A does not address approach VNAV and does not have approach VNAV requirements. Appendix H only discusses non-approach VNAV

Person and/or Company	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
					capability. The paragraph has been changed as shown below to clarify that C115c/DO-283A is for 2D RNP and VNAV approach functions require compliance to other standards. "TSO-C115c requires RTCA/DO-283A for 2-dimensional RNP navigation computer functions; that is, no VNAV approach capability. The baro-VNAV guidance in this AC must be used when including baro-VNAV for approach capability." The next paragraph discusses incomplete system TSO-C146c Class Gamma for SBAS-based VNAV by stating: "FMSs may qualify as TSO-C146c Class Gamma navigation computer

Person and/or Company	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
					systems when receiving inputs from a TSO-C145c Class Beta-2 or Class Beta-3 sensor. An incomplete system TSO-C146c Class Gamma approval (Gamma-2 or Gamma-3 as appropriate) can be added to the TSO-C115b (or later revision) approval, or replace the TSO-C129(AR) approval if one exists, to provide GPS/SBAS-based VNAV approach capability. Class Gamma-1 can be used for FMSs that don't intend to process GPS/SBAS vertical deviations."
CMC	Page 96 Para 15-2 (and others)	Paragraph 15-2 refers to 8-3.g(2) using a note. This occurs almost everywhere TO/FROM indications are mentioned. Is the intent of these notes to state that 8-3.g(2) supersedes all paragraphs that discuss TO/FROM indications for TO/TO navigation equipment?	A note is not a strong enough statement to override the need for a TO/FROM indication.	In 15-1 indicate clearly that paragraph 8-3.g(2) takes precedence for TO/TO navigation.	**Not Accepted.** Paragraph 15-2 (and others) clearly applies to TO/FROM navigation systems and displays. The note clearly directs readers to paragraph 8-3.g(2) for information on TO/TO navigation systems and displays since they are not addressed in paragraph 15-2 (and others).

Person and/or Company	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
CMC	Page 27 Para 5-5.2(c)	Is the intent of this paragraph to indicate that no RAIM checks are required for NPA operations using TSO-C145 or C196 equipment? Is an alternative method of predicting integrity availability required?	The second part of the note states that C196 equipment has a fault detection prediction requirement to support flying outside SBAS coverage but C196 is never in "SBAS coverage" since it does not use SBAS.		**Partially Accepted.** It is obvious from the wording that paragraph 5-5.2(c) explicitly refers to a TSO-C129(AR) requirement to perform a RAIM check 2nm prior to the FAF. The paragraph provides an explicit example of a benefit to having a TSO-C145(AR) or TSO-C196(AR) sensor in that there is no need to do the TSO-C129() RAIM check 2 nm prior to the FAF. Note 2 further explains the primary intended function for the fault prediction requirement in DO-229D applicable to TSO-C145(AR) and DO-316 applicable to TSO-C196(AR). It was assumed that people using this document have a basic understanding that TSO-C196(AR) does not include SBAS signals and could interpret the note's

Person and/or Company	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
					intended meaning. However, to be abundantly clear, the note is changed as follows: "...pre-departure fault detection checks for TSO-C196(AR) equipment or when flying outside of the GPS/SBAS service provider's coverage area for TSO-C145(AR) equipment.
CMC	Page 64 Para. 10-2 Table 6 Note 3	Note 3 of Table 6 states that the horizontal coupling error (HCE) should be included in the error budget values indicated in the table. This contradicts DO-283A's definition of Vertical total system error and DO-236B Section 4.2.2.	This seems to make the performance expectations unrealistic except for GNSS nav modes. DO-283A & DO-236B limits the vertical track error to ASE+PDE+PSE (no HCE). See attached document for additional references.  AC20-138B Vertical Performance Limit for	Remove the last sentence of Note 3 that introduces the HCE into the vertical error budget. This will make Table 6 in-line with DO-283A & DO-236B and hence TSO-C115c.	**Not Accepted.** The comment is incorrect because DO-236B, Figure 1-3 and the definition of Vertical Total System Error in paragraph 1.7.2.2 explicitly state that horizontal coupling error is included. This same note was in AC 20-138B.
CMC	Page A2-14 Para A.2-4(c)	Is there any intent to limit bank angles when close to the ground (less than 400ft AGL)?	The different limit of 8 instead of 25 below 400 ft could imply that an upper limit is recommended in order to minimize wing	If the intent is to limit the bank angle, re-word this paragraph to clearly state that the bank angle upper limit exists. If no limit is	**Not Accepted.** The paragraph clearly states that below 400 ft flight guidance systems can only command a bank angle up

Person and/or Company	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
			movements when close to the ground.	intended add a note to that effect.	to 8 degrees. Above 400 ft there is a different limit.
CMC	Page A2-14 Para A.2-4(c)	What is the rationale behind an 8 degree value and why does this value apply only to RNP AR RF legs?	8 degrees seems shallow to perform an RF leg.	Provide a note to clarify this issue.	**Not Accepted.** The paragraph is clear that below 400 ft flight guidance systems can only command a bank angle up to 8 degrees. Additionally, the paragraph is in the section on RNP AR approaches with RF legs (and approaches include the missed approach segment as well) so it should be obvious that the paragraph applies to RF legs.
CMC	Page 21 Para 5-2.3 (d) Note	The web site states "TEST ONLY" and has no TSO-C196 button.		Will this Web site be operational before AC20-138C is in effect?	**Partially Accepted.** The transition to the FAA's RAIM prediction site did not take place as anticipated when AC 20-138B was published. The note has been changed to continue referencing the Volpe RAIM prediction

Person and/or Company	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
					site and state the FAA plans a transition to the new site and plans to include FDE prediction capability.
CMC	Paragraphs A4-10.d and A4-11.d.	The paragraphs seem to imply modifying the DO-229D accuracy tests which was not the intent.	The wording should be changed to ensure there is no misinterpretation that the paragraphs intend to modify the DO-229D accuracy tests.	Suggest changing the first sentence in A4-10.d and A4-11.d as follows: A4-10.d Performing the test described in paragraphs A4-10.a through A4-10.c confirms that the σ_i and d_U used to compute the VFOM accuracy metric provide a sufficient error over-bound. A4-11.d Performing the test described in paragraphs A4-11.a through A4-11.c confirms that the σ_i and d_{major}, d_{east}, and d_{north} used to compute the HFOM accuracy metric provide a sufficient error over-bound.	**Accepted.**

Person and/or Company	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
Garmin	Page 7, paragraph 3-1.a.	The reference to the revision of TSO-C196a should be lower case.	Editorial	"The TSO has been updated to revision "a"…"	**Accepted.**
Garmin	Page 9, paragraph 3-2.e., Note 1	States: While the display and navigation computer components can receive incomplete system TSOAs, the end manufacturer or aircraft integrator ensuring compatibility among the sensor, navigation computer, and display components may wish to apply for a complete system TSOA to further streamline the installation approval.	It is unclear how "the end manufacturer or aircraft integrator" can "apply for a complete system TSOA" given that the end manufacturer or aircraft integrator may not be the manufacturer of the display and/or navigation computer. The manufacturer that designs and builds the display and/or navigation computer component is the TSOA holder and TSOAs cannot be transferred (see FAA Order 8150.1B paragraph 11.b.(7)). So, how can an end manufacturer or aircraft integrator that is not the TSOA holder be granted TSOA for a component it doesn't design, doesn't manufacture, and doesn't have TSOA on?	Remove Note 1 or clarify its intent.	**Accepted.** The original intent was focused at OEMs but was not well stated. The note has been deleted.

Person and/or Company	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
Garmin	Page 19, paragraph 5-2.1.a.	Includes the statement: Using a different antenna specification constitutes a major design change that requires a new TSOA/LODA.	While a different antenna specification may constitute a major design change for the antenna, it is not necessarily true for the receiver as multiple antennas may be compatible with the receiver design. Given that this paragraph mixes discussion of antenna and receiver components, suggest clarifying that this sentence applies only to the antenna.	"Using a different antenna specification constitutes a major design change that requires a new antenna TSOA/LODA."	**Partially Accepted.** This paragraph refers to the case where the receiver and antenna were approved together as a unit under TSO-C129 or C129a. Unless two (or more) antennas with different part numbers were approved under the TSOA, a new antenna would be a major design change. Modified the sentence as follows (see bold): However, combinations where both the antenna and receiver were certified together **as a unit** under TSO-C129/C129a will need a new certification if antennas meeting the original TSOA are no longer available. Using a different antenna specification constitutes a major design change that requires a new TSOA/LODA **unless the**

Person and/or Company	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
					original TSOA contains part numbers for multiple antennas.
Garmin	Page 22, paragraph 5-2.3.l.	States: Prediction programs supporting ADS-B out should meet the requirements in 14 CFR 91.227. The program should identify the maximum RAIM or FDE outage time, and any predicted surveillance capability outages.	While this text is unchanged from AC 20-138B, it is unclear which "requirements in 14 CFR 91.227" a prediction program "supporting ADS-B out should meet." A seemingly obvious 91.227 requirement might be paragraph (c)(1)(i) for NACp < 0.05 nm. However, less obvious is the 91.227 (c)(1)(ii) requirement for NACv < 10 m/s. In any case, there are other 91.227 requirements that are even more ambiguous as to their applicability and others still that have no applicability to a prediction program.	Suggest clarifying this text or removing it.	**Accepted.** Changed the sentence to specify 91.227(c)(1)(i) and (iii) as the applicable requirements for a RAIM or FDE prediction program intended to support ADS-B.
Garmin	Page 41, paragraph 6-7.b.	Includes the statement: It is acceptable for tightly coupled integrations to meet the requirements of appendix R and be	Order 8110.4C Chg 4 paragraph 6-9.b.(1) defines a non-TSO function as: A non-TSO function is one that … does not	Remove the quoted statement from this paragraph.	**Partially Accepted.** The original thought was the hosting article for an INS/IRU - GNSS sensor is an FMS that typically has some revision of a TSO-

Person and/or Company	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
		approved as an FMS non-TSO function.	support or affect the hosting article's TSO function(s) … Garmin's understanding is that the tightly coupled function is hosted within the INS/IRU sensor not the GNSS sensor. Consequently, since there is no TSO for the hosting INS/IRU sensor there is no basis for approving the hosted tightly coupled function as "an FMS non-TSO function" per the Order 8110.4C Chg 4 paragraph 6-9.b.(1) definition.		C115 TSOA. Interpreting whether or not an INS/IRU - GNSS sensor "affects the hosting article's (FMS in this case) TSO function became more complex given that TSO-C115c references no particular sensors like TSO-C115b did and instead references DO-283A which is sensor independent for providing RNP capability; that is, does the sensor affect the FMSs RNP navigator functions. The point is to define Appendix R as an acceptable method to qualify tightly coupled INS/IRU - GNSS integrations. A similar case exists for loosely coupled systems by referencing Part 121 Appendix G. The last sentence in paragraph 6-7.b has been modified as follows:

Person and/or Company	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
					"It is acceptable for tightly coupled INS/IRU – GNSS hybrid sensors meeting appendix R to be integrated with FMS or multi-mode receivers for operational use under instrument flight rules on RNAV or RNP instrument routes or procedures."
Garmin	Page 41, paragraph 6-7.d.	Includes the statements: Tightly coupled INS/IRU systems integrated with GNSS sensors outputting PVT that is the same as GNSS may be demonstrated to be equivalent to either TSO-C145c, or TSO-C196a and receive a GNSS TSOA/LODA. Any discrepancies should be identified and resolved as part of the TSO approval, but appendix R will take precedence.	As noted in Garmin's comment on paragraph 6-7.b, our understanding is that the tightly coupled function is hosted within the INS/IRU sensor not the GNSS sensor. As stated in paragraph 6-7.b: … [RTCA/DO-229D and RTCA/DO-316] appendix R is not invoked by any TSO. Consequently, it is unclear how a tightly coupled INS/IRU can "receive a GNSS TSOA/LODA" per paragraph 6-7.d.	Clarify that TSO-C145c/TSO-C196a is applicable only to the integrated GNSS sensor (as opposed to the INS/IRU). Additionally, clarify how the same "function" can obtain both TSOA/LODA and "non-TSO".	**Partially Accepted.** Paragraph 6-7.b has been modified as noted in the comment above. However, paragraph 6-7.d remains unchanged since it has always been possible to receive a TSO-C129(AR) TSOA for tightly coupled INS/IRU - GNSS hybrid sensors depending upon the architecture and PVT outputs. Additionally, a TSOA is not the only possible means to achieve a design approval. Paragraph 6-7.d merely states that new applications will need to use either TSO-C145c or

Person and/or Company	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
			It is also unclear how both paragraphs 6-7.b and 6-7.d can be retained simultaneously within AC 20-138C as one advocates obtaining a TSOA/LODA while the other advocates obtaining "an FMS non-TSO function" for the same tightly coupled function.		TSO-C196a as the basis for these types of sensors if a TSOA is applicable and desired because TSO-C129a has been cancelled.
Garmin	Page 54, paragraph 8-4.c.(2)(c), Note 1	"paragraphs" should be singular.	Editorial	change to "paragraph"	**Accepted.**
Garmin	Page 61, paragraph 9-4.a.(2), Note 1	"paragraphs" should be singular.	Editorial	change to "paragraph"	**Accepted.**
Garmin	Page 69, paragraph 11-3.b., Note	Paragraphs 11-3.a and 11-3.b include the titles for AC 20-115B and AC 20-152, respectively (although this seems inconsistent with most other paragraphs within the document that do not include the document	Editorial	Include the title of AC 20-174.	**Accepted.** The required convention is to include the document name on first use.

Person and/or Company	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
		title). However, to be consistent within this area of the AC, it seems like the AC 20-174 title should be included within this note.			
Garmin	Page 69, paragraph 11-3.b., Note	AC 20-174 1.a states: "This … (AC) recognizes … (SAE) … (ARP) 4754A… as an acceptable method for establishing a development assurance process." AC 20-174 1.e uses the phrase "development assurance levels". To be consistent, suggest changing "design" to "development" in this Note.	Editorial	Change "design" to "development"	**Not Accepted.** "Design" is the term used throughout AC 20-138C and it was an intentional decision to not mix the "design" and "development" terms for consistency to avoid confusion. We are relying on the reader having some basic understanding of certification processes to comprehend the intent.
Garmin	Page 89, paragraph 14-6.8.b.	Includes the statement: For example, using vertical performance monitoring and alerting can meet the paragraph's intent.	It is not clear from this statement whether the normal LPV "vertical performance monitoring and alerting" required by TSO-C146 is sufficient to "meet the paragraph's intent" or whether some other "vertical performance monitoring and	Clarify whether the TSO-C146 normal LPV "vertical performance monitoring and alerting" is what is intended by the quoted statement.	**Partially Accepted.** The example is included in the GPS/SBAS section to indicate that SBAS monitoring and alerting is acceptable. However, the term "GPS/SBAS" was inserted in front of "vertical" to ensure there is

Person and/or Company	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
			alerting" is intended.		no confusion.
Garmin	Page 113, Chapter 21, Title	"Mult-Sensor" should be "Multi-Sensor'	Editorial	Correct spelling: "Multi-Sensor"	**Accepted.**
Garmin	Page 113, paragraph 21-1.	States: Refer to TSO-C115b/RTCA/DO-187 or TSO-C115c/RTCA-DO-283A, as appropriate, for RNAV multi-sensor equipment ground test information.	It is unclear which portions of DO-187 or DO-283A are being referred to. E.g., is it the entire DO-283A section 3 or only 3.4.1 titled "Ground Test Procedures"? If only, 3.4.1, while these requirements do not appear to be onerous, the reference to them is inconsistent with the recently agreed to RTCA MOPS Drafting Guide whose section 3 includes the following statements: The installed performance limits or validation requirements are	Installed performance requirements should be included directly in the AC rather than referencing other documents.	**Not Accepted.** The intent was simply an update for the 20-138B reference to C115b/DO-187 by including a reference to C115c/DO-283A.

Person and/or Company	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
			generally provided in separate installation guidance related to the function(s) provided. These are often provided in the form of Aviation Circulars (ACs) specific to aircraft installation or their non U.S. equivalents. When draft AC 20-138B was being reviewed, FAA agreed with Garmin's comments that installed performance requirements should be included directly in the AC rather than referencing other documents (e.g., FTE requirements were originally referenced to DO-283A but then incorporated directly into 20-138B section 16-2).		
Garmin	Page A2-1,	2nd draft TSO-C151c Appendix 1 Paragraph 3.1.4 includes conditions under which TAWS FLTA imminent terrain impact caution and warning alerts may be suppressed,	2nd draft TSO-C151c includes specific requirements to provide GPWS Mode 5 alerts on LPV and GLS approaches. AC 20-138C also includes similar guidance.	Recommend harmonizing the AC 20-138C and TSO-C151c requirements with respect to required TAWS alerting during RNP AR procedures.	**Accepted.** New language is in section 17 for baro-VNAV and paragraph A2-1 for RNP AR for applicants to consider implementing a glidepath warning function but, that GPWS/TAWS

Person and/or Company	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
		including a condition that: The GPWS Mode 5 alert must include the RNP AR glidepath. This appears to imply that if TAWS FLTA alerts are suppressed, then the GPWS Mode 5 alert must be provided during RNP AR approaches. However, AC 20-138C doesn't include similar specific requirements.			Mode 5 alerting isn't the only acceptable method. The new paragraphs instruct the applicant to reference the latest revision of TSO-C151 if implementing the capability through GPWS/TAWS which should address the TAWS FLTA alert suppression comment. The AC publication will be delayed to give the public a chance to comment on the new language.
Garmin	Page A2-1, paragraph A2-1.c.	Includes the statement: Doing so could streamline the operator's RNP AR operational approve …	Editorial	Change "approve" to "approval"	**Accepted.**

Person and/or Company	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
Garmin	Page A2-3, paragraph A2-3.a.(1)(a), Note	"countires" should be "countries"	Editorial	Correct spelling.	**Accepted.**
Garmin	Page A2-4, paragraph A2-3.a.(1)(c), Note 1	Note 1 refers to adjusting HPL with a K_H constant. There is no definition or reference for K_H given in the document and the relationship between adjusted HPL and GPS/SBAS vertical is not clear.	Clarification needed.	Provide additional explanation or remove the note.	**Accepted.** The K_H constant is a DO-229D requirement for a GPS/SBAS general least-squares protection level solution that is described in appendix J. the paragraphs are GPS/SBAS specific, so the following parenthetical has been inserted for clarification (see bold): "...the K_H constant **(described in RTCA/DO-229D, appendix J)** on the interface..."
Garmin	Page A2-6, paragraph A2-3.b.(2)	The last sentence is missing the word "only". It should read "…will use a fly-over turn at a fix ***only*** when there is no requirement for RNP containment"	Editorial	Change "when" to "only when".	**Accepted.**

Person and/or Company	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
Garmin	Page A2-6, paragraph A2-3.b.(2), Table 11	The table contains a column labeled "AFS-400 Approval" but there is no explanation of how it is used.	Editorial	Include an explanation for using the "AFS-400 Approval" column or remove this column.	**Not Accepted.** This table has not changed from the previous revision. The table was added from Order 8260.52 to address information on tailwind component rather than referencing an Order. How AFS-400 provides approval to use the tailwind components described in that column rather than using the standard tailwind component for RNP AR is out of scope for AC 20-138C.
Garmin	Page A2-6, paragraph A2-3.b.(2), Table 11, "*"	The note associated with the "*" is inappropriate in the context of airborne equipment requirements (the table comes from FAA Order 8260.52 which is a procedure design standard).	Editorial	Remove the "*" by table heading "Standard Tailwind Component (Knots)" and the associated note.	**Not Accepted.** This table has not changed from the previous revision. The star and note are added for completeness. A note is explanatory in nature and can be ignored if the applicant believes the explanation is redundant.
Garmin	Page A2-14, paragraph A2-5.b. Note	AC 20-174 1.a states: "This … (AC) recognizes … (SAE) … (ARP) 4754A… as an acceptable	Editorial	Change "design" to "development" (2 instances)	**Not Accepted.** "Design" is the term used throughout AC 20-138C and it was an intentional decision to not mix the "design" and

Person and/or Company	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
		method for establishing a development assurance process." AC 20-174 1.e uses the phrase "development assurance levels". To be consistent, suggest changing "design" to "development" in this Note.			"development" terms for consistency to avoid confusion. We are relying on the reader having some basic understanding of certification processes to comprehend the intent.
Garmin	Page A2-14, paragraph A2-5.c. Note 3	Based on the position of this note (following paragraph A2-5.c) it seems that the reference to "A2-5.b" in the note is incorrect.	Editorial	Review and correct the paragraph references in Note 3 as needed.	**Accepted.** The note has been changed to refer to paragraphs A2-5.b and A2-5.c.
Garmin	Page A2-16, paragraph A2-6.a.(2) Note 2	AC 20-174 1.a states: "This … (AC) recognizes … (SAE) … (ARP) 4754A… as an acceptable method for establishing a development assurance process." AC 20-174 1.e uses the phrase "development assurance levels". To be consistent, suggest	Editorial	Change "design" to "development"	**Not Accepted.** "Design" is the term used throughout AC 20-138C and it was an intentional decision to not mix the "design" and "development" terms for consistency to avoid confusion. We are relying on the reader having some basic understanding of certification processes to comprehend the intent.

Person and/or Company	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
		changing "design" to "development" in this Note.			
Garmin	Page A4-9, paragraph A4-10.c.	Suggest "those" instead of "the ones" (2 places)	Editorial	Replace "the ones" with "those" (2 places).	**Accepted.**
Garmin	Page A4-9, paragraph A4-10.d.	Includes the statements: The VFOM accuracy metric can be calculated after performing the test described in paragraphs A4-10.a through A4-10.c to confirm the σ_i and variance used provides a sufficient error over-bound. The vertical position accuracy metric must be greater than or equal to 1.96 d_U where d_U is computed using the same σ_i employed during the HAE accuracy test procedure.	The DO-229D 2.5.8.3 test procedure is intended to verify the accuracy of the HAE output itself. It does not validate the VFOM metric. The accuracy of the VFOM metric itself is demonstrated by meeting all three criteria in attachment 1 of the ADS-B Position Out Gap Matrices: Criterion 1 is an analysis/inspection to show that the position is computed using a least squares solution.	Remove the first sentence of the paragraph, and change the second sentence to read: The VFOM accuracy metric must be greater than …	**Partially Accepted.** Paragraph A4-10 was developed from the RTCA SC-159 Ad Hoc committee results on qualifying GNSS equipment developed to the different MOPS for use as an ADS-B position source. The first sentence was changed as follows for clarity; the second sentence remains unchanged: "Performing the test described in paragraphs A4-10.a through A4-10.c confirms that the σ_i and d_U used to compute the VFOM accuracy metric provides a

Person and/or Company	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
		This first quoted sentence implies that the VFOM accuracy metric is computed as a result of the DO-229D 2.5.8.3 test. This is not consistent with the ADS-B Position Out Gap Matrices produced by SC-159.	Criterion 2 is a test to show that the position errors observed during the test are consistent with the geometry and measurement variances assumed in the least squares solution. Criterion 3 is an analysis/inspection to show that the computation of the VFOM metric is a statistically correct 95% (or greater) bound.		sufficient error over-bound."
Garmin	Page A4-10, paragraph A4-11.b	Includes the statement: The HFOM output must be calculated using the general least squares position solution of DO-229D appendix J.1 (or any mathematically equivalent linear combination of range measurements). To be consistent with the ADS-B Position Out Gap Matrices developed by SC-	The requirement is on the computation of the position solution rather than the HFOM output although they are related.	Change the first sentence to read: The horizontal position output must be …	**Accepted.**

Person and/or Company	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
		159, this item should refer to the horizontal position output, rather than the HFOM.			
Garmin	Page A4-10, paragraph A4-11.c.	Suggest "those" instead of "the ones" (2 places)	Editorial	Replace "the ones" with "those" (2 places).	**Accepted.**
Garmin	Page A4-10, paragraph A4-11.d.	Includes the statements: The HFOM accuracy metric can be calculated after performing the test described in paragraphs A4-11.a through A4-11.c to confirm the σ_i and variance used provides a sufficient error over-bound. The accuracy metric must be greater than 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 σ_i employed during the horizontal accuracy test	The DO-229D 2.5.8.3 test procedure is intended to verify the accuracy of the horizontal position output itself. It does not validate the HFOM metric. The accuracy of the HFOM metric itself is demonstrated by meeting all three criteria in attachment 1 of the ADS-B Position Out Gap Matrices: Criterion 1 is an analysis/inspection to show that the position is computed using a least squares solution.	Remove the first sentence of the paragraph, and change the second sentence to read: The HFOM accuracy metric must be greater than …	**Partially Accepted.** Paragraph A4-11 was developed from the RTCA SC-159 Ad Hoc committee results on qualifying GNSS equipment developed to the different MOPS for use as an ADS-B position source. The first sentence was changed as follows for clarity; the second sentence remains unchanged: "Performing the test described in paragraphs A4-11.a through A4-11.c confirms that the σ_i and d_{major}, d_{east}, and d_{north} used to compute the HFOM

Person and/or Company	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
		procedure. The first quoted sentence implies that the HFOM accuracy metric is computed as a result of the 229D 2.5.8.3 test. This is not consistent with the ADS-B Position Out Gap Matrices produced by SC-159.	Criterion 2 is a test to show that the position errors observed during the test are consistent with the geometry and measurement variances assumed in the least squares solution. Criterion 3 is an analysis/inspection to show that the computation of the HFOM metric is a statistically correct 95% (or greater) bound.		accuracy metric provide a sufficient error over-bound."
Garmin	Page A4-12, paragraph A4-12.c.(4)	This section states: GNSS manufacturers developing data for the minimum valid velocity should consider the following: This statement is followed by four bullet points. It is not clear that these points are intended to be used as assumptions manufacturers should use. Suggest adding the word "assumption" to	Editorial	Modify first sentence to read: GNSS manufacturers developing data for the minimum valid velocity should consider the following assumptions:	**Accepted.**

Person and/or Company	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
		the end of the first sentence to clarify.			
Garmin	Page A8-1, after paragraph A8-1.g.	AC 20-174, *Development of Civil Aircraft and Systems*, is now referenced in multiple notes. Suggest including it here.	Editorial	Add a reference to AC 20-174.	**Accepted.**
Edmund Riley /GE Aviation	Page 49, 8.3.e	The Note in this section states no RNP requirements for missed approach if based on conventional nav. Does this same note apply to the initial and intermediate segments of the approach?	It seems the alert described in section 8.3.e is levied on GPS, but does it also apply to VOR/DME approaches?	Request text be added to clarify.	**Not Accepted.** The note and paragraph 8-3.e are verbatim from AC 90-105 and are quite clear on the requirements for an initial and intermediate segment of an RNP approach. It would not be an RNP approach if the initial or intermediate segments are based on conventional VOR, VOR/DME, or NDB use. Initial and intermediate segments are not defined in DO-236B using legacy navaids for conventional paths.

Person and/or Company	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
Edmund Riley /GE Aviation	Page A2-2, A2-2.d(2)	Is the intent of the requirement in section A2-2.d(2) (failure probability of 10-7 pfh) applicable to all RNP AR given that the General AR Requirement in A2-3.e(1) suggests a Design Assurance commensurate with a Major severity for misleading lateral or vertical guidance.	Is the intent of section A2-3.e, meant to describe Design Assurance relative to DO178B and DO254, or is the term Design Assurance meant in a general sense such that the requirement would be 10-5 in section A2-3.e(1).	Request text be added to clarify the intent of Design Assurance as used in this document. One possible solution is to add Design/Development Assurance to the definitions list in Section 7.	**Not Accepted.** The text is verbatim from AC 90-101A. The first paragraph in A2-2 states: "This paragraph defines the general performance requirements [underline added for emphasis] for aircraft qualification. Paragraphs A2-3, A2-4, and A2-5 of this appendix provide guidance material on an acceptable means of satisfying these requirements." Additionally, the term "design assurance" is not used anywhere in section A2-2.
Edmund Riley /GE Aviation	PageA2-15, A2-6.a.2	The word "display" is bold in this sentence. Is the intent of this requirement meant to be levied on the display system or the generation and display of RNP lateral guidance?			**Partially Accepted.** This text is verbatim from AC 90-101A and "display" was highlighted in bold because previous comments indicated the word was being overlooked. However, the bold has been deleted to not cause confusion or unnecessary

Person and/or Company	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
					anxiety and be consistent with AC 90-101A and AC 20-138B.
Jennifer VanNorwick, GE Aviation	14-6.8.a	It is unclear if the last sentence refer's to baro-VNAV as well.	If the intent is to include baro-VNAV, there is a question over what is the expected vertical performance limit associated with the warning. Also, can baro-VNAV vertical performance monitoring and alerting meet the paragraph's intent?	Provide clarification that the intent of the last sentence applies only to SBAS.	**Partially Accepted.** The last sentence in paragraph 14-6.8.a was changed as follows (change highlighted in bold): It is desirable to provide a glideslope warning function on any **GPS/SBAS** approach with vertical guidance. However, another industry comment indicated that the glideslope warning function should be extended to RNP AR approaches as well to achieve the safety benefits for the same reasons as ILS, LPV, and GLS. Since most RNP AR approvals use baro-VNAV, this means extending the function to baro-VNAV.

Person and/or Company	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
					New language is in section 17 for baro-VNAV and paragraph A2-1 for RNP AR for applicants to consider implementing a glidepath warning function but, that GPWS/TAWS Mode 5 alerting isn't the only acceptable method. The AC publication will be delayed to give the public a chance to comment on the new language. The AC publication will be delayed and the new paragraphs specific to this topic will be released for public comment.
Universal Avionics Systems Corp.	Page 10, Paragraph 3-4.a	This paragraph states that production under TSO-C115b or earlier revisions may continue. There is not a statement that this equipment is eligible for installation under this AC as there is in paragraph 3.2.b. for TSO-C145b.	This can lead to confusion whether the continued production is only to support previously approved installations or may be used for new installations and approvals under this AC.	Add a statement that equipment produced under TSO-C115b is still eligible for installation in accordance with the guidance in this AC.	**Accepted.**