

**Clearance Record  
DOCUMENT COMMENT LOG**

<b>Originating Office:</b> AIR-130	<b>Document Description:</b> AC 20-AHRS	<b>Project Lead:</b> Sheila Mariano	<b>Reviewing Office:</b> AIR-130	<b>Date of Review:</b> 2/27/2014
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<b>Comment Number</b>	<b>Page &amp; Paragraph</b>	<b>Comment</b>	<b>Rationale for Comment</b>	<b>Recommendation</b>	<b>Disposition</b>
1. GAMA	Page 1 Section 1.1	The list of ACs is said to apply to the “ <i>aircraft type specific primary flight instruments airworthiness certification process.</i> ” GAMA requests that the FAA clarify how would it apply to standby instruments.			<b>Accepted.</b> This AC addresses AHRS used for primary flight instruments. Included standby instruments to paragraph 1.1 and 1.4. If there is guidance on standby instruments in the ACs referenced in para 1.1, then use them as appropriate. Standby instruments may use this AC as information as a guideline. Standby instruments do not require the same fidelity as primary flight instruments.
2. Garmin	Page 2 Section 2	The word “longitudinal” should be removed from the following sentence: “Global Navigation Satellite Services (GNSS) and air data computer (ADC) aiding sources are commonly used to identify aircraft longitudinal accelerations to reduce errors in the attitude function.”	GNSS and ADC aiding sources are often used to identify lateral as well as longitudinal accelerations.	“Global Navigation Satellite Services (GNSS) and air data computer (ADC) aiding sources are commonly used to identify aircraft <del>longitudinal</del> accelerations to reduce errors in the attitude function.”	<b>Accepted.</b> Corrections were incorporated in Section 2.

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3. GAMA	Page 2 Section 2	This paragraph includes the language “ <i>aiding sources are commonly used to identify aircraft longitudinal accelerations...</i> ”		GAMA requests that the word “longitudinal” be removed as GNSS and ADC aiding sources are often used to identify other accelerations such as lateral accelerations as well as longitudinal accelerations.	<b>Accepted.</b> Corrections were incorporated in Section 2. See comment number #2.
4. GAMA	Page 2 Section 2.1	This paragraph seems out of place as it does not provide guidance for rotorcraft aiding sources but rather methods manufacturers should use to resolve AHRS issues with helicopter vibration.			<b>Accepted.</b> Moved paragraph to section 5.5.
5. Universal	Page 4 Section 2.6	5 <sup>th</sup> sentence – should the word “couple” be “coupled”?		5 <sup>th</sup> sentence – should the word “couple” be “coupled”?	<b>Accepted.</b> Word was changed to “coupled”. Text is now in section 5.5.c
6. GAMA	Page 5 Section 3.1	GAMA questions the statement that “ <i>TSO-C201 degraded mode was intended for smaller lower performance, such as 14 CFR parts 23 and “non-Appendix B” 27 aircraft, and would not</i>	Typical AHRS systems make use of available data; data from aiding sources. Even very expensive AHRS systems (\$150k+) make use of available sources. If an aiding source fails, the	GAMA requests the FAA consider removing the statement “ <i>TSO-C201 degraded mode was intended for smaller lower performance, such as 14 CFR parts 23 and “non-Appendix B” 27 aircraft, and would not</i>	<b>Partially Accepted.</b> The language is revised such that there is no inferred aircraft type restriction for degraded mode.

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		<i>typically be suitable for larger or higher performance 14 CFR parts 25, 27 Appendix “B” or 29 aircraft which require redundant primary attitude functions installed as part of the TC”</i>	AHRS solution will be less accurate, but it does not mean the data is unusable by the pilot.	<i>typically be suitable for larger or higher performance 14 CFR parts 25, 27 Appendix “B” or 29 aircraft which require redundant primary attitude functions installed as part of the TC” and leave “Determine if the degraded mode performance is an acceptable method of compliance for aircraft usage.” and “The degraded mode is an in-flight backup application only and should not be enabled while on the ground either during initial system start- up or after engine start.”</i>	
7. Garmin	Page 5 Section 3.2	This paragraph includes three uses of the word “airplane” instead of “aircraft”.	The AC is to be used for 23/25/27/29 and has many references to rotorcraft. By using “airplane” it implies excluding rotorcraft from that requirement which does not seem to be the intent.	Search and replace “airplane” with “aircraft” where not used intentionally.	<b>Accepted.</b> In Section 3.2, two of the three “airplane” words were replaced with “aircraft”. The third use of the word “airplane” is intentional and refers to the airplane/rotorcraft flight manual supplement.

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8. GAMA	Page 5 Section 3.2	This paragraph includes three uses of the word “airplane” instead of “aircraft”.  GAMA also requests the word “light” be changed to “flight”	The AC is to be used for 23/25/27/29 and has many references to rotorcraft. By using “airplane” it implies excluding rotorcraft from that requirement which does not seem to be the intent.	GAMA recommends the FAA search and replace “airplane” with “aircraft” where not used intentionally.	<b>Accepted</b> 1. Corrections were incorporated in Section 3.2. See comment number #2. 2. Typo” light” changed to “flight”.
9. Universal	Page 5, Section 3.2	Last sentence – should the word “light” be replaced with “flight”?		Last sentence – should the word “light” be replaced with “flight”?	<b>Accepted.</b> Word was changed to “flight”.
10. GAMA	Page 5 Section 3.2	GAMA also questions the value of this paragraph.	The paragraph reads as though the degraded mode needs to provide the same level of usability as the non-degraded mode. As stated on page 5, paragraph 3., “RTCA DO-334, Minimum Operational Performance Standards (MOPS) for Solid-State Strapdown Attitude and Heading Reference Systems (AHRS), indicates the degraded mode can support cruise flight, climbs, descents,	Remove paragraph.	<b>Not Accepted.</b> In response to the question about the value of the paragraph, the degraded mode will need to provide much of the same usability as the primary modes (aircraft control) and will require specific evaluation at installation. For example, the degraded mode allows for an overall slight reduction in performance in un-accelerated straight and level flight. It also allows additional error during limited maneuvers for a period of time. For more substantial maneuvers, the

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			<p>holding, and instrument approaches.” Paragraph 3.2 is speculative versus guidance. Paragraph 3 does an adequate task of explaining the function of the degraded mode. In addition, aircraft are equipped with attitude redundancy to assist in flying the aircraft.</p>		<p>TSO-C201 requirement is for the indication to “not provide objectionable” indications. (RTCA/DO-334 para 2.2.4.2.1). Because “objectionable” indications could be interpreted differently in different aircraft types, evaluating the degraded mode during installation in this manner is appropriate.</p>
<p>11. Garmin</p>	<p>Page 6 Section 5.1</p>	<p>This paragraph includes the statement: “The polar region environment is defined within 5° to 30° of the north or south pole.”</p>	<p>The basis for defining the polar region in this manner is unclear. This definition seems to suggest the polar region is a band around the Earth from +60 to +85 degrees of latitude in the Northern Hemisphere and from -60 to -85 degrees of latitude in the Southern Hemisphere. It would appear that the intent is to indicate that the polar region has a lower limit that varies between 60 and 85 degrees latitude depending on the current longitude but this is not clear. For example, the</p>	<p>Recommend: “The polar region environment is defined as the area beginning at 5° to 30° from the pole, depending on location, and extending to either the north or south pole.”</p>	<p><b>Accepted.</b> Changes were incorporated in section 5.1.</p>

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			Northern polar region extends much farther south in the Canadian area than in the European area.		
12. GAMA	Page 6 Section 5.1	This paragraph includes the statement: <i>“The polar region environment is defined within 5° to 30° of the north or south pole.”</i>	The basis for defining the polar region in this manner is unclear. This definition seems to suggest the polar region is a band around the Earth from +60 to +85 degrees of latitude in the Northern Hemisphere and from -60 to -85 degrees of latitude in the Southern Hemisphere. It would appear that the intent is to indicate that the polar region has a lower limit that varies between 60 and 85 degrees latitude depending on the current longitude but this is not clear. For example, the Northern polar region extends much farther south in the Canadian area than in the European area.	GAMA recommends the FAA revise to state: “The polar region environment is defined as the area beginning at 5° to 30° from the pole, depending on location, and extending to either the north or south pole.”	<b>Accepted.</b> Changes were incorporated in section 5.1.

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13. Garmin	Page 6 Section 5.1.1	This paragraph states: “If the aircraft’s TC does not contain limitations prohibiting flight in the Polar Regions, a flight test demonstration should be conducted in the applicable region for new installations.”	This paragraph could be interpreted to mean that a flight test is the only means to perform testing in the Polar Region. Additionally, this paragraph could be interpreted to mean that such a flight test must be performed for each aircraft TC/STC that utilizes a particular AHRS article. As long as the AHRS article has been shown to work in the polar regions either through simulation or flight testing, an aircraft flight test should not be necessary.	Recommend: “If the AHRS article is intended to be installed in aircraft operating in the Polar Regions, it must have been shown to operate properly in these regions. Acceptable methods of showing proper operation include, but are not limited to, flight test demonstration, evidence of previous successful flight test demonstration, or simulation data.”	<b>Partially Accepted.</b> Language regarding airworthiness certification for polar operations is updated to allow typically accepted methods of compliance for follow on installations. However, consistent with current practice, the first time a new design AHRS is installed in an aircraft, airworthiness approval of the new AHRS article will require flight test versus simulation or analysis. Subsequent installations or minor changes to the AHRS articles may use methods other than flight test consistent with established current practice.
14. GAMA	Page 6 Section 5.1.1	This paragraph states: “If the aircraft’s TC does not contain limitations prohibiting flight in the Polar Regions, a flight test demonstration should be conducted in the applicable region for new installations.”	This paragraph could be interpreted to mean that a flight test is the only means to perform testing in the Polar Region. Additionally, this paragraph could be interpreted to mean that such a flight test must be performed for each aircraft TC/STC that	GAMA recommends the language read: “If the AHRS article is intended to be installed in aircraft operating in the Polar Regions, it must have been shown to operate properly in these regions. Acceptable methods of showing proper operation include, but are not limited to, flight test demonstration,	<b>Partially Accepted.</b> See response for comment #13.

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			<p>utilizes a particular AHRS article. As long as the AHRS article has been shown to work in the Polar Regions either through simulation or flight testing, an aircraft flight test should not be necessary.</p>	<p>evidence of previous successful flight test demonstration, or simulation data.”</p>	
<p>15. Embraer</p>	<p>Page 6 Section 5.1.1</p>	<p>1) The guidance should make clear that aircraft/AHRS to be approved for operation in a portion of the defined Polar Region should be subjected to compliance demonstration within that part of the Polar Region</p> <p>2) Means of compliance must not be restricted to flight testing, but should also include analysis or simulation, depending on the aircraft/AHRS equipment operation, AHRS equipment qualification and aircraft system installation.</p>	<p>1) All aircraft that operate in, at least, part of what was defined as being the “polar region environment” should be required to demonstrate compliance with the applicable polar operation requirements.</p> <p>2) Means of compliance should also consider analysis and simulation depending on the aircraft /AHRS equipment operation, AHRS equipment qualification and aircraft system installation . Currently there are several aircraft that operate in part of the polar region environment</p>	<p>The text passage: “If the aircraft’s TC does not contain limitations prohibiting flight in the Polar Region , a flight test demonstration should be conducted in the applicable region for new installations .”</p> <p>should be changed to:</p> <p>“If the aircraft’s TC: (i) does not contain limitations prohibiting flight in the Polar Regions ; or (ii) permits operation in portions of the Polar Region then flight test demonstration, analysis or simulation should be conducted, for new installations. The applicable means of compliance will be</p>	<p><b>Partially Accepted.</b> See response for comment #13.</p>

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			<p>and adequate performance has been demonstrated by analysis and/or simulation. Some of these demonstrations have been performed based on performance specifications provided by the equipment manufacturer, when engineering judgment reveals that the overall performance in polar regions is not dependent on the equipment installation. Stating that demonstration should only be accomplished through flight testing would create an unreasonable burden to the aircraft OEMs, since adequate performance can be demonstrated through other means.</p>	<p>selected based on the aircraft /AHRS equipment operation, AHRS equipment qualification and aircraft system installation.”</p>	
<p>16. Embraer</p>	<p>Page 7 Section 5.1.5</p>	<p>Depending on the AHRS system design, aircraft operation and the Flightdeck philosophy, an aural annunciation for the AHRS performance may not be necessary,</p>	<p>Embraer understands, in accordance with FAA AC 25.1322-1, that conditions that require an alert depend on the specific system and airplane design, and overall flight-</p>	<p>The text passage: “If AHRS performance degrades in the polar region an annunciation, both aural and visual, should be provided to the flight crew.” should be changed to: “If</p>	<p><b>Accepted.</b> Changes were incorporated in section 5.1.5</p>

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		but just a visual indication	deck philosophy. Thus, depending on the specific AHRS system design, aircraft operation and its flight-deck philosophy, an aural alert may not be necessary, but just a visual indication, to increase the flight crew awareness, allowing the flight crew the discretion to take the necessary actions.	AHRS performance degrades in the polar region a visual indication should be provided to the flight crew. An aural annunciation may be provided as well, depending on the specific system design and overall flight-deck philosophy.”	
17. GAMA	Page 8 Section 5.3	GAMA requests that the FAA consider removing this paragraph as the AHRS would be tested for this condition in DO-160 testing under the power input section.			<b>Not Accepted.</b> DO-160 testing is not equivalent to installation testing. Issues were found even though DO-160 testing was conducted. The low power evaluation is necessary because the FAA has identified concerns with low power settings causing fluctuations and erroneous orientations of heading and attitude displays.
18. GAMA	Page 8 Section 5.5	GAMA requests the FAA consider either removing or allowing a one-time flight test to a nominal helicopter flight profile and not aircraft specific.	Experience has also shown for both gimballed and MEMS systems, vibration related issues manifest themselves in lab testing. Therefore, a rotorcraft test platform to	Conduct a onetime flight test to a nominal helicopter flight profile. Vibration performance would be validated in the test lab to DO-160 helicopter vibration profiles	<b>Comment Noted.</b> The initial type or supplemental type certification of a unique AHRS on a specific aircraft type will likely require flight test. These determinations are made with the ACO on specific

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			uncover issues should not be required. This places redundant and undue test costs on the final integrator of equipment		programs. Installed performance particularly where aiding systems are used in determination of an attitude solution are model specific. The integration of those type of systems with existing or new aircraft systems does not lend well to a one type lab testing environment. Experience in recent helicopter projects has shown that that using fixed wing service history and TSO bench testing is not a guarantee of performance in a given helicopter design.
19. Universal	Page 8, Section 5.5	There is no reference to the Appendix.		Add "C" as the referenced Appendix	<b>Comment Noted.</b> The original Appendix C was removed for reasons unrelated to this comment.
20. Universal	Page C-1 Section C.4 and C.7	May want to consider being consistent with lower case instructions or upper case (first letter), throughout this table		May want to consider being consistent with lower case instructions or upper case (first letter), throughout this table.	<b>Comment Noted.</b> The original Appendix C was removed for reasons unrelated to this comment
21. GAMA	Pages C-1 to C-4 Appendix C	Under the Pass / Fail Criteria for VFR, the following statement should be changed: "Return to +/- 3° within 5 seconds of Maneuver	If a system slaves back from an error of 6 degrees back to 3 degrees in 5 seconds, it is slaving at 0.6 degrees per second. This is a very high and	GAMA requests it be changed to "Return to +/- 3° within 1 minute of Maneuver completion"	<b>Not Accepted.</b> The original Appendix C was removed for reasons unrelated to this comment. Removal from this AC does not constitute elimination of their use by the

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		completion”.	unusual rate for an AHRS.		FAA for rotorcraft certification.
22. GAMA	Page C4 Appendix C	GAMA recommends the FAA allow TC or STC holder flexibility for verification of the dynamic flight profile. The intent is to show the MEMS aiding source used does not drive off under a dynamic helicopter flight profile. The mandated use of a truth reference needs clarification or should state a truth reference “may” be used.	To align with other FAA documents that provide this sort of flexibility	GAMA recommends the FAA modify the note to; Note: Required Data A calibrated attitude and heading truth source may be used against the test indicator. The data may be recorded using a data acquisition system, video recording and test notes. In addition, some test environments may require a mechanical G meter, production airspeed indicator, and a production altimeter in assessing maneuver performance. Alternatively a simplified means for assessing pass/fail for VFR Only may be acceptable. However, the following will need to be addressed; Method to Establish Pitch and Roll Horizon References:  i. Establish external references (typically on the windscreen) for pitch and roll. The location should take into account viewer parallax. This marking	<b>Not Accepted.</b> The original Appendix C was removed for reasons unrelated to this comment.

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				<p>reference should also take into account the pass/fail criteria noted in the table.</p> <p>ii. In addition, prior to each maneuver, the unaccelerated straight and level flight pitch and roll should be marked on the indicator and windscreen against the reference conditions. The objective is that at the completion of the maneuver that the attitude system shows the same relative pitch indication and roll reference within the specified tolerance.</p>	