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Superseding ARP5413			
Certification of Aircraft Electrical/Electronic Systems for the Indirect Effects of Lightning			

RATIONALE

This document was developed due to the need to update the requirements that were contained in AC 20-136; the agreement within the committee and with the FAA was that when the AC was updated, this document would be cancelled to prevent any type of conflict; the FAA has announced the release of AC 20-136A so this document is no longer needed.

CANCELLATION NOTICE

This document has been declared "CANCELLED" as of March 2007. By this action, this document will remain listed in the Numerical Section of the Aerospace Standards Index.

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**Certification of Aircraft Electrical/Electronic
Systems for the Indirect Effects of Lightning**

FOREWORD

Whenever a reference document appears in this Standard, it carries the minimum revision level of the reference document acceptable to meet the intended requirements. Later versions of the reference document are also acceptable but earlier versions are not acceptable. In all cases, other documents shown to be equivalent to the referenced document are also acceptable.

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1. SCOPE:

This SAE Aerospace Recommended Practice (ARP) provides guidance for a means of showing compliance with the regulations for hazards caused by the lightning environment to electrical/electronic systems installed either on or within aircraft. Equipment hazards addressed include those due to indirect effects on equipment and its associated wiring that is mounted on the aircraft exterior as well as indirect effects on equipment and its associated wiring located within the aircraft interior. This document applies to new aircraft and equipment designs, modifications of existing aircraft or equipment, and applications of existing (off the shelf) equipment on new aircraft.

NOTE: This ARP does not address direct effects such as burning, eroding, blasting, of aircraft structure nor does it address fuel ignition hazards (see related reading material in 2.3 of this document). This ARP does not address lightning zoning methods or lightning test requirements, methods, and techniques. Coverings (fairing, skin, cowl, etc.) should normally prevent direct attachment of the lightning channel to underlying system components. However, if a direct lightning strike attachment to a system component can occur, a complete evaluation of both direct and indirect effects will be necessary.

It should be noted that electrical/electronic systems or components are sometimes exposed to lightning currents directly conducted from the aircraft exterior, as may happen when an antenna is struck and a portion of lightning current flows in its cable. Care should be taken to identify any such possibilities and either eliminate these situations by design modifications, or address them in the certification plan. No further discussion of these situations is included in this ARP.

1.1 Purpose:

This ARP provides information and guidance concerning a means, but not the only means, of compliance with Parts 23, 25, 27, and 29 of the Federal Aviation Regulations (FAR) and Joint Airworthiness Requirements (JAR), as applicable for preventing hazards, due to lightning indirect effects, from occurring to electrical/electronic systems.

2. REFERENCES:

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

ARP5412, Aircraft Lightning Environment and Related Test Waveforms

ARP5414, Aircraft Lightning Zoning

ARP5415 (DRAFT), User's Manual for Certification of Aircraft Electrical/Electronic Systems Against the Indirect Effects of Lightning

ARP5416 (DRAFT), Aircraft Lightning Test Methods

2.2 Related FAR and JAR Information:

2.2.1 Federal Aviation Regulations (FAR):

Federal Aviation Regulations 14 CFR Parts 23, 25, 27, 29 and 33; Sections .901, .903, .1301, .1309, .1316, .1431, and .1529 (as applicable). 14 CFR Part 33, Sections .28 and .91 (as applicable)

2.2.2 FAA Advisory Circulars: The following Advisory Circulars (AC) may provide additional information:

AC 23.1309-1C, System and Equipment Installations in Part 23 Airplanes, dated March 12, 1999

AC 25.1309-1A, System Design and Analysis, dated June 21, 1988

AC 27-1A, Certification of Normal Category Rotorcraft, dated August 8, 1985, including to Change 4 dated September 30, 1997

AC 29-2B, Certification of Transport Category Rotorcraft, dated September 16, 1987, including to Change 3 dated July 31, 1997

AC 21-16D, Radio Technical Commission for Aeronautics Document DO-160D, dated March, 1998

AC 20-136, Certification of Aircraft Electrical/Electronic Systems for the Indirect Effects of Lightning

2.2.3 Joint Airworthiness Requirements (JAR):

Joint Airworthiness Requirements Parts 23.1309, 25X899, 25.1309, 25.1431, 27.610, 27.1309, 29.610, 29.1431, JAR E AMJ 20X-1

2.2.4 JAA Advisory and Interpretive Material:

ACJ 25X899, Electrical Bonding and Protection Against Lightning and Static Electricity (Interpretive Material and Acceptable Means of Compliance)

ACJ 29.610, Lightning and Static Electricity Protection (Interpretive Material and Acceptable Means of Compliance)

AMJ 20X-1, Certification of Aircraft Propulsion Systems Equipped with Electronic Controls

AMJ 25.1309, System Design and Analysis

AMJ 29.1309, Equipment, System and Installation

2.3 Related Reading Material:

A comprehensive discussion on the material in this Standard, with additional guidance information, is available in the following documents:

2.3.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001:

ARP4754, Certification Considerations for Highly Integrated or Complex Aircraft Systems

2.3.2 EUROCAE Documents:

EUROCAE ED-14D, Environmental Conditions and Test Procedures for Airborne Equipment, dated July 1997

2.3.3 RTCA Publications: Available from RTCA, Inc., 1140 Connecticut Avenue, NW, Suite 1020, Washington, DC 20036-4001:

RTCA, Inc., DO-160D, Environmental Conditions and Test Procedures for Airborne Equipment, dated July, 1997

2.4 Definitions:

See Appendix A for list of definitions.

3. BACKGROUND:

- a. Aircraft electrical/electronic systems may be vulnerable to lightning hazards. Aircraft which utilize an increasing number of electrical/electronic systems are currently being and will continue to be certified.
- b. Lightning indirect effects may result when the electromagnetic fields produced by a direct strike to the aircraft induce voltage and current transients into the electrical/electronic equipment or components. These transients can be produced by electromagnetic field penetration into the aircraft interior or by structural IR (current times resistance) voltage rises due to current flow on the aircraft.
- c. The trend toward increased reliance on electrical/electronic systems for flight and engine control functions, navigation, and instrumentation requires that effective protection against lightning induced transients be designed and incorporated into these systems. Reliance upon redundancy as a sole means of protection against lightning indirect effects is generally not adequate because the electromagnetic fields and structural IR voltages can interact concurrently with all electrical wiring aboard an aircraft.

4. APPROACHES TO COMPLIANCE:

The following seven (7) activities are elements of an iterative process for certification of aircraft electrical/electronic systems with respect to the indirect effects of lightning. The particular order of activities addressed, and the iterative application of the elements appropriate for a particular situation, are left to the applicant and strict adherence to the particular ordering of the elements in the list is not intended.

- a. Review the safety analysis with respect to the indirect effects of lightning on the aircraft.
- b. Determine the lightning strike zones for the aircraft.
- c. Establish the airframe lightning current paths for the zones.
- d. Establish the effects of the internal environment.
- e. Establish Transient Control Levels (TCL) and Equipment Transient Design Levels (ETDL).
- f. Verify compliance.
- g. Corrective measures.

The elements are described in more detail in paragraphs (a) through (g).

- a. Review the safety analysis with respect to the indirect effects of lightning. A Functional Hazard Assessment (FHA) is conducted to identify all failures and classify them in functional and operational terms. The results of the FHA should be reviewed to ensure that any unique indirect effects of lightning have been identified, such as common mode failures. Airworthiness requirements for classifying these functions are based on Section .1309 of FAR/JAR Parts 23, 25, 27, and 29. FAA/JAA advisory circulars which provide guidance in classifying these failure conditions according to their severity are as follows: AC 23.1309-1C, 25.1309-1A, 27-1A, 29-2B, AMJ 25.1309 and ACJ 29.1309.

The failure condition classifications listed below are derived from this guidance material and are included to assist in the use of this document. The classifications are:

1. Catastrophic: Failure conditions which would prevent continued safe flight and landing.
2. Hazardous/Severe-Major: Failure conditions which would reduce the capability of the aircraft or the ability of the crew to cope with adverse operating conditions to the extent that there would be:
 - (a) A large reduction in safety margins or functional capabilities.
 - (b) Physical distress or higher workload such that the flight crew could not be relied on to perform their tasks accurately or completely, or
 - (c) Serious (or fatal¹) injury to a relatively small number of the occupants.

1. JAA only.

4. (Continued):

3. Major: Failure conditions which would reduce the capability of the aircraft or the ability of the crew to cope with adverse operating conditions to the extent that there would be, for example, a significant reduction in safety margins or functional capabilities, a significant increase in crew work load or in conditions impairing crew efficiency, or discomfort to occupants, possibly including injuries.
4. Minor: Failure conditions which would not significantly reduce aircraft safety, and which involve crew actions that are well within their capabilities. Minor failure conditions may include, for example, a slight reduction in safety margins or functional capabilities, a slight increase in crew workload, such as routine flight plan changes, or some inconvenience to occupants.
5. No Effects: Failure conditions which do not affect the operational capability of the aircraft or increase crew workload.

The system development assurance level would also be assessed when performing the FHA and would be approved by the cognizant aviation certification authority. Guidance for selecting the system development assurance level is provided in ARP4754.

The following development assurance levels are related to the failure condition classifications.

Level A: Electrical and electronic systems whose failure would cause or contribute to a failure of function resulting in a catastrophic failure condition for the aircraft.

Level B: Electrical and electronic systems whose failure would cause or contribute to a failure of function resulting in a hazardous/severe-major failure condition for the aircraft.

Level C: Electrical and electronic systems whose failure would cause or contribute to a failure of function resulting in a major failure condition for the aircraft.

Level D: Electrical and electronic systems whose failure would cause or contribute to a failure of function resulting in a minor failure condition for the aircraft. Once a system has been confirmed, by the cognizant aviation certification authority, as being Level D, no further application of this regulation is required.

Level E: Electrical and electronic systems whose failure would cause or contribute to a failure of function resulting in no effect on aircraft operational capability or crew workload. Once a system has been confirmed, by the cognizant aviation certification authority, as being Level E, no further application of this regulation is required.

- b. Determine the lightning strike zones for the aircraft. The characteristics of currents entering the aircraft vary according to attachment point locations on the aircraft. To establish the lightning characteristics appropriate for different portions of the aircraft, lightning strike zones have been defined in ARP5414.