# AC 20-136B (Public Coordination)
# Comment and Disposition Matrix

<table>
<tr><th>Para</th><th>Commenter/ Organization</th><th>Comment Summary</th><th>Proposed Resolution</th><th>Disposition</th></tr>
<tr><td>1.b</td><td>Garmin</td><td> Excerpt from draft AC: <blockquote>This AC is not mandatory and does not constitute a regulation. However, if you use the means described in this AC to comply with 14 CFR §§ 23.1306, 25.1316, 27.1316, and 29.1316, you must follow it in its entirety.</blockquote> The guidance in the AC body includes the terms “must” and “should”; consequently it is unclear exactly what “means described in this AC” must be followed “entirely”. </td><td> This AC should provide guidance regarding the terms “must” and “should” to make it clear what guidance must be followed entirely and what guidance is optional. For example, AC 20-172 paragraph 1-1.c includes the statements: <blockquote>The term “must” is used to indicate mandatory requirements when following the guidance in this AC. The terms “should” and “recommend” are used when following the guidance is recommended but not required to comply with this AC.</blockquote></td><td> Accepted. Added new paragraph 1.c: c. The term “must” is used to indicate mandatory requirements when following the guidance in this AC in its entirety. The terms “should” and “recommend” are used when following the guidance is recommended but not required to comply with this AC. </td></tr>
</table>

| | | | | |
|---|---|---|---|---|
| 6.c.(2)(a)<br><br>6.c.(2)(b) | Garmin | The following excerpt from draft AC 6.c.(2)(a) discusses redundancy for Level A systems:<br><br>> Redundancy alone cannot protect against lightning because the lightning-generated electromagnetic fields, conducted currents and induced currents in the aircraft can simultaneously induce transients in all electrical wiring on an aircraft.<br><br>The following excerpt from draft AC 6.c.(2)(b) discusses redundancy for Level B and C systems:<br><br>> …redundant external sensors may mitigate direct lightning attachment damage, if there is acceptable separation between the sensors to prevent damage to multiple sensors so that the function is maintained.<br><br>Multiple external sensors in a system that independently support Level A functions should also be allowed to take credit for redundancy.<br><br>There are limited cases when redundancy may help a system that is subject to direct lightning attachments and the system is spatially separated on the aircraft such that all redundant systems may not be struck by lightning at the certification level (defined by lightning zones) or at all. In these cases transients resulting from both direct and indirect effects of lightning must be considered.<br><br>Example 1 might be a left and right smart air data probe located in zone 1A, that provide primary air data information. For the purpose of system functional loss or malfunction it would be reasonable to assume that both probes would not be subject to the 200KA strike in a single lightning event. If there was a split in the lightning channel that did strike both probes then the 200KA would be split between the probes. Conservatively 50% on each side could be assumed so long as there are no failure modes from a single strike at 100% impacting both sides; i.e. both sides are totally independent from each other. A single strike at 200KA associated with lightning zone 1A must be evaluated for direct effects of lightning.<br><br>(comment continued in following row) | The quoted 6.c.(2)(a) excerpt should be removed.<br><br>Recommend adding the following to 6.c.(2) such that it is applicable to Level A, B, and C systems:<br><br>> There are limited cases where redundancy may help those systems that are subject to direct lightning attachments and the system is spatially separated on the aircraft such that all redundant systems may not be struck at the same time or struck to the same Certification level. Redundancy alone cannot protect against the indirect effects of lightning because the electromagnetic fields and structural IR voltages can interact, at the same time, with all electrical wiring aboard an aircraft since the indirect effects of lightning can cause a common mode failure. However, redundancy can provide protection against direct effects of lightning, for example, damage to an external sensor, if there is acceptable separation between redundant sensors to prevent common mode damage and the associated interfacing electronics to ensure the function is maintained.<br><br>Citing one of the examples provided in the "Comment Summary" column also may be appropriate. | Not Accepted.<br><br>First, there is no method defined in FAA or industry guidance to divide the lightning amplitude for spatially separated attachment points. The proposal by the commenter allows applicants to make this division, without any acceptable guidance on how to make this division.<br><br>Second, while multiple lightning strikes to an aircraft during a single flight are rare, they occur and are foreseeable. The commenter is proposing a compliance approach for a system that performs functions with catastrophic failure conditions that is based on the expectation that lightning-related failures can occur when lightning strikes, and that relies on avoiding adverse effects assuming the aircraft is not struck again on the same flight. This approach is not intended for systems with catastrophic failure conditions.<br><br>Third, if this approach was accepted, then the applicant would have to assess the reliability and integrity of the system assuming that lightning would damage one or more channels of the redundant system. The FAA and industry have intentionally avoided adding lightning to the reliability and integrity assessment required by other regulations, such as 14 CFR §23.1309. That is one reason why the regulations such as 14 CFR § 23.1306 were adopted as specific stand-alone regulations. |

| | | | | |
|---|---|---|---|---|
| 6.c.(2)(a)<br>6.c.(2)(b)<br>Con't | | Example 2 might be strikes to antennas. In some aircraft non-restorable loss of NAV and COM is considered catastrophic. There are numerous antennas that can support both VHF and NAV functions on the aircraft. Spatial separation where redundant antennas in zone 2A (not in zone 1) that are subject to swept stroke are located on the top and bottom of the fuselage (typical of VHF antennas installations) is considered sufficient separation that a strike to both antennas does not need to be considered. The same is true for separation between VHF antenna (top or bottom of fuselage) and VOR antenna that is typically mounted on the vertical stabilizer. When considering spatial separation of antennas as mitigation, the systems connected to these antennas still must meet level A requirement from indirect effects of lightning. | | |
| 6.c.(2)(b) | Garmin | Excerpt from draft AC 6.c.(2)(b):<br>…If so, these systems should be designated as Level A systems. <u>One example is the situation where multiple aircraft Level B and C systems are connected to a single, non-redundant power bus, where the lightning effects on the power bus could result in failure or malfunction of the systems</u>…<br>The <u>underlined</u> example is not a realistic example as system safety analysis under 2x.1309 would not allow a single point failure leading to catastrophic failure condition to occur. | Suggest removing the quoted excerpt or add an explanation that this is for illustration purpose only or a design that would be allowed under 2x.1309.<br>Alternative suggested example if the failure of multiple level B/C can be CAT:<br>An example might be that multiple level B and C systems are on redundant power busses where transfer of power to the cross-side bus may be controlled by an electrical/electronic system that may prevent the transfer of power during the same lightning event that takes down one of the redundant power busses. In this example, one side bus may fail from the lightning event and the equipment /wiring, controlling the transfer, may be co-located in the same area and subject to failure also at the same time. In this example the power source would need to meet Level A OR if the power sources were Level B/C then the system transferring the power would be required to be Level A. | Accepted.<br>Deleted the quoted excerpt from § 6.c.(2)(b). |

| | | | | |
|---|---|---|---|---|
| 6.g.(1) | Garmin | The current AC20-136A (reference paragraph 4.e.(1)) has text that allows failure of a system at higher Equipment Transient Design Levels (ETDLs). This is an important clarification to maintain for systems with multiple functions with differing criticality and to verify that the functional upset does not occur at the ETDL appropriate for the criticality of those functions. As an example it is acceptable to have failure of a Level C function when the system is tested to the Level A ETDL requirements.<br><br>The preamble for the 14 CFR 23.1306, 25.1316, 27.1316 and 29.1316 (new lightning rule) had some clarification on this also on page 33132 in response to Garmin comments on systems with multiple functions. The FAA agreed with Garmin's position and clarified that the other functions supported by the system would not be required to "automatically" return to normal operation.<br><br>As an example, a system that has a function whose failure is considered catastrophic and another function whose failure is considered major would require the system to be tested to ETDL that is derived based on Level A requirements with no adverse affect on the function whose failure is considered catastrophic. During this test it would be acceptable for the function whose failure is considered to be major to be upset or for the equipment to sustain damage. The damage must not result in a condition that would be considered catastrophic. However the major function in this example must not be adversely affected when tested to ETDL derived from Level C requirements. | Recommend adding the following to 6.g.(1):<br><br>The ETDLs for a specific system depend on the anticipated system and wiring installation locations on the aircraft, the expected shielding performance of the wire bundles and structure, and the system criticality. Systems may have multiple functions with their failures having different criticalities. For these systems, the testing should be performed to the ETDL associated with the highest criticality. During this test the functions whose failure has the highest criticality must not be adversely affected. Other functions whose failures are of lower criticality within the system may be upset or sustain permanent damage. The criticality of the failure conditions resulting from the damage must be lower than the highest criticality that set the ETDL for the test. Additionally each of these lower criticality functions must not be adversely affected at the appropriate ETDL associated with their respective criticality.<br><br>Citing the example provided in the "Comment Summary" column also may be appropriate. | Partially Accepted.<br><br>Changed paragraph 8.g.3 as shown below.<br><br>We agree that non-Level A system equipment interfacing with Level A systems must be evaluated as a part of the Level A system-level verification process to ensure that equipment will not adversely affect the critical functions by that system. The evaluation should consider potential failure/upset condition of the non-Level A system equipment that will adversely affect the functions with catastrophic failures performed by the Level A system. Although equipment is qualified to their respective non-level A qualification levels is generally accepted as sufficient, equipment qualification may not fully address the certification applicant's system certification aspects.<br><br>We don't agree to add the recommend wordings to paragraph 6.g.(1) since the paragraph discusses Establish Equipment Transient Design Levels (ETDLs) and Aircraft Actual Transient Levels (ATLs).<br><br>However, the intent of this comment can be achieved by adding sentences to paragraph 8.g.3 to read:<br><br>8.g.(3) You should evaluate any system effects observed during the qualification tests to ensure they do not adversely affect the system's continued performance. The Level A system perfor mance should be evaluated for functions of which failures or malfunctions would prevent the continued safe flight and landing of the aircraft. Other functions performed by the system of which failures or malfunctions would reduce the capability of the aircraft or the ability of the flightcrew to respond to an adverse operating condition should be evaluated using the guidance in section **9**. You should obtain the cognizant ACO approval of your evaluation. |
| | Cessna Aircraft Company | Cessna Aircraft Company appreciates the FAA's consideration of our comments. Cessna Aircraft Company has no comment on this issue at this time. | | Acknowledged |

| | | | | |
|---|---|---|---|---|
| 6 f. (2) page 6<br><br>8 g.(2) page 14 | Marc Ponçon / Eurocopter | The present AC 136B proposal is unclear on how transient on equipment interface and wire bundle current have to be used in the process.<br>(see Discussion and Position on next rows)<br><br>§ 6 f. (2) states:<br><br>"…You may determine the lightning transients in terms of the wire bundle current, or the open circuit voltage and the short circuit current appearing at system wiring and equipment interface circuits."<br><br>Then the document addresses ETDL and ATL without detailing the considered parameter, therefore keeping the possibility to run the process with equipment interface transients (Voc/Isc) or wire bundle currents.<br><br>§ 8 g. (2) states:<br><br>"You should verify the ETDLs using single stroke, multiple stroke, and multiple burst tests on the system wire bundles. Use waveform sets and test levels for the defined ETDLs. Show that the system operates within the defined pass/fail criteria during these tests. No equipment damage should occur during these system tests or during single stroke pin injection tests using the defined ETDLs." | Complete § 6 f. (2) as follows:<br><br>"You may determine the lightning transients in terms of the wire bundle current, or the open circuit voltage and the short circuit current appearing at system wiring and equipment interface circuits. *Combining the two approaches should allow a consolidated and comprehensive test data base to be elaborated, which will be more appropriate for the demonstration of complex level A system.*"<br><br>Modify § 8 g. (2) as follows:<br><br>"You should verify the ETDL using single stroke, multiple stroke, and multiple burst *current injection* tests on the system wire bundles *and single stroke pin to case test on a sample of the pin of the equipment constituting a level A system*. Use waveform sets and test levels for the defined ETDLs. Show that the system *complies with* the defined pass/fail criteria during these tests. *In particular,* no equipment damage should occur during these __tests__." | Not Accepted.<br><br>This AC is not intended to describe all potential methods for determining the actual transient levels on the aircraft systems, nor is it intended to define detailed test methods for applying the transients to the systems in the laboratory tests. This AC is intended to guide the user to determine aircraft actual transient levels and compare these to appropriate system laboratory test waveforms and amplitudes. The detailed description of these tests approaches are provided in SAE ARP5415 and ARP5416, which are referenced in this AC.<br><br>The proposals by the commenter are one approach for achieving the intent above, but not the only approach. |

| | | | | |
|---|---|---|---|---|
| 6 f. (2) page 6<br><br>8 g.(2) page 14<br><br>Con't | Marc Ponçon / Eurocopter | <u>Discussion</u>:<br><br>From § 6 f. (2) it seems that Voc/Isc **<u>or</u>** wire bundle current can be used alone or in combination to define the Lightning transient environment associated with the system.<br><br>Then § 8 g.(2) starts indicating test on systems wire bundle is the only method for ETDL verification. But two sentences later it mentions that damages aspects may be verified with pin to case test.<br><br>So two main questions may be raised:<br><br>- For aircraft measurements:<br>If wire bundle current is used alone, how to handle the complexity of modern harnesses while measuring on aircraft? Indeed at low frequency the branches, loading and shield connection aspects of most harnesses will make the measurement of bundle current near the equipment connector totally irrelevant for representing the actual threat at equipment interface (i.e. transient developed along the bundle and reaching the pin of the equipment).<br>It could be then recommended to measure on the core wire and per bundle going at the same loading extremity in the system, but it is very likely to result in an unpractical test.<br><br>- For system test:<br>If Voc/Isc was used for aircraft measurement, typically to overcome the problem mentionned above, what is the procedure to define the associated wire bundle current to be injected on wire bundles during single stroke, multiple stroke, and multiple burst tests, which obviously are mandatory for level A system demonstration. | | |

| | | | | |
|---|---|---|---|---|
| 6 f.(2) page 6<br><br>8g.(2) page 14<br><br>Con’t | Marc Ponçon / Eurocopter | Position:<br><br>My position is that for Level A systems, both wire bundle current and pin to case approaches should be considered insufficient by itself and, until some more detailed methodologies have been proposed, and preferably well established in SAE2 and Eurocae WG31 groups, on how to use one or the other alone, both measurements should be performed on aircraft in order to allow a consolidated and comprehensive test measurement set to be elaborated. From that measurement set the most relevant test levels should be derived for both bundles and equipment interface circuits. Both pin to case and wire bundle tests should then be run on level A equipment and systems in order to guaranty a minimum level of tolerance to pin transient damage and bundle transient current upset. | | |

FAA POC: Mr. Lee Nguyen 202-385-4676 or lee.nguyen@faa.gov