Notice of Proposed Amendment 2014-16

High-intensity radiated fields (HIRF) and lightning

RMT.0223 (MDM.024) & RMT.0224 (MDM.025) — 25.6.2014

EXECUTIVE SUMMARY

This Notice of Proposed Amendment (NPA) addresses a safety and regulatory coordination issue related to High-intensity radiated fields (HIRF) and lightning.

Aircraft electrical and electronic equipment can be susceptible to adverse effects from electromagnetic radiation and lightning. With the increased use of critical and essential electrical/electronic systems on aircraft, coupled with the development and use of non-metallic structural materials that are more 'transparent' to electromagnetic radiation and have low electrical conductivity, it has been recognised for many years that HIRF and lightning standards must be enhanced to counter the growing threat.

In the field of product certification, EASA is currently reliant upon raising Certification Review Items (CRIs) to introduce Special Conditions (SCs) and Interpretative Material based on JAA interim policies. The approach proposed in this NPA is largely based on the results of the Electromagnetic Effect Harmonisation Working Group (EEHWG). It relies on previous work conducted by EUROCAE and the Society of Automotive Engineers and is coordinated with the FAA to ensure the highest possible level of harmonisation.

EASA considers this NPA necessary on the basis of Article 2 of Regulation (EC) No 216/2008 and, in particular, paragraphs 1 (high uniform level of safety) and 2(e) (cooperation with third countries). The essential requirements for airworthiness, as outlined in Annex I to Regulation (EC) No 216/2008, stipulate in particular in paragraph 2.c.1. that '…no unsafe condition must occur from exposure to phenomena such as […] lightning, high frequency radiated fields, […] reasonably expected to occur during product operation.'.

This NPA proposes to amend CS-23, CS-25, CS-27 and CS-29 introducing provisions for protection against HIRF and lightning, and introduce new general AMCs in the AMC-20 series related to the above new requirements.

The proposed changes are expected to reduce regulatory burden and improve harmonisation.

Applicability	
Affected regulations and decisions:	CS-23, CS-25, CS-27, CS-29, AMC-20
Affected stakeholders:	Applicants for TC/STC or change
Driver/origin:	Safety, Regulatory coordination
Reference:	JAA INT POLs 23/1, 23/3, 25/2, 25/4, 27&29/1

Process Map	
Concept Paper:	No
Terms of Reference:	10.2.2012
Rulemaking group:	No
RIA type:	Light
Technical consultation during NPA drafting:	No
Duration of NPA consultation:	3 months
Review group:	No
Focussed consultation:	No
Publication date of the Decision:	2015/Q3

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1. Procedural information

1.1. The rule development procedure

The European Aviation Safety Agency (hereinafter referred to as the 'Agency') developed this Notice of Proposed Amendment (NPA) in line with Regulation (EC) No 216/2008[1] (hereinafter referred to as the 'Basic Regulation') and the Rulemaking Procedure[2].

This rulemaking activity is included in the Agency's 4-year Rulemaking Programme under RMT.0223 (MDM.024) and RMT.0224 (MDM.025).

The proposals in this NPA have been developed by the Agency, based on joint progress in the Electromagnetic Effect Harmonisation Working Group (EEHWG), to which industry contributed. Therefore, drafting groups were not deemed necessary. It is hereby submitted for consultation of all interested parties[3].

The process map on the title page contains the major milestones of this rulemaking activity to date and provides an outlook of the timescale of the next steps.

1.2. The structure of this NPA and related documents

Chapter 1 of this NPA contains the procedural information related to this task. Chapter 2 (Explanatory Note) explains the core technical content. Chapter 3 contains the proposed text for the new requirements. Chapter 4 contains the Regulatory Impact Assessment showing which options were considered and what impacts were identified, thereby providing the detailed justification for this NPA.

1.3. How to comment on this NPA

Please submit your comments using the automated **Comment-Response Tool (CRT)** available at **http://hub.easa.europa.eu/crt/**[4].

The deadline for submission of comments is **25 September 2014.**

1.4. The next steps in the procedure

Following the closing of the NPA public consultation period, the Agency will review all comments.

The outcome of the NPA public consultation will be reflected in the respective Comment-Response Document (CRD).

The Agency will publish the CRD with the Decision.

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1 Regulation (EC) No 216/2008 of the European Parliament and the Council of 20 February 2008 on common rules in the field of civil aviation and establishing a European Aviation Safety Agency, and repealing Council Directive 91/670/EEC, Regulation (EC) No 1592/2002 and Directive 2004/36/EC (OJ L 79, 19.3.2008, p. 1), as last amended by Commission Regulation (EU) No 6/2013 of 8 January 2013 (OJ L 4, 9.1.2013, p. 34).

2 The Agency is bound to follow a structured rulemaking process as required by Article 52(1) of the Basic Regulation. Such process has been adopted by the Agency's Management Board and is referred to as the 'Rulemaking Procedure'. See Management Board Decision concerning the procedure to be applied by the Agency for the issuing of Opinions, Certification Specifications and Guidance Material (Rulemaking Procedure), EASA MB Decision 01-2012 of 13 March 2012.

3 In accordance with Article 52 of the Basic Regulation and Articles 5(3) and 6 of the Rulemaking Procedure.

4 In case of technical problems, please contact the CRT webmaster (crt@easa.europa.eu).

2. Explanatory Note

Background and regulation history

HIRF:

1. The electromagnetic HIRF environment results from the transmission of electromagnetic energy from radar, radio, television, and other ground-based, shipborne, or airborne radio frequency (RF) transmitters. This environment has the capability of adversely affecting the operation of aircraft electric and electronic systems.

2. Although the HIRF environment did not pose a significant threat to earlier generations of aircraft, in the late 1970s designs for civil aircraft first started to be developed that included flight-critical electronic controls, electronic displays, and electronic engine controls, such as those used in military aircraft. These systems are more susceptible to the adverse effects of operation in the HIRF environment. Accidents and incidents on civil aircraft with flight-critical electrical and electronic systems have also brought attention to the need to protect these critical systems from HIRF.

3. Concern for the protection of electrical and electronic systems in aircraft has increased substantially in the last decades because of:

   (a) the greater dependence on electrical and electronic systems performing functions required for the continued safe flight and landing of the aircraft;

   (b) the reduced electromagnetic shielding afforded by some composite materials used in aircraft designs;

   (c) the increase in susceptibility of electrical and electronic systems to HIRF because of increased data bus or processor operating speeds, higher density integrated circuits and cards, and greater sensitivities of electronic equipment;

   (d) expanded frequency usage, especially above 1 gigahertz (GHz);

   (e) the increased severity of the HIRF environment because of an increase in the number and power of RF transmitters; and

   (f) the adverse effects experienced by some aircraft when exposed to HIRF.

4. The first certification HIRF environment was developed in Europe to support the establishment of a Special Condition addressing the protection of critical and essential systems from the effect of external radiations for the Airbus A320. In 1987, the FAA contracted with the Department of Defence Electromagnetic Compatibility Analysis Center (ECAC) (currently the Joint Spectrum Center) to research and define the U.S. HIRF environment to be used for the certification of aircraft and the development of Technical Standard Orders (TSOs). In February 1988, the FAA and the JAA tasked the Society of Automotive Engineers (SAE) and the European Organization for Civil Aviation Equipment (EUROCAE) to develop Acceptable Means of Compliance (AMC) and Guidance Material to support the FAA and JAA efforts to develop HIRF certification requirements. In response, one panel reviewed and revised the assumptions used for ECAC's definition of an HIRF environment and published several iterations of that HIRF environment for fixed-wing aircraft based on revised assumptions. Another panel prepared advisory material to support the FAA/JAA's rulemaking efforts.

5. Subsequently, in the early 1990s the JAA and the FAA agreed that the proposed HIRF certification requirements needed further international harmonisation before a rule could be adopted.

6. As a result, the JAA in coordination with the FAA established the Electromagnetic Effects Harmonisation Working Group (EEHWG) under the Aviation Rulemaking Advisory Committee on Transport Airplane and Engine Issues (57 FR 58843, December 11, 1992) and tasked it to develop HIRF certification requirements for

aircraft. The EEHWG expanded the existing HIRF environments developed by the ECAC with the SAE-AE4R/EUROCAE WG-33 Committees to include HIRF environments appropriate for aircraft certified under Part/JAR-23, 25, 27, and 29.

7. In 1994, The EEHWG received HIRF electromagnetic environment data on European transmitters from European governments. The EEHWG converted the U.S. and European data into a set of harmonised HIRF environments, prepared draft Advisory Circular/Advisory Material Joint (AC/AMJ), and also prepared a harmonised JAA draft HIRF NPA and an FAA draft HIRF NPRM (Notice of Proposed Rulemaking).

8. In November 1997, the EEHWG adopted a set of HIRF environments agreed on by the JAA, the FAA, and industry participants. The HIRF environments contained in these proposed rules reflected the HIRF environments adopted by the EEHWG. The information contained in this NPA is based on the draft NPA/NPRM documents.

9. The current requirements CS 23.1309, CS 25.1309, CS 27.1309, and CS 29.1309 provide general certification requirements applicable to the installation of all aircraft systems and equipment, but they do not include specific certification requirements for protection against HIRF, except CS 23.1309(e), whose requirements are very general. Because of the lack of specific HIRF certification requirements, Special Conditions (SCs) to address HIRF protection have been imposed on applicants seeking issuance of a Type Certificate (TC), change to TC (including Supplemental Type Certificate (STC)), since 1986. Applicants have to show compliance using the external HIRF environment as defined in HIRF SCs and/or categories of the ED-14G Section 20 for critical and essential systems.

Lightning:

10. In the 1960s, regulations applicable to lightning protection for aircraft design, construction, and fuel systems were adopted for aircraft certified under FAR 23, 25, 27 and 29. The regulations required that the aircraft be protected against catastrophic effects of lightning, but did not have specific requirements for electrical and electronic system lightning protection. At that time, most aircraft were designed with mechanical systems, or simple electrical and electronic systems. Airframe components were made from aluminium materials, with high electrical conductivity, and offered good protection against lightning.

11. In the late 1970s, large aeroplanes designed according to JAR-25 introduced more complex electrical and electronic systems. For example, flight-critical electronic primary flight controls, electronic primary flight displays, and full-authority electronic engine controls became commonplace. At this time, the JAA began to impose lightning protection requirements for critical and essential electrical and electronic systems through SCs, when appropriate, for JAR-25 aeroplane certification projects.

12. As electrical and electronic systems became more common on JAR-25 certified aeroplanes, the JAA issued JAR 25.1316, specifically requiring protection for electrical and electronic systems on JAR-25 large aeroplanes. This regulation, in effect today as CS 25.1316, requires lightning protection for electrical and electronic systems based on the consequences of failure for functions these systems perform. The current requirement provides specific considerations that the applicant must design in order to validate that the electrical and electronic systems and functions are protected from the effects of lightning.

13. The current CS-25 for lightning protection focusses on protection of electrical and electronic systems that perform critical and essential functions. This is now considered outdated as it is no longer compatible or consistent with the latest classification concepts, terminology, and practices used in lightning certification. CS-23, CS-27 and CS-29 are less prescriptive, and require the applicant only to ‘consider’ lightning. While the focus on protection of electrical and electronic systems that perform critical or essential functions was fundamental to the wording of earlier airworthiness standards regarding systems, this proposal focusses on the effects that failure

conditions would have on aircraft safety. The Agency proposes that lightning protection design required for each aircraft be determined by the type of electrical and electronic systems installed on the aircraft, and how critical the system or function is to either continued safe flight and landing, or the aircraft capability and flight crew's ability to respond to adverse operating conditions.

2.1. Overview of the issues to be addressed

14. The JAA adopted part of the regulatory proposals with a JAR requirement for large aeroplanes (JAR 25.1316) and through the following Interim Policies:

— JAA INT/POL/23/1 Protection from the Effects of HIRF and INT/POL/23/3 Lightning Protection; Indirect Effects for Small Aeroplanes;

— JAA INT/POL/25/2 Protection from the Effects of HIRF and INT/POL/25/4 Lightning Protection; Indirect Effects for Large Aeroplanes;

— JAA INT/POL/27&29/1 Protection from the Effects of HIRF for Small and Large Rotorcraft.

The Agency has adopted JAR 25.1316 as CS 25.1316 and the JAA Interim Policies via Certification Review Items as Special Conditions and/or Guidance Material.

15. The FAA has already adopted the proposals in their regulations with new paragraphs in 14.CFR.Parts, as follows:

— For Lightning - 23.1306 (Amdt 23-61), 25.1316 (Amdt 25-134), 27.1316 (Amdt 27-46), 29.1316(Amdt 29-53) and AC 20-136B, dated Aug/Sep 2011.

— For HIRF - 23.1308 (Amdt 23-57), 25.1317 (Amdt 25-122), 27.1317 (Amdt 27-42), 29.1317 (Amdt 29-49) and AC 20-158, dated Jul/Sep 2007. The Agency is also aware of a new draft FAA AC 20-158A, which was subject to FAA public consultation until April 2014. The Agency has reviewed this draft and compared it to the new AMC 20-158 proposed in this NPA. No significant differences were found.

16. Some differences in implementation of the EEHWG recommendations between the Agency's proposals and those of the FAA should be noted. In particular:

— for level A systems, FAA issued HIRF requirements allowing a transition period up to 1 December 2012, where the reuse of a compliance demonstration based on the former FAA SCs was allowed. This has now expired. The Agency has not introduced this transition provision as the existing CRIs are already closely aligned with the proposed rules.

— for Level B/C systems the Agency and FAA refer to different revisions of ED-14G/DO-160G due to the different time of their respective regulation. This results in different HIRF environments being applied during the equipment tests. Applicants should be aware of this difference and ensure testing is performed to meet the more stringent requirements.

2.2. Objectives

The overall objectives of the EASA system are defined in Article 2 of the Basic Regulation. This proposal will contribute to the achievement of the overall objectives by addressing the issues outlined in Chapter 2 of this NPA.

The specific objective of this proposal are:

1. To update the CSs and AMC-20 to incorporate changes in HIRF & Lightning standards based on the recommendations from the EEHWG but duly amended to reflect recent developments. This will enable the Agency to fulfil its obligation under Article 19 of the Basic Regulation to maintain the CSs to reflect the state of the art and best practice.

2. To establish consistent standards for HIRF & lightning protection for electrical and electronic systems across different aircraft categories.
3. To provide greater harmonisation between the FAA and EASA in matters of HIRF & lightning protection.

2.3. Summary of the Regulatory Impact Assessment (RIA)

A light RIA has been performed (see Section 4), which concludes that Option 3 is recommended ('Amend CSs and AMC-20'). Overall, the proposals will have no significant impact on safety and will not create any social or environmental impacts. The proposals will ensure that the EASA CSs & GM reflect the state of the art, will provide greater harmonisation with the FAA, and will streamline the certification process to reduce the burden on both the Agency and applicants.

2.4. Overview of the proposed amendments

The following paragraphs detail the proposed changes. They are based on the outputs from both the EEHWG reports and the FAA regulations.

***CS-23*:**

1. CS 23.1306(a) is created for Level A systems exposed to lightning. (Note: For definitions refer to AMC 20-136 Table 1)

   CS 23.1306(b) is created for Level B/C systems exposed to lightning.
2. CS 23.1308(a) is created for Level A systems exposed to HIRF. (Note: For definitions refer to AMC 20-158 Table 1)

   CS 23.1308(b) is created for Level B systems exposed to HIRF.

   CS 23.1308(c) is created for Level C systems exposed to HIRF.
3. CS 23.1309(e) is amended by deleting the reference to the HIRF and lightning strikes as critical environment and atmospheric conditions.
4. CS-23 Appendix K is created to introduce the HIRF environments and equipment test levels.

Note:

The ToR for RMT.0498 (Reorganisation of Part 23 and CS-23), was published in October 2013. One of the objectives of this task is to reorganise CS-23 to make a single set of Certification Specifications for aeroplanes in the range from CS-LSA up to CS-23, that:

1) contain requirements based on proportionate performance, complexity and type of operation;

2) make certification specifications for light aeroplanes less susceptible to changes as a result of technological developments or new compliance-showing methods by defining design-independent safety objectives;

3) are complemented by acceptable consensus standards that contain the detailed technical requirements to meet the safety objectives set by the certification specifications.

Therefore, prior to final publication, the Agency will coordinate the outcome of this NPA on HIRF and lightning with the principles and conclusions of RMT.0498 on a reorganised CS-23 and Part 23.

***CS-25*:**

5. CS 25.1316 is amended to align with the most recent wording and to suppress sub-paragraph (c) related to means of compliance.
6. CS 25.1317(a) is created for Level A systems exposed to HIRF.

   CS 25.1317(b) is created for Level B systems exposed to HIRF.

   CS 25.1317(c) is created for Level C systems exposed to HIRF.
7. CS-25 Appendix R is created to introduce the HIRF environments and equipment test levels.

CS-27:

8. CS 27.610(d)(4) is amended by deleting the reference to lightning.
9. CS 27.1309(d) is deleted.
10. CS 27.1316(a) is created for Level A systems exposed to lightning.

    CS 27.1316(b) is created for Level B/C systems exposed to lightning.
11. CS 27.1317(a) is created for Level A systems exposed to HIRF.

    Sub paragraph CS 27.1317(a)(4) is created to take into account the higher field level exposure experienced by small rotorcraft flying at low level in VFR flight.

    CS 27.1317(b) is created for Level B hazardous systems exposed to HIRF.

    CS 27.1317(c) is created for Level C systems exposed to HIRF.
12. CS-27 Appendix D is created to introduce the HIRF environments and equipment test levels.

***CS-29*:**

13. CS 29.610(d)(4) is amended by deleting the reference to lightning.
14. CS 29.1309(h) is recommended to be completely deleted.
15. CS 29.1316(a) is created for Level A systems exposed to lightning.

    CS 29.1316(b) is created for Level B/C systems exposed to lightning.
16. CS 29.1317(a) is created for Level A systems exposed to HIRF.

    Sub paragraph CS 29.1317(a)(4) is created to take into account the higher field level exposure experienced by large rotorcraft flying at low level in VFR flight.

    CS 29.1317(b) is created for Level B systems exposed to HIRF.

    CS 29.1317(c) is created for Level C systems exposed to HIRF.
17. CS-29 Appendix E is created to introduce the HIRF environments and equipment test levels.

***AMC-20*:**

18. AMC 20-136 is created as general acceptable means of compliance and guidance material for the protection of electrical and electronic systems from the effect of lightning.
19. AMC 20-158 is created as general acceptable means of compliance and guidance material for the protection of electrical and electronic systems from the effect of HIRF.

3. Proposed amendments

The text of the amendment is arranged to show deleted text, new or amended text as shown below:

(a) deleted text is marked with ~~strike through~~;

(b) new or amended text is highlighted in grey;

(c) an ellipsis (…) indicates that the remaining text is unchanged in front of or following the reflected amendment.

3.1. Draft Certification Specifications (Draft EASA Decision)

CS-23

Proposal 1: Create CS 23.1306 as follows:

CS 23.1306 Electrical and Electronic System Lightning Protection
(See AMC 20-136)

(a) Each electrical and electronic system that performs a function for which failure would prevent the continued safe flight and landing of the aeroplane must be designed and installed so that:

(1) the function is not adversely affected during and after the time the aeroplane is exposed to lightning; and

(2) the system automatically recovers normal operation of that function in a timely manner after the aeroplane is exposed to lightning.

(b) For aeroplanes approved for instrument flight rules operation, each electrical and electronic system that performs a function for which failure would reduce the capability of the aeroplane or the ability of the flight crew to respond to an adverse operating condition, must be designed and installed so that the function recovers normal operation in a timely manner after the aeroplane is exposed to lightning.

Proposal 2: Create CS 23.1308 as follows:

CS 23.1308 High-Intensity Radiated Fields (HIRF) Protection
(See AMC 20-158)

(a) Each electrical and electronic system that performs a function whose failure would prevent the continued safe flight and landing of the aeroplane must be designed and installed so that:

(1) the function is not adversely affected during and after the time the aeroplane is exposed to HIRF environment I, as described in Appendix K;

(2) the system automatically recovers normal operation of that function, in a timely manner, after the aeroplane is exposed to HIRF environment I, as described in Appendix K; and

(3) the system is not adversely affected during and after the time the aeroplane is exposed to HIRF environment II, as described in Appendix K.

(b) Each electrical and electronic system that performs a function whose failure would significantly reduce the capability of the aeroplane or the ability of the flight crew to respond to an adverse operating condition must be designed and installed so that the system is not adversely affected when the equipment providing the function is exposed to equipment HIRF test level 1 or 2, as described in Appendix K.

(c) Each electrical and electronic system that performs a function whose failure would reduce the capability of the aeroplane or the ability of the flight crew to respond to an adverse operating condition must be designed and installed so that the system is not adversely affected when the equipment providing the function is exposed to equipment HIRF test level 3, as described in Appendix K.

Proposal 3: Amend CS 23.1309 as follows:

CS 23.1309 Equipment, Systems and installations

...

(e) In showing compliance with this paragraph with regard to the electrical power system and to equipment design and installation, critical environmental and atmospheric conditions, ~~*including radio frequency energy and the effects (both direct and indirect) of lightning strikes,*~~ must be considered. For electrical generation, distribution, and utilisation equipment required by or used in complying with this subpart, the ability to provide continuous, safe service under foreseeable environmental conditions may be shown by environmental tests, design analysis, or reference to previous comparable service experience on other aeroplanes

...

Proposal 4: Create CS-23 Appendix K as follows:

Appendix K — HIRF Environments and Equipment HIRF Test Levels

This appendix specifies the HIRF environments and equipment HIRF test levels for electrical and electronic systems under CS 23.1308. The field strength values for the HIRF environments and equipment HIRF test levels are expressed in root-mean-square units measured during the peak of the modulation cycle.

(a) HIRF environment I is specified in the following table:

Table I — HIRF Environment I

FREQUENCY	FIELD STRENGTH (V/m)	
	PEAK	AVERAGE
10 kHz – 2 MHz	50	50
2 MHz – 30 MHz	100	100
30 MHz – 100 MHz	50	50
100 MHz – 400 MHz	100	100
400 MHz – 700 MHz	700	50
700 MHz – 1 GHz	700	100
1 GHz – 2 GHz	2000	200
2 GHz – 6 GHz	3000	200
6 GHz – 8 GHz	1000	200
8 GHz – 12 GHz	3000	300
12 GHz – 18 GHz	2000	200
18 GHz – 40 GHz	600	200

In this table, the higher field strength applies at the frequency band edges.

(b) HIRF environment II is specified in the following table:

Table II — HIRF Environment II

FREQUENCY	FIELD STRENGTH (V/m)	
	PEAK	AVERAGE
10 kHz – 500 kHz	20	20
500 kHz – 2 MHz	30	30
2 MHz – 30 MHz	100	100
30 MHz – 100 MHz	10	10
100 MHz – 200 MHz	30	10
200 MHz – 400 MHz	10	10
400 MHz – 1 GHz	700	40
1 GHz – 2 GHz	1300	160
2 GHz – 4 GHz	3000	120
4 GHz – 6 GHz	3000	160
6 GHz – 8 GHz	400	170
8 GHz – 12 GHz	1230	230
12 GHz – 18 GHz	730	190
18 GHz – 40 GHz	600	150

In this table, the higher field strength applies at the frequency band edges.

(c) Equipment HIRF Test Level 1.

(1) From 10 kilohertz (kHz) to 400 megahertz (MHz), use conducted susceptibility tests with continuous wave (CW) and 1 kHz square wave modulation with 90 per cent depth or greater. The conducted susceptibility current must start at a minimum of 0.6 milliamperes (mA) at 10 kHz, increasing 20 decibels (dB) per frequency decade to a minimum of 30 mA at 500 kHz.

(2) From 500 kHz to 40 MHz, the conducted susceptibility current must be at least 30 mA.

(3) From 40 MHz to 400 MHz, use conducted susceptibility tests, starting at a minimum of 30 mA at 40 MHz, decreasing 20 dB per frequency decade to a minimum of 3 mA at 400 MHz.

(4) From 100 MHz to 400 MHz, use radiated susceptibility tests at a minimum of 20 volts per meter (V/m) peak with CW and 1 kHz square wave modulation with 90 per cent depth or greater.

(5) From 400 MHz to 8 gigahertz (GHz), use radiated susceptibility tests at a minimum of 150 V/m peak with pulse modulation of 4 per cent duty cycle with a 1 kHz pulse repetition frequency. This signal must be switched on and off at a rate of 1 Hz with a duty cycle of 50 per cent.

(d) *Equipment HIRF Test Level 2.* Equipment HIRF test level 2 is HIRF environment II in Table II of this appendix reduced by acceptable aircraft transfer function and attenuation curves. Testing must cover the frequency band of 10 kHz to 8 GHz.

(e) *Equipment HIRF Test Level 3.*

(1) From 10 kHz to 400 MHz, use conducted susceptibility tests, starting at a minimum of 0.15 mA at 10 kHz, increasing 20 dB per frequency decade to a minimum of 7.5 mA at 500 kHz.

(2) From 500 kHz to 40 MHz, use conducted susceptibility tests at a minimum of 7.5 mA.

(3) From 40 MHz to 400 MHz, use conducted susceptibility tests, starting at a minimum of 7.5 mA at 40 MHz, decreasing 20 dB per frequency decade to a minimum of 0.75 mA at 400 MHz.

(4) From 100 MHz to 8 GHz, use radiated susceptibility tests at a minimum of 5 V/m.

CS-25

Proposal 5: Amend CS 25.1316 by deleting the existing text and replacing with the following:

CS 25.1316 Electrical and Electronic System Lightning Protection

(See AMC 20-136)

~~(a) For functions whose failure would contribute to or cause a condition that would prevent the continued safe flight and landing of the aeroplane, each electrical and electronic system that performs these functions must be designed and installed to ensure that the operation and operational capabilities of the systems to perform these functions are not adversely affected when the aeroplane is exposed to lightning.~~

~~(b) For functions whose failure would contribute to or cause a condition that would reduce the capability of the aeroplane or the ability of the flight crew to cope with adverse operating conditions, each electrical and electronic system that performs these functions must be designed and installed to ensure that these functions can be recovered in a timely manner after the aeroplane is exposed to lightning.~~

~~(c) Compliance with the lightning protection criteria prescribed in subparagraphs (a) and (b) of this paragraph must be shown for exposure to a severe lightning environment. The aeroplane must be designed for and it must be verified that aircraft electrical/electronic systems are protected against the effects of lightning by:~~

~~(1) Determining the lightning strike zones for the aeroplane;~~

~~(2) Establishing the external lightning environment for the zones;~~

~~(3) Establishing the internal environment;~~

~~(4) Identifying all the electrical and electronic systems that are subject to the requirements of this paragraph, and their locations on or within the aeroplane;~~

~~(5) Establishing the susceptibility of the systems to the internal and external lightning environment;~~

~~(6) Designing protection; and~~

~~(7) Verifying that the protection is~~

~~adequate.~~

(a) Each electrical and electronic system that performs a function, for which failure would prevent the continued safe flight and landing of the aeroplane, must be designed and installed so that:

(1) the function is not adversely affected during and after the time the aeroplane is exposed to lightning; and

(2) the system automatically recovers normal operation of that function in a timely manner after the aeroplane is exposed to lightning.

(b) Each electrical and electronic system that performs a function, for which failure would reduce the capability of the aeroplane or the ability of the flight crew to respond to an adverse operating condition, must be designed and installed so that the function is recovered in a timely manner after the aeroplane is exposed to lightning.

Proposal 6: Create CS 25.1317 as follows:

CS 25.1317 High-Intensity Radiated Fields (HIRF) Protection
(See AMC 20-158)

(a) Each electrical and electronic system that performs a function whose failure would prevent the continued safe flight and landing of the aeroplane must be designed and installed so that:

(1) The function is not adversely affected during and after the time the aeroplane is exposed to HIRF environment I, as described in Appendix R;

(2) The system automatically recovers normal operation of that function, in a timely manner, after the aeroplane is exposed to HIRF environment I, as described in Appendix R; and

(3) The system is not adversely affected during and after the time the aeroplane is exposed to HIRF environment II, as described in Appendix R.

(b) Each electrical and electronic system that performs a function whose failure would significantly reduce the capability of the aeroplane or the ability of the flight crew to respond to an adverse operating condition must be designed and installed so that the system is not adversely affected when the equipment providing the function is exposed to equipment HIRF test level 1 or 2, as described in Appendix R.

(c) Each electrical and electronic system that performs a function whose failure would reduce the capability of the aeroplane or the ability of the flight crew to respond to an adverse operating condition must be designed and installed so that the system is not adversely affected when the equipment providing the function is exposed to equipment HIRF test level 3, as described in Appendix R.

Proposal 7: Create CS-25 Appendix R as follows:

Appendix R — HIRF Environments and Equipment HIRF Test Levels

This appendix specifies the HIRF environments and equipment HIRF test levels for electrical and electronic systems under CS 25.1317. The field strength values for the HIRF environments and equipment HIRF test levels are expressed in root-mean-square units measured during the peak of the modulation cycle.

(a) HIRF environment I is specified in the following table:

Table I — HIRF Environment I

FREQUENCY	FIELD STRENGTH (V/m)	
	PEAK	AVERAGE
10 kHz – 2 MHz	50	50
2 MHz – 30 MHz	100	100
30 MHz – 100 MHz	50	50
100 MHz – 400 MHz	100	100
400 MHz – 700 MHz	700	50
700 MHz – 1 GHz	700	100
1 GHz – 2 GHz	2000	200
2 GHz – 6 GHz	3000	200
6 GHz – 8 GHz	1000	200
8 GHz – 12 GHz	3000	300
12 GHz – 18 GHz	2000	200
18 GHz – 40 GHz	600	200

In this table, the higher field strength applies to the frequency band edges.

(b) HIRF environment II is specified in the following table:

Table II — HIRF Environment II

FREQUENCY	FIELD STRENGTH (V/m)	
	PEAK	AVERAGE
10 kHz – 500 kHz	20	20
500 kHz – 2 MHz	30	30
2 MHz – 30 MHz	100	100
30 MHz – 100 MHz	10	10
100 MHz – 200 MHz	30	10
200 MHz – 400 MHz	10	10
400 MHz – 1 GHz	700	40
1 GHz – 2 GHz	1300	160
2 GHz – 4 GHz	3000	120
4 GHz – 6 GHz	3000	160
6 GHz – 8 GHz	400	170
8 GHz – 12 GHz	1230	230
12 GHz – 18 GHz	730	190
18 GHz – 40 GHz	600	150

In this table, the higher field strength applies to the frequency band edges.

(c) *Equipment HIRF Test Level 1.*

(1) From 10 kilohertz (kHz) to 400 megahertz (MHz), use conducted susceptibility tests with continuous wave (CW) and 1 kHz square wave modulation with 90 per cent depth or greater. The conducted susceptibility current must start at a minimum of 0.6 milliamperes (mA) at 10 kHz, increasing 20 decibels (dB) per frequency decade to a minimum of 30 mA at 500 kHz.

(2) From 500 kHz to 40 MHz, the conducted susceptibility current must be at least 30 mA.

(3) From 40 MHz to 400 MHz, use conducted susceptibility tests, starting at a minimum of 30 mA at 40 MHz, decreasing 20 dB per frequency decade to a minimum of 3 mA at 400 MHz.

(4) From 100 MHz to 400 MHz, use radiated susceptibility tests at a minimum of 20 volts per meter (V/m) peak with CW and 1 kHz square wave modulation with 90 per cent depth or greater.

(5) From 400 MHz to 8 gigahertz (GHz), use radiated susceptibility tests at a minimum of 150 V/m peak with pulse modulation of 4 per cent duty cycle with a 1 kHz pulse repetition frequency. This signal must be switched on and off at a rate of 1 Hz with a duty cycle of 50 per cent.

(d) *Equipment HIRF Test Level 2.* Equipment HIRF Test Level 2 is HIRF environment II in Table II of this appendix reduced by acceptable aircraft transfer function and attenuation curves. Testing must cover the frequency band of 10 kHz to 8 GHz.

(e) *Equipment HIRF Test Level 3.*

(1) From 10 kHz to 400 MHz, use conducted susceptibility tests, starting at a minimum of 0.15 mA at 10 kHz, increasing 20 dB per frequency decade to a minimum of 7.5 mA at 500 kHz.

(2) From 500 kHz to 40 MHz, use conducted susceptibility tests at a minimum of 7.5 mA.

(3) From 40 MHz to 400 MHz, use conducted susceptibility tests, starting at a minimum of 7.5 mA at 40 MHz, decreasing 20 dB per frequency decade to a minimum of 0.75 mA at 400 MHz.

(4) From 100 MHz to 8 GHz, use radiated susceptibility tests at a minimum of 5 V/m.

CS-27

Proposal 8: Amend CS 27.610 as follows:

CS 27.610 Lightning and static electricity protection

…

(d) The electrical bonding and protection against lightning and static electricity must:

…

(4) Reduce to an acceptable level the effects of ~~*lightning and*~~ static electricity on the functioning of essential electrical and electronic equipment.

…

Proposal 9: Delete CS 27.1309(d):

CS 27.1309 Equipment, systems, and installations

…

~~(d) In showing compliance with subparagraph (a), (b), or (c), the effects of lightning strikes on the rotorcraft must be considered in accordance with CS 27.610.~~

…

Proposal 10: Create CS 27.1316 as follows:

CS 27.1316 Electrical and electronic system lightning protection

(a) Each electrical and electronic system that performs a function whose failure would prevent the continued safe flight and landing of the rotorcraft, must be designed and installed so that:

(1) the function is not adversely affected during and after the time the rotorcraft is exposed to lightning; and

(2) the system automatically recovers normal operation of that function in a timely manner after the rotorcraft is exposed to lightning.

(b) For rotorcraft approved for instrument flight rules operation, each electrical and electronic system that performs a function, for which failure would reduce the capability of the rotorcraft or the ability of the flight crew to respond to an adverse operating condition, must be designed and installed so that the function recovers normal operation in a timely manner after the rotorcraft is exposed to lightning.

Proposal 11: Create CS 27.1317 as follows:

CS 27.1317 High-Intensity Radiated Fields (HIRF) Protection

(a) Each electrical and electronic system that performs a function whose failure would prevent the continued safe flight and landing of the rotorcraft, must be designed and installed so that:

(1) the function is not adversely affected during and after the time the rotorcraft is exposed to HIRF environment I, as described in Appendix D;

(2) the system automatically recovers normal operation of that function, in a timely manner, after the rotorcraft is exposed to HIRF environment I, as described in Appendix D;

(3) the system is not adversely affected during and after the time the rotorcraft is exposed to HIRF environment II, as described in Appendix D; and

(4) each function required during operation under visual flight rules is not adversely affected during and after the time the rotorcraft is exposed to HIRF environment III, as described in Appendix D.

(b) Each electrical and electronic system that performs a function whose failure would significantly reduce the capability of the rotorcraft or the ability of the flight crew to respond to an adverse operating condition must be designed and installed so that the system is not adversely affected when the equipment providing the function is exposed to equipment HIRF test level 1 or 2, as described in Appendix D.

(c) Each electrical and electronic system that performs a function whose failure would reduce the capability of the rotorcraft or the ability of the flight crew to respond to an adverse operating condition must be designed and installed so that the system is not adversely affected when the equipment providing the function is exposed to equipment HIRF test level 3, as described in Appendix D.

Proposal 12: Create CS-27 Appendix D as follows:

Appendix D — HIRF Environments and Equipment HIRF Test Levels

This appendix specifies the HIRF environments and equipment HIRF test levels for electrical and electronic systems under CS 27.1317. The field strength values for the HIRF environments and equipment HIRF test levels are expressed in root-mean-square units measured during the peak of the modulation cycle.

(a) HIRF environment I is specified in the following table:

Table I — HIRF Environment I

FREQUENCY	FIELD STRENGTH (V/m)	
	PEAK	AVERAGE
10 kHz – 2 MHz	50	50
2 MHz – 30 MHz	100	100
30 MHz – 100 MHz	50	50
100 MHz – 400 MHz	100	100
400 MHz – 700 MHz	700	50
700 MHz – 1 GHz	700	100
1 GHz – 2 GHz	2000	200
2 GHz – 6 GHz	3000	200
6 GHz – 8 GHz	1000	200
8 GHz – 12 GHz	3000	300
12 GHz – 18 GHz	2000	200
18 GHz – 40 GHz	600	200

In this table, the higher field strength applies to the frequency band edges.

(b) HIRF environment II is specified in the following table:

Table II — HIRF Environment II

FREQUENCY	FIELD STRENGTH (V/m)	
	PEAK	AVERAGE
10 kHz – 500 kHz	20	20
500 kHz – 2 MHz	30	30
2 MHz – 30 MHz	100	100
30 MHz – 100 MHz	10	10
100 MHz – 200 MHz	30	10
200 MHz – 400 MHz	10	10
400 MHz – 1 GHz	700	40
1 GHz – 2 GHz	1300	160
2 GHz – 4 GHz	3000	120
4 GHz – 6 GHz	3000	160
6 GHz – 8 GHz	400	170

8 GHz – 12 GHz	1230	230
12 GHz – 18 GHz	730	190
18 GHz – 40 GHz	600	150

In this table, the higher field strength applies to the frequency band edges.

(c) HIRF environment III is specified in the following table:

Table III — HIRF Environment III

FREQUENCY	FIELD STRENGTH (V/m)	
	PEAK	AVERAGE
10 kHz – 100 kHz	150	150
100 kHz – 400 MHz	200	200
400 MHz – 700 MHz	730	200
700 MHz – 1 GHz	1400	240
1 GHz – 2 GHz	5000	250
2 GHz – 4 GHz	6000	490
4 GHz – 6 GHz	7200	400
6 GHz – 8 GHz	1100	170
8 GHz – 12 GHz	5000	330
12 GHz – 18 GHz	2000	330
18 GHz – 40 GHz	1000	420

In this table, the higher field strength applies at the frequency band edges.

(d) *Equipment HIRF Test Level 1*.

(1) From 10 kilohertz (kHz) to 400 megahertz (MHz), use conducted susceptibility tests with continuous wave (CW) and 1 kHz square wave modulation with 90 per cent depth or greater. The conducted susceptibility current must start at a minimum of 0.6 milliamperes (mA) at 10 kHz, increasing 20 decibels (dB) per frequency decade to a minimum of 30 mA at 500 kHz.

(2) From 500 kHz to 40 MHz, the conducted susceptibility current must be at least 30 mA.

(3) From 40 MHz to 400 MHz, use conducted susceptibility tests, starting at a minimum of 30 mA at 40 MHz, decreasing 20 dB per frequency decade to a minimum of 3 mA at 400 MHz.

(4) From 100 MHz to 400 MHz, use radiated susceptibility tests at a minimum of 20 volts per meter (V/m) peak with CW and 1 kHz square wave modulation with 90 per cent depth or greater.

(5) From 400 MHz to 8 gigahertz (GHz), use radiated susceptibility tests at a minimum of 150 V/m peak with pulse modulation of 4 per cent duty cycle with a 1 kHz pulse repetition frequency. This signal must be switched on and off at a rate of 1 Hz with a duty cycle of 50 per cent.

(e) *Equipment HIRF Test Level 2*. Equipment HIRF Test Level 2 is HIRF environment II in Table II of this appendix reduced by acceptable aircraft transfer function and attenuation curves. Testing must cover the frequency band of 10 kHz to 8 GHz.

(f) *Equipment HIRF Test Level 3.*

(1) From 10 kHz to 400 MHz, use conducted susceptibility tests, starting at a minimum of 0.15 mA at 10 kHz, increasing 20 dB per frequency decade to a minimum of 7.5 mA at 500 kHz.

(2) From 500 kHz to 40 MHz, use conducted susceptibility tests at a minimum of 7.5 mA.

(3) From 40 MHz to 400 MHz, use conducted susceptibility tests, starting at a minimum of 7.5 mA at 40 MHz, decreasing 20 dB per frequency decade to a minimum of 0.75 mA at 400 MHz.

(4) From 100 MHz to 8 GHz, use radiated susceptibility tests at a minimum of 5 V/m.

CS-29

Proposal 13: Amend CS 29.610 as follows:

CS 29.610 Lightning and static electricity protection

…

(d) The electrical bonding and protection against lightning and static electricity must:

…

(4) Reduce to an acceptable level the effects of ~~lightning and~~ static electricity on the functioning of essential electrical and electronic equipment.

…

Proposal 14: Delete CS 29.1309(h):

CS 29.1309 Equipment, systems, and installations

…

~~(h) In showing compliance with subparagraph (a), (b), the effects of lightning strikes on the rotorcraft must be considered.~~

…

Proposal 15: Create CS 29.1316 as follows:

CS 29.1316 Electrical and electronic system lightning protection

(a) Each electrical and electronic system that performs a function whose failure would prevent the continued safe flight and landing of the rotorcraft, must be designed and installed so that:

(1) the function is not adversely affected during and after the time the rotorcraft is exposed to lightning; and

(2) the system automatically recovers normal operation of that function in a timely manner after the rotorcraft is exposed to lightning.

(b) Each electrical and electronic system that performs a function whose failure would reduce the capability of the rotorcraft or the ability of the flight crew to respond to an adverse operating condition, must be designed and installed so that the function recovers normal operation in a timely manner after the rotorcraft is exposed to lightning.

Proposal 16: Create CS 29.1317 as follows:

CS 29.1317 High-Intensity Radiated Fields (HIRF) Protection

(a) Each electrical and electronic system that performs a function whose failure would prevent the continued safe flight and landing of the rotorcraft, must be designed and installed so that:

(1) the function is not adversely affected during and after the time the rotorcraft is exposed to HIRF environment I, as described in Appendix E;

(2) the system automatically recovers normal operation of that function, in a timely manner, after the rotorcraft is exposed to HIRF environment I, as described in Appendix E;

(3) the system is not adversely affected during and after the time the rotorcraft is exposed to HIRF environment II, as described in Appendix E; and

(4) each function required during operation under visual flight rules is not adversely affected during and after the time the rotorcraft is exposed to HIRF environment III, as described in Appendix E.

(b) Each electrical and electronic system that performs a function whose failure would significantly reduce the capability of the rotorcraft or the ability of the flight crew to respond to an adverse operating condition must be designed and installed so that the system is not adversely affected when the equipment providing the function is exposed to equipment HIRF test level 1 or 2, as described in Appendix E.

(c) Each electrical and electronic system that performs a function whose failure would reduce the capability of the rotorcraft or the ability of the flight crew to respond to an adverse operating condition must be designed and installed so that the system is not adversely affected when the equipment providing the function is exposed to equipment HIRF test level 3, as described in Appendix E.

Proposal 17: Create CS-29 Appendix E as follows:

Appendix E — HIRF Environments and Equipment HIRF Test Levels

This appendix specifies the HIRF environments and equipment HIRF test levels for electrical and electronic systems under CS 29.1317. The field strength values for the HIRF environments and equipment HIRF test levels are expressed in root-mean-square units measured during the peak of the modulation cycle.

(a) HIRF environment I is specified in the following table:

Table I — HIRF Environment I

FREQUENCY	FIELD STRENGTH (V/m)	
	PEAK	AVERAGE
10 kHz – 2 MHz	50	50
2 MHz – 30 MHz	100	100
30 MHz – 100 MHz	50	50
100 MHz – 400 MHz	100	100
400 MHz – 700 MHz	700	50
700 MHz – 1 GHz	700	100
1 GHz – 2 GHz	2000	200
2 GHz – 6 GHz	3000	200
6 GHz – 8 GHz	1000	200
8 GHz – 12 GHz	3000	300
12 GHz – 18 GHz	2000	200
18 GHz – 40 GHz	600	200

In this table, the higher field strength applies to the frequency band edges.

(b) HIRF environment II is specified in the following table:

Table II — HIRF Environment II

FREQUENCY	FIELD STRENGTH (V/m)	
	PEAK	AVERAGE
10 kHz – 500 kHz	20	20
500 kHz – 2 MHz	30	30
2 MHz – 30 MHz	100	100
30 MHz – 100 MHz	10	10
100 MHz – 200 MHz	30	10
200 MHz - 400 MHz	10	10
400 MHz - 1 GHz	700	40
1 GHz - 2 GHz	1300	160
2 GHz - 4 GHz	3000	120
4 GHz - 6 GHz	3000	160
6 GHz - 8 GHz	400	170
8 GHz - 12 GHz	1230	230
12 GHz – 18 GHz	730	190

18 GHz - 40 GHz	600	150

In this table, the higher field strength applies to the frequency band edges.

(c) HIRF environment III is specified in the following table:

Table III — HIRF Environment III

FREQUENCY	FIELD STRENGTH (V/m)	
	PEAK	AVERAGE
10 kHz – 100 kHz	150	150
100 kHz – 400 MHz	200	200
400 MHz – 700 MHz	730	200
700 MHz – 1 GHz	1400	240
1 GHz – 2 GHz	5000	250
2 GHz – 4 GHz	6000	490
4 GHz – 6 GHz	7200	400
6 GHz – 8 GHz	1100	170
8 GHz – 12 GHz	5000	330
12 GHz – 18 GHz	2000	330
18 GHz – 40 GHz	1000	420

In this table, the higher field strength applies to the frequency band edges.

(d) Equipment HIRF Test Level 1.

(1) From 10 kilohertz (kHz) to 400 megahertz (MHz), use conducted susceptibility tests with continuous wave (CW) and 1 kHz square wave modulation with 90 per cent depth or greater. The conducted susceptibility current must start at a minimum of 0.6 milliamperes (mA) at 10 kHz, increasing 20 decibels (dB) per frequency decade to a minimum of 30 mA at 500 kHz.

(2) From 500 kHz to 40 MHz, the conducted susceptibility current must be at least 30 mA.

(3) From 40 MHz to 400 MHz, use conducted susceptibility tests, starting at a minimum of 30 mA at 40 MHz, decreasing 20 dB per frequency decade to a minimum of 3 mA at 400 MHz.

(4) From 100 MHz to 400 MHz, use radiated susceptibility tests at a minimum of 20 volts per meter (V/m) peak with CW and 1 kHz square wave modulation with 90 per cent depth or greater.

(5) From 400 MHz to 8 gigahertz (GHz), use radiated susceptibility tests at a minimum of 150 V/m peak with pulse modulation of 4 per cent duty cycle with a 1 kHz pulse repetition frequency. This signal must be switched on and off at a rate of 1 Hz with a duty cycle of 50 per cent.

(e) *Equipment HIRF Test Level 2.* Equipment HIRF test level 2 is HIRF environment II in Table II of this Appendix reduced by acceptable aircraft transfer function and attenuation curves. Testing must cover the frequency band of 10 kHz to 8 GHz.

(f) *Equipment HIRF Test Level 3.*

(1) From 10 kHz to 400 MHz, use conducted susceptibility tests, starting at a minimum of 0.15 mA at 10 kHz, increasing 20 dB per frequency decade to a minimum of 7.5 mA at 500 kHz.

(2) From 500 kHz to 40 MHz, use conducted susceptibility tests at a minimum of 7.5 mA.

(3) From 40 MHz to 400 MHz, use conducted susceptibility tests, starting at a minimum of 7.5 mA at 40 MHz, decreasing 20 dB per frequency decade to a minimum of 0.75 mA at 400 MHz.

(4) From 100 MHz to 8 GHz, use radiated susceptibility tests at a minimum of 5 V/m.

3.2. Draft Acceptable Means of Compliance and Guidance Material (Draft EASA Decision)

Proposal 18: Create AMC 20-136 as follows:

AMC 20-136

Subject: AIRCRAFT ELECTRICAL AND ELECTRONIC SYSTEM LIGHTNING PROTECTION

Content:

1. Purpose

a. This Acceptable Means of Compliance provides information and guidance material on how aircraft electrical and electronic systems can be protected from the effects of lightning. This AMC describes a means, but not the only means to show compliance with Certification Specifications CS 23.1306, 25.1316, 27.1316, and 29.1316, *Electrical and electronic system lightning protection*, as they pertain to aircraft type certification or supplemental type certification.

b. This AMC is not mandatory and does not constitute a regulation. In using the means described in this AMC, it must be followed in all important respects.

c. The verb 'must' is used to indicate mandatory requirements when following the guidance in this AMC in its entirety. The terms 'should' and 'recommend' are used when following the guidance is recommended but not required to comply with this AMC.

2. Applicability

This AMC applies to all applicants for a new type certificate (TC) or a change to an existing TC when the certification basis contains either CS 23.1306, or CS 25.1316, or CS 27.1316, or CS 29.1316.

3. Scope

a. This AMC provides acceptable means of compliance and guidance material for complying with CS 23.1306, CS 25.1316, CS 27.1316, and CS 29.1316 for the effects on electrical and electronic systems due to lightning transients induced or conducted onto equipment and wiring.

b. CS 23.1306, CS 25.1316, CS 27.1316, and CS 29.1316 are also applicable for the effects on electrical and electronic systems when lightning directly attaches to equipment, components, or wiring. This AMC addresses the functional aspects of these effects for aircraft electrical and electronic equipment, components, or wiring. However, this AMC does not address lightning effects such as burning, eroding, and blasting of aircraft equipment, components, or wiring. For showing compliance for these effects, we recommend using ED-113, *Aircraft Lightning Direct Effects Certification*.

c. For information on fuel ignition hazards, see AMC 25.954 and FAA AC 20-53, *Protection of Aircraft Fuel Systems Against Fuel Vapor Ignition Caused By Lightning*. This AMC does not address lightning zoning methods, lightning environment definition, or lightning test methods. For information on lightning zoning methods and lightning environment definition, see *ED-91 and ED-84A*. For information on Fuel Structural Lightning Protection see EUROCAE policy ER-002. For information on lightning test methods, see ED-105A, *Aircraft Lightning Test Methods,* or ED-14G, Section 22, *Lightning Induced Transient Susceptibility*, and Section 23, *Lightning Direct Effects.*

4. Related Material.

a. European Aviation Safety Agency (EASA).

(1). Certification Specifications CS-23: 23.867, 23.901, 23.954, 23.1301, 23.1306, 23.1309, 23.1529

(2). Certification Specifications CS-25: 25.581, 25.901, 25.954, 25.1301, 25.1309, 25.1316, 25.1529

(3). Certification Specifications CS-27: 27.610, 27.901, 27.954, 27.1301, 27.1309, 27.1316, 27.1529

(4). Certification Specifications CS-29: 29.610, 29.901, 29.954, 29.1301, 29.1309, 29.1316, 29.1529

You can get copies of these CS requirements. European Aviation Safety Agency, Postfach 10 12 53, D-50452 Cologne, Germany; telephone +49 221 8999 000; fax: +49 221 8999 099;

Website: http://easa.europa.eu/official-publication/

b. Title 14 of the Code of Federal Regulations (14 CFR).

You can get copies of the following 14 CFR sections from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402-9325. Telephone 202-512-1800, fax 202-512-2250. You can also access copies from the Government Printing Office (GPO), electronic CFR Internet website at www.access.gpo.gov/ecfr/.

Part 23, Airworthiness Standards: Normal, Utility, Acrobatic, and Commuter Category Airplanes:

§ 23.867 Electrical bonding and protection against lightning and static electricity

§ 23.901 Installation

§ 23.954 Fuel system lightning protection

§ 23.1301 Function and installation

§ 23.1309 Equipment, systems, and installations

§ 23.1306 Electrical and electronic system lightning protection

§ 23.1529 Instructions for continued airworthiness

Part 25, Airworthiness Standards: Transport Category Airplanes:

§ 25.581 Lightning protection

§ 25.901 Installation

§ 25.954 Fuel system lightning protection

§ 25.1301 Function and installation

§ 25.1309 Equipment, systems, and installations

§ 25.1316 Electrical and electronic system lightning protection

§ 25.1529 Instructions for continued airworthiness

Part 27, Airworthiness Standards: Normal Category Rotorcraft:

§ 27.610 Lightning and static electricity protection

§ 27.901 Installation

§ 27.954 Fuel system lightning protection

§ 27.1301 Function and installation

§ 27.1309 Equipment, systems, and installations

§ 27.1316 Electrical and electronic system lightning protection

§ 27.1529 Instructions for continued airworthiness

Part 29, Airworthiness Standards: Transport Category Rotorcraft:

§ 29.610 Lightning and static electricity protection

§ 29.901 Installation

§ 29.954 Fuel system lightning protection

§ 29.1301 Function and installation

§ 29.1309 Equipment, systems, and installations

§ 29.1316 Electrical and electronic system lightning protection

§ 29.1529 Instructions for continued airworthiness

c. FAA Advisory Circular/Acceptable Means of Compliance.

(1). AC 20-155, SAE Documents to Support Aircraft Lightning Protection Certification.

(2). AC 21-16, RTCA Document DO-160 Versions D, E, F, and G, Environmental Conditions and Test Procedures for Airborne Equipment.

(3). AC 23-17, Systems and Equipment Guide for Certification of Part 23 Airplanes and Airships.

(4). AC 23.1309-1, System Safety Analysis and Assessment for Part 23 Airplanes.

(5). AC 27-1B, Certification of Normal Category Rotorcraft.

(6). AC 29-2C, Certification of Transport Category Rotorcraft.

You can access copies of these ACs at:

Website: http://www.faa.gov/regulations_policies/advisory_circulars

d. Industry Documents.

Note: The industry documents referenced in this section refer to the current revisions or regulatory authorities accepted revisions.

(1). European Organization for Civil Aviation Equipment (EUROCAE). You can get copies of the following documents from EUROCAE, 102 rue Etienne Dolet, 92240 Malakoff. Telephone: +33 1 40 92 79 30, Fax: +33 1 46 55 62 65,

Website: http://www.eurocae.net.

EUROCAE ED-79A, *Guidelines for Development of Civil Aircraft and Systems.*

EUROCAE ED-14G, *Environmental Conditions and Test Procedures for Airborne*

Equipment.

EUROCAE ED-84A, *Aircraft Lightning Environment and Related Test Waveforms*

EUROCAE ED-91, *Aircraft Lightning Zoning*

EUROCAE ED-105A, *Aircraft Lightning Test Methods*.

EUROCAE ED-113, *Aircraft Lightning Direct Effects Certification*.

(2). RTCA. You can get copies of RTCA/DO-160G, *Environmental Conditions and Test Procedures for Airborne Equipment*, from RTCA, Inc., 1150 18th Street NW, Suite 910, Washington, D.C. 20036. Telephone: +1 202 833 9339, Fax +1 202 833 9434, Website: http://www.rtca.org.

This document is technically equivalent to EUROCAE ED-14G. Anywhere there is a reference to RTCA/DO-160G, EUROCAE ED-14G may be used.

(3). SAE International. You can get copies of the following documents from SAE Customer Service, 400 Commonwealth Drive, Warrendale, PA 15096-0001. Telephone: +1 724 776 4970, Fax: 724-776-0790, Website: www.sae.org.

ARP 4754A, *Guidelines for Development of Civil Aircraft and Systems*. This document is technically equivalent to EUROCAE ED-79A. Anywhere there is a reference to ARP 4754A, EUROCAE ED-79A may be used.

ARP 4761, *Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment*.

ARP 5412B, *Aircraft Lightning Environment and Related Test Waveforms*. This document is technically equivalent to EUROCAE ED-84A. Anywhere there is a reference to ARP 5412A, EUROCAE ED-84A may be used.

ARP 5414A, *Aircraft Lightning Zoning*. This document is technically equivalent to EUROCAE ED-91. Anywhere there is a reference to ARP 5414A, EUROCAE ED-91 may be used.

ARP 5415A, *User's Manual for Certification of Aircraft Electrical/Electronic Systems for the Indirect Effects of Lightning*.

ARP 5416A, *Aircraft Lightning Test Methods*. This document is technically equivalent to EUROCAE ED-105A. Anywhere there is a reference to ARP 5416A, EUROCAE ED-105A may be used.

ARP 5577, *Aircraft Lightning Direct Effects Certification*. This document is technically equivalent to EUROCAE ED-113. Anywhere there is a reference to ARP 5577, EUROCAE ED-113 may be used.

5. Background.

a. Regulatory Applicability. The certification specifications for aircraft electrical and electronic system lightning protection are based on the aircraft's potential for lightning exposure and the consequences of system failure. The regulations require lightning protection of aeroplane/rotorcraft electrical and electronic systems with catastrophic, hazardous, or major failure conditions for aeroplane/rotorcraft certificated under CS-25 and 29. The requirements also apply to CS-23 aeroplanes and CS-27 rotorcraft approved for operations under instrument flight rules. Those CS-23 aeroplanes and CS-27 rotorcraft approved solely for operations under visual flight rules require lightning protection of electrical or electronic systems having catastrophic failure conditions.

b. Regulatory Requirements. Protection against the effects of lightning for aircraft electrical and electronic systems, regardless of whether these are 'indirect' or 'direct' effects of lightning, are addressed under CS 23.1306, 25.1316, 27.1316, and 29.1316. The terms 'indirect' and 'direct' are often used to classify the effects of lightning. However, the regulations do not, and are not intended to, differentiate between the effects of lightning. The focus is to protect aircraft electrical and electronic systems from effects of lightning. The regulations listed in this paragraph introduce several terms which are further explained below, including:

(1) System. A system can include equipment, components, parts, wire bundles, software, and firmware. Electrical and electronic systems consist of pieces of equipment connected by electrical conductors, all of which are required to perform one or more functions.

(2) Function. The specific action of a system, equipment, and flight crew performance aboard the aircraft that, by itself, provides a completely recognizable operational capability. For example, "display aircraft heading to the pilots" is a function. One or more systems may perform a specific function or one system may perform multiple functions.

(3) Adverse Effect. A lightning effect resulting in system failure, malfunction, or misleading information to a degree that is unacceptable for the specific aircraft function or system addressed in the system lightning protection regulations.

(4) Timely Manner. The meaning of "in a timely manner" depends upon the function performed by the system being evaluated, the specific system design, interaction between that system and other systems, and interaction between the system and the flight crew. The definition of "in a timely manner" must be determined for each specific system and for specific functions performed by the system. The applicable definition should be included in the certification plan for review and approval by the certification authorities.

6. Steps for Showing Compliance.

a. The following seven steps describe how compliance with CS 23.1306, CS 25.1316, CS 27.1316, and CS 29.1316 may be shown:

(1) Identify the systems to be assessed.

(2) Determine the lightning strike zones for the aircraft.

(3) Establish the aircraft lightning environment for each zone.

(4) Determine the lightning transient environment associated with the systems.

(5) Establish equipment transient design levels (ETDLs) and aircraft actual transient levels (ATLs).

(6) Verify compliance to the requirements.

(7) Take corrective measures, if needed.

b. Lightning considerations

The steps above should be performed to address lightning transients induced in electrical and electronic system wiring and equipment, and lightning damage to aircraft external equipment and sensors that are connected to electrical and electronic systems, such as radio antennas and air data probes. Additional guidance on lightning protection against lightning damage for external equipment and sensor installations can be found in ED-113.

c. Identify the Systems to be Assessed.

(1) General. The aircraft systems requiring lightning assessment should be identified. Address any lightning-related electrical or electronic system failure that may cause or contribute to an adverse effect on the aircraft. The effects of a lightning strike, therefore, should be assessed in a manner that allows for the determination of the degree to which the aircraft and/or its systems safety may be influenced. This assessment should cover:

(a) All normal aircraft operating modes, stages of flight, and operating conditions; and

(b) All lightning related failure conditions and their subsequent effect on aircraft operations and the flight crew.

(2) Safety Assessment. A safety assessment related to lightning effects should be performed to establish and classify the system failure condition. Based on the failure condition classification established by the safety assessment, the systems should be assigned appropriate lightning certification levels, as shown in Table **1**. The failure condition classifications and terms used in this AMC are consistent with those used in AC 23.1309-1, System Safety Analysis and Assessment for CS-23 Aeroplanes, and AMC 25.1309 for CS-25 Aeroplanes. Further guidance on processes for performing safety assessments can be found in those AMC/AC, AC 27-1B, Certification of Normal Category Rotorcraft, AC 29-2C, Certification of Transport Category Rotorcraft, ED-79A, Guidelines for Development of Civil Aircraft and Systems, and ARP 4761, Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment. The specific aircraft safety assessment related to lightning effects required by CS 23.1306, CS 25.1316, CS 27.1316 and CS 29.1316 takes precedence over the more general safety assessment process described in AC 23.1309-1, AMC 25.1309, AC 27-1B, and AC 29-2C. Lightning effects on electrical and electronic systems are generally assessed independently from other system failures that are unrelated to lightning, and do not need be considered in combination with latent or active failures unrelated to lightning.

Table 1. Lightning Failure Conditions and Certification Levels

Lightning Requirement Provisions From: CS 23.1306, CS 25.1316, CS 27.1316, CS 29.1316	Failure Condition	System Lightning Certification Level
(a) Each electrical and electronic system that performs a function, for which failure would prevent the continued safe flight and landing of the aircraft…	*Catastrophic*	A
(b) Each electrical and electronic system that performs a function, for which failure would reduce the capability of the aircraft or the ability of the flight crew to respond to an adverse operating condition…	*Hazardous* *Major*	B C

(a) Level A Systems. The system safety assessment should consider effects of lightning-related failures or malfunctions on systems with lower failure classification that may affect the function of Level A systems. You should show that any system with wiring connections to a Level A system will not adversely affect the functions with catastrophic failure conditions performed by the Level A system when the *aircraft* is exposed to lightning. 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*.

(b) Level B or C Systems. Simultaneous and common failures due to lightning exposure generally do not have to be assumed for Level B or C systems incorporating redundant, spatially separated installations in the aircraft. This is because aircraft transfer function tests and in-service experience have shown these redundant and spatially separated installations are not simultaneously exposed to the maximum lightning induced transients. For example, 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. Therefore, simultaneous loss of all of these redundant and spatially separated Level B or C systems due to lightning exposure does not need to be considered. However, if multiple Level B or C systems are designed and installed within the same location in the aircraft, or share a common wiring connection, then the combined failure due to lightning exposure should be assessed to determine if the combined failures are catastrophic. If so, these systems should be designated as Level A systems.

(c) Failure Conditions. The safety assessment may show that some systems have different failure conditions in different phases of flight. Therefore, different lightning requirements may have to be applied to the system for different phases of flight. For example, an automatic flight control system may have a catastrophic failure condition for autoland, while automatic flight control system operations in cruise may have a hazardous failure condition.

d. Determine the Lightning Strike Zones for the Aircraft.

The purpose of lightning zoning is to determine those areas of the aircraft likely to experience lightning channel attachment and those structures that may conduct lightning current between lightning attachment points. You should determine the lightning attachment zones for your aircraft configuration, since the zones will be dependent upon the aircraft's geometry, materials, and operational factors. Lightning attachment zones often vary from one aircraft type to another.

Note: ED-91 provides guidance to determine the lightning attachment zones for your aircraft.

e. Establish the Aircraft Lightning Environment for Each Zone.

Zones 1 and 2 identify where lightning is likely to attach and, as a result, the entrance and exit points for current flow through the aircraft. The appropriate voltage waveforms and current components to apply in those zones should be identified. By definition, Zone 3 areas carry lightning current flow between initial (or swept stroke) attachment points, so they may include contributions from all of the current components. We accept analysis to estimate Zone 3 current levels that result from the external environment. The external lightning environment is:

(1) Caused by the lightning flash interacting with the exterior of the aircraft.

(2) Represented by combined waveforms of the lightning current components at the aircraft surface.

Note: ED-84A provides guidance for selecting the lightning waveforms and their applications.

f. Determine the Lightning Transient Environment Associated with the Systems.

(1) The lightning environment, as seen by electrical and electronic systems, consists of voltages and currents produced by lightning current flowing through the aircraft. The voltages and currents that appear at system wiring interfaces result from aperture coupling, structural voltages, or conducted currents resulting from direct attachments to equipment and sensors.

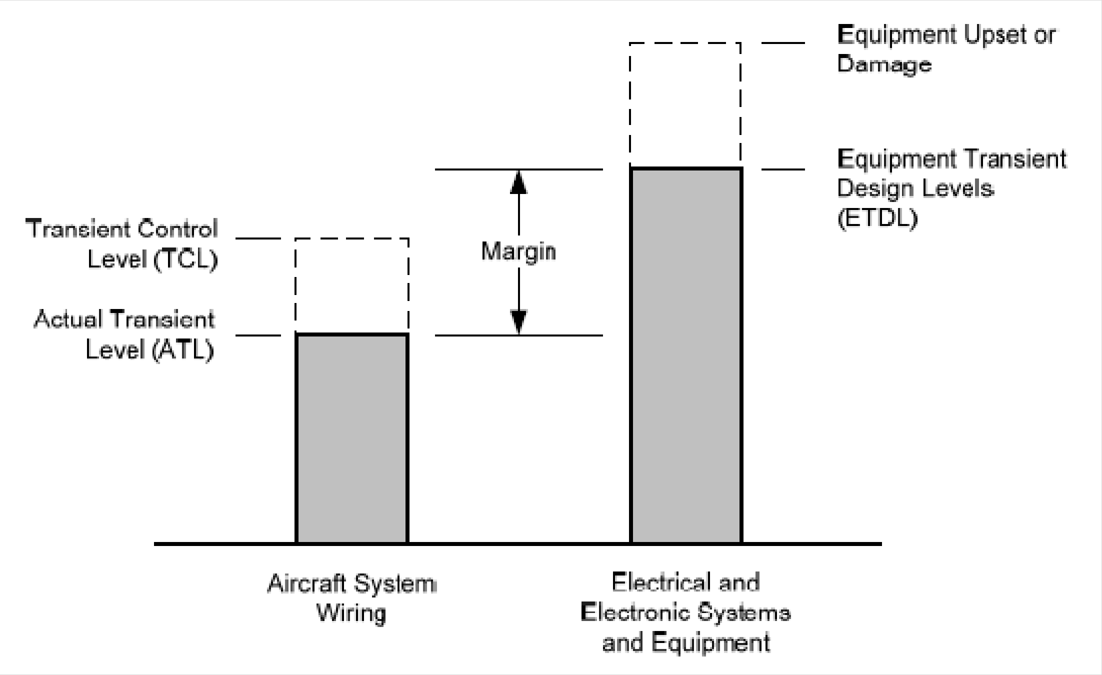
(2) Determine the lightning voltage and current transient waveforms and amplitudes that can appear at the electrical and electronic equipment interface circuits for each system identified in paragraph **6.c**. You may determine the lightning transients in terms of the wire bundle current, or the open circuit voltage and the short circuit current appearing at system wiring and equipment interface circuits. The voltage and current transient waveforms and amplitudes are dependent upon the loop impedances of the system and its interconnecting wiring.

g. Establish Equipment Transient Design Levels (ETDLs) and Aircraft Actual Transient Levels (ATLs). The regulations in CS 23.1306, CS 25.1316, CS 27.1316, and CS 29.1316 define requirements in terms of functional effects that are performed by aircraft electrical and electronic systems. From a design point of view, lightning protection for systems is shared between protection incorporated into the aircraft structure and wiring, and protection incorporated into the equipment. Therefore, requirement allocations for the electrical and electronic system lightning protection can be based on the concept of ETDLs and ATLs.

(1) Determine and specify the ETDLs for the electrical and electronic equipment that make up the systems to be assessed. The ETDLs set qualification test levels for the systems and equipment. They define the voltage and current amplitudes and waveforms that the systems and equipment must withstand without any adverse effects. 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.

(2) The ATLs are the voltage and current amplitudes and waveforms actually generated on the aircraft wiring when the aircraft is exposed to lightning, as determined by aircraft test, analysis, or similarity. The difference between an ETDL and ATL is the margin. Figure **1** shows the relationship among the ATL and ETDL. You should evaluate the aircraft, interconnecting wiring, and equipment protection to determine the most effective combination of ATLs and ETDLs that will provide acceptable margin. Appropriate margins to account for uncertainties in the verification techniques may be required as discussed in paragraph **8.i** of this AMC.

Figure 1. Relationships Among Transient Levels



(3) Typically, you specify the ETDLs prior to aircraft certification lightning tests or analyses to determine the aircraft ATLs. Therefore the expected aircraft transients must be based upon results of lightning tests on existing aircraft, engineering analysis, or knowledgeable estimates. These expected aircraft lightning transient levels are termed transient control levels (TCL). Specify the TCLs voltage and current amplitudes and waveforms based upon the expected lightning transients that would be generated on wiring in specific areas of the aircraft. The TCLs should be equal to or greater than the maximum expected aircraft ATLs. The TCLs for a specific wire bundle depend on the configuration of the aircraft, the wire bundle, and the wire bundle installation. You should design your aircraft lightning protection to meet the specified TCLs.

h. Verify Compliance to the Requirements.

(1) You should show that the systems comply with the applicable requirements of CS 23.1306, CS 25.1316, CS 27.1316, or CS 29.1316.

(2) You should show that the ETDLs exceed the ATLs by the margin established in your certification plan.

(3) Verification may be accomplished by tests, by analysis, or by demonstrating similarity with previously certified aircraft and systems. The certification process for Level A systems is discussed in paragraph **8**. The certification process for Level B and C systems is discussed in paragraph **9**.

(4) Submit your certification plan early in the program to EASA for review. Experience shows, particularly with aircraft using new technology or those that have complex systems, that early agreement on the certification plan benefits both the applicant and EASA. The plan should define acceptable ways to resolve critical issues during the certification process. Analysis and test results during the certification process may warrant modifications in the design or verification methods. When significant changes are necessary, update the certification plan accordingly. The plan may include the items listed in Table **2**.

i. Take Corrective Measures. If tests and analyses show that the system did not meet the pass/fail criteria, review the aircraft, installation or system design and improve protection against lightning.

Table 2. Items Recommended for a Lightning Certification Plan

Item	Discussion
Description of systems	Describe systems' installation, including unusual or unique features; the system failure condition classifications; the operational aspects; lightning attachment zones; lightning environment; preliminary estimate of ETDLs and TCLs; and acceptable margins between ETDLs and ATLs.
Description of compliance method	Describe how to verify compliance. Typically, your verification method includes similarity, analytical procedures, and tests. If using analytical procedures, describe how to verify them. (See paragraph **8.d** of this AMC.)
Acceptance criteria	Determine the pass/fail criteria for each system by analysing how safe the system is. During this safety analysis, assess the aircraft in its

	various operational states; account for the failure and disruption modes caused by the effects of lightning.
Test plans	Plan each test you include as part of your certification process. As an applicant, you can decide if your test plans are separate documents or part of the compliance plan. Your test plans should state the test sequence.

7. Effects of Transients. Lightning causes voltage and current transients to appear on equipment circuits. Equipment circuit impedances and configurations will determine whether lightning transients are primarily voltage or current. These transient voltages and currents can degrade system performance permanently or temporarily. The two primary types of degradation are component damage and system functional upset.

a. Component Damage. This is a permanent condition in which transients alter the electrical characteristics of a circuit. Examples of devices that may be susceptible to component damage include:

(1) Active electronic devices, especially high frequency transistors, integrated circuits, microwave diodes, and power supply components;

(2) Passive electrical and electronic components, especially those of very low power or voltage rating;

(3) Electro-explosive devices, such as squibs and detonators;

(4) Electromechanical devices, such as indicators, actuators, relays, and motors; and

(5) Insulating materials (for example, insulating materials in printed circuit boards and connectors) and electrical connections that can burn or melt.

b. System Functional Upset.

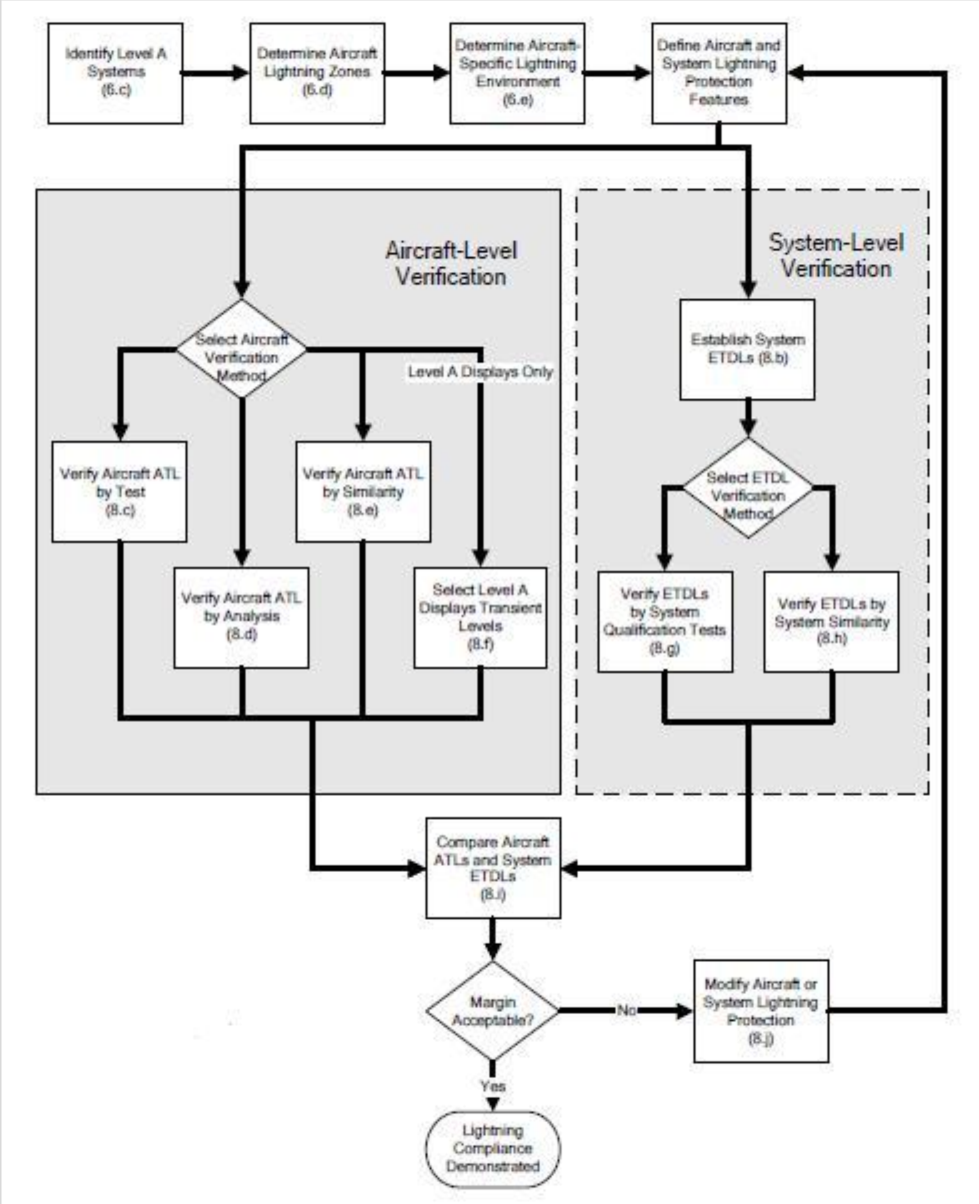
(1) Functional upset is mainly a system problem caused by electrical transients. It may permanently or momentarily upset a signal, circuit, or a system component, which can adversely affect system performance enough to compromise flight safety. A functional upset is a change in digital or analogue state that may or may not require manual reset. In general, functional upset depends on circuit design and operating voltages, signal characteristics and timing, and system and software configuration.

(2) Systems or devices that may be susceptible to functional upset include computers and data/signal processing systems; electronic engine and flight controls; and power generating and distribution systems.

8. Level A System Lightning Certification. Figure **2** illustrates a process that you can use to show that your level A system complies with CS 23.1306, 25.1316, 27.1316, and 29.1316.

a. Identify Level A Systems. Identify your Level A systems as described in paragraph **6.c**. Define the detailed system performance pass/fail criteria. EASA should concur on this criterion before you begin testing or analysing your Level A system. Identify specific equipment, components, sensors, power systems and wiring associated with each Level A system in order to perform the ETDL verification discussed in paragraphs **8.g** and **8.h**.

Figure 2. Typical Compliance Process for Level A Systems



Note: Numbers in parenthesis refer to sections in this AMC.

b. Establish System ETDLs. Establish the aircraft system ETDLs from an evaluation of expected lightning transient amplitudes and waveforms for the system installation, structure and wiring configuration on a specific aircraft. You should establish ETDLs that exceed the ATLs by acceptable margin. In general, the ETDLs for equipment in a complex system will not be the same for all wire bundles connecting them to other equipment in the system. You may use results of lightning tests on existing similar aircraft, engineering analysis, or knowledgeable estimates to establish appropriate system ETDLs. While specific aircraft configurations and system installations may lead to ETDLs that have amplitudes and waveforms different than those defined in ED-14G Section 22, ETDLs are often specified using the information from Section 22. The ETDLs must exceed the ATLs by an acceptable margin.

c. Determine ATLs Using Aircraft Tests. See SAE ARP 5415A, *User's Manual for Certification of Aircraft Electrical/Electronic Systems Against the Indirect Effects of Lightning*, and ED-105A for guidance on how to determine the ATLs.

d. Determine ATLs Using Analysis. See SAE ARP 5415A for guidance on how to analyse aircraft to determine the ATLs. Acceptance of the analysis method you choose depends on the accuracy of the method. You should confirm your analysis method accuracy using experimental data, and gain agreement of your analysis approach from EASA.

e. Determine ATLs Using Similarity.

(1) You may use similarity to determine the ATLs when there are:

(a) Only minor differences between the previously certified aircraft and system installation and the aircraft and system installation to be certified; and

(b) There is no unresolved in-service history of problems related to lightning strikes to the previously certified aircraft.

(2) If significant differences are found that will affect the aircraft ATLs, you should perform more tests and analyses to resolve the open issues.

(3) To use similarity, you should assess the aircraft, wiring, and system installation differences that can adversely affect the system susceptibility. When assessing a new installation, consider differences affecting the internal lightning environment of the aircraft and its effects on the system. The assessment should cover:

(a) Aircraft type, equipment locations, airframe construction, structural materials, and apertures that could affect attenuation of the external lightning environment;

(b) System wiring size, length, and routing; wire types (whether parallel or twisted wires), connectors, wire shields, and shield terminations;

(c) Lightning protection devices such as transient suppressors and lightning arrestors; and

(d) Grounding and bonding.

(4) You cannot use similarity for a new aircraft design with new systems.

f. Determine Transient Levels Using ED-14G Section 22 Guidance for Level A Displays Only.

(1) You may select ETDLs for your Level A display system using guidance in this section, without specific aircraft test or analysis. Level A displays involve functions for which the pilot will be in the loop through pilot/system information exchange. Level A display systems typically include the displays; symbol generators; data concentrators; sensors (such as attitude, air data, and heading sensors); interconnecting wiring; and associated control panels.

(2) This approach should not be used for other Level A systems, such as control systems, because failures and malfunctions of those systems can more directly and abruptly contribute to a catastrophic failure event than display system failures and malfunctions. Therefore, other Level A systems require a more rigorous lightning transient compliance verification program.

(3) You should use the information in Table **3** to evaluate your aircraft and system installation features to select appropriate ETDLs for your system. Table **3** defines test levels for ETDLs, based on ED-14G Section 22, Tables 22-2 and 22-3. Provide EASA with a description of your aircraft and display system installation features and compare these to the information in Table **3** to substantiate the ETDL selected for your aircraft and Level A display system installation. When selecting ETDLs using guidance provided in Table **3**, acceptable margin between anticipated ATLs for display system installations is incorporated in the selected ETDLs.

Table 3. Equipment Transient Design Levels — Level A Displays

ED-14GSection 22 Level	Display System Installation Location
Level 5	Use this level when the equipment under consideration, its associated wire bundles, or other components connected by wiring to the equipment are in aircraft areas exposed to *very severe* lightning transients. These areas are: • Areas with composite materials whose shielding is not very effective; • Areas where there is no guarantee of structural bonding; and • Other open areas where there is little shielding. You can also use this level to cover a broad range of installations. You may need higher ETDLs when there are high current density regions on mixed conductivity structures (such as wing tips, engine nacelle fin, and so on) because the system wiring may divert some of the lightning current. If you are the system designer, apply measures to reduce the need for higher ETDLs.
Level 4	Use this level when the equipment under consideration, its associated wire bundles, or other components connected by wiring to the equipment, are in aircraft areas exposed to *severe* lightning transients. We define these areas as outside the fuselage (such as wings, fairings, wheel wells, pylons, control surfaces, and so on).
Level 3	Use this level when the equipment under consideration, its associated wire bundles, and other components connected by wiring to the equipment are entirely in aircraft areas with *moderate* lightning transients. We define these areas as the inside metal aircraft structure or composite aircraft structure whose shielding without improvements is as effective as metal aircraft structure. Examples of such areas are avionics bays not enclosed by bulkheads, cockpit areas, and locations with large apertures (that is, doors without electromagnetic interference (EMI) gaskets, windows, access panels, and so on). Current-carrying conductors in these areas (such as hydraulic tubing, control cables, wire bundles, metal wire trays, and so on) are not necessarily electrically grounded at bulkheads. When few wires exit the areas, either use a higher level (that is, *Level 4* or *5*) for these wires or offer more protection for these wires.
Level 2	Use this level when the equipment under consideration, its associated wire bundles, and other components connected by wiring to the equipment are entirely in *partially protected* areas. We define these areas as the inside of a metallic or composite aircraft structure whose shielding is as effective as metal aircraft structure, if you take measures to reduce the lightning coupling to wires. Wire bundles in these areas pass through bulkheads, and have shields that end at the bulkhead connector. When a few wires exit these areas, use either a higher level (that is, *Level 3* or *4*) or provide more protection for these wires. Install wire bundles close to the ground plane, to take advantage of other inherent shielding from metallic structures. Current-carrying conductors (such as hydraulic tubing, control cables, metal wire trays, and so on) are electrically grounded at all bulkheads.
Level 1	Use this level when the equipment under consideration, its associated wire bundles, and other components connected by wiring to the equipment are entirely in *well-protected* aircraft areas. We define these areas as

	electromagnetically enclosed.

g. Verify System ETDLs Using System Qualification Tests.

(1) You should identify the equipment, components, sensors, power systems, and wiring associated with the Level A system undergoing ETDL verification tests, specifically considering the system functions whose failures have catastrophic failure consequences. For complex Level A systems, the system configuration may include redundant equipment, multiple power sources, multiple sensors and actuators, and complex wire bundles. Define the system configuration used for the ETDL verification tests. You should obtain EASA approval of your system configuration for ETDL verification tests.

(2) 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. ED-14G Section 22 provides acceptable test procedures and waveform set definitions. In addition, ED-105A provides acceptable test methods for complex and integrated systems.

(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 performance 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 flight crew to respond to an adverse operating condition should be evaluated using the guidance in Section 10. You should obtain EASA approval of your evaluation.

h. Verify System ETDLs Using Existing System Data (Similarity).

(1) You may base your ETDL verification on similarity to previously certified systems without performing more tests. You may do this when:

(a) There are only minor differences between the previously certified system and installation, and the system and installation to be certified;

(b) There are no unresolved in-service system problems related to lightning strikes on the previously certified system; and

(c) The previously certified system ETDLs were verified by qualification tests.

(2) To use similarity to previously certified systems, you should assess differences between the previously certified system and installation and the system and installation to be certified that can adversely affect the system susceptibility. The assessment should cover:

(a) System interface circuits;

(b) Wire size, routing, arrangement (parallel or twisted wires), connector types, wire shields, and shield terminations;

(c) Lightning protection devices such as transient suppressors and lightning arrestors;

(d) Grounding and bonding; and

(e) System software, firmware, and hardware.

(3) If you are unsure how the differences will affect the systems and installations, you should perform more tests and analyses to resolve the open issues.

(4) You should assess every system, even if it uses equipment and installation techniques that have previous certification approval.

(5) You should not use similarity for a new aircraft design with new systems.

i. Verify Compliance to the Requirements. You should compare the verified system ETDLs with the aircraft ATLs and determine if an acceptable margin exists between the ETDLs and ATLs. Margins account for uncertainty in the verification method. As confidence in the verification method increases, the margin can decrease. An ETDL exceeding the ATL by a factor of two is an acceptable margin for Level A systems, if this margin is verified by aircraft test or by analysis supported by aircraft tests. For Level A display systems where the ETDLs are determined using guidance provided in Table **3**, an acceptable margin is already incorporated in the selected ETDLs. For other verification methods, the margin should be agreed upon with EASA.

j. Take Corrective Measures.

(1) When your system fails to meet the certification requirements, corrective actions should be selected. The changes or modifications you make to the aircraft, system installation or the equipment may require more testing and analysis.

(2) To meet the certification requirements, you may need to repeat system qualification testing, or aircraft testing and analysis (in whole or in part). You also may need to modify the system or installation to get certification. You should review these changes or modifications with EASA to determine if they are significant. If these changes or modifications are significant, update your lightning certification plan accordingly. The updated certification plan should be resubmitted to EASA for review.

9. Level B and C System Lightning Certification.

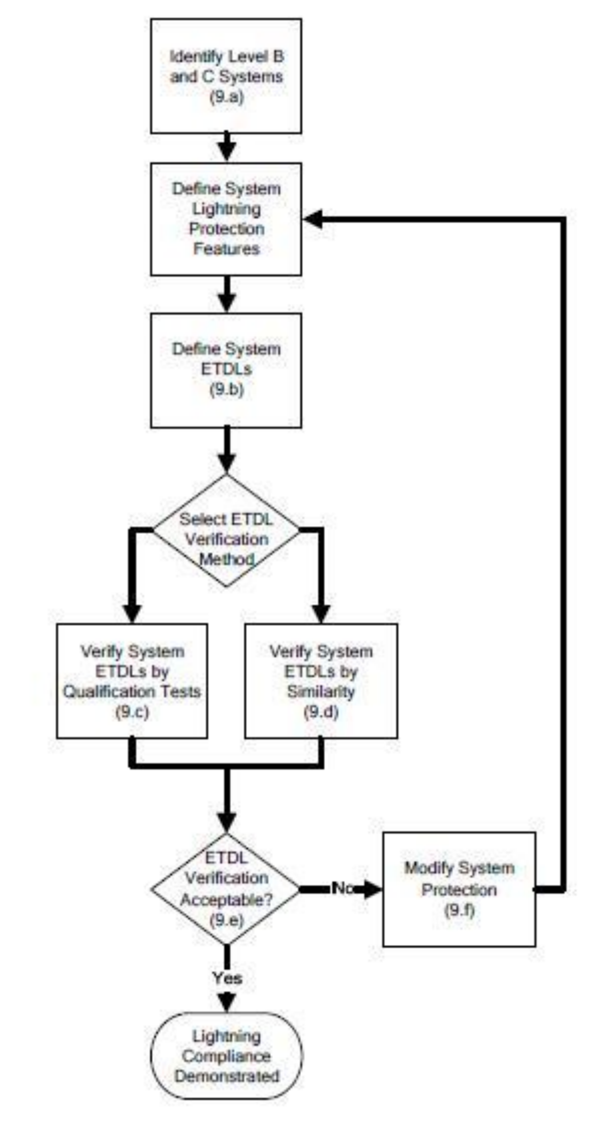
a. Identify Level B and C Systems.

(1) Identify your Level B and C systems as described in paragraph **6.c**.

(2) Define the detailed system performance pass/fail criteria. You should get EASA concurrence on this criterion before you start testing or analysing your Level B and C systems.

(3) Figure **3** illustrates a process you can use to show that your Level B and C systems comply with CS requirements.

Figure 3. Typical Compliance Process for Level B and C Systems



Note: Numbers in parenthesis refer to sections in this AMC.

b. Establish ETDLs.

(1) You may use the ATLs determined during aircraft tests or analyses performed for Level A systems to establish appropriate ETDLs for Level B and C systems.

(2) Alternatively, you may use the definitions in ED-14G Section 22 to select appropriate ETDLS for your Level B and C systems. The following should be considered when selecting an appropriate level:

(a) Use ED-14G, Section 22, Level 3 for most Level B systems.

(b) For Level B systems and associated wiring installed in aircraft areas with more severe lightning transients, use ED-14G, Section 22, Level 4 or 5 as appropriate to the environment. Examples of aircraft areas with more severe lightning transients are those external to the fuselage, areas with composite structures showing poor shielding effectiveness, and other open areas.

(c) Use ED-14G, Section 22, Level 2 for most Level C systems.

(d) For Level C systems installed in aircraft areas with more severe lightning transients, use ED-14G, Section 22, Level 3. Examples of aircraft areas with more severe lightning transients are those external to the fuselage, areas with composite structures showing poor shielding effectiveness, and other open areas.

(e) Provide EASA with a description of your aircraft and system installation features to substantiate the ED-14G, Section 22 levels selected for your system.

c. Verify System ETDLs Using Equipment Qualification Tests.

(1) You should perform equipment qualification tests using the selected test levels and single stroke, multiple stroke, and multiple burst waveform sets. Show that the equipment operates within the defined pass/fail criteria during these tests. No equipment damage should occur during these equipment qualification tests or during single stroke pin injection tests using the defined ETDLs. ED-14G, Section 22, provides acceptable test procedures and waveform set definitions.

(2) You should evaluate any equipment effects observed during the qualification tests to ensure these do not adversely affect the system's continued performance. You should obtain EASA approval of your evaluation.

(3) Multiple stroke and multiple burst testing is not required if an analysis shows that the equipment is not susceptible to upset or, that the equipment may be susceptible to upset, but a reset capability exists so the system recovers in a timely manner.

d. Verify System ETDLs Using Existing Equipment Data (Similarity).

(1) You may verify ETDLs by similarity to previously certified systems without performing more tests. You may do this when:

(a) There are only minor differences between the previously certified system and installation, and the system and installation to be certified;
(b) There are no unresolved in-service system problems related to lightning strikes on the previously certified system; and

(c) The previously certified system ETDLs were verified by qualification tests.

(2) The assessment should cover:

(a) Equipment interface circuits;

(b) Wire size, routing, arrangement (parallel or twisted wires), connector types, wire shields, and shield terminations;

(c) Lightning protection devices such as transient suppressors and lightning arrestors;

(d) Grounding and bonding; and

(e) Equipment software, firmware, and hardware.

(3) If significant differences are found that will affect the systems and installations, you should perform more tests and analyses to resolve the open issues.

e. Verify Compliance to the Requirements. You should show that the Level B and C systems meet their defined acceptance criteria during the qualification tests at the selected system ETDLs.

f. Take Corrective Measures. When your system fails to meet the certification requirements, you should decide on corrective actions. If you change or modify the system or installation, you may need to repeat equipment qualification testing. You should review these changes or modifications with EASA to determine if they are significant. If these changes or modifications are significant, update your lightning certification plan accordingly. The updated certification plan should be resubmitted to EASA for review.

10. Maintenance and Surveillance.

a. You should identify the minimum maintenance required for the aircraft electrical and electronic system lightning protection in the instructions for continued airworthiness (ICA). You should define the requirements for periodic and conditional maintenance and surveillance of lightning protection devices or features to ensure acceptable protection performance while the aircraft is in service. Avoid using devices or features that may degrade with time because of corrosion, fretting, flexing cycles, or other causes. Alternatively, identify when to inspect or replace these devices.

b. You should define the inspection techniques and intervals needed to ensure that the aircraft and system lightning protection remains effective in service. Also, identify built-in test equipment, resistance measurements, continuity checks of the entire system, or other means to determine your system's integrity periodically and conditionally.

c. See SAE ARP 5415A for more information on aircraft lightning protection maintenance and surveillance.

Appendix 1: Definitions and Acronyms

a. Definitions

Actual Transient Level: The level of transient voltage or current that appears at the equipment interface circuits because of the external environment. This level may be less than or equal to the transient control level, but should not be greater.

Aperture: An electromagnetically transparent opening.

Attachment Point: A point where the lightning flash contacts the aircraft.

Component Damage: A condition in which transients permanently alter the electrical characteristics of a circuit. Because of this, the component can no longer perform to its specifications.

Continued Safe Flight and Landing: The aircraft can safely abort or continue a take-off, or continue controlled flight and landing, possibly using emergency procedures. The aircraft must do this without requiring exceptional pilot skill or strength. Some aircraft damage may occur because of the failure condition or on landing. For large aeroplanes, the pilot must be able to land safely at a suitable airport. For CS-23 aeroplanes, it is not necessary to land at an airport. For rotorcraft, the rotorcraft must continue to cope with adverse operating conditions, and the pilot must be able to land safely at a suitable site.

Direct Effects: Physical damage to the aircraft or electrical and electronic systems. Direct attachment of lightning to the system's hardware or components causes the damage. Examples of direct effects include tearing, bending, burning, vaporization, or blasting of aircraft surfaces and structures, and damage to electrical and electronic systems.

Equipment Component of an electrical or electronic system with interconnecting electrical conductors.

Equipment Transient Design Level: The peak amplitude of transients to which you qualify your equipment.

External Environment: The natural lightning environment, outside the aircraft, for design and certification purposes. See ED-84A, which references documents that provide additional guidance on aircraft lightning environment and related waveforms.

Indirect Effects: Electrical transients induced by lightning in aircraft electrical or electronic circuits.

Internal Environment: The potential fields and structural voltages inside the aircraft produced by the external environment.

Lightning Flash: The total lightning event. It may occur in a cloud, among clouds, or between a cloud and the ground. It can consist of one or more return strokes, plus intermediate or continuing currents.

Lightning Strike: Attachment of the lightning flash to the aircraft.

Lightning Strike Zones: Aircraft surface areas and structures that are susceptible to lightning attachment, dwell time, and current conduction. See ED-91, which references documents that provide additional guidance on aircraft lightning zoning.

Lightning Stroke (Return Stroke): A lightning current surge that occurs when the lightning leader (the initial current charge) makes contact with the ground or another charge centre. A charge centre is an area of high potential of opposite charge.

Margin: The difference between the equipment transient design levels and the actual transient level.

Multiple Burst: A randomly spaced series of bursts of short duration, low amplitude current pulses, with each pulse characterized by rapidly changing currents. These bursts may result as the lightning leader progresses or branches, and are associated with the cloud-to-cloud and intra-cloud flashes. The multiple bursts appear most intense when the initial leader attaches to the aircraft. See ED-84A.

Multiple Stroke: Two or more lightning return strokes during a single lightning flash. See ED-84A.

Transient Control Level (TCL): The maximum allowable level of transients that appear at the equipment interface circuits because of the defined external environment.

b. Acronyms

AC:	Advisory Circular
AMC:	Acceptable Means of Compliance
ARP:	Aerospace Recommended Practice
ATL:	Actual Transient Level
CS:	Certification Specifications
ETDL:	Equipment Transient Design Level
EASA:	European Aviation Safety Agency
EUROCAE:	European Organization for Civil Aviation Equipment
FAA:	Federal Aviation Administration
ICA:	Instructions for Continued Airworthiness
TCL:	Transient Control Level

Proposal 19: Create AMC 20-158 as follows:

AMC 20-158

Subject: AIRCRAFT ELECTRICAL AND ELECTRONIC SYSTEM HIGH-INTENSITY RADIATED FIELDS (HIRF) PROTECTION

Content:

1. Purpose of this Acceptable Means of Compliance (AMC)

a. This AMC provides acceptable means of compliance and guidance material related to High-Intensity Radiated Fields (HIRF) protection and the showing of compliance with Certification Specifications CS 23.1308, CS 25.1317, CS 27.1317, and CS 29.1317.

b. This AMC is not mandatory and does not constitute a regulation. It describes an acceptable means, but not the only means to show compliance with the requirements for protection of the operation of electrical and electronic systems on an aircraft when the aircraft is exposed to an external HIRF environment. In using the means described in this AMC, they must be followed it in all important respects.

2. Scope of this AMC

This AMC applies to all applicants for a new type certificate (TC) or a change to an existing TC when the certification basis requires the address of the HIRF certification requirements of CS 23.1308, CS 25.1317, CS 27.1317, and CS 29.1317.

3. Related Material.

a. European Aviation Safety Agency (EASA). Certification Specifications CS 23.1308, CS 25.1317, CS 27.1317, and CS 29.1317, *High-intensity Radiated Fields (HIRF) protection*; CS 23.1309, CS 25.1309, CS 27.1309, and CS 29.1309, *Equipment, systems, and installations*; and CS 23.1529, CS 25.1529, CS 27.1529, and CS 29.1529, *Instructions for Continued Airworthiness*. You can get copies of these documents from European Aviation Safety Agency, Postfach 10 12 53, D-50452 Cologne, Germany; Telephone +49 221 8999 000; Fax: +49 221 8999 099;

Website: http://easa.europa.eu/official-publication/

b. Title 14 of the Code of Federal Regulations (14 CFR). Sections 23.1308, 25.1317, 27.1317, and 29.1317, *High-intensity Radiated Fields (HIRF) protection*; §§ 23.1309, 25.1309, 27.1309, and 29.1309, *Equipment, systems, and installations*; and §§ 23.1529, 25.1529, 27.1529, and 29.1529, *Instructions for Continued Airworthiness*. You can get copies of the above 14 CFR sections from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402-9325, telephone 202-512-1800, fax 202-512-2250. You can also get copies from the Government Printing Office (GPO), electronic CFR Internet web site at http://www.gpoaccess.gov/cfr/.

c. FAA ACs. AC 20-158A, *The Certification of Aircraft Electrical and Electronic Systems for Operation in the High-Intensity Radiated Fields (HIRF) Environment*. AC 23.1309-1E, *System Safety Analysis and Assessment for Part 23 Airplanes*; and AC 25.1309-1A, *System Design and Analysis*. You can order copies of these documents from the U.S. Department of Transportation, Subsequent Distribution Office, DOT Warehouse M30, Ardmore East Business Center, 3341 Q 75th Avenue, Landover, MD 20785; telephone +1 301 322 5377. You can also get copies on the Internet from the FAA website:

http://www.faa.gov/regulations_policies/advisory_circulars/.

d. European Organization for Civil Aviation Equipment (EUROCAE). You can order copies of the following documents from EUROCAE, 102 rue Etienne Dolet, 92240 Malakoff, France; Telephone: +33 1 40 92 79 30; Fax: +33 1 46 55 62 65; web site: http://www.eurocae.net.

(1) EUROCAE ED-107A, *Guide to Certification of Aircraft in a High Intensity Radiated Field (HIRF) Environment*. ED-107A and SAE ARP 5583A, referenced in paragraph 3.f.(1) below, are technically equivalent and either document may serve as the "User's Guide" referred to in this AMC.

(2) EUROCAE ED-14G, *Environmental Conditions and Test Procedures for Airborne Equipment*. This document is technically equivalent to RTCA/DO-160G. Whenever there is a reference to RTCA/DO-160G in this AMC, you may use EUROCAE ED-14G.

(3) EUROCAE ED-79A, Guidelines for Development of Civil Aircraft and Systems. This document is technically equivalent to ARP 4754A. Whenever there is a reference to ARP 4754A in this AMC, you may use EUROCAE ED-79A.

e. RTCA, Inc. RTCA/DO-160G, *Environmental Conditions and Test Procedures for Airborne Equipment*. You can order copies of this document from RTCA, Inc., 1828 L Street NW, Suite 805, Washington, DC 20036; Telephone: +1 202 833 9339; Website: http://www.rtca.org.

This document is technically equivalent to EUROCAE ED-14G.

f. SAE International. You can order copies of the following documents from SAE World Headquarters, 400 Commonwealth Drive, Warrendale, Pennsylvania 15096-0001; Telephone: +1 724 776 4970; Website: http://www.sae.org.

(1) SAE Aerospace Recommended Practice (ARP) 5583A, *Guide to Certification of Aircraft in a High Intensity Radiated Field (HIRF) Environment*. SAE ARP 5583A and ED-107A, referenced in paragraph **3.d.(1)** above, are technically equivalent and either document may serve as the "User's Guide" referred to in this AMC.

(2) SAE ARP 4754A, *Guidelines For Development Of Civil Aircraft And Systems, December 2010.*

(3) SAE ARP 4761, *Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment*, December 1996.

4. Background.

a. Aircraft Protection. Concern for the protection of aircraft electrical and electronic systems has increased substantially in recent years because of:

(1) Greater dependence on electrical and electronic systems performing functions required for continued safe flight and landing of an aircraft;

(2) Reduced electromagnetic shielding afforded by some composite materials used in aircraft designs;

(3) Increased susceptibility of electrical and electronic systems to HIRF because of increased data bus and processor operating speeds, higher density integrated circuits and cards, and greater sensitivities of electronic equipment;

(4) Expanded frequency usage, especially above 1 gigahertz (GHz);

(5) Increased severity of the HIRF environment because of an increase in the number and radiated power of radio frequency (RF) transmitters; and

(6) Adverse effects experienced by some aircraft when exposed to HIRF.

b. HIRF Environment. The electromagnetic HIRF environment exists because of the transmission of electromagnetic RF energy from radar, radio, television, and other ground-based, shipborne, or airborne RF transmitters. The User's Guide (EUROCAE ED-107A) provides a detailed description of the derivation of these HIRF environments.

5. Definitions.

Adverse Effect: HIRF effect that results in system failure, malfunction, or misleading information to a degree that is unacceptable for the specific aircraft function or system addressed in the HIRF regulations. A determination of whether a system or function is adversely affected should consider the HIRF effect in relation to the overall aircraft and its operation.

Attenuation: term used to denote a decrease in electromagnetic field strength in transmission from one point to another. Attenuation may be expressed as a scalar ratio of the input magnitude to the output magnitude or in decibels (dB).

Bulk Current Injection (BCI): method of electromagnetic interference (EMI) testing that involves injecting current into wire bundles through a current injection probe.

Continued Safe Flight and Landing: The aircraft can safely abort or continue a take-off, or continue controlled flight and landing, possibly using emergency procedures. The aircraft must do this without requiring exceptional pilot skill or strength. Some aircraft damage may occur because of the failure condition or on landing. For large aeroplanes, the pilot must be able to land safely at a suitable airport. For CS-23 aeroplanes, it is not necessary to land at an airport. For rotorcraft, the rotorcraft must continue to cope with adverse operating conditions, and the pilot must be able to land safely at a suitable site.

Continuous Wave (CW): RF signal consisting of only the fundamental frequency with no modulation in amplitude, frequency, or phase.

Coupling: process whereby electromagnetic energy is induced in a system by radiation produced by an RF source.

Current Injection Probe: inductive device designed to inject RF signals directly into wire bundles when clamped around them.

Direct Drive Test: EMI test that involves electrically connecting a signal source directly to the unit being tested.

Equipment: component of an electrical or electronic system with interconnecting electrical conductors.

Equipment Electrical Interface: location on a piece of equipment where an electrical connection is made to the other equipment in a system of which it is a part. The electrical interface may consist of individual wires or wire bundles that connect the equipment.

External High-intensity Radiated Fields Environment: electromagnetic RF fields at the exterior of an aircraft.

Field Strength: magnitude of the electromagnetic energy propagating in free space expressed in volts per meter (V/m).

High-intensity Radiated Fields (HIRF) Environment: electromagnetic environment that exists from the transmission of high power RF energy into free space.

HIRF Vulnerability: susceptibility characteristics of a system that cause it to suffer adverse effects when performing its intended function as a result of having been subjected to an HIRF environment.

Immunity: capacity of a system or piece of equipment to continue to perform its intended function, in an acceptable manner, in the presence of RF fields.

Interface Circuit: electrical or electronic device connecting the electrical inputs and outputs of equipment to other equipment or devices in an aircraft.

Internal HIRF Environment: the RF environment inside an airframe, equipment enclosure, or cavity. The internal RF environment is described in terms of the internal RF field strength or wire bundle current.

Margin: difference between equipment susceptibility or qualification levels and the aircraft internal HIRF environment. Margin requirements may be specified to account for uncertainties in design, analysis, or test.

Modulation: process whereby certain characteristics of a wave, often called the carrier wave, are varied in accordance with an applied function.

Radio Frequency (RF): frequency useful for radio transmission. The present practical limits of RF transmissions are roughly 10 kilohertz (kHz) to 100 gigahertz (GHz). Within this frequency range, electromagnetic energy may be detected and amplified as an electric current at the wave frequency.

Reflection Plane: conducting plate that reflects RF signals.

Similarity: process of using existing HIRF compliance documentation and data from a system or aircraft to demonstrate HIRF compliance for a nearly identical system or aircraft of equivalent design, construction, and installation.

Susceptibility: property of a piece of equipment that describes its inability to function acceptably when subjected to unwanted electromagnetic energy.

Susceptibility Level: level where the effects of interference from electromagnetic energy become apparent.

System: piece of equipment connected via electrical conductors to another piece of equipment, both of which are required to make a system function. A system may contain pieces of equipment, components, parts, and wire bundles.

Transfer Function: ratio of the electrical output of a system to the electrical input of a system, expressed in the frequency domain. For HIRF, a typical transfer function is the ratio of the current on a wire bundle to the external HIRF field strength, as a function of frequency.

Upset: impairment of system operation, either permanent or momentary. For example, a change of digital or analogue state that may or may not require a manual reset.

User's Guide: refers to SAE document ARP 5583A or EUROCAE document ED-107A .

6. Approaches to Compliance.

a. General. The following activities should be elements of a proper HIRF certification programme. The iterative application of these activities is left to you. Adherence to the sequence shown is not necessary. You should:

(1) Identify the systems to be assessed;

(2) Establish the applicable aircraft external HIRF environment;

(3) Establish the test environment for installed systems;

(4) Apply the appropriate method of HIRF compliance verification; and

(5) Verify HIRF protection effectiveness.

b. Identify the Systems to be Assessed.

(1) **General.** The aircraft systems that require HIRF assessment must be identified. The process used for identifying these systems should be similar to the process for showing compliance with CS 23.1309, 25.1309, 27.1309, and 29.1309, as applicable. These sections address any system failure that may cause or contribute to an effect on the safety of flight of an aircraft. The effects of an encounter with HIRF, therefore, should be assessed in a manner that allows for the determination of the degree to which the aircraft and its systems safety may be influenced. The operation of the aircraft systems should be assessed separately and in combination with, or in relation to, other systems. This assessment should cover:

(a) all normal aircraft operating modes, stages of flight, and operating conditions;

(b) all failure conditions and their subsequent effect on aircraft operations and the flight crew; and

(c) any corrective actions required.

(2) **Safety Assessment.** A safety assessment related to HIRF must be performed to establish and classify the equipment or system failure condition. Table **1** provides the corresponding failure condition classification and system HIRF certification level for the appropriate HIRF regulations. The failure condition classifications and terms used in this AMC

are similar to those used in AC 23.1309-1D and AMC 25.1309, as applicable. Only those systems identified as performing or contributing to functions whose failure would result in catastrophic, hazardous, or major failure conditions are subject to HIRF regulations. Based on the failure condition classification established by the safety assessment, the systems should be assigned appropriate HIRF certification levels, as shown in Table **1**. Further guidance on performing the safety assessment can be found in AC 23.1309-1D, AMC 25.1309, ED-79A, and SAE ARP 4761.

Table 1 — HIRF Failure Conditions and System HIRF Certification Levels

HIRF REQUIREMENTS EXCERPTS FROM §§ 23.1308, 25.1317, 27.1317, AND 29.1317	FAILURE CONDITION	SYSTEM HIRF CERTIFICATION LEVEL
Each electrical and electronic system that performs a function whose failure would prevent the continued safe flight and landing of the aircraft	Catastrophic	A
Each electrical and electronic system that performs a function whose failure would significantly reduce the capability of the aircraft or the ability of the flight crew to respond to an adverse operating condition	Hazardous	B
Each electrical and electronic system that performs a function whose failure would reduce the capability of the aircraft or the ability of the flight crew to respond to an adverse operating condition	Major	C

(3) **Failure Conditions.** Your safety assessment should consider all potential adverse effects due to system failures, malfunctions, or misleading information. The safety assessment may show that some systems have different failure conditions in different phases of flight; therefore, different HIRF requirements may have to be applied to the system for different phases of flight. For example, an automatic flight control system may have a catastrophic failure condition for autoland, while automatic flight control system operations in cruise may have a hazardous failure condition.

c. Establish the Applicable Aircraft External HIRF Environment. The external HIRF environments I, II, and III, as published in CS 23.1308, 25.1317, 27.1317, and 29.1317, are shown in tables **2**, **3**, and **4**, respectively. The field strength values for the HIRF environments and test levels are expressed in root-mean-square (rms) units measured during the peak of the modulation cycle, which is how many laboratory instruments indicate amplitude.

Table 2 — HIRF Environment I

FREQUENCY	FIELD STRENGTH (V/m)	
	PEAK	AVERAGE
10 kHz – 2 MHz	50	50
2 MHz – 30 MHz	100	100
30 MHz – 100 MHz	50	50
100 MHz – 400 MHz	100	100
400 MHz – 700 MHz	700	50
700 MHz – 1 GHz	700	100
1 GHz – 2 GHz	2000	200
2 GHz – 6 GHz	3000	200
6 GHz – 8 GHz	1000	200
8 GHz – 12 GHz	3000	300
12 GHz – 18 GHz	2000	200
18 GHz – 40 GHz	600	200
In this table, the higher field strength applies to the frequency band edges.		

Table 3 — HIRF Environment II

FREQUENCY	FIELD STRENGTH (V/m)	
	PEAK	AVERAGE
10 kHz – 500 kHz	20	20
500 kHz – 2 MHz	30	30
2 MHz – 30 MHz	100	100
30 MHz – 100 MHz	10	10
100 MHz – 200 MHz	30	10
200 MHz – 400 MHz	10	10
400 MHz – 1 GHz	700	40
1 GHz – 2 GHz	1300	160
2 GHz – 4 GHz	3000	120
4 GHz – 6 GHz	3000	160
6 GHz – 8 GHz	400	170
8 GHz – 12 GHz	1230	230
12 GHz – 18 GHz	730	190
18 GHz – 40 GHz	600	150
In this table, the higher field strength applies to the frequency band edges.		

Table 4 — HIRF Environment III

FREQUENCY	FIELD STRENGTH (V/m)	
	PEAK	AVERAGE
10 kHz – 100Hz	150	150
100 kHz – 400 MHz	200	200
400 MHz – 700 MHz	730	200
700 MHz – 1 GHz	1400	240
1 GHz – 2 GHz	5000	250
2 GHz – 4 GHz	6000	490
4 GHz – 6 GHz	7200	400
6 GHz – 8 GHz	1100	170
8 GHz – 12 GHz	5000	330
12 GHz – 18 GHz	2000	330
18 GHz – 40 GHz	1000	420
In this table, the higher field strength applies to the frequency band edges.		

d. Establish the Test Environment for Installed Systems.

(1) **General.** The external HIRF environment will penetrate the aircraft and establish an internal RF environment to which installed electrical and electronic systems will be exposed. The resultant internal RF environment is caused by a combination of factors, such as aircraft seams and apertures, re-radiation from the internal aircraft structure and wiring, and characteristic aircraft electrical resonance.

(2) **Level A Systems.** The resulting internal HIRF environments for level A systems are determined by aircraft attenuation to the external HIRF environments I, II, or III, as defined in CS-23 Appendix K, CS-25 Appendix R, CS-27 Appendix D, and CS-29 Appendix E, as applicable. The attenuation is aircraft and zone specific and should be established by aircraft test, analysis, or similarity. The steps for showing level A HIRF compliance are presented in paragraph **9.** of this AMC.

(3) **Level B Systems.** The internal RF environments for level B systems are defined in CS-23 Appendix K, CS-25 Appendix R, CS-27 Appendix D, and CS-29 Appendix E, as applicable, as equipment HIRF test levels 1 or 2. The steps for showing level B HIRF compliance are presented in paragraph **10** of this AMC.

(4) **Level C Systems.** The internal RF environments for level C systems are defined in CS-23 Appendix K, CS-25 Appendix R, CS-27 Appendix D, and CS-29 Appendix E, as equipment HIRF test level 3. The steps for showing level C HIRF compliance are also presented in paragraph **10** of this AMC.

e. Apply the Appropriate Method of HIRF Compliance Verification.

(1) General. Table **5** summarises the relationship between the aircraft performance requirements in the HIRF regulations (sections (a), (b) and (c)), and the HIRF environments and test levels.

(2) Pass/Fail Criteria. Establish specific HIRF compliance pass/fail criteria for each system as it relates to the applicable HIRF regulation performance criteria. These pass/fail criteria should be presented to EASA for approval. The means for monitoring system performance relative to these criteria also should be established by the applicant and approved by EASA. All effects that define the pass/fail criteria should be the result of identifiable and traceable analysis that includes both the separate and interdependent operational characteristics of the systems. The analysis should evaluate the failures, either singularly or in combination, which could adversely affect system performance. This should include failures that could negate any system redundancy, or failures that could influence more than one system performing the same function.

Table 5 — HIRF Certification Requirements Summary

HIRF FAILURE CONDITION FROM CS 23.1308, 25.1317, 27.1317, AND 29.1317	PERFORMANCE CRITERIA	ITEM THE ENVIRONMENT OR TEST LEVEL APPLIES TO	HIRF ENVIRONMENT OR TEST LEVEL
Each electrical and electronic system that performs a function whose failure would prevent the continued safe flight and landing of the aircraft must be designed and installed so that	Each function is not adversely affected during and after the time…	the aircraft…	is exposed to HIRF environment I.
	Each electrical and electronic system automatically recovers normal operation of that function, in a timely manner after…	the aircraft…	is exposed to HIRF environment I
	Each electrical and electronic system is not adversely affected during and after…	the aircraft…	is exposed to HIRF environment II.
	Each function required during operation under visual flight rules is not adversely affected during and after…	the rotorcraft…	is exposed to HIRF environment III (Parts 27 and 29 only).
Each electrical and electronic system that performs a function whose failure would significantly reduce the capability of the aircraft or the ability of the flight crew to respond to an adverse operating condition must be designed and installed so that	The system is not adversely affected when…	the equipment providing these functions…	is exposed to equipment HIRF test level 1 or 2.
Each electrical and electronic system that performs such a function whose failure would reduce the capability of the aircraft or the ability of the flight crew to respond to an adverse operating condition must be designed and installed so that	The system is not adversely affected when…	the equipment providing these functions…	is exposed to equipment HIRF test level 3.

f. Verify HIRF Protection Effectiveness. You should show that the RF current on system and equipment wire bundles and the RF fields on the system, created by the HIRF environment, are lower than the equipment or system HIRF qualification test levels.

7. Margins. A margin is normally not necessary for HIRF compliance based on tests on the specific aircraft model and system undergoing certification. However, when determining compliance based on analysis or similarity, a margin may be required depending on the validation of the analysis or similarity process. Where data have limited substantiation, a margin may be required depending on the available justifications. The justification for a selected margin should be part of the HIRF Compliance Plan as discussed in paragraph **8** below.

8. HIRF Compliance.

a. HIRF Compliance Plan. An overall HIRF compliance plan should be established to clearly identify and define HIRF certification requirements, HIRF protection development, and the design, test, and analysis activities intended to be part of the compliance effort. This plan should provide definitions of the aircraft systems, installations, and protective features against which HIRF compliance will be assessed. The HIRF compliance plan should be discussed with, and submitted to, EASA for approval before being implemented. If the aircraft, system, or installation design changes after EASA approval, a revised HIRF compliance plan should be submitted to EASA for approval. The HIRF compliance plan should include the following:

(1) an HIRF compliance plan summary;

(2) identification of the aircraft systems, with classification based on the safety assessment as it relates to HIRF (see paragraph **6.b(2)**);

(3) the HIRF environment for the aircraft and installed systems; and

(4) the verification methods, such as test, analysis, or similarity.

b. HIRF Verification Test, Analysis, or Similarity Plan. Specific HIRF test, analysis, or similarity plans should be prepared to describe specific verification activities. One or more verification plans may be necessary. For example, there may be several systems or equipment laboratory test plans, an aircraft test plan, or a similarity plan for selected systems on an aircraft.

(1) **Test Plan.**

(a) An HIRF compliance test plan should include the equipment, system, and aircraft test objectives for the acquisition of data to support HIRF compliance verification. The plan should provide an overview of the factors being addressed for each system test requirement. The test plan should include:

1 the purpose of the test;

2 a description of the aircraft and/or system being tested;

3 system configuration drawings;

4 the proposed test setup and methods;

5 intended test levels, modulations, and frequency bands;

6 pass/fail criteria; and

7 the test schedule and test location.

(b) The test plan should cover level A, B, and C systems and equipment, as appropriate. Level A systems may require both integrated systems laboratory tests and aircraft tests. Level B and level C systems and equipment require only equipment laboratory testing.

(c) The test plan should describe the appropriate aspects of the systems to be tested and their installation. Additionally, the test plan should reflect the results of any analysis performed in the overall process of the HIRF compliance evaluation.

(2) **Analysis Plan.** An HIRF compliance analysis plan should include the objectives, both at the system and equipment level, for generating data to support HIRF compliance verification. Comprehensive modelling and analysis for RF field coupling to aircraft systems and structures is an emerging technology; therefore, the analysis plan should be coordinated with EASA to determine an acceptable scope for the analysis. The analysis plan should include:

(a) the purpose and scope of the analysis;

(b) a description of the aircraft and/or system addressed by the analysis;

(c) system configuration descriptions;

(d) proposed analysis methods;

(e) the approach for validating the analysis results; and

(f) pass/fail criteria, including margins to account for analysis uncertainty.

(3) **Similarity Plan.** A similarity plan should describe the approach undertaken to use the certification data from previously certified systems, equipment, and aircraft in the proposed HIRF compliance program. The similarity plan should include:

(a) the purpose and scope of the similarity assessment;

(b) specific systems addressed by the similarity assessment;

(c) data that will be used from the previously certified systems, equipment, and aircraft; and

(d) any significant differences between the aircraft and system installation proposed for certification and the aircraft and system installation from which the data will be used. Include appropriate margins to account for similarity uncertainty.

c. Compliance Reports. One or more compliance reports may be necessary to document the results of your test, analysis, or similarity assessments. For new or significantly modified aircraft, HIRF compliance reports may include many system and equipment test reports, aircraft test reports, and HIRF vulnerability analysis reports. For these types of HIRF certification programs, a compliance summary report may be useful to summarize the results of tests and analysis. For HIRF certification programs on relatively simple systems, a single compliance report may be adequate.

(1) **Test Reports.** Comprehensive test reports should be produced at the conclusion of HIRF compliance testing. The test reports should include descriptions of the salient aspects of equipment or system performance during the test, details of any area of noncompliance with HIRF requirements, actions taken to correct the noncompliance, and any similarity declarations. You should also provide supporting rationale for any deviations from system performance observed during testing.

(2) **Analysis Reports.** Analysis reports should describe the details of the analytical model, the methods used to perform the analysis, and the results of the analysis. The reports should identify any modelling uncertainty and justify the margins established in the analysis plan.

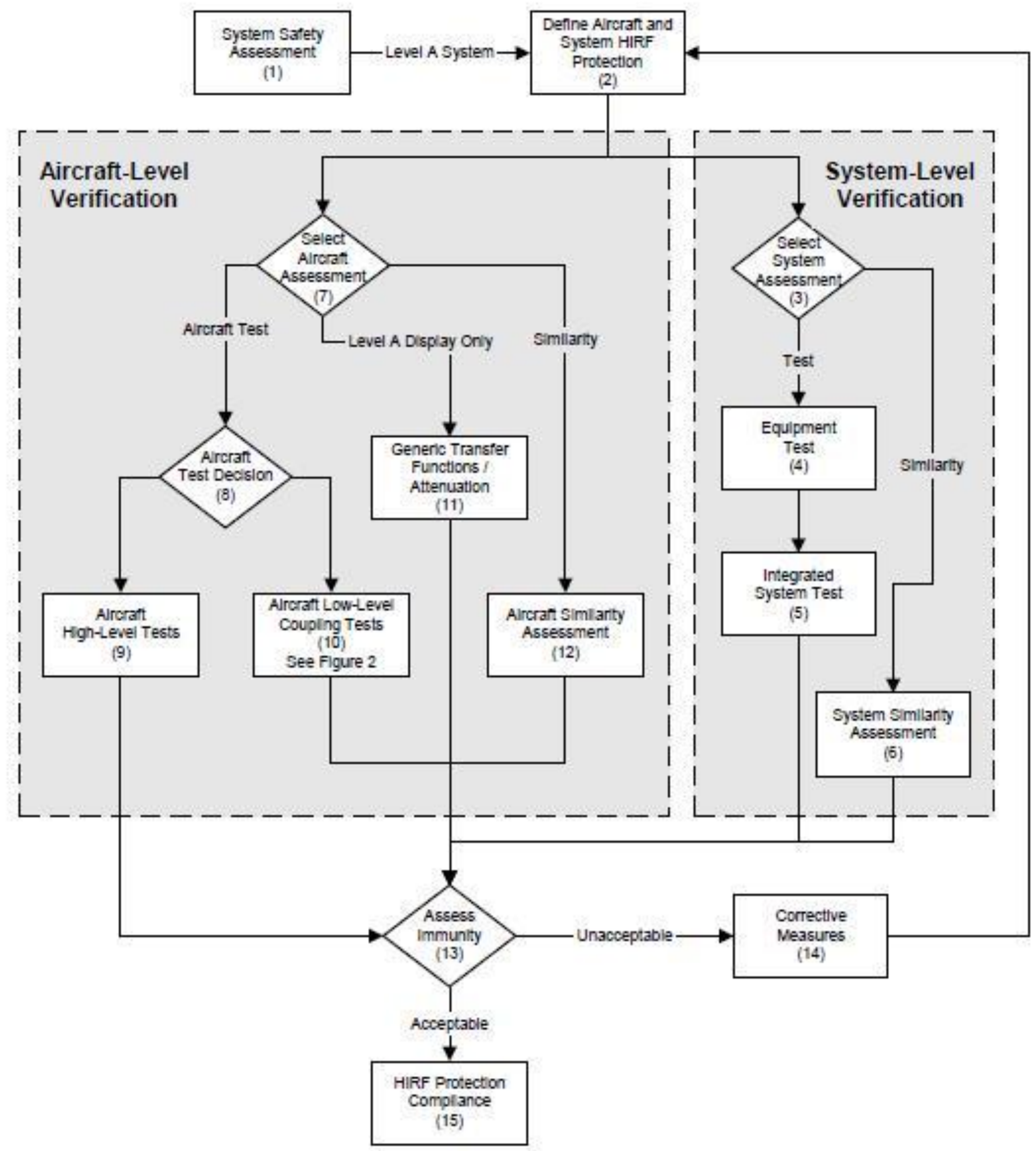
(3) **Similarity Reports.** Similarity reports should document the significant aircraft, system, equipment, and installation features common between the aircraft or system that is the subject of the similarity analysis and the aircraft or system that previously was certified for HIRF. Identify all significant differences encountered, along with the assessment of the impact of these differences on HIRF compliance. These reports should also justify the margins established in the similarity plan.

d. Methods of Compliance Verification.

(1) Various methods are available to aid in demonstrating HIRF compliance. Methods acceptable to EASA are described in paragraphs **9** and **10**. Figures **1** and **2** below outline the steps to HIRF compliance for systems requiring level A HIRF certification. Figure **3** below outlines the steps to HIRF compliance for systems requiring level B or C HIRF certification. The steps in these figures are not necessarily accomplished sequentially. Wherever a decision point is indicated on these figures, you should complete the steps in that path as described in paragraphs **9** and **10**.

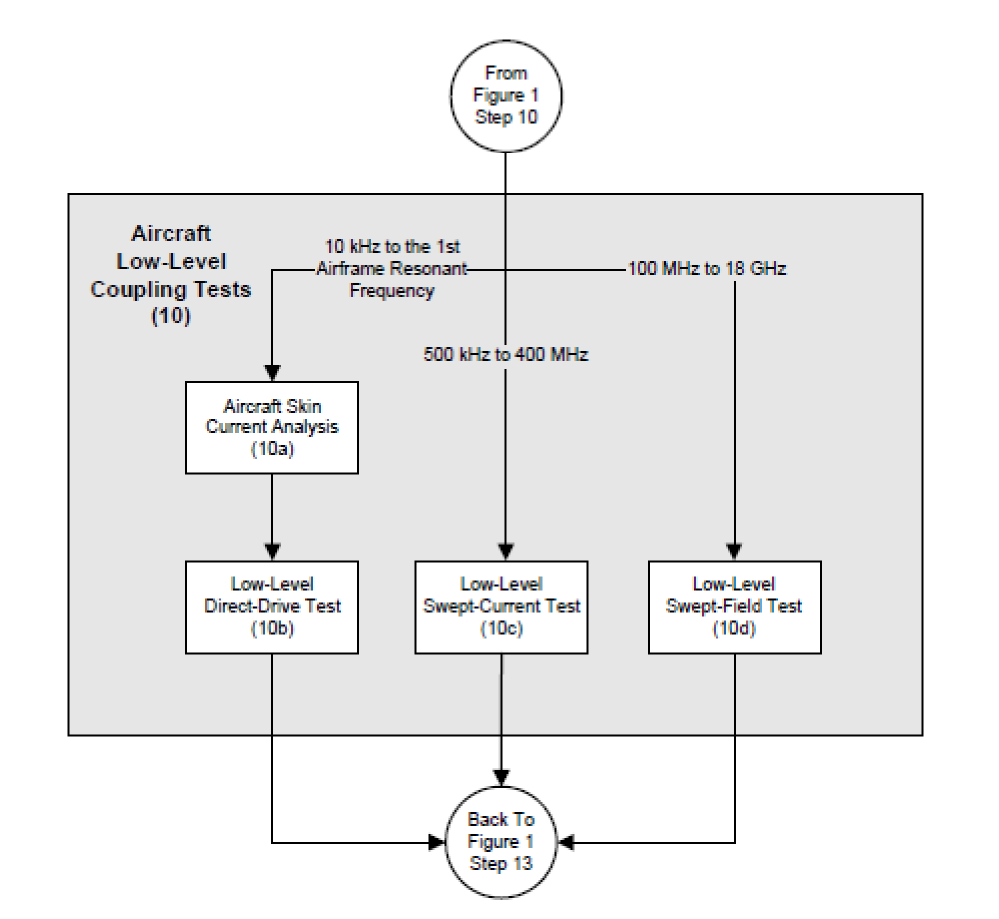
(2) Other HIRF compliance techniques may be used to demonstrate system performance in the HIRF environment; however those techniques should be approved by EASA before using them.

Figure 1 — Routes to HIRF Compliance — Level A Systems



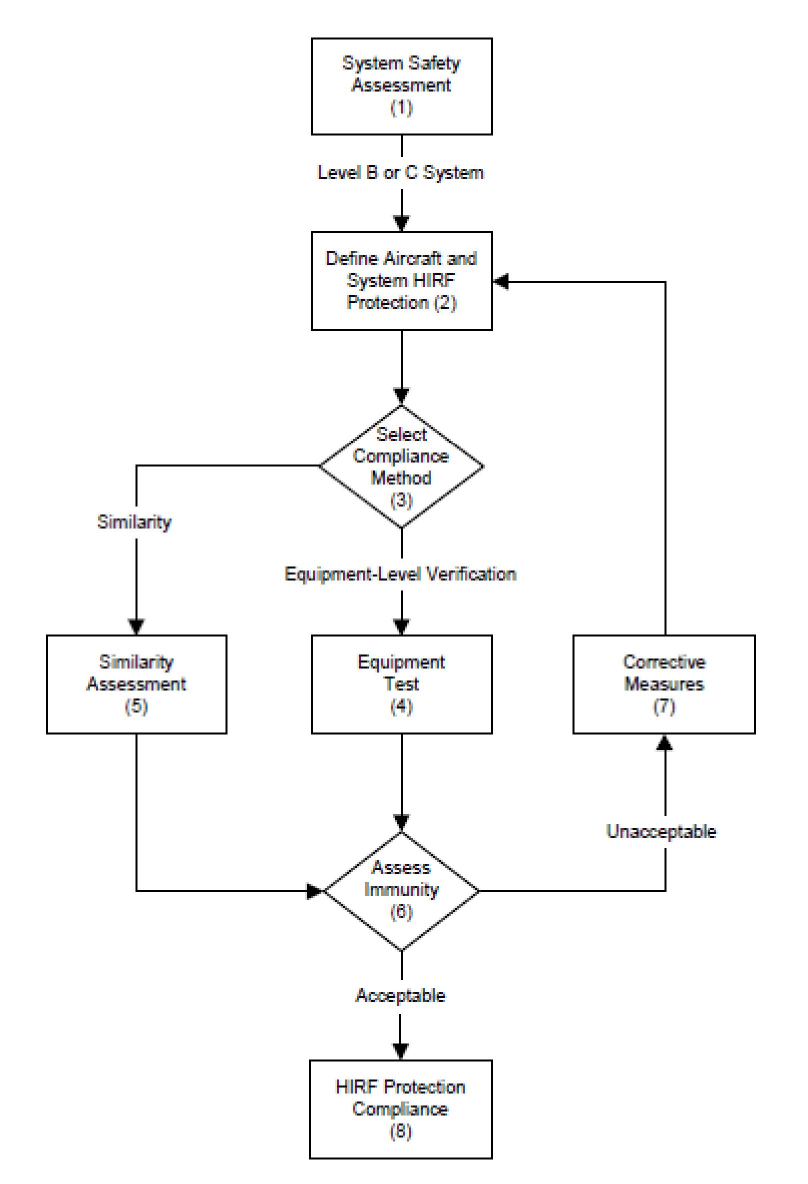
(n) = Step number as described in Paragraph 9 of this AMC.

Figure 2 — Aircraft Low-Level Coupling Tests — Level A Systems



(n) = Step number as described in Paragraph 9 of this AMC.

Figure 3 — Routes to HIRF Compliance — Level B and C Systems



(n) = Step number as described in Paragraph 10 of this AMC.

9. Steps to Level A System HIRF Compliance.

a. Step 1 — System Safety Assessment. Determine the system failure condition classification for the systems being certified on your aircraft, using a system safety assessment as discussed in paragraph **6.b(2)**. For systems classified with catastrophic failure conditions (Level A systems), follow compliance steps 2 through 15 listed below, as appropriate. These compliance steps are also depicted in Figures **1** and **2** of this AMC, and are not necessarily accomplished sequentially. Systems classified with hazardous or major failure conditions (Level B and C systems) should follow the compliance steps outlined in paragraph **10**.

b. Step 2 — Define Aircraft and System HIRF Protection. Define the HIRF protection features that will be incorporated into the aircraft and system designs, based on the HIRF environments that are applicable to your aircraft and its level A systems. Equipment, system, and aircraft HIRF protection design may occur before aircraft-level tests are performed, and before the actual internal HIRF environment is determined. Therefore, the equipment, system and aircraft HIRF protection design should be based on an estimate of the expected internal HIRF environment. Consider all aircraft configurations that may affect HIRF protection, such as opened landing gear doors. Consider these configurations in the aircraft assessment (see Step 7).

c. Step 3 — System Assessment Decision. Determine if you will perform integrated system HIRF tests on the level A system, or if you will base the system verification on previous integrated system HIRF tests performed on a similar system. Aircraft and system tests and assessments need not be performed for the HIRF environments above 18 GHz if data and design analysis show the integrated system tests results (see Step 5) satisfy the pass criteria from 12 GHz to 18 GHz, and the systems have no circuits that operate in the 18 GHz to 40 GHz frequency range.

d. Step 4 — Equipment Test.

(1) Radiated and conducted RF susceptibility laboratory tests of ED-14G, Section *20 may be used to build confidence in the equipment's HIRF immunity before conducting integrated* system laboratory tests in step 5. The equipment should be tested in accordance with the test levels (wire bundle currents and RF field strengths) of ED-14G Section 20 or to a level estimated for the aircraft and equipment installation using the applicable external HIRF environment.

(2) Equipment HIRF tests may be used to augment the integrated system HIRF tests where appropriate. For equipment whose HIRF immunity is evaluated as part of the integrated system-level HIRF tests discussed in step 5, the individual equipment’s HIRF testing described in this step may be considered optional.

e. Step 5 — Integrated System Test.

(1) Radiated and conducted RF susceptibility laboratory tests on an integrated system should be performed for level A systems. The HIRF field strengths and wire bundle currents selected for this test should be based on the attenuated external HIRF environment determined in the aircraft assessment (see Steps 10, 11, or 12). In many cases, the integrated system test is performed before the aircraft assessment is complete. In these cases, the integrated system test field strengths and currents should be selected based on the expected aircraft attenuation or transfer function.

(2) The installation details for the laboratory integrated system tests should be similar to the installation in the aircraft. For example, the bonding and grounding of the system, wire size, routing, arrangement (whether parallel or twisted wires), connector types, wire shields, and shield terminations, and the relative position of the elements to each other and the ground plane in the laboratory should match closely the system installation on the aircraft to be certificated. For this reason, the laboratory integrated system rig should have an EASA conformity inspection prior to conducting any EASA certification credit testing.

(3) The integrated system should be tested with the system operating, and should include connected displays, sensors, actuators, and other equipment. To ensure the integrated system is tested when operating at its maximum sensitivity, the system should be placed in various

operating modes. If the connected equipment is not related to the functions with catastrophic failures, these items may be simulated by test sets, if the test sets accurately represent the terminating circuit impedance of the sensor. However, the connected equipment should meet the appropriate HIRF requirements required for their failure condition classification.

(4) The test levels should be selected based on the expected aircraft internal HIRF environment determined through aircraft tests (see Step 10), generic transfer functions and attenuation (see Step 11), or aircraft similarity assessment (see Step 12), using the applicable external HIRF environment. Integrated system test procedures are described in detail in the User's Guide (SAE ARP 5583A/EUROCAE ED-107A).

(5) Wire bundle current injection should be used for frequencies from 10 kHz to 400 megahertz (MHz). RF currents are injected into the integrated system wiring via a current transformer. Each wire bundle in the system should be injected and the induced wire bundle current measured. If a system wire bundle branches, then each wire bundle branch also should be tested. Simultaneous multi-bundle current injection may be necessary on systems where there are redundant or multi-channel architectures.

(6) High-level radiated susceptibility tests should be used at frequencies greater than 100 MHz. The radiating antenna should be far enough away to ensure the total volume of the equipment and at least half a wavelength of the wiring is simultaneously and uniformly illuminated during the test.

(7) Define appropriate pass/fail criteria for the system, based on the system safety assessment and the appropriate HIRF regulation. Any system susceptibility, including system malfunctions, upset, or damage should be recorded and evaluated based on these previously defined pass/fail criteria.

(8) Using only the modulation to which the system under evaluation is most sensitive may minimize the test time. The User's Guide provides guidance on modulation selection and suggested default modulations and dwell times.

(9) The equipment tests in step 4, using the techniques in ED-14G, Section 20, normally are not sufficient to show HIRF compliance for step 5. However, for simple systems, these standard ED-14G Section 20 tests may be sufficient if paragraphs **9.e(2)** and **(3)** of this step are met.

f. Step 6 — System Similarity Assessment.

(1) The integrated system HIRF tests performed for a system previously certified on one aircraft model may be used to demonstrate system verification for a similar system. Each system considered under the similarity approach needs to be assessed independently even if it may use equipment and installation techniques that have been the subject of a previous certification.

(2) The system used as the basis for similarity must have been certified previously for HIRF compliance on another aircraft model, and must have successfully completed integrated system HIRF tests. Similarity assessment requires comparison of both equipment and installation differences that could adversely affect HIRF immunity. The assessment should consider the differences between the previously HIRF certified system and the equipment circuit interfaces, wiring, grounding, bonding, connectors, and wire-shielding practices, of the equipment that comprise the new system.

(3) If the assessment finds only minimal differences between the previously certified system and the new system to be certified, similarity may be used as the basis for system-level verification without the need for additional integrated system tests, providing there are no unresolved in-service HIRF problems related to the previously certified system. If there is uncertainty about the effects of the differences, additional tests and analysis should be conducted as necessary and appropriate to resolve the uncertainty. The amount of additional testing should be commensurate with the degree of difference identified between the new

system and the system previously certified. If significant differences are found, similarity should not be used as the basis for system-level verification.

g. Step 7 — Aircraft Assessment Decision

(1) Level A systems require an aircraft assessment. The aircraft assessment should determine the actual internal HIRF environment where the level A systems are installed in the aircraft. You should choose whether you will use aircraft tests, previous coupling/attenuation data from similar aircraft types (similarity), or, for level A display systems only, the generic transfer functions and attenuation in Appendix **1** to this AMC. Alternately, the aircraft assessment may be a test that exposes the entire aircraft with operating level A systems to external HIRF environments I, II, or III (Tables **2**, **3**, and **4**, respectively), as appropriate, to demonstrate acceptable level A system performance.

(2) Other methods for aircraft HIRF assessment, such as analysis, may be acceptable. However, comprehensive modelling and analysis for RF field coupling to the aircraft structure is an emerging technology. Therefore, analysis alone is currently not adequate to show HIRF compliance for level A systems and should be augmented by testing.

(3) If analysis is used to determine aircraft attenuation and transfer function characteristics, test data should be provided to support this analysis. Any analysis results should take into account the quality and accuracy of the analysis. Significant testing, including aircraft level testing, may be required to support the analysis.

(4) Aircraft and system tests and assessments need not be performed for the HIRF environments above 18 GHz if data and design analysis show the integrated system tests results (see Step 5) satisfy the pass criteria from 12 GHz to 18 GHz, and the systems have no circuits that operate in the 18 GHz to 40 GHz frequency range.

h. Step 8 — Aircraft Test Decision.

(1) Various aircraft test procedures are available and accepted for collecting data for aircraft HIRF verification. The two main approaches to aircraft testing are the aircraft high-level test (see Step 9) and the aircraft low-level coupling test (see Step 10) The aircraft high-level field-illumination test involves radiating the aircraft at test levels equal to the applicable external HIRF environment in the HIRF regulations. Aircraft low-level coupling tests involve measuring the airframe attenuation and transfer functions, so that the internal HIRF electric fields and currents can be compared to the integrated system test levels.

(2) Some test procedures may be more appropriate than others because of the size of the aircraft and the practicality of illuminating the entire aircraft with the appropriate external HIRF environment. The aircraft low-level coupling tests (see Step 10) may be more suitable for testing large aircraft than the high-level field-illumination test in step 9, which requires illumination of the entire aircraft with the external HIRF environment.

i. Step 9 — Aircraft High-Level Tests.

(1) The aircraft high-level field-illumination test requires generating RF fields external to an aircraft at a level equal to the applicable external HIRF environment.

(2) At frequencies below 400 MHz, the distance between the aircraft and the transmitting antenna should be sufficient to ensure the aircraft is illuminated uniformly by the external HIRF environment. The transmit antenna should be placed in at least four positions around the aircraft, typically illuminating the nose, tail, and each wingtip. The aircraft should be illuminated by the antenna at each position while sweeping the frequency range. Perform separate frequency sweeps with the transmit antenna oriented for horizontal and vertical polarization. The RF field should be calibrated by measuring the RF field strength in the centre of the test volume before the aircraft is placed there.

(3) At frequencies above 400 MHz, the RF illumination should be localized to the system under test, provided all parts of the system and at least one wavelength of any associated wiring (or the total length if less than one wavelength) are illuminated uniformly by the RF

field. You may need reflection planes to illuminate relevant apertures on the bottom and top of the aircraft.

(4) To ensure the systems are tested when operating at their maximum sensitivity, level A systems should be fully operational and the aircraft should be placed in various simulated operating modes.

(5) The test time can be minimized by using only the modulation to which the system under evaluation is most sensitive. If you do this, the rationale used to select the most sensitive modulation should be documented in the HIRF test plan as discussed in paragraph **8.b(1)**. The User's Guide provides guidance on modulation selection and suggested default modulations and dwell times.

(6) As an alternative to testing at frequencies below the first airframe resonant frequency, it is possible to inject high-level currents directly into the airframe using aircraft high-level direct-drive test methods. Aircraft skin current analysis should be performed as described in the User's Guide, or low-level swept-current measurements should be made to determine the skin current distribution that will exist for different RF field polarizations and aircraft illumination angles so that these can be simulated accurately during this test. Aircraft high-level direct-drive testing, although applicable only from 10 kHz to the first airframe resonant frequency, is advantageous because it is possible to test all systems simultaneously.

j. Step 10 — Aircraft Low-Level Coupling Tests.

(1) **General.**

(a) The aircraft low-level coupling tests include three different tests that cover the frequency range of 10 kHz to 18 GHz (see Figure 2). Detailed descriptions are available in the User's Guide. Other techniques may be valid, but must be discussed with and approved by EASA before being used.

(b) The low-level direct-drive test (see Step 10b, Figure **2**) and the low-level swept-current test (see Step 10c) are used for frequencies at or below 400 MHz. The low-level swept-field test (see Step 10d) is used for frequencies at and above 100 MHz. There is an overlap of test frequencies from 100 MHz to 400 MHz in the low-level swept-current test and the low-level swept-field test. The division at 400 MHz is not absolute but rather depends on when HIRF penetration of the equipment case becomes a significant factor.

(2) **Steps 10a and 10b — Aircraft Skin Current Analysis and Low-Level Direct-Drive Test.** Low level direct-drive tests in conjunction with skin current analysis should be used to determine the transfer function between the skin current and individual equipment wire bundle currents. The low-level direct-drive test is typically used for frequencies from 10 kHz to the first airframe resonant frequency. For the low-level direct-drive test to be applied successfully, a three dimensional model of the aircraft should be derived using aircraft skin current analysis. The three dimensional model can then be used to derive the aircraft's skin current pattern for the applicable external HIRF environment. Guidance on skin current analysis is in the User's Guide. If the relationship between the external HIRF environment and the skin current is known for all illumination angles and polarization, either because of aircraft skin current analysis or the use of the low-level swept-current test, the skin current can be set up by direct injection into the airframe. The resultant currents on the system wire bundles are measured with a current probe and normalized to 1 V/m electric field strength so they can be scaled to the appropriate external HIRF environment. This test method has improved sensitivity over the low-level swept-current test and may be necessary for small aircraft or aircraft with high levels of airframe shielding.

(3) **Step 10c — Low-Level Swept-Current Test.**

(a) The low-level swept-current test involves illuminating the aircraft with a low-level external HIRF field to measure the transfer function between the external field and the aircraft and equipment wire bundle currents. This test is typically used in the frequency range of 500 kHz to 400 MHz. The transfer function is resonant in nature and is dependent on both the aircraft structure and the system installation. Because the transfer function relates wire bundle currents to the external field, the induced bulk current injection test levels can be related to an external HIRF environment.

(b) The transmit antenna should be placed in at least four positions around the aircraft, typically the nose, tail, and each wingtip, with the distance between the aircraft and the transmitting antenna sufficient to ensure the aircraft is illuminated uniformly. The aircraft should be illuminated by the antenna at each position while sweeping the frequencies in the range of 500 kHz to 400 MHz. Perform separate frequency sweeps with the transmit antenna oriented for horizontal and vertical polarization. Measure the currents induced on the aircraft wire bundles.

(c) Calculate the ratio between the induced wire bundle current and the illuminating antenna field strength and normalize this ratio to 1 V/m. This provides the transfer function in terms of induced current per unit external field strength. Then the current induced by the applicable external HIRF environment can be calculated by multiplying the transfer function by the external HIRF field strength. The calculated HIRF currents for all transmit antenna positions for each aircraft wire bundle being assessed should be overlaid to produce worst-case induced current for each wire bundle. These worst-case induced currents can be compared with the current used during the integrated system test in step 5.

(4) **Step 10d — Low-Level Swept-Field Test.** Low-level swept-field testing is typically used from 100 MHz to 18 GHz. The test procedures for the low-level swept-field test are similar to those used for the low-level swept-current test; however, in the low-level swept-field test, the internal RF fields in the vicinity of the equipment are measured instead of the wire bundle currents. Various techniques can be used to ensure the maximum internal field in the vicinity of the equipment is measured. Depending on the size of the aircraft and the size of the aircraft cabin, flight deck, and equipment bays, multipoint measurement or mode stirring can be used to maximize the internal field in the vicinity of the equipment. See the User's Guide for detailed low-level swept-field test procedures.

k. Step 11 — Generic Transfer Functions and Attenuation — Level A Display Systems Only.

(1) Level A displays involve functions for which system information is displayed directly to the pilot. For level A display systems, the aircraft attenuation data may be determined using generic attenuation and transfer function data. This approach should not be used for other level A systems, such as control systems, because failures and malfunctions of those systems can more directly and abruptly contribute to a catastrophic failure event than display system failures and malfunctions; therefore, other level A systems should have a more rigorous HIRF compliance verification program.

(2) The integrated system test levels specified in step 5 may be derived from the generic transfer functions and attenuation for different types of aircraft. Acceptable transfer functions for calculating the test levels are given in appendix **1** to this AMC. Appendix **1** to this AMC also contains guidelines for selecting the proper generic attenuation. The generic transfer functions show the envelope of the currents that might be expected to be induced in the types of aircraft in an external HIRF environment of 1 V/m. The current levels should be multiplied linearly by HIRF environment I, II, or III, as appropriate, to determine the integrated system test levels.

(3) The internal HIRF electric field levels are the external HIRF environment divided by the appropriate attenuation, in linear units. For example, 20 dB or a 10:1 attenuation means the test level is the applicable external HIRF environment electric field strength reduced by a factor of 10.

(4) The internal HIRF environments for level A display systems can also be measured using on-aircraft low-level coupling measurements of the actual system installation (see Step 10). This procedure should provide more accurate information to the user, and the test levels may be lower than the generic transfer functions or attenuation, which are worst-case estimates.

l. Step 12 — Aircraft Similarity Assessment.

(1) The aircraft attenuation and transfer functions tests performed for a previously certified aircraft may be used to support aircraft-level verification for a similar aircraft model. The aircraft used as the basis for similarity must have been previously certified for HIRF compliance, using HIRF attenuation and transfer functions determined by tests on that aircraft.

(2) The similarity assessment for the new aircraft should consider the aircraft differences that could impact the internal HIRF environment affecting the level A systems and associated wiring. The comparison should consider equipment and wiring locations, airframe materials and construction, and apertures that could affect attenuation for the external HIRF environment.

(3) If the assessment finds only minimal differences between the previously certified aircraft and the new aircraft to be certified, similarity may be used to determine aircraft attenuation and transfer functions without the need for additional aircraft tests, providing there are no unresolved in-service HIRF problems related to the existing aircraft. If there is uncertainty about the effects of the differences, additional tests and analysis should be conducted as necessary and appropriate to resolve the uncertainty. The amount of additional testing should be commensurate with the degree of difference identified between the new aircraft and the aircraft previously certified. If significant differences are found, similarity should not be used as the basis for aircraft-level verification.

m. Step 13 — Assess Immunity.

(1) Compare the test levels used for the integrated system test of step 5 with the internal RF current or RF fields determined by the aircraft low-level coupling tests (see Step 10), the generic transfer functions and attenuation (see Step 11), or the aircraft similarity assessment (see Step 12). The actual aircraft internal RF currents and RF fields should be lower than the integrated system test levels. Your comparison method should be included in the HIRF compliance plan. The method should enable a direct comparison between the system test level and the aircraft internal HIRF environment at the equipment or system location, using current for frequencies from 10 kHz through 400 MHz, and using electric field strength for frequencies from 100 MHz through 18 GHz.

(2) If the conducted RF susceptibility test levels used for the integrated system test (see Step 5) were too low when compared with the aircraft-induced currents determined in steps 10b, 10c, 11 or 12, then corrective measures may be needed (see Step 14). If the radiated RF susceptibility test levels used for integrated system tests (see Step 5) were too low when compared with the aircraft internal fields determined in steps 10d, 11 or 12, then corrective measures may also be needed (see Step 14).

(3) When comparing the current measured during low-level swept-current tests in step 10c with the current used during the integrated system tests in step 5, there may be differences. These differences may be due to variations between the actual aircraft installation and the integrated system laboratory installation, such as wire bundle lengths, shielding and bonding, and wire bundle composition. The worst-case current signature for a particular wire bundle should be compared to the current induced at the particular test level or equipment malfunction over discrete frequency ranges such as 50 kHz to 500 kHz, 500 kHz to 30 MHz, and 30 MHz to 100 MHz. This comparison should be broken into discrete frequency ranges because the resonant frequencies may differ between the integrated system tests and the aircraft tests.

(4) If you used aircraft high-level tests (see Step 9) for aircraft HIRF verification, you should determine if there were any level A system susceptibilities. Any level A system susceptibilities should be evaluated based on the pass/fail criteria as established in the test plan (see paragraphs **8.b(1)**). If the HIRF susceptibilities are not acceptable, then corrective measures may be needed (see Step 14).

(5) HIRF susceptibilities that were not anticipated or defined in the test plan pass/fail criteria may be observed during aircraft high-level tests or integrated system laboratory tests. If so, the data collected during the HIRF compliance verification process should be used to determine the effect of the HIRF susceptibility on the aircraft systems and functions. The pass/fail criteria may be modified if the effects neither cause nor contribute to conditions that adversely affect the aircraft functions or systems, as applicable, in the HIRF regulations. You should provide an assessment of and supporting rationale for any modifications to the pass/fail criteria to EASA for approval. If the HIRF susceptibilities are not acceptable, then corrective measures may be needed (see Step 14).

(6) If the level A systems show no adverse effects when tested to levels derived from HIRF environment I or III, as applicable, then this also demonstrates compliance of the system with HIRF environment II.

(7) If the integrated system tests results (see Step 5) satisfy the pass criteria from 12 GHz to 18 GHz, and design analysis shows the system has no circuits that operate in the 18 GHz to 40 GHz frequency range, then this demonstrates by analysis that the system is not adversely affected when exposed to HIRF environments above 18 GHz. If these conditions are satisfied, further aircraft and system tests and assessments above 18 GHz are not necessary.

(8) Review the actual system installation in the aircraft and the system configuration used for the integrated system test (see Step 5). If significant configuration differences are identified, corrective measures may be needed (see Step 14).

(9) Certain RF receivers with antennas connected should not be expected to perform without effects during exposure to the HIRF environments, particularly in the RF receiver operating band. Because the definition of adverse effects and the RF response at particular portions of the spectrum depends on the RF receiver system function, refer to the individual RF receiver minimum performance standards for additional guidance. However, because many RF receiver minimum performance standards were prepared before implementation of HIRF requirements, the RF receiver pass/fail criteria should be coordinated with EASA.

n. Step 14 — Corrective Measures. Take corrective measures if the system fails to satisfy the HIRF immunity assessment of step 13. If changes or modifications to the aircraft, equipment, system or system installation are required, then additional tests may be necessary to verify the effectiveness of the changes. The ED-14G, Section 20 equipment tests, integrated system tests, and aircraft tests, in whole or in part, may need to be repeated to show HIRF compliance.

o. Step 15 — HIRF Protection Compliance. Submit the test results and compliance report to the cognizant EASA certification office for approval as part of the overall aircraft type certification or supplemental type certification process.

10. Steps to Level B and C System HIRF Compliance.

a. Step 1 — System Safety Assessment. Determine the system failure condition classification for the systems being certified on your aircraft, using a system safety assessment as discussed in paragraph **6.b(2)**. For systems classified with hazardous or major failure conditions (Level B and C systems), follow compliance steps 2 through 8 listed below, as appropriate. These compliance steps are also depicted in figure **3** of this AMC, and are not necessarily accomplished sequentially. Systems classified with catastrophic failure conditions (Level A systems) should follow the compliance steps outlined in paragraph **9**.

b. Step 2 — Define Aircraft and System HIRF Protection. Define the HIRF protection features that will be incorporated into the aircraft and system designs, based on the HIRF environments that are applicable to your aircraft and its level B and C systems. Equipment, system, and aircraft HIRF protection design may occur before aircraft-level tests are performed, and before the actual internal HIRF environment is determined. Therefore the equipment, system and aircraft HIRF protection design should be based on an estimate of the expected internal HIRF environment.

c. Step 3 — Select Compliance Method. Determine if you will perform equipment HIRF tests on the level B and C systems, or if you will base the compliance on previous equipment tests performed for a similar system.

d. Step 4 — Equipment Test.

(1) Level B and level C systems do not require the same degree of HIRF compliance testing as level A systems, and therefore do not require aircraft-level testing. ED-14G, Section 20 laboratory test procedures should be used, using equipment test levels defined in the regulations. The test levels used depend on whether the system is categorized as level B or C. Equipment HIRF test level 1 or 2, as applicable, should be used for level B systems. ED-14G Section 20, Category RR (using the alternative modulation for radiated susceptibility), satisfies the requirements of equipment HIRF test level 1. For equipment HIRF test level 2, you may use the approach in paragraph **9.k** to help determine acceptable aircraft transfer function and attenuation curves for your level B system. Equipment HIRF test level 3 should only be used for level C systems. ED-14G Section 20, Category TT, satisfies the requirements of equipment HIRF test level 3. When applying modulated signals, the test levels are given in terms of the peak of the test signal as measured by a root-mean-square (rms)-indicating spectrum analyser's peak detector. See the User's Guide (SAE ARP 5583A/EUROCAE ED-107A) for more details on modulation.

(2) Define appropriate pass/fail criteria for the system, based on the system safety assessment and the appropriate HIRF regulation (see paragraph **6.b(2)**). Any susceptibility noted during the equipment tests, including equipment malfunctions, upset, or damage, should be recorded and evaluated based on the defined pass/fail criteria.

e. Step 5 — Similarity Assessment.

(1) The equipment HIRF tests performed for a system previously certified on one aircraft model may be used to show compliance for a similar system. Each system considered for similarity needs to be assessed independently even if it may use equipment and installation techniques that have been the subject of a previous certification.

(2) The system used as the basis for certification by similarity must have been previously certified for HIRF compliance on another aircraft model, and must have successfully completed equipment HIRF tests. Similarity assessment requires comparison of both equipment and installation differences that could adversely affect HIRF immunity. An assessment of a new system should consider the differences in the equipment circuit interfaces, wiring, grounding, bonding, connectors, and wire-shielding practices.

(3) If the assessment finds only minimal differences between the previously certified system and the new system to be certified, similarity may be used for HIRF compliance without the need for additional equipment HIRF tests, providing there are no unresolved in-service HIRF problems related to the previously certified system. If there is uncertainty about the effects of the differences, additional tests and analysis should be conducted as necessary and appropriate to resolve the uncertainty. The amount of additional testing should be commensurate with the degree of difference identified between the new system and the system previously certified. If significant differences are found, similarity should not be used as the basis for HIRF compliance.

f. Step 6 — Assess Immunity.

(1) Review the results of the equipment test to determine if the pass/fail criteria is satisfied. HIRF susceptibilities that were not anticipated or defined in the test plan pass/fail criteria may be observed during equipment HIRF tests. If so, you should determine the effect of the HIRF susceptibility on the aircraft systems and functions. The pass/fail criteria may be modified if the effects neither cause nor contribute to conditions that adversely affect the aircraft functions or systems, as applicable, in the HIRF regulations. You should provide an assessment of, and supporting rationale for, any modifications to the pass/fail criteria to EASA for

approval. If the HIRF susceptibilities are not acceptable, then corrective measures may be needed (see Step 7).

(2) Review the actual system installation in the aircraft and the configuration used for the equipment tests (see Step 4). If significant differences in grounding, shielding, connectors, or wiring are identified, corrective measures may be needed (see Step 7).

(3) Certain RF receivers with antennas connected should not be expected to perform without effects during exposure to the HIRF environments, particularly in the RF receiver operating band. Because the definition of adverse effects and the RF response at particular portions of the spectrum depends on the RF receiver system function, refer to the individual RF receiver minimum performance standards for additional guidance. However, because many RF receiver minimum performance standards were prepared before implementation of HIRF requirements, the RF receiver pass/fail criteria should be coordinated with EASA. Future modifications of the minimum performance standards should reflect HIRF performance requirements.

g. Step 7 — Corrective Measures. Take corrective measures if the system fails to satisfy the HIRF immunity assessment of step 6. If changes or modifications to the equipment, system, or system installation are required, then additional tests may be necessary to verify the effectiveness of the changes. The ED-14G, Section 20 equipment tests, in whole or in part, may need to be repeated to show HIRF compliance

h. Step 8 — HIRF Protection Compliance. Submit the test results and compliance report to the cognizant EASA certification office for approval as part of the overall aircraft type certification or supplemental type certification process.

11. Maintenance, Protection Assurance, and Modifications.

a. The minimum maintenance required to support HIRF certification should be identified in instructions for continued airworthiness as specified in CS 23.1529, CS 25.1529, CS 27.1529, and CS 29.1529, as appropriate. Dedicated devices or specific features may be required to provide HIRF protection for an equipment or system installation. Appropriate maintenance procedures should be defined for these devices and features to ensure in-service protection integrity. A HIRF protection assurance program may be necessary to verify that the maintenance procedures are adequate. The User's Guide (SAE ARP 5583A/EUROCAE ED-107A) provides further information on these topics.

b. The maintenance procedures should consider the effects of corrosion, fretting, flexing cycles, or other causes that could degrade these HIRF protection devices. Whenever applicable, specific replacement times of these devices and features should be identified.

c. Aircraft or system modifications should be assessed for the impact any changes will have on the HIRF protection. This assessment should be based on analysis and/or measurement.

Appendix 1. Generic Transfer Functions and Attenuation

1. Generic Transfer Functions

a. Suitable transfer functions for calculating the bulk current injection test levels for level A display systems (see paragraph **9.k**) are given in figures **A1-1** through **A1-5**. These are derived generic transfer functions acquired from test results obtained from a significant number of aircraft. The test results were then processed to establish a 95 per cent population probability.

b. The transfer functions are normalized to a 1 V/m HIRF environment and may be multiplied linearly by the external HIRF environment to establish the bulk current injection test level requirements in the frequency range from 10 kHz up to 400 MHz. For example, if the HIRF environment is 100 V/m at 3 MHz, then using figure **A1-1**, multiple 0.7 mA/V/m by 100 V/m to establish a test level of 70 milliamperes (mA).

c. Consult the User's Guide (SAE ARP 5583A/EUROCAE ED-107A) for details on the use of generic transfer functions.

2. Generic Attenuation.

a. Figure **A1-6** shows the generic attenuation for frequencies from 100 MHz to 18 GHz that can be used for determining the internal HIRF environment where equipment and associated wiring for level A display systems (see paragraph **9.k**) are installed. This internal HIRF environment provides the test level for the integrated system radiated susceptibility laboratory test. The external HIRF environment should be divided by the appropriate attenuation, in linear units, to determine the internal HIRF environment. For example, 12 dB or a 4:1 attenuation means the test level is the applicable external HIRF environment electric field strength reduced by a factor of 4.

b. Guidance on the use of the generic attenuation is given below:

(1) **No Attenuation.** No attenuation credit can be used when the level A display equipment and associated wiring are located in aircraft areas with no HIRF shielding, such as areas with unprotected nonconductive composite structures, areas where there is no guarantee of structural bonding, or other open areas where no shielding is provided. You may choose to use no attenuation for equipment that may be installed in a broad range of aircraft areas.

(2) **6 dB Attenuation.** This attenuation is appropriate when the level A display equipment and associated wiring are located in aircraft areas with minimal HIRF shielding, such as a cockpit in a nonconductive composite fuselage with minimal additional shielding, or areas on the wing leading or trailing edges, or in wheel wells.

(3) **12 dB Attenuation.** This attenuation is appropriate when the level A display equipment and associated wiring are located entirely within aircraft areas with some HIRF shielding, in aircraft with a metal fuselage or a composite fuselage with shielding effectiveness equivalent to metal. Examples of such areas are avionics bays not enclosed by bulkheads, cockpits, and areas near windows, access panels, and doors without EMI gaskets. Current-carrying conductors in this area, such as hydraulic tubing, control cables, wire bundles, and metal wire trays, are not all electrically bonded to bulkheads they pass through.

(4) **20 dB Attenuation.** This attenuation is appropriate when the level A display equipment and associated wiring are located entirely within aircraft areas with moderate HIRF shielding, in aircraft with a metal fuselage or a composite fuselage with shielding effectiveness equivalent to metal. In addition, wire bundles passing through bulkheads in these areas have shields electrically bonded to the bulkheads. Wire bundles are installed close to metal structure and take advantage of other inherent shielding characteristics provided by metal structure. Current-carrying conductors, such as hydraulic tubing, cables, and metal wire trays are electrically bonded to all bulkheads they pass through.

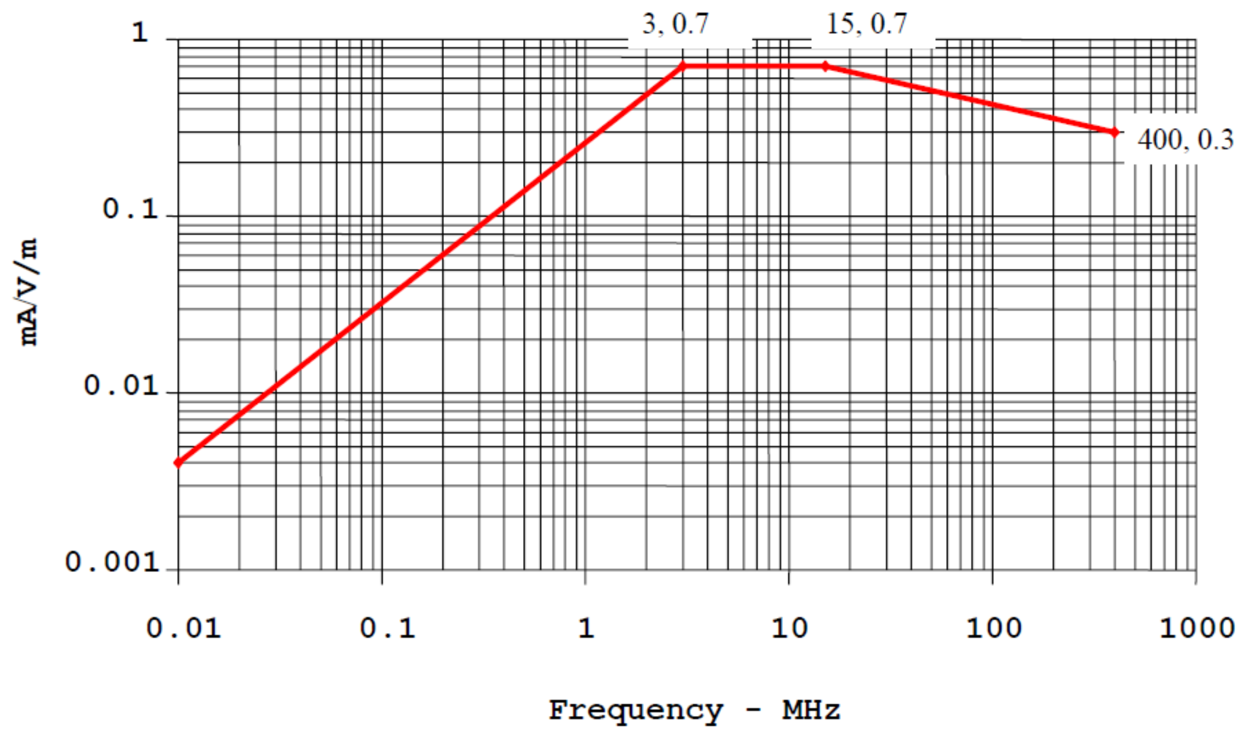
(5) **32 dB Attenuation.** This attenuation is appropriate when the level A display equipment and all associated wiring to and from equipment are located entirely within areas with very effective HIRF shielding to form an electromagnetic enclosure.

c. Different attenuation values may be appropriate for different frequency ranges. For example, 0 dB attenuation may be used for the frequency range of 100 MHz to 400 MHz, 6 dB attenuation for the frequency range of 400 MHz to 1 GHz, and 12 dB attenuation for the frequency range of 1 GHz to 18 GHz. If you intend to use different attenuation values for various frequency ranges, then you should also provide the supporting rationale.

d. Consult the User's Guide for details on the use of generic attenuation.

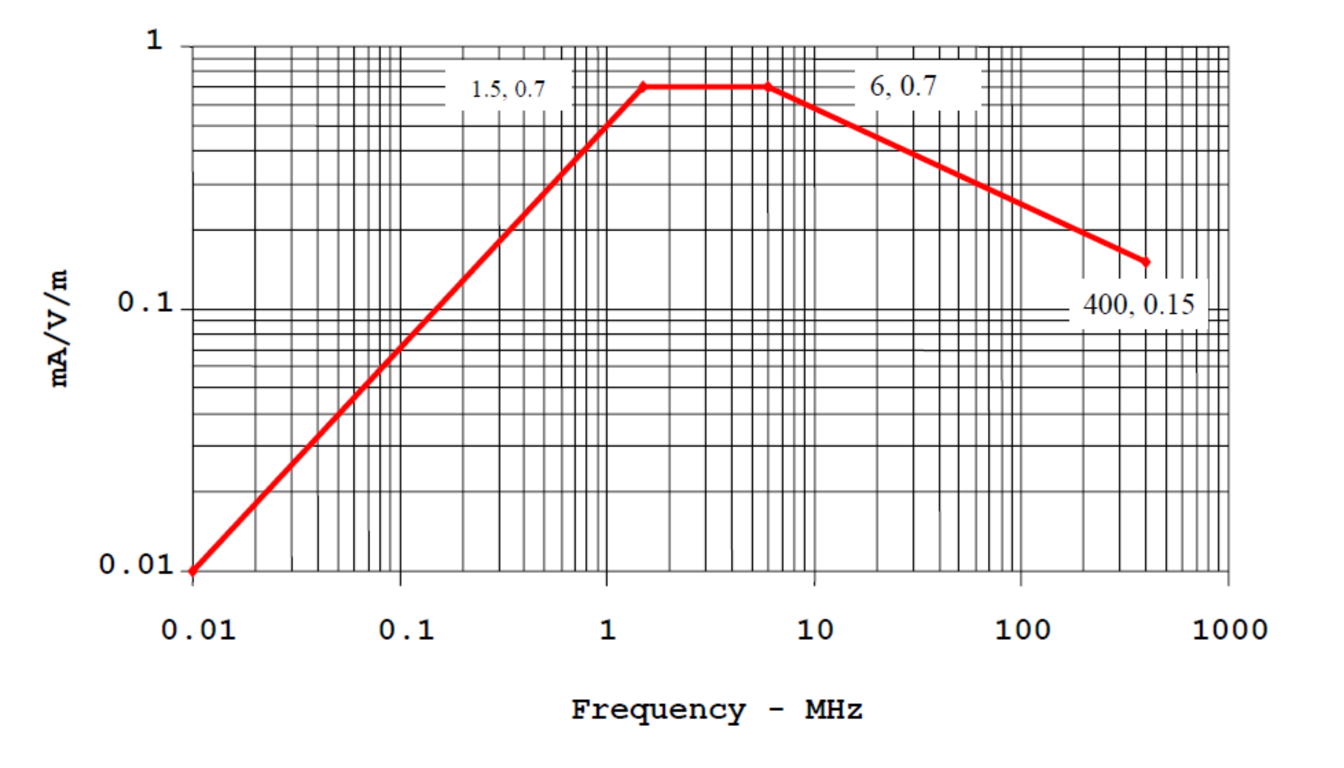
3. Measured Transfer Functions or Attenuation. You can produce your own generic transfer functions and attenuation for your level A display systems (see paragraph **9.k**) based on actual measurements on your aircraft models. These transfer functions and attenuation can then be used in your HIRF compliance submission in place of the generic transfer functions and attenuation specified in this appendix. EASA encourages this approach because it provides a more accurate reflection of the true internal HIRF environment for your aircraft models. However, if you intend to produce your own generic transfer functions and attenuation, then this approach should also be addressed in the HIRF compliance plan (see paragraph **8.a**) that is submitted to EASA for approval.

FIGURE A1-1 — Generic Transfer Function — Aeroplane



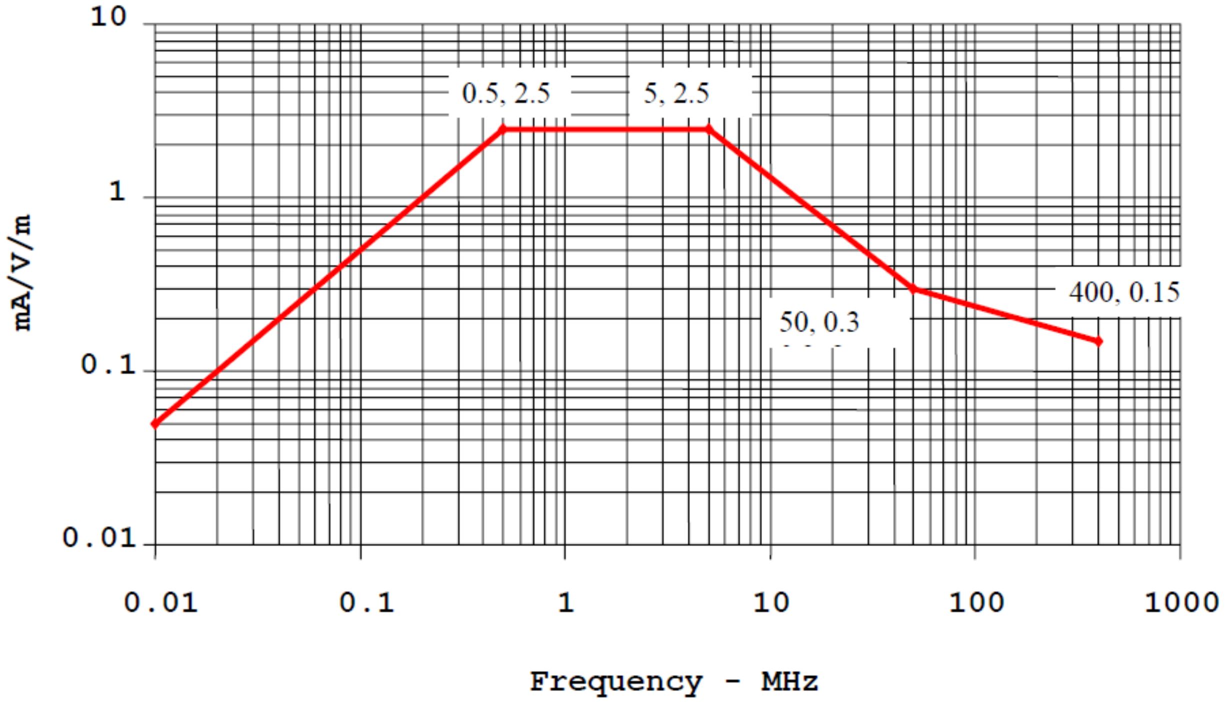
Generic transfer function normalized to 1 V/m for an aeroplane with a fuselage length of ≤ 25m.

FIGURE A1-2 — Generic Transfer Function — Aeroplane



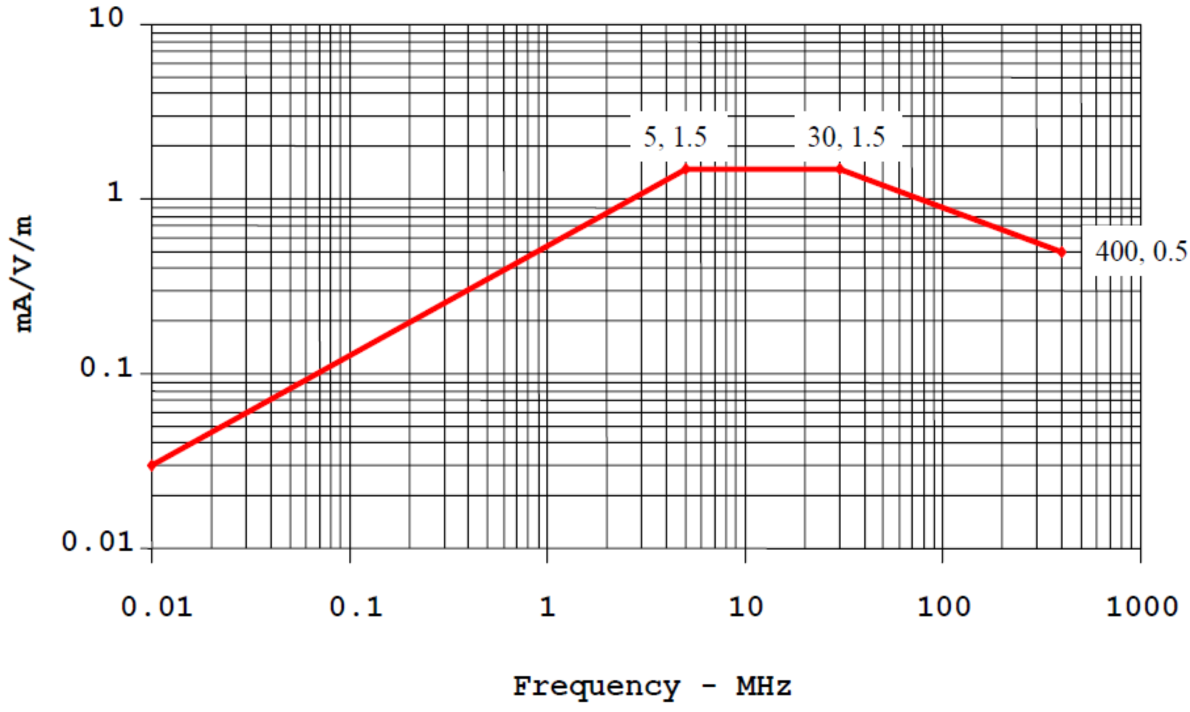
Generic transfer function normalized to 1 V/m for an aeroplane with a fuselage length of > 25m and ≤ 50m.

FIGURE A1-3 — Generic Transfer Function – Aeroplane



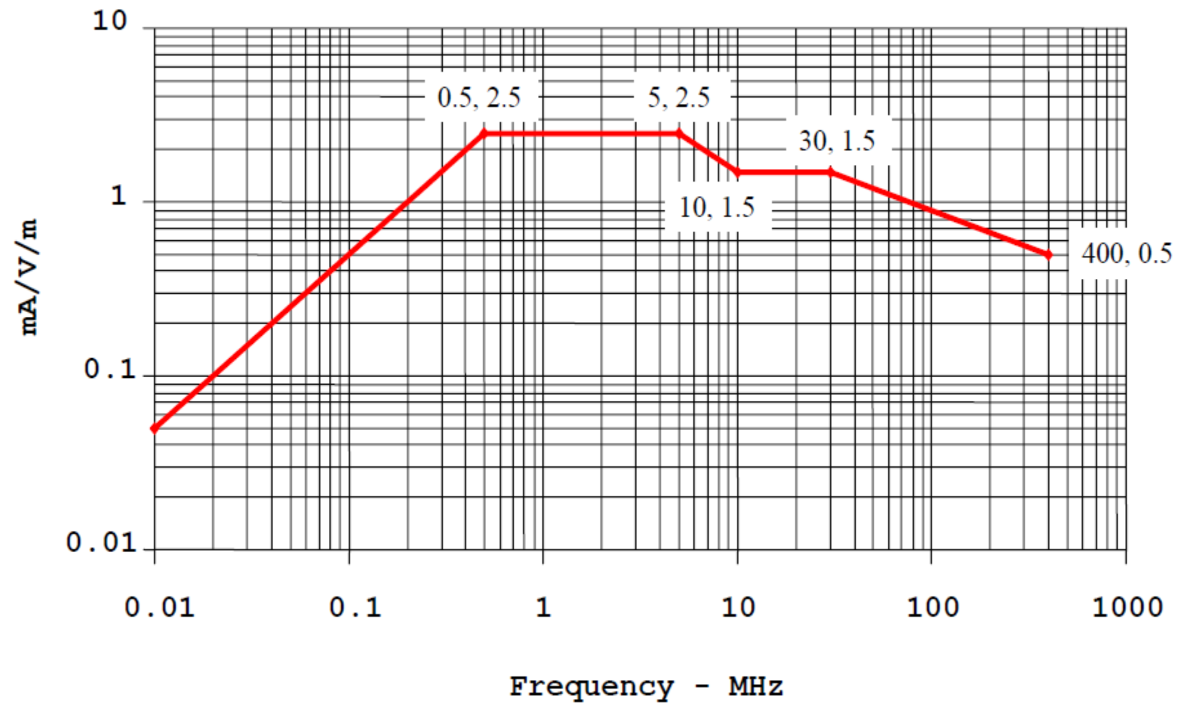
Generic transfer function normalized to 1 V/m for an aeroplane with a fuselage length of > 50 m.

FIGURE A1-4 — Generic Transfer Function — Rotorcraft



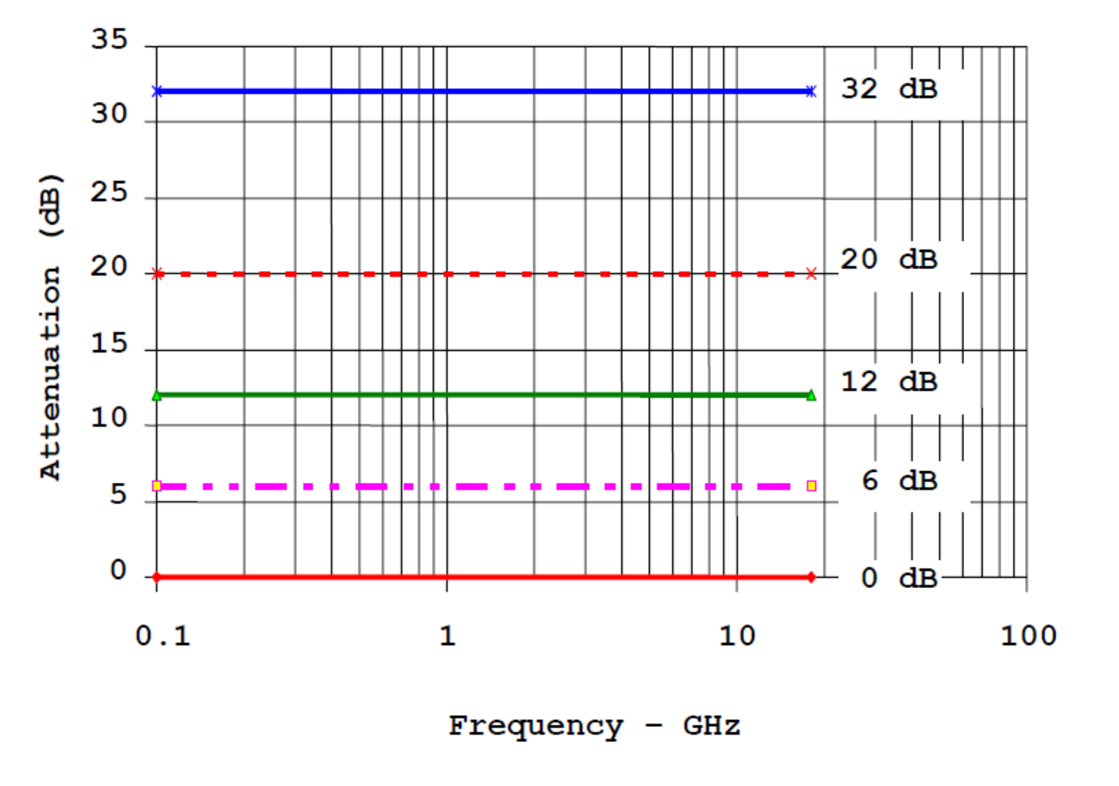
Generic transfer function normalized to 1 V/m for a rotorcraft.

FIGURE A1-5 — Generic Transfer Function — Rotorcraft



Generic transfer function normalized to 1 V/m for all aeroplanes.

FIGURE A1-6 — GENERIC ATTENUATIONVALUES — All Aircraft 100 MHz to 18 GHz



4. Regulatory Impact Assessment (RIA)

4.1. Issues to be addressed

Aircraft electrical and electronic equipment can be susceptible to adverse effects due to electromagnetic radiation and lightning. With the increased use of critical and essential electrical/electronic systems on aircraft, coupled with the development and use of non-metallic structural materials that are more 'transparent' to electromagnetic radiation and have low electrical conductivity, it has been recognized that HIRF & lightning standards would need to be enhanced to counter the growing threat.

4.1.1. Safety risk assessment

The environmental standards for HIRF and Lightning were developed and jointly agreed within the EEHWG during the 1990s. Since this time, however, the paths taken by the FAA and JAA/EASA to fully implement the agreed rules have not been coordinated or aligned, and this has led to different application of the rules. The safety levels achieved are nevertheless considered equivalent and there is no evidence that regulatory shortcomings have led to any safety risks. The present regulations and the ones given in this NPA are similar from a safety point of view.

4.1.2. Who is affected?

The sectors of the civil aviation community concerned by this NPA are aircraft and rotorcraft manufacturers, system/equipment manufacturers and competent authorities, including the Agency.

4.1.3. How could the issue/problem evolve?

The absence of harmonised regulation between the Agency and the FAA could lead to an increase of costs and time for the applicants/authority during the validation process of Type Certificates (TCs) or Supplemental Type Certificates (STCs).

The reference in type certification basis to Agency standard CRIs dated in excess of 10 years ago, increases the risk of obsolescence during the test.

The Agency would also not fully comply with the objective of Article 19 of the Basic Regulation.

4.2. Objectives

The objective of this proposal is to introduce HIRF and Lightning requirements in Certification Specifications for Aeroplanes and Rotorcraft. This will harmonise EASA Certification Specifications and associated Guidance Materials with FAA and eliminate the need to maintain generic SC.

4.3. Policy options

Four options have been identified as follows:

Table 1: Selected policy options

Option No	*Short title*	**Description**
0	Do nothing	Baseline option.
1	Amend the Special Conditions	Amend the Special Conditions to allow the use of more recent standards.
2	Amend CS-25 and Publish AMC 25.1316 and AMC 25.1317	Create CS 25.1317 and publish AMC Materials in Book 2 of CS-25 to introduce guidance material for HIRF & Lightning Protection.
3	Amend CS-23, CS-25, CS-27, CS-29 & AMC-20	Amend and add new requirements for all the products and publish AMC 20-136 and AMC 20-158 applicable for all products.

4.4. Analysis of impacts

All identified impacts are qualitatively assessed ('light' RIA) and expressed in terms of a score = a numerical single digit from –3 (highly negative) to +3 (highly positive).

Safety scores, since safety is the primary objective of the Agency as per Article 2 of the Basic Regulation, are assigned a 'weight' of 3. Environmental scores, based on the same Article, have a weight of 2. Other scores have a weight of 1.

4.4.1. Safety impact

The option 'do nothing', is considered neutral in terms of safety (= no change in respect of the current situation), since there is no evidence that it is unsafe.

The four Options can be compared from the safety perspective in the table below:

Options	**0**	**1**	**2**	**3**
	Do nothing	**Amend Special Conditions**	**CS 25.1317, AMCs 25.1316 & AMC 25.1317**	**Amend CSs & publish AMC 20-136 AMC 20-158**
Assessment	Safety will remain at the current level.	Quality of certification process for all products slightly improved.	Quality of certification processes only improved for large aeroplanes.	Quality of certification processes for all products improved.
Score (unweighted)	0	1	1	1
Weight	Multiply the unweighted score by: 3			
Score (weighted)	**0**	**3**	**3**	**3**

4.4.2. Environmental impact

All four identified options are neutral from the environmental perspective.

4.4.3. Social impact

All four identified options are neutral from the social perspective.

4.4.4. Economic impact

The option 'do nothing', is considered neutral in terms of economic impact.

The four options can be compared from the economic perspective in the table below:

Options	0	1	2	3
	Do nothing	**Amend Special Conditions**	**CS 25.1317, AMC 25.1316 & AMC 25.1317**	**Amend CSs & publish AMC 20-136 AMC 20-158**
Assessment	Neutral	Cost-efficiency of regulatory processes improved for both the Agency and the applicants.	As Option 0, The guidance introduced by AMC 25.1316 and 25.1317 already taken into account by the Applicants in the industrial Standards.	The total harmonisation between the Agency and FAA regulation simplify the validation process.
Score (unweighted)	0	1	0	2
Weight	Multiply the unweighted score by: 1			
Score (weighted)	**0**	**1**	**0**	**2**

4.4.5. General aviation and proportionality issues

The four options can be compared from the proportionality perspective in the table below:

Options	0	1	2	3
	Do nothing	**Amend Special Conditions**	**CS 25.1317, AMC 25.1316 & AMC 25.1317**	**Amend CSs & publish AMC 20-136 AMC 20-158**
Assessment	Neutral. Situation remains unchanged.	All products are equally affected.	As Option 0.	Provides greater prior knowledge and transparency for manufacturers of small aircraft
Score (unweighted)	0	0	0	1
Weight	Multiply the unweighted score by: 1			
Score (weighted)	**0**	**0**	**0**	**1**

A positive impact is expected on small aircraft/rotorcraft and equipment manufacturers, who may not be currently aware of the regulations applied by the Agency.

4.4.6. Impact on 'better regulation' and harmonisation

'Do nothing' would lead to a decrease in harmonisation with the FAA, since that authority, based on the work of the same expert groups mentioned above, has already introduced amendments to 14.CFR Part-23, Part-25, Part-27 and Part-29.

The four options can be compared from the proportionality perspective in the table below:

Options	0	1	2	3
	Do nothing	**Amend Special Conditions**	**CS 25.1317, AMC 25.1316 & AMC 25.1317**	**Amend CSs & publish AMC 20-136 AMC 20-158**
Assessment	Loss of harmonisation with other regulators	Improvement for the compliance demonstration of essential systems	Harmonisation only for large aeroplanes	Maximum possible harmonisation with FAA
Score (unweighted)	−2	1	1	3
Weight	Multiply the unweighted score by: 1			
Score (weighted)	**−2**	**1**	**1**	**3**

4.5. Comparison and conclusion

4.5.1. Comparison of options

The above considerations can be presented also using the Multi-Criteria Analysis (MCA) methodology, the 'weighted' scores assigned above are algebraically summed:

Options	0	1	2	3
	Do nothing	**Amend Special Conditions**	**CS 25.1317, AMC 25.1316 & AMC 25.1317**	**Amend CSs & publish AMC 20-136 AMC 20-158**
	Weighted score			
Safety	0	3	3	3
Social impact	0	0	0	0
Environment	0	0	0	0
Economic impact	0	1	0	2
Proportionality	0	0	0	1
Regulatory harmonisation	−2	1	1	3
TOTAL	**−2**	**5**	**4**	**9**

From the table above one could observe that Option 0 ('do nothing') shows a negative score from the harmonisation perspectives (being neutral from the other points of view).

Option 1 improves slightly safety, economic and regulatory harmonisation and is neutral for the other aspects.

Option 2 improves slightly safety and harmonisation for large aeroplanes. It will not impact other products.

Option 3 is positive from a safety, economic, proportionality and harmonisation standpoint. No negative impacts are identified.

Therefore, Option 3 (Amend CSs and publish new AMC-20s) is the preferred one.

5. References

5.1. Affected regulations

None

5.2. Affected CS, AMC and GM

— ED Decision 2003/14/RM on certification specifications, including airworthiness codes and acceptable means of compliance for normal, utility, aerobatic and commuter category aeroplanes (« CS-23 »). Decision as last amended by ED Decision 2012/012/R[5].

— ED Decision 2003/02/RM on certification specifications, including airworthiness codes and acceptable means of compliance, for large aeroplanes (« CS-25 »). Decision as last amended by ED Decision 2013/033/R[6].

— ED Decision 2003/15/RM on certification specifications for Small Rotorcraft (« CS-27 »). Decision as last amended by ED Decision 2012/021/R[7].

— ED Decision 2003/16/RM, as last amended by ED Decision 2012/022/R, certification specifications for large rotorcraft (« CS-29 »). Decision as last amended by ED Decision 2012/022/R[8].

— ED Decision 2003/12/RM on general acceptable means of compliance for airworthiness of products, parts and appliances (« AMC-20 »). Decision as last amended by ED Decision 2014/001/R[9].

[5] See: http://easa.europa.eu/agency-measures/certification-specifications.php#CS-23
[6] See: http://easa.europa.eu/agency-measures/certification-specifications.php#CS-25
[7] See: http://easa.europa.eu/agency-measures/certification-specifications.php#CS-27
[8] See: http://easa.europa.eu/agency-measures/certification-specifications.php#CS-29
[9] See: http://easa.europa.eu/agency-measures/certification-specifications.php#AMC-20