

**Clearance Record  
DOCUMENT COMMENT LOG**

<b>Originating Office:</b> AIR-130	<b>Document Description:</b> TSO-C115c	<b>Project Lead:</b> Veronica Gardner	<b>Reviewing Office:</b>	<b>Date of Review:</b> December 2011
---------------------------------------	---	--	--------------------------	---

<b>Company &amp; Group</b>	<b>Page &amp; Paragraph</b>	<b>Comment</b>	<b>Rationale for Comment</b>	<b>Recommendation</b>	<b>Disposition</b>
Garmin	Page 1, par 2.c.	<p>Includes the statement:</p> <p style="padding-left: 40px;">This TSO does not address LP/LPV capability.</p> <p>The scope of TSO-C146c covers much more than LP/LPV capability. In fact, TSO-C146c almost completely overlaps the scope of TSO-C115c.</p> <p>A priority needs to be established to cover differences between TSO-C115c/DO-283A and TSO-C146c/DO-229D requirements. For example, draft TSO-C115c par 3 includes the statement:</p> <p style="padding-left: 40px;">An FMS intending to support vertical navigation (VNAV) operations must also meet the requirements in Appendix H of RTCA/DO-283A.</p> <p>DO-283A Appendix H expects vertical guidance to be provided via baro VNAV for all flight phases, including approaches (DO-283A H.2.3.1 includes multiple references to approach vertical navigation requirements including the statements (with <u>emphasis</u>):</p> <p style="padding-left: 40px;"><u>Upon selection of published terminal procedures (SIDs/DPs, STARs, and approaches), associated</u></p>	<p>Some equipment manufacturers will want to mark equipment with both TSO-C115c and TSO-C146c. Additionally, the AC 20-138B installation guidance requires that systems incorporating GNSS/SBAS comply with TSO-C146/DO-229.</p>	<p>Include additional requirements (similar to the language in TSO-C115b paragraph a.(3) titled “<u>Use of Global Positioning System Sensors</u>”) so that TSO-C146c/DO-229D requirements take precedence over TSO-C115c/DO-283A in the case of conflicting criteria.</p>	<p><b>Not Accepted.</b></p> <p>Taking credit for SBAS is a manufacturer option. DO-229D navigator requirements (section 2.2) are a subset and a specific method to comply with DO-283A navigator requirements for RNP.</p>

Company & Group	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
		<p><u>altitudes and speeds shall be extracted from the navigation database.</u></p> <p>...</p> <p><i>Note: For the final approach segment of an instrument approach where minimums are based upon vertical navigation, VNAV paths are only defined by flight path angles that come from a database.</i></p> <p>However, TSO-C146c Class 2 and Class 3 requires the use of SBAS-based vertical guidance for LNAV/VNAV approaches (equivalent to RNP 0.3 per AC 90-105 Appendix 1). For example, DO-229D 2.2.4.6.3 includes the statement (with <u>emphasis</u>):</p> <p>If the aircraft is below 1000 ft HAT, or if the LTP/FTP/MAWP is the active waypoint, the vertical flag or equivalent indicator shall be displayed within one second of the onset of any of the following conditions:</p> <p>a) There are an insufficient number of <u>SBAS HEALTHY</u> satellites ...</p> <p>Another example which is not as clear cut is DO-283A 2.2.4.2 requires RNP 4 to have a 4.0 NM cross-track deviation but DO-229D 2.2.2.4.2 indicates that oceanic/remote mode non-numeric cross-track deviation shall not exceed +/-</p>			

Company & Group	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
Garmin	Page 2, par 3.b.	<p>5 NM.</p> <p>Includes the statements:</p> <p style="padding-left: 40px;">Use the criteria listed below. Design the system consistent with these failure condition classifications.</p> <p>Wording needs to change to allow failure condition to be determined at the aircraft level.</p>	<p>This statement implies the failure condition classification of an appliance is determined by the TSO regardless of mitigations employed to meet aircraft level safety requirements such as redundant appliances/systems. Unless the DAL cannot be affected by the installation, the aircraft System Safety Assessment should determine the failure classification and by extension, the design assurance level (DAL) requirement. The aircraft FHA/SSA ultimately determines the DAL requirement for a particular installation. Specifying the DAL at the appliance level without the benefit of the specific aircraft level FHA/SSA means that in some cases the DAL will undoubtedly be higher and more costly than necessary. This will have a chilling effect on the installation of new, safety enhancing technologies since the cost will be greater than necessary. It is possible to build and certify a TSOA appliance that cannot be approved for installation in one or more aircraft types because it does not have the required DAL. Similarly, just because the appliance meets a TSO DAL does not mean it can be approved for installation. We recommend that no failure classification/DAL requirement be included in a TSO when the installation can affect or mitigate the hazard level and therefore consideration should be given to revising paragraph 3.b in this TSO to the general guidance in the Recommendation column. (Note that TSO-C112c is an example where a classification/DAL may be appropriate as a transponder output is used by the national airspace system and the installation has no ability to mitigate the safety risk.)</p>	<p>Suggest changing to the following wording:</p> <p>“Develop each system to at least the design assurance level required by the anticipated installation for the function defined in paragraph 3a”</p>	<p><b>Accepted.</b></p> <p>Paragraph 3.b. second sentence has been changed to: “Design the system to the appropriate failure condition classification(s).”</p> <p>The Design Assurance criteria for RNP is consistent with AC 20-138B. Like LPV, the DAL is specified by TSO consistent with the limitations of GPS. The same is true for RNP.</p>

Company & Group	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
Garmin	Page 2, par 3.b.(2)	<p>This paragraph and its subparagraphs discuss design assurance for RNP&lt;0.3.</p> <p>It is simplistic and inappropriate to establish design assurance requirements for RNP&lt;0.3 given the fact that DO-283A does not address RNP&lt;0.3.</p> <p>For example, see DO-283A 1.6.3 and 2.2.4.1.2, which indicate only RNP 0.3, RNP 1, RNP 2 and RNP 4 were anticipated; especially consider 2.2.4.1.2 where the cross-track deviation full-scale deflection does not go below RNP 0.3.</p> <p>Additionally, see DO-283A 2.1.9.2, which indicates an acceptable approach to software development is to develop navigation and integrity software to at least Level C, which is equivalent to a major failure condition, and which does not account for AC 20-138B Appendix 2 and AC 90-101A Appendix 2 requirements for hazardous (severe/major) failure conditions for RNP&lt;0.3.</p>	RNP <0.3 has many additional issues not covered in either DO-283A or this Draft TSO-C115c but which are covered in AC 20-138B Appendix 2 and AC 90-101A Appendix 2.	Delete requirements for RNP <0.3 – replace with a statement that the TSO does not address RNP <0.3.	<p><b>Not Accepted.</b></p> <p>TSO-C115c is providing TSOA support for RNP capability. The applicant does not have to apply for RNP&lt;0.3 performance capability. However, we want to lay a foundation for FMS manufacturers designing RNP&lt;0.3 capability.</p>
Garmin	Page 3, par 4.b.(2)	<p>Paragraph 4.b.(2) states:</p> <p>Each subassembly of the article that you determined may be interchangeable.</p> <p>This language is confusing.</p>	The language for this requirement is confusing. This could mean that a stuffed printed circuit board needs the TSO number.	Suggest removing the statement or if removing causes problems, work with industry to establish wording that is better understood.	<p><b>Not Accepted.</b></p> <p>This is the standard boilerplate language. Paragraph 4.b. (2) states the applicant determines which subassemblies are interchangeable and therefore which subassemblies require marking.</p>

Company & Group	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
Garmin	Page 4, par 5.a.(4)(d)	This paragraph requires listing the “failure condition classification” in the installation manual which can be misleading to the installer and is inconsistent with the process of determining failure condition classification at the aircraft level.	<p>Failure condition classification is determined by system safety assessment at the aircraft level and can vary based on installation. By providing a failure condition classification at the appliance level this creates an impression that the safety analysis for these functions is complete.</p> <p>Additionally, TSO-C115c paragraphs 5.a.(4)(a) and 5.a.(4)(b) already require the Manual(s) to contain the software and AEH design assurance levels that an installer needs to determine whether the equipment can support the aircraft level failure condition classification.</p>	Remove the requirement to list “failure condition classification” in the Manual(s).	<p><b>Not Accepted.</b></p> <p>This is the standard boilerplate language. This document is intended as an over arching generic vs. specific avionics manufacturer/OEM relationship. Providing installers with both DAL &amp; Failure Condition Classification is important to distinguish applicable XX.1309 compliance (eg. Part 23 vs. Part 25).</p>
Garmin	Page 5, par 5.f	TSO paragraph 5.f and its subparagraphs define required information to be supplied to the ACO. This guidance is inconsistent with Order 8110.4C CHG 4.	<p>TSO paragraph 5.f indicates that “you must ... include the following information with your TSO application” but the TSO 5.f subparagraphs which specify the required information to be supplied to the ACO for a non-TSO function are inconsistent with the Order 8110.4C CHG 4 paragraph 6-9.b.(3) “Manufacturer Data Submittal” requirements. For example, TSO paragraphs 5.f.(5) and 5.f.(6) require submittal of “Results of test/analysis” while Order 8110.4C CHG 4 paragraph 6-9.b.(3) requires submittal of “proposed test procedures”; while both sets of guidance use the word “test”, otherwise there is no similarity.</p>	Reword to point to Order 8110.4C CHG 4 paragraph 6-9.b.(3).	<p><b>Not Accepted.</b></p> <p>We do not reference orders in our TSOs. This TSO contains the latest applicable information for non-TSO functions.</p>
Garmin	Page 5, par 5.f	TSO paragraph 5.f and its subparagraphs include definition of non-TSO functions and the data to be submitted to the ACO for non-TSO functions. This guidance is inconsistent with Order 8110.4C CHG 4.	<p>TSO paragraph 5.f states “Identify functionality or performance contained in the article not evaluated under paragraph 3 of this TSO (that is, non-TSO functions).” Use of the term “performance” in the definition of a non-TSO function is inconsistent with the Order 8110.4C CHG 4 paragraph 6-9.b.(1) and 6-9.b.(3)(a) guidance regarding how to define a non-TSO function. The issue is non-TSO should not be defined as “performance”. It will create difficulty if these criteria are used. For example, if a TSO requires a minimum 10 watt transmitter and a company makes one that is robust at 11 watts, the performance exceeding</p>	Reword to point to Order 8110.4C CHG 4 paragraph 6-9.b.(1) and 6-9.b.(3)(a) for the definition of non-TSO function.	<p><b>Not Accepted.</b></p> <p>We do not reference orders in our TSOs. This TSO contains the latest applicable information for non-TSO functions.</p>

Company & Group	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
			<p>the TSO is not called out under the TSO; consequently, by the paragraph 5.f “performance” definition, the 11 watt transmitter has a non-TSO 1 watt capability. The distinction of a “function that can be accomplished outside the TSO box” as is specified in Order 8110.4C CHG 4 paragraph 6-9 is critical to making non-TSO function work long term.</p>		
Garmin	Page 6, par 7.b	TSO paragraph 7.b contains wording that is inconsistent with several FAA Orders.	<p>TSO paragraph 7.b includes additional guidance about what furnished data should be provided to an operator or repair station when the equipment includes a non-TSO function. The problematic guidance states “include one copy of the data in paragraphs 5.f.(1) through 5.f.(4).” This guidance is inconsistent with Order 8110.4C CHG 4. Order 8110.4C CHG 4 paragraph 6-9.b.(6) defines the FAA-industry agreed data that must be provided to an installer when equipment includes a non-TSO function and it would be better if the TSO simply pointed to Order 8110.4C CHG 4 paragraph 6-9.b.(6).</p>	Reword to point to Order 8110.4C CHG 4 paragraph 6-9.b.(6).	<p><b>Not Accepted.</b></p> <p>We do not reference orders in our TSOs. This TSO contains the latest applicable information for non-TSO functions.</p>
UASC (Universal Avionics Systems corporation)	DO-283A Section 2.2.4.11(g),	This could be misconstrued to require the capability to recognize "RNP airspace" other than that defined by leg records or by the default RNP for Oceanic/Remote, Enroute, Terminal and Approach.	Clarification	Note the definition of “RNP airspace” in the TSO.	<p><b>Not Accepted.</b></p> <p>DO-283A is an industry developed and approved minimum performance standard.</p> <p>Airspace definitions would be inappropriate but the issue can be presented to SC-227 when they address the next DO-283A revision.</p>
UASC	DO-283A Section 2.2.4.11(g),	It is unclear why the specification for enabling RNP alerting is considered a minimum requirement. Why is crosstrack deviation considered to enable alerting, since alerting is not based on it? In this implementation, alerting would be inhibited if the aircraft remained at a lateral offset	Requirement is unnecessarily restrictive.	Note in TSO that the minimum requirement is to enable RNP alerting to the RNP given for a leg no later than when the system begins providing guidance to that leg. Any additional restriction should be justified.	<p><b>Acknowledged.</b></p> <p>DO-283A is an industry developed and approved minimum performance standard.</p> <p>Recommendation for note is already considered to be met with text in DO-283A MOPS,</p>

Company & Group	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
		> 0.5*RNP. Is there a reason not to enable RNP alerting when the leg becomes active (turn anticipation point)?			2.2.4.11(g); enables alerting when aircraft passes the first fix.
UASC	DO-283A Appendix H, Section H.2.4.1	It is unclear why the system needs to support any vertical restriction other than "AT" during the final approach segment. Glide path should be a constant descent to the end-of-approach waypoint.	Requirement is unnecessarily restrictive, or perhaps unclear.	The requirement should exclude final approach.	<p><b>Not Accepted.</b></p> <p>DO-283A is an industry developed and approved minimum performance standard.</p> <p>The issue can be presented to SC-227 when they address the next DO-283A revision.</p>
UASC	DO-283A Section H.2.4.4 sub-bullet 2, Sections H.2.4.4.3 and H.2.5.5	It is unclear why the system needs to support vertical path legs defined in the procedure database by a flight path angle during the descent phase.	Requirement is unnecessarily restrictive.	<p>Excepting final approach, descent paths are preferably defined by three-dimensional waypoints. Why is it necessary to require an additional method of defining them?</p> <p>Implementation methods are beyond the scope of the MPS. Recommend procedure designers place a waypoint at top-of-descent.</p>	<p><b>Acknowledged.</b></p> <p>DO-283A is an industry developed and approved minimum performance standard.</p> <p>The issue can be presented to SC-227 when they address the next DO-283A revision.</p>
UASC	DO-238A Section H.2.6	Climb and Cruise modes are required but not defined. Section H.2.4.3 specifically declines to define these modes. Therefore, these do not appear to be minimum requirements.	Requirement is unnecessarily restrictive.	Either define Climb and Cruise modes, or change the requirement for climb and cruise modes to "should".	<p><b>Not Accepted.</b></p> <p>DO-283A is an industry developed and approved minimum performance standard.</p> <p>The issue can be presented to SC-227 when they address the next DO-283A revision.</p>
EC (Eurocopter)	2.b;	If TSO C115c replaces the TSO C129, does it mean that AC 20-138B calling TSO C115b will be updated accordingly			<p><b>Accepted.</b></p> <p>AC 20-138C is already in coordination with TSO-C115c updates.</p>

Company & Group	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
EC	3b	<p>Loss of lateral guidance is associated to a major failure conditions.</p> <p>The loss of FMS has thus to occur with a probability of less than 10-5/F.H. This could impact architectures. In addition consistency with ICAO PBN is not clear where it is written for many RNP requirements :</p> <p><i>Continuity</i>: Loss of function is classified as a minor failure condition if the operator can revert to a different navigation system and proceed to a suitable airport.</p>			<p><b>Acknowledged.</b></p> <p>The failure condition classification does meet the ICAO PBN Manual. The intent of this TSO is to raise the standard for FMS equipment in modern applications compared to the standard set in TSO-C115b.</p>
EC	3c	<p>This TSO calls for DO 283. Does it mean that DO236 is no more relevant?</p>			<p><b>Acknowledged.</b></p> <p>DO-236 is a MASPS while DO-283A is a MOPS. This does not mean that DO-236 is irrelevant.</p>
EC	3c	<p>Similar topics : the DO 283 calls for integrity and other topics the DO 208 as well as DO 229. The DO 208 has been amended by TSO C129. This is called again in the DO 283 (based on the 2002 release and not the one mentioned).</p> <p>Example of DO 283 appendix C : Position accuracy requirement for GNSS are defined in RTCA/DO-229C and RTCA/DO-208 (as modified by TSO-C129).</p> <p>As the TSO C129 is no more relevant could you confirm that the last issue of DO 283 mentioned this TSO C129 change vs. DO 208</p>			<p><b>Acknowledged (Change added).</b></p> <p>There is a disconnect between the aircraft level integrity requirement defined in DO-283A paragraph 2.2.5.2 and the system level equipment performance requirements defined in the GNSS MOPS. DO-283A requires a 10<sup>-5</sup> integrity requirement at the aircraft level while the GNSS MOPS (which support the ICAO PBN Manual requirements) have a 10<sup>-7</sup> integrity requirement at the system level related to satellite faults. This discrepancy was addressed in TSO-C115b by adding the requirements defined in TSO-C129/DO-208 when integrating GPS. An exception</p>

Company & Group	Page & Paragraph	Comment	Rationale for Comment	Recommendation	Disposition
					<p>has been added to TSO-C115c to modify DO-283A paragraph 2.2.5.2 with an additional system performance requirement and explanatory note as follows:  “When using GNSS, the aircraft navigation system shall provide an alert when the probability of signal-in-space errors causing a lateral position error greater than two times the desired RNP (2 X RNP) exceeds <math>1 \times 10^{-7}</math> per hour.”</p> <p><b>Note:</b> This exception supports international harmonization of requirements for RNAV and RNP. The exception is comparable to the TSO-C115b exception that invoked TSO-C129 system performance requirements when integrating GNSS as part of a multi-sensor navigation solution.</p>
UAL (United Airlines)	Page 2 Para 3.d.	Para 3.d can be clarified with the note at top of Page 3. 3.d. states that a different procedure may be used other than RTCA/DO-160D, but the note states that RTCA/DO-160 with only Chg 1 & 2 is not appropriate.	Language is not clear on what revision of RTCA/DO-160 should be used.	State clearly whether DO-160D DOES or DOES NOT have adequate environmental testing procedures.	<p><b>Partially Accepted.</b></p> <p>Clarified that DO-160D with change 3 is acceptable.</p>
AIRBUS	Page 2 § 3b REQUIREMENTS / Failure Condition Classifications	<p>In § 3b, there is a reference to aircraft failure conditions (“misleading lateral or vertical guidance”, “loss of lateral guidance”, “loss of vertical guidance”, which are considered as either HAZ, MAJ or MIN depending on the RNP level).</p> <p>For <math>RNP \geq 0.3</math> and <math>RNP &lt; 0.3</math>, Airbus would suggest to:  - Remove the “major” and “hazardous” classifications</p>	<p>As per 25.1309 regulation (and related AMC for European regulations), the criticality of any aircraft hazard shall take into account aircraft architecture and cues available to the crew (number of equipment involved, alerts available...). Classification of an aircraft failure condition must be assessed in light of aircraft integration and architecture, knowledge of human factors, operating procedures, training and others as per 25.1309.</p> <p>Therefore, these classifications should be assessed during the Type Certification exercise at aircraft manufacturer level.</p>		<p><b>Acknowledged.</b></p> <p>Paragraph 3.b provides failure condition classifications. This paragraph defines the equipment failure requirements necessary to support the defined RNP values. The aircraft manufacturer still assesses failure condition classification.</p>

<b>Company &amp; Group</b>	<b>Page &amp; Paragraph</b>	<b>Comment</b>	<b>Rationale for Comment</b>	<b>Recommendation</b>	<b>Disposition</b>
		associated to the aircraft failure condition “misleading lateral or vertical guidance” and “loss of lateral guidance” - Remove the “minor” classification associated to aircraft failure condition “loss of vertical guidance”.			