Federal Aviation Administration
Aviation Rulemaking Advisory Committee

Transport Airplane and Engine Issue Area
Electromagnetic Effects Harmonization Working Group

Task 1 – High Energy Radiated Fields

Task Assignment

Aviation Rulemaking Advisory Committee; Transport Airplane and Engine Subcommittee; Electromagnetic Effects Harmonization Working Group

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Notice of establishment of Electromagnetic Effects Harmonization Working Group.

SUMMARY: Notice is given of the establishment of the Electromagnetic Effects Harmonization Working Group of the Transport Airplane and Engine Subcommittee. This notice informs the public of the activities of the Transport Airplane and Engine Subcommittee of the Aviation Rulemaking Advisory Committee.

FOR FURTHER INFORMATION CONTACT: Mr. William J. (Joe) Sullivan, Executive Director, Transport Airplane and Engine Subcommittee, Aircraft Certification Service (AIR-3), 800 Independence Avenue SW., Washington, DC 20591, Telephone: (202) 267-9554; FAX: (202) 267-5364.

SUPPLEMENTARY INFORMATION: The Federal Aviation Administration (FAA) established an Aviation Rulemaking Advisory Committee (56 FR 2190, January 22, 1991) which held its first meeting on May 23, 1991 (56 FR 20492, May 3, 1991). The Transport Airplane and Engine Subcommittee was established at that meeting to provide advice and recommendations to the Director, Aircraft Certification Service, FAA, regarding the airworthiness standards for transport airplanes, engines and propellers in parts 25, 33 and 35 of the Federal Aviation Regulations (14 CFR parts 25, 33 and 35).

The FAA announced at the Joint Aviation Authorities (JAA)-Federal Aviation Administration (FAA) Harmonization Conference in Toronto, Ontario, Canada, (June 2-5, 1992) that it would consolidate within the Aviation Rulemaking Advisory Committee structure an ongoing objective to "harmonize" the Joint Aviation Requirements (JAR) and the Federal Aviation Regulations (FAR). Coincident with that announcement, the FAA assigned to the Transport Airplane and Engine Subcommittee those projects related to JAR/FAR 25, 33 and 35 harmonization which were then in the process of being coordinated between the JAA and the FAA. The harmonization process included the intention to present the results of JAA/FAA coordination to the public in the form of either a Notice of Proposed Rulemaking or an advisory circular—an objective comparable to and compatible with that assigned to the Aviation Rulemaking Advisory Committee. The Transport Airplane and Engine Subcommittee, consequently, established the Electromagnetic Effects Harmonization Working Group.

Specifically, the Working Group's tasks are the following:

The Electromagnetic Effects Harmonization Working Group is charged with making recommendations to the Transport Airplane and Engine Subcommittee concerning the FAA disposition of the following subjects recently coordinated between the JAA and the FAA:

Task 1—High Energy Radiated Fields: Develop new requirements for aircraft exposure to high energy radiated fields (new FAR 25.1316 and 25.1317 and related provisions of FAR parts 23, 27, 29, 33, and 35, as appropriate). The working group should draw members for this task from the interests represented by the General Aviation and Business Airplane, and Rotocraft Subcommittees.

Task 2—Lightning Protection Requirements: Revise advisory material on lightning protection requirements in Advisory Circulars 20-53B and 20-136 (FAR 25.1316 and related provisions of FAR parts 23, 27, 29, 33 and 35, as appropriate; AC 20-53B and 20-136). The working group should draw members for this task from the interests represented by the General Aviation and Business Airplane, and Rotorcraft Subcommittees.

Reports:

A. Recommend time line(s) for completion of each task, including rationale, for Subcommittee consideration at the meeting of the subcommittee held following publication of this notice.

B. Give a detailed conceptual presentation on each task to the Subcommittee before proceeding with the work stated under items C and D, below.

C. Draft a Notice of Proposed Rulemaking for task 1 proposing new requirements, a supporting economic analysis, and other required analysis, with any other collateral documents (such as Advisory Circulars) the Working Group determines to be needed. When the detailed briefing under item B, above, and this report are presented to the subcommittee, the Subcommittee and Working Group Chairs should arrange for a joint meeting with the General Aviation and Business Airplane and Rotorcraft Subcommittees to consider and join in the consensus on the results of those reports.

D. Draft changes to Advisory Circulars 20-53B and 20-136 for task 2 providing appropriate advisory material for the task. When the detailed briefing under item B, above, and this report are presented to the subcommittee, the Subcommittee and Working Group Chairs should arrange for a joint meeting with the General Aviation and Business Airplane and Rotorcraft Subcommittees to consider and join in the consensus on the results of those reports.

E. Give a status report on each task at each meeting of the Subcommittee.

The Installation Harmonization Working Group will be comprised of experts from those organizations having an interest in the tasks assigned. A Working Group member need not necessarily be a representative of one of the organizations of the parent Transport Airplane and Engine Subcommittee or of the full Aviation Rulemaking Advisory Committee. An individual who has exerptise in the subject matter and wishes to become a member of the Working Group should write the person listed under the caption "**FOR FURTHER INFORMATION CONTACT**" expressing that desire, describing his or her interest in the task, and the expertise he or she would bring to the Working Group. The request will be reviewed with the Subcommittee and Working Group Chairs and the individual will be advised whether or not the request can be accommodated.

The Secretary of Transportation has determined that the information and use of the Aviation Rulemaking Advisory Committee and its subcommittee are necessary in the public interest in connection with the performance of duties of the FAA by law. Meetings of the full Committee and any subcommittees will be open to the public except as authorized by section 10(d) of the Federal Advisory Committee Act. Meetings of the Installation Harmonization Working Group will not be open to the public except to the extent that individuals with an interest and expertise are selected to participate. No public announcements of Working Group meetings will be made.

Issued in Washington, DC, on December 4, 1992.

William J. Sullivan,

Executive Director, Transport Airplane and Engine Subcommittee, Aviation Rulemaking Advisory Committee.

[FR Doc. 92-30117 Filed 12-10-92; 8:45 am]

BILLING CODE 4910-13-M

Recommendation Letter

Pratt & Whitney
400 Main Street
East Hartford, CT 06108

Pratt & Whitney
A United Technologies Company

[redacted]

September 25, 2000

Federal Aviation Administration
800 Independence Avenue S.W.
Washington, D.C. 20591

Attention: Mr. Thomas McSweeny - Associate Administrator for Regulation and Certification

Reference: FAA Tasking to Aviation Rulemaking Advisory Committee, Federal Register page 58843, dated December 11, 1992.

Dear Tom,

The ARAC Transport Airplane and Engine Issues Group is pleased to submit the attached proposed NPRM and Advisory Circular regarding HIRF as an ARAC recommendation. These documents were prepared by the Electromagnetic Effects Harmonization Working Group in accordance with the reference tasking.

Task #1
AIR-93-739-A

These documents have had a legal review but economic review has not been completed. It is the understanding of TAEIG that the economic review is only partially complete because it has been given a relatively low priority within APO.

TAEIG requests your assistance in raising the priority within the FAA for the processing of this package so that Federal Register publication of the NPRM and Advisory Circular availability notice can occur as soon as possible. The FAA and JAA have used Special Conditions to implement these HIRF requirements on all certification programs for the last several years. Timely publication of this rule would relieve the FAA of the administrative burden associated with continued processing of Special Conditions. TAEIG also believes that the fact that Special Conditions have been applied for several years now to all certification projects should make the economic evaluation relatively straightforward since there is no additional cost to comply with the NPRM requirements beyond that which already exists when the Special Conditions have been applied.

In addition, recent requirements termed the EMC Directive have been instituted by the European Union regarding the import of electrical equipment. The proposed HIRF requirements have been used as a part of the basis for a recommended exemption of aircraft from this directive, thus relieving a large compliance burden from industry in showing compliance with this EU requirement.

Your support in expediting publication of this package is appreciated.

Sincerely yours,

Craig R. Bolt

C. R. Bolt
Assistant Chair, TAEIG

Copies: Brenda Courtney, FAA-Washington, DC-AIR
Kris Carpenter, FAA-NWR
Effie Upshaw, FAA-Washington, DC
John McGraw, FAA-Washington, DC
Joe Cross, Raytheon (EEHWG Chair)
John Rodgers, FAA-Washington, DC.-Office of Policy and Plans

crb091800

U.S. Department
of Transportation
**Federal Aviation
Administration**

800 Independence Ave., S.W.
Washington, D.C. 20591

DEC - 1 2000

Mr. Craig Bolt
Assistant Chair, Transport Airplanes
and Engines Issues Group
400 Main Street
East Hartford, CT 06108

Dear Mr. Bolt:

This letter acknowledges receipt of your September 25 letter transmitting the recommendation from the Transport Aircraft Engine (TAE) issues group regarding high intensity radiated fields (HIRF). The two-part recommendation includes a proposed rulemaking and an advisory circular.

I would like to thank the Aviation Rulemaking Advisory Committee, particularly those members associated with the TAE issues group and the Electromagnetic Effects Harmonization Working Group. We appreciate the work and resources that industry has given to the development of the recommendation package. We also share your concern about the need to have regulations and advisory guidance addressing HIRF. At the November rulemaking council review, we allocated resources to work on the project; we expect to have the regulatory assessment completed in March 2001.

At this time, the FAA considers submittal of this package as completion of the task. Therefore, we shall close the task and keep the TAE apprised of the agency's efforts through the FAA's report at TAE meetings. Further, if the proposed rule and advisory material generate substantive or controversial comments once they are published in the *Federal Register*, the FAA may task the TAE to dispose of any comments received in response to the documents.

Sincerely,

Margaret Gilligan

for Thomas E. McSweeny
Associate Administrator
For Regulation and Certification

Recommendation

UNEDITED WORKING DRAFT
January 26, 2000

[4910-13]

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Parts 23, 25, 27, and 29

[**Docket No.** ; **Notice No.**]

RIN 2120-

High Intensity Radiated Fields (HIRF) Protection for Aircraft Electrical and Electronic Systems

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Notice of proposed rulemaking (NPRM).

SUMMARY: The FAA proposes to add certification standards for aircraft electrical and electronic systems because of their increased use in aircraft and vulnerability to high intensity radiated fields (HIRF). The proposed rule would define specific HIRF certification requirements to provide protection against HIRF effects that would apply to any applicant seeking issuance of a type certificate, amended type certificate, or supplemental type certificate for the initial approval of a new type of aircraft design or a change in aircraft type design.

DATES: Comments must be received on or before *[Insert date 90 days after date of publication in the Federal Register.]*

ADDRESSES: Comments on this document should be mailed or delivered, in duplicate, to: U.S. Department of

Transportation Dockets, Docket No. [ ], 400 Seventh Street SW., Room Plaza 401, Washington, DC 20590. Comments may be filed and examined in Room Plaza 401 between 10 a.m. and 5 p.m. weekdays, except Federal holidays. Comments also may be sent electronically at anytime to the Dockets Management System (DMS) at the following Internet address: http://dms.dot.gov/. Commenters who wish to file comments electronically should follow the instructions on the DMS web page.

FOR FURTHER INFORMATION CONTACT: John P. Dimtroff, Avionics Systems Branch, Aircraft Engineering Division, AIR-130, Federal Aviation Administration, 800 Independence Avenue SW., Washington, DC 20591; telephone (425) 227-1371; electronic mail: John.Dimtroff@faa.gov.

SUPPLEMENTARY INFORMATION:

Comments Invited

Interested persons are invited to participate in the making of the proposed action by submitting such written data, views, or arguments as they may desire. Comments relating to the environmental, energy, federalism, or economic impact that might result from adopting the proposals in this document also are invited. Substantive comments should be accompanied by cost estimates. Comments must identify the regulatory docket or notice number and be submitted in duplicate to the DOT Rules Docket address specified above.

All comments received, as well as a report summarizing each substantive public contact with FAA personnel concerning this proposed rulemaking, will be filed in the docket. The docket is available for public inspection before and after the comment closing date.

All comments received on or before the closing date will be considered by the Administrator before taking action on this proposed rulemaking. Comments filed late will be considered as far as possible without incurring expense or delay. The proposals in this document may be changed in light of the comments received.

Commenters wishing the FAA to acknowledge receipt of their comments submitted in response to this document must include a pre-addressed, stamped postcard with those comments on which the following statement is made: "Comments to Docket No. [ ]." The postcard will be date stamped and mailed to the commenter.

Availability of NPRMs

An electronic copy of this document may be downloaded using a modem and suitable communications software from the FAA regulations section of the FedWorld electronic bulletin board service (telephone: (703) 321-3339) or the Government

Printing Office (GPO)'s electronic bulletin board service (telephone: (202) 512-1661).

Internet users may reach the FAA's web page at http://www.faa.gov/avr/arm/nprm/nprm.htm or the GPO's web page at http://www.access.gpo.gov/nara for access to recently published rulemaking documents.

Any person may obtain a copy of this document by submitting a request to the Federal Aviation Administration, Office of Rulemaking, ARM-1, 800 Independence Avenue SW., Washington, DC 20591, or by calling (202) 267-9680. Communications must identify the docket or notice number of this NPRM.

Persons interested in being placed on the mailing list for future rulemaking documents should request from the above office a copy of Advisory Circular No. 11-2A, Notice of Proposed Rulemaking Distribution System, which describes the application procedure.

Background

Statement of the Problem

The electromagnetic HIRF environment exists because of the transmission of electromagnetic energy from radar, radio, and television transmitters, and other ground-based, shipborne, or airborne radio frequency (RF) transmitters. In the late 1970s, designs for civil aircraft were first proposed that included flight-critical electronic controls, electronic displays, and electronic engine controls, such as those used in military aircraft since the mid-1970s. Accidents and incidents on civil aircraft with flight-critical electrical and electronic systems have brought attention to the need to provide HIRF protection for these critical systems.

On April 15, 1990, an Airship Industries Airship-600 traversed the beam of a highly directional RF broadcast from a Voice of America antenna and suffered a complete loss of power in both engines that resulted in a collision with trees and the terrain during a forced landing in North Carolina. The National Transportation Safety Board stated in its investigation of the accident that the lack of HIRF certification standards for airships at the time of the airship's certification was a factor in the accident.

More recently, on March 2, 1999, a Robinson R-44 helicopter passed within 1,000 meters of the main beam of a high frequency (HF), high energy broadcast transmission antenna in Portugal. The pilot reported strong interference in the intercommunication and communication systems and navigation radios, followed by illumination of the low rotor revolutions per minute (RPM) and clutch lights. He further noted the engine noise dropped to idle level and the engine and rotor RPM indicators dropped. The pilot entered autorotation and landed the helicopter successfully with only damage to the main rotors. Following landing, the pilot reported all cockpit indications were normal. The accident investigation division of Portugal's Instituto Nacional da Aviação Civil stated in its investigation of the incident that the probable cause was severe electromagnetic and RF interference.

The FAA has issued three airworthiness directives (ADs) in response to HIRF effects between 1991 and 1998. In AD 91-03-05, Airship Industries Skyship Model 600 Airships, the FAA required the installation of a modified ignition control unit because of the previously described dual-engine failure that occurred when the ignition control units were exposed to HIRF.

In AD 96-21-13, LITEF GmbH Attitude and Heading System Reference (AHRS) Unit Model LCR-92, LCR-92S, and LCR-92H, the FAA stated there are indications of an unusual AHRS reaction to certain RF signals that could cause the AHRS to give misleading roll and pitch information. As a result, the FAA required either (1) the installation of a placard adjacent to each primary attitude indicator stating that flight is limited to day visual flight rules (VFR) operations only, or, if the primary attitude instruments have been deactivated, stating flight is limited to VFR operations only, or (2) a modification and inspection of the AHRS wiring cables, a repetitive inspection of the cable shielding, and an insertion of a statement in the aircraft flight manual regarding unannounced heading errors that could occur after switching from DC to MAG or operation of the ± switch in flight with any bank angle.

In AD 98-24-05, HOAC-Austria Model DV-20 Katana Airplanes, the FAA required the replacement of engine electronic modules to prevent electromagnetic interference in the engine electronic module. The FAA required the replacement of the modules because electromagnetic interference could cause the airplane's engine to stop due to an interruption in the ignition system resulting in loss of control.

Concern for the protection of electrical and electronic systems in aircraft has increased substantially in recent years because of—

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

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

(3) 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;

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

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

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

History

In 1987, the FAA contracted with the Department of Defense 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. In February 1988, the FAA and the Joint Aviation Authorities (JAA) tasked the Society of Automotive Engineers (SAE) and the European Organization for Civil Aviation Equipment (EUROCAE) to develop guidance material and acceptable means of compliance (AMC) documents to support FAA and JAA efforts to develop HIRF certification requirements. In response, one SAE panel reviewed and revised the assumptions used for ECAC's definition of a HIRF environment and published several iterations of that HIRF environment for fixed wing aircraft based on revised assumptions. Another SAE panel prepared advisory material to support the FAA's rulemaking efforts.

Because of efforts being undertaken by the FAA and the JAA to harmonize the JAA's airworthiness requirements and the FAA's airworthiness regulations in the early 1990s, the FAA and the JAA agreed that the proposed HIRF certification requirements needed further international harmonization before a rule could be adopted.

As a result, the FAA established the Electromagnetic Effects Harmonization 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, in coordination with the JAA, HIRF certification requirements for aircraft. The EEHWG expanded the existing HIRF environments developed by the ECAC with the SAE committee to include HIRF environments appropriate for aircraft certificated under parts 23, 25, 27, and 29. In 1994, the FAA tasked the Naval Air Warfare Center Aircraft Division (NAWCAD) to conduct a HIRF electromagnetic field survey study to support the efforts of the EEHWG. The EEHWG also received HIRF electromagnetic environment data on European transmitters from European governments. The EEHWG converted the U.S. and European data into a set of harmonized HIRF environments, prepared draft advisory circular/advisory material joint (AC/AMJ), and also prepared the harmonized FAA draft HIRF NPRM and JAA draft HIRF notice of proposed amendment (NPA). In November 1997, the EEHWG adopted a set of HIRF environments agreed on by the FAA, the JAA, and the industry participants. The HIRF environments contained in these proposed rules reflect the HIRF environments adopted by the EEHWG. In addition, the information contained in this NPRM is based on the draft NPRM/NPA document.

Current Requirements

Currently, §§ 23.1309, 25.1309, 27.1309, and 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. AC No. 23.1309-1C, "Equipment, Systems, and Installations in Part 23 Airplanes," states that § 23.1309 is not intended to include certification requirements for protection against HIRF. Because of the lack of specific HIRF certification requirements, special conditions to address HIRF have been imposed on applicants seeking issuance of a type certificate (TC), amended TC, or supplemental type certificate (STC) since 1986. Applicants have the option of demonstrating compliance using the external HIRF environment defined in HIRF special conditions or a system bench test level of 100 volts per meter (V/m), whichever is less. The FAA issued additional interim guidance for the certification of aircraft operating in HIRF environments in FAA Notice No. N8110.71, Guidance for the Certification of Aircraft Operating in High Intensity Radiated Field (HIRF) Environments, dated April 2, 1998, with a cancellation date of April 2, 1999. [The FAA has issued [insert additional interim guidance.] **REMOVE SENETENCE IF NO GUIDANCE IS AVAILABLE BEFORE PUBLICATION.]**

Development of the HIRF Environments

The HIRF environment was originally categorized into the rotorcraft severe, fixed-wing severe, certification, and normal HIRF environments. Each of these four HIRF environments was developed based on specific assumptions dealing with distance between the aircraft and transmitter, appropriate for the class of aircraft. The EEHWG investigated the likelihood that fixed wing aircraft and rotorcraft operate in the vicinity of these high power transmitters. The EEHWG also investigated testing practicality and availability of test facilities for the HIRF environment levels. The EEHWG used these factors to select the levels for the HIRF environments used in the proposed rules.

The U.S. HIRF environments were calculated by the NAWCAD based on the assumptions agreed on by the EEHWG, using unclassified and classified data on government and civilian transmitters, such as electromagnetic effects data bases, technical manuals, and information provided by transmitter operators.

In developing the U.S. rotorcraft severe, fixed-wing severe, certification, and normal HIRF environments, the NAWCAD reviewed the Joint Spectrum Center's HIRF data and updated the transmitter information to ensure the most current licensed and authorized transmitters were used. A subset of data was created that contained the licensing information and equipment descriptions on the 25 highest radiated power transmitters in each of the following 17 HIRF frequency bands for each of the HIRF environments: 10 to 100 kilohertz (kHz), 100 to 500 kHz, 500 kHz to 2 megahertz (MHz), 2 to 30 MHz, 30 to 70 MHz, 70 to 100 MHz, 100 to 200 MHz, 200 to 400 MHz, 400 to 700 MHz, 700 MHz to 1 GHz, 1 to 2 GHz, 2 to 4 GHz, 4 to 6 GHz, 6 to 8 GHz, 8 to 12 GHz, 12 to 18 GHz, and 18 to 40 GHz.

The NAWCAD then selected the five transmitters with the highest peak and the five transmitters with the highest average radiated power in each frequency band. To select each of these transmitters, the NAWCAD performed further analysis and investigation to confirm the transmitters were operating and producing the radiated power indicated in the licensing information. If one of the transmitters was located in prohibited or restricted airspace, the NAWCAD noted that information, removed the transmitter from consideration as a potential HIRF transmitter, and selected the next lower radiated power transmitter not in prohibited or restricted airspace. Once the five highest peak and five highest average power transmitters were identified and confirmed operational, the NAWCAD recalculated their electromagnetic field strengths, in V/m. Finally, the NAWCAD created each U.S. HIRF environment using the transmitters with the highest calculated field strength in each of the 17 frequency bands for peak and average power. JAA-member nations undertook similar efforts to develop the European HIRF environments.

To create the harmonized HIRF environments the EEHWG compared the U.S. and European HIRF environments and selected the transmitters with the highest field strength values for each of the 17 frequency bands for peak and average power.

The harmonized HIRF environments are based on the individual U.S. and European HIRF environments and form an estimate of the international electromagnetic field strength, in V/m, over a frequency range from 10 kHz to 40 GHz. The FAA, the JAA, and other governmental and international agencies, such as the International Civil Aviation Organization (ICAO) and the International Telecommunications Union, plan to monitor the future growth of the harmonized HIRF environment.

The following general assumptions were used to develop the HIRF environments:

(1) The HIRF environment was divided into 17 frequency bands, ranging from 10 kHz to 40 GHz.

(2) The main-beam illumination and maximum-beam gain of the transmitting antenna were used.

(3) The duty cycle of pulsed transmitters was used to calculate the average power; however, the modulation of a transmitted signal was not considered. The duty cycle was defined as the product of pulse width and pulse repetition frequency and applied only to pulsed systems.

(4) Constructive ground reflections (direct and reflected waves) of HF signals were assumed to be in phase.

(5) The noncumulative field strength was calculated; however, simultaneous illumination by more than one antenna was not considered.

(6) Near-field corrections were used for aperture and phased-array antennas.

(7) Field strengths were calculated at minimum distances dependent on the locations of the transmitter and the aircraft.

(8) The field strength was calculated for each frequency band using the maximum field strength for all transmitters within that band for peak and average power, given in V/m. The field strength values were expressed in root-mean-square (rms) units measured during the peak of the modulation cycle, as many laboratory instruments indicate amplitude. The true peak field strength values will be higher by a factor of the square root of two.

(9) The peak field strength was based on the transmitter's maximum authorized peak power, maximum antenna gain, and system losses.

(10) The average field strength was based on the transmitter's maximum authorized peak power, maximum duty cycle, maximum antenna gain, and system losses.

(11) The aircraft's altitude and the transmitter's maximum antenna elevation were taken into account. The slant range was defined as the line-of-sight distance between the transmitter and the aircraft. The adjusted slant range was defined as the line-of-sight distance at which the aircraft encounters the maximum illumination from an elevation-limited antenna's main beam. If the transmitter's maximum antenna elevation angle was not available, 90 degrees was assumed.

(12) Transmitters located in prohibited areas, restricted areas, or warning areas (ICAO danger areas) were not included.

(13) Proposed special-use airspace (SUA) boundaries were defined for selected high-power transmitters. The size of the proposed SUA was derived from transmitter data and, therefore, varied from transmitter site to transmitter site. For transmitters located within a proposed SUA, the transmitter field strength was assessed at the boundary of the proposed SUA.

(14) Transmitters with experimental licenses and nonairport mobile tactical military transmitters were excluded.

(15) Certain transmitters have the capability to reduce power or restrict scanning coverage if aircraft operate in close vicinity. This capability was assumed to be operating for calculating illumination and power density.

(16) Transmitter losses into the antenna were estimated at 3 decibels in the U.S. HIRF environment, unless transmitter data were available. For further information on the development of the HIRF environments, consult NAWCAD Technical Memorandum, Report No. NAWCADPAX-98-156-TM, High Intensity Radiated Field External Environments for Civil Aircraft Operating in the United States of America (Unclassified), dated November 12, 1998. A copy of the NAWCAD Technical Memorandum is available in the docket.

Table I - Summary of Transmitter Locations Used to Develop the HIRF Environments

Geographic Location of Transmitter Source	Transmitter Distance from Aircraft (feet, slant or adjusted (adj.) slant range)			
	Rotorcraft Severe	Fixed-wing Severe	Certification (All Aircraft)	Normal (All Aircraft)
Airport[1], heliport, and offshore platform[2]				
Fixed:				
Air route/Airport surveillance radar	300 adj. slant	500 adj. slant	500 adj. slant	500 adj. slant
All others	100 slant	250 adj. slant	250 adj. slant	250 adj. slant
Mobile:				
Aircraft weather radar	150 slant	150 slant	150 slant	250 slant
All others	50 slant	50 slant	50 slant	50 slant
Land-based (other than airport and heliport)[3]				
HIRF SUA	Edge of SUA	Edge of SUA	Edge of SUA	Edge of SUA
All others (distance from facility)				
>0-3 nautical miles (nm)	100 slant	500 adj. slant	500 adj. slant	500 adj. slant
3-5 nm	100 slant	500 adj. slant	1000 adj. slant	1000 adj. slant
5-10 nm	100 slant	500 adj. slant	1000 adj. slant	1500 adj. slant
10-25 nm	100 slant	500 adj. slant	1000 adj. slant	2500 adj. slant
>25 nm	100 slant	500 adj. slant	1000 adj. slant	1000 adj. slant

1 The airport environment consisted of all fixed and mobile transmitters located within a 5-nm boundary around the airport. The fixed transmitters considered included the marker beacon, localizer, very-high-frequency omnirange (VOR) navigation, glide slope, tactical air navigation (TACAN), weather radar, telemetry, ground controlled approach radar, distance measuring equipment, microwave landing system (MLS), airport surveillance radar, air route surveillance radar, ultra high frequency/very high frequency (UHF/VHF) communications, and air traffic control radar beacon system (ATCRBS) interrogator. The mobile transmitters considered included all the ground transmitters not in a fixed location, such as VHF radios on ground support equipment and the following aircraft transmitters: high frequency (HF)/UHF communication, TACAN, Doppler navigation radar, radio altimeter, weather radar, and ATCRBS beacon.

2 The heliport and offshore platform environments consisted of all transmitters, fixed and mobile, located on commercial heliport and offshore platforms. The transmitters considered included satellite, HF, and UHF/VHF communications, VOR navigation, homing beacons, weather radar, surface search radar, and MLS.

3 The land-based environment (other than the airport and heliport environments) consisted of all ground transmitters not located on an airport, heliport, or offshore platform. The transmitters considered included sounders, submarine and UHF/VHF communication, radar astronomy, land mobile equipment, test and training equipment, weather radar, national defense radar, long-range navigation (LORAN),

Geographic Location of Transmitter Source	Transmitter Distance from Aircraft (feet, slant or adjusted (adj.) slant range)			
	Rotorcraft Severe	Fixed-wing Severe	Certification (All Aircraft)	Normal (All Aircraft)
Ship-based transmitters[4]				
All ships	500 slant	500 adj. slant	1000 adj. slant	Not applicable
Air-to-air[5]				
Interceptor	Not applicable	100 slant	100 slant	Not applicable
All others	Not applicable	500 slant	500 slant	Not applicable

television broadcast, air route surveillance radar, and satellite uplinks.

4 The ship-based environment consisted of all transmitters located on all commercial and military ships located at sea or in harbors near airports. The transmitters considered included air search radar, fire control radar, satellite, HF, and UHF/VHF communications, TACAN, weather radar, surface search radar, MLS, and ATCRBS interrogator.

5 The air-to-air environment consisted only of those transmitters on military aircraft because the transmitters on civilian aircraft were considered in the mobile airport environment. For military aircraft on intercept courses all nonhostile transmitters were assumed to be operational, and for all military aircraft on intercept courses all transmitters were assumed to be operational.

HIRF Environments

Table II - HIRF Environments, as developed versus as proposed

HIRF Environment, as developed	HIRF Environment, as proposed
Fixed-wing Severe	Not used
Rotorcraft Severe	HIRF Environment III
Certification	HIRF Environment I
Normal	HIRF Environment II

The fixed-wing severe and rotorcraft severe HIRF environments present worst-case estimates of the electromagnetic field strength in the airspace in which fixed-wing aircraft and rotorcraft operations, respectively, are permitted. The rotorcraft severe HIRF environment, as shown in table III, is HIRF environment III as proposed; however, the fixed-wing severe HIRF environment, as shown in table IV, was used only to develop the certification HIRF environment.

The certification HIRF environment, as shown in table V (HIRF environment I as proposed) provides test and analysis levels to demonstrate that the aircraft and its systems meet HIRF certification requirements. HIRF environment I is based on likely aircraft separation distances and takes into account high peak power microwave transmitters that typically do not operate continuously at their maximum output levels. Based on statistical analysis of aircraft operations, the EEHWG determined that the assumptions used for calculating HIRF environment I were more appropriate for aircraft certification than the assumptions of the fixed-wing severe HIRF environment; therefore, the fixed-wing severe HIRF environment is not used in the proposed rules.

The normal HIRF environment, as shown in table VI (HIRF environment II as proposed) also provides test and analysis levels to demonstrate that the aircraft and its systems meet HIRF certification requirements. HIRF environment II is an estimate of the electromagnetic field strength in the airspace above an airport or heliport in which routine departure and arrival operations take place. HIRF environment II also takes into account high peak power microwave transmitters that typically do not operate continuously at their maximum output levels. The EEHWG determined that the assumptions used for HIRF environment II are most appropriate for aircraft in the vicinity of airports.

Table III – Rotorcraft Severe HIRF Environment

(HIRF Environment III)

FREQUENCY	FIELD STRENGTH (V/M)	
	PEAK	AVERAGE
10 kHz - 100 kHz	150	150
100 kHz - 500 kHz	200	200
500 kHz - 2 MHz	200	200
2 MHz - 30 MHz	200	200
30 MHz - 70 MHz	200	200
70 MHz - 100 MHz	200	200
100 MHz - 200 MHz	200	200
200 MHz - 400 MHz	200	200
400 MHz - 700 MHz	730	200
700 MHz - 1 GHz	1,400	240
1 GHz - 2 GHz	5,000	250
2 GHz - 4 GHz	6,000	490
4 GHz - 6 GHz	7,200	400
6 GHz - 8 GHz	1,100	170
8 GHz - 12 GHz	5,000	330
12 GHz - 18 GHz	2,000	330
18 GHz - 40 GHz	1,000	420

Table IV — Fixed-Wing Severe HIRF Environment

FREQUENCY	FIELD STRENGTH (V/M)	
	PEAK	AVERAGE
10 kHz - 100 kHz	50	50
100 kHz - 500 kHz	60	60
500 kHz - 2 MHz	70	70
2 MHz - 30 MHz	200	200
30 MHz - 70 MHz	30	30
70 MHz - 100 MHz	30	30
100 MHz - 200 MHz	90	30
200 MHz - 400 MHz	70	70
400 MHz - 700 MHz	730	80
700 MHz - 1 GHz	1,400	240
1 GHz - 2 GHz	3,300	160
2 GHz - 4 GHz	4,500	490
4 GHz - 6 GHz	7,200	300
6 GHz - 8 GHz	1,100	170
8 GHz - 12 GHz	2,600	330
12 GHz - 18 GHz	2,000	330
18 GHz - 40 GHz	1,000	420

Table V – Certification HIRF Environment

(HIRF Environment I)

FREQUENCY	FIELD STRENGTH (V/M)	
	PEAK	AVERAGE
10 kHz - 100 kHz	50	50
100 kHz - 500 kHz	50	50
500 kHz - 2 MHz	50	50
2 MHz - 30 MHz	100	100
30 MHz - 70 MHz	50	50
70 MHz - 100 MHz	50	50
100 MHz - 200 MHz	100	100
200 MHz - 400 MHz	100	100
400 MHz - 700 MHz	700	50
700 MHz - 1 GHz	700	100
1 GHz - 2 GHz	2,000	200
2 GHz - 4 GHz	3,000	200
4 GHz - 6 GHz	3,000	200
6 GHz - 8 GHz	1,000	200
8 GHz - 12 GHz	3,000	300
12 GHz - 18 GHz	2,000	200
18 GHz - 40 GHz	600	200

Table VI — Normal HIRF Environment

(HIRF Environment II)

FREQUENCY	FIELD STRENGTH (V/M)	
	PEAK	AVERAGE
10 kHz - 100 kHz	20	20
100 kHz - 500 kHz	20	20
500 kHz - 2 MHz	30	30
2 MHz - 30 MHz	100	100
30 MHz - 70 MHz	10	10
70 MHz - 100 MHz	10	10
100 MHz - 200 MHz	30	10
200 MHz - 400 MHz	10	10
400 MHz - 700 MHz	700	40
700 MHz - 1 GHz	700	40
1 GHz - 2 GHz	1,300	160
2 GHz - 4 GHz	3,000	120
4 GHz - 6 GHz	3,000	160
6 GHz - 8 GHz	400	170
8 GHz - 12 GHz	1,230	230
12 GHz - 18 GHz	730	190
18 GHz - 40 GHz	600	150

Equipment Test Levels

The EEHWG developed four equipment HIRF test levels, which have been included in this proposed rule. The four test levels were created using typical aircraft HIRF protection characteristics and data from aircraft service experience to provide the ability to perform testing in a laboratory environment.

Equipment HIRF test levels 1 and 2 are based on the normal HIRF environment reduced by typical aircraft attenuation. The typical aircraft attenuation was determined using the mean attenuation measured on a number of transport airplanes, small airplanes, and rotorcraft. Equipment HIRF test level 3 is based on the normal HIRF environment reduced by the aircraft attenuation for a specific aircraft. Equipment HIRF test level 4 was developed to provide assurance for HIRF protection based on service experience for certain aircraft systems. To develop level 4, the EEHWG reviewed all available reports of HIRF interference. This equipment HIRF test level was selected to minimize the effects of HIRF and is 5 to 10 times higher than the system test levels currently used.

General Discussion of the Proposals

HIRF Certification Requirements

The proposed HIRF certification requirements would apply to applicants seeking issuance of TCs, amended TCs, and STCs to meet the airworthiness requirements in parts 23, 25, 27, and 29 for the initial approval of a new type of aircraft design or a change in type design.

An applicant for a TC, amended TC, or STC first would determine the aircraft's hazards and failures in compliance with §§ 23.1309, 25.1309, 27.1309, and 29.1309. Acceptable approaches for this hazard assessment are described in AC No. 23.1309-1C and AC No. 25.1309-1A, "Systems Design and Analysis."

The hazard assessment conducted to show compliance with §§ 23.1309, 25.1309, 27.1309, and 29.1309 then could be used to assist in determining the appropriate HIRF certification requirements for the aircraft electrical and electronic systems. HIRF certification requirements in the proposed rule would be established only for aircraft electrical and electronic systems whose failure would (1) prevent the continued safe flight and landing of the aircraft, (2) significantly reduce the capability of the aircraft or the ability of the flightcrew to cope with adverse operating conditions, or (3) reduce the capability of the aircraft or the ability of the flightcrew to cope with adverse operating conditions. This resulting failure classification would determine to which HIRF environment the aircraft and/or electrical and electronic systems would be exposed during certification testing.

Under the proposed rule, electrical and electronic systems that perform a function whose failure would prevent the continued safe flight and landing of the aircraft must be designed and installed so that—

(1) Each function is not affected adversely during and after the aircraft is exposed to HIRF environment I;

(2) Each electrical and electronic system automatically recovers normal operation, in a timely manner, after the aircraft is exposed to HIRF environment I, unless this conflicts with other operational or functional requirements of that system; and

(3) Each electrical and electronic system is not adversely affected during and after the aircraft is exposed to HIRF environment II.

In addition, functions required for operations under VFR in rotorcraft would be required to meet additional HIRF certification standards because rotorcraft operating under VFR do not have to comply with the same minimum safe altitude restrictions for airplanes in 14 CFR part 91 and, therefore, may operate closer to transmitters. Accordingly, under the proposed rule, for functions required during operation under VFR whose failure would prevent the continued safe flight and landing of the rotorcraft, the electrical and electronic systems that perform such a function, considered separately and in relation to other systems, must be designed and installed so that, in addition to the first design and installation requirement specified above, each function is not adversely affected during and after the time the rotorcraft is exposed to HIRF environment III. Rotorcraft operating under instrument flight rules (IFR) have to comply with more restrictive altitude limitations and, therefore, electrical and electronic systems with functions required for IFR operations would be required to meet only HIRF environment I.

The proposed rule would mandate that each electrical and electronic system that performs a function whose failure would reduce significantly the capability of the aircraft or the ability of the flightcrew to cope with adverse operating conditions must be designed and installed so the system is not affected adversely when the equipment providing these functions is exposed to equipment HIRF test level 1, 2, or 3. Any one of these test levels is acceptable. Test levels 1 and 2 have equivalent energy, but provide different modulation applications. This allows the test laboratories to use existing test equipment. Test level 2 allows an applicant to use equipment test levels developed for the specific aircraft being certified. Any one of these test levels may be used to demonstrate HIRF protection.

Lastly, under the proposed rule, each electrical and electronic system that performs a function whose failure would reduce the capability of the aircraft or the ability of the flightcrew to cope with adverse operating conditions must be designed and installed so the system is not affected adversely when the equipment providing these functions is exposed to equipment HIRF test level 4.

HIRF environments I, II, and III, and equipment HIRF test levels 1, 2, 3, and 4 would be found in proposed appendixes to the affected parts.

Compliance With HIRF Certification Requirements

Acceptable operation of a system or equipment installation during exposure to a HIRF environment or equipment HIRF test level could be shown through similarity with existing systems, analyses, testing, or any combination acceptable to the FAA. However, certification by similarity could not be used for a combination of new aircraft design and new equipment design. In addition, service experience alone would not be acceptable because such experience may not include exposure to HIRF environments. Acceptable system performance could be attained by demonstrating that the system under consideration continued to perform its intended function. Deviations from the performance specifications of systems under consideration could be acceptable, but they would need to be assessed independently to ensure the effects of the deviations neither cause nor contribute to conditions that would affect adversely aircraft operational capabilities. When deviations in performance occur as a consequence of the system's or equipment's exposure to the HIRF environment or equipment HIRF test level, an assessment of the acceptability of the performance should be made. This assessment should be supported by data and analyses.

Because aircraft control system failures and malfunctions could contribute more directly and abruptly to the continued safe flight and landing of an aircraft than display system failures and malfunctions, compliance with the proposed rule for systems performing display functions would not require aircraft level testing. Therefore, systems performing display functions could demonstrate compliance with the appropriate HIRF certification requirements in a laboratory using generic HIRF attenuation curves for that aircraft developed during previous HIRF aircraft level testing. The compliance should address instructions for continued airworthiness of the HIRF protection features.

Paperwork Reduction Act

In accordance with the Paperwork Reduction Act of 1995 (44 U.S.C. 3507(d)), the FAA has determined that there are no requirements for information collection associated with this proposed rule.

International Compatibility

In keeping with U.S. obligations under the Convention on International Civil Aviation, it is FAA policy to comply with International Civil Aviation Organization (ICAO) Standards and Recommended Practices to the maximum extent timely input by elected officers (or their designees) of State, local, and tribal governments on a proposed "significant intergovernmental mandate." A "significant intergovernmental mandate" under the Act is any provision in a Federal agency regulation that would impose an enforceable duty upon State, local, and tribal governments, in the aggregate, of $100 million (adjusted annually for inflation) in any one year. Section 203 of the Act, 2 U.S.C. 1533, which supplements section 204(a), provides that before establishing any regulatory requirements that might significantly or uniquely affect small governments, the agency shall have developed a plan that, among other things, provides for notice to potentially affected small governments, if any, and for a meaningful and timely opportunity to provide input in the development of regulatory proposals.

This proposed rule [does/does not] contain a Federal intergovernmental or private sector mandate that exceeds $100 million in any one year.

Environmental Analysis

FAA Order 1050.1D defines FAA actions that may be categorically excluded from preparation of a National Environmental Policy Act (NEPA) environmental assessment or environmental impact statement. In accordance with FAA Order 1050.1D, appendix 4, paragraph 4(j), this rulemaking action qualifies for a categorical exclusion.

Energy Impact

The energy impact of the notice has been assessed in accordance with the Energy Policy and Conservation Act (EPCA), Public Law 94-163, as amended (43 U.S.C. 6362) and FAA Order 1053.1. It has been determined that the notice is not a major regulatory action under the provisions of the EPCA.

List of Subjects

14 CFR Part 23

Air transportation, Aircraft, Aviation safety, Certification, Safety.

14 CFR Part 25

Air transportation, Aircraft, Aviation safety, Certification, Safety.

14 CFR Part 27

Air transportation, Aircraft, Aviation safety, Certification, Rotorcraft, Safety.

14 CFR Part 29

Air transportation, Aircraft, Aviation safety, Certification, Rotorcraft, Safety.

The Proposed Amendment

In consideration of the foregoing, the Federal Aviation Administration proposes to amend parts 23, 25, 27, and 29 of Title 14, Code of Federal Regulations (14 CFR) as follows:

PART 23 – AIRWORTHINESS STANDARDS: NORMAL, UTILITY, ACROBATIC, AND COMMUTER CATEGORY AIRPLANES

1. The authority citation for part 23 continues to read as follows:

Authority: 49 U.S.C. §§ 106(g), 40113, 44701, 44702, 44704.

2. Add § 23.1308 to subpart F to read as follows:

§ 23.1308 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 airplane must be designed and installed so that–

(1) Each function is not adversely affected during and after the time the airplane is exposed to HIRF environment I, as described in appendix J to this part;

(2) Each electrical and electronic system automatically recovers normal operation, in a timely manner, after the airplane is exposed to HIRF environment I, as described in appendix J to this part, unless the system's recovery conflicts with other operational or functional requirements of the system; and

(3) Each electrical and electronic system is not adversely affected during and after the time the airplane is exposed to HIRF environment II, as described in appendix J to this part.

(b) Each electrical and electronic system that performs a function whose failure would significantly reduce the capability of the airplane or the ability of the flightcrew to cope with adverse operating conditions must be designed and installed so the system is not adversely affected when the equipment providing these functions is exposed to equipment HIRF test level 1, 2, or 3, as described in appendix J to this part.

(c) Each electrical and electronic system that performs a function whose failure would reduce the capability of the airplane or the ability of the flightcrew to cope with adverse operating conditions must be designed and installed so the system is not adversely affected when the equipment providing these functions is exposed to equipment HIRF test level 4, as described in appendix J to this part.

3. Add appendix J to part 23 to read as follows:

Appendix J to Part 23— HIRF Environments and Equipment HIRF Test Levels

This appendix specifies the HIRF environments and equipment HIRF test levels for electrical and electronic systems under § 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 as follows:

Table I — HIRF Environment I

FREQUENCY	FIELD STRENGTH (V/M)	
	PEAK	AVERAGE
10 kHz - 100 kHz	50	50
100 kHz - 500 kHz	50	50
500 kHz - 2 MHz	50	50
2 MHz - 30 MHz	100	100
30 MHz - 70 MHz	50	50
70 MHz - 100 MHz	50	50
100 MHz - 200 MHz	100	100
200 MHz - 400 MHz	100	100
400 MHz - 700 MHz	700	50
700 MHz - 1 GHz	700	100
1 GHz - 2 GHz	2,000	200
2 GHz - 4 GHz	3,000	200
4 GHz - 6 GHz	3,000	200
6 GHz - 8 GHz	1,000	200
8 GHz - 12 GHz	3,000	300
12 GHz - 18 GHz	2,000	200
18 GHz - 40 GHz	600	200

[editing will combine the frequencies with identical field strengths for all the charts and add the language up to and including]

(b) HIRF environment II is specified as follows:

Table II — HIRF Environment II

FREQUENCY	FIELD STRENGTH (V/M)	
	PEAK	AVERAGE
10 kHz - 100 kHz	20	20
100 kHz - 500 kHz	20	20
500 kHz - 2 MHz	30	30
2 MHz - 30 MHz	100	100
30 MHz - 70 MHz	10	10
70 MHz - 100 MHz	10	10
100 MHz - 200 MHz	30	10
200 MHz - 400 MHz	10	10
400 MHz - 700 MHz	700	40
700 MHz - 1 GHz	700	40
1 GHz - 2 GHz	1,300	160
2 GHz - 4 GHz	3,000	120
4 GHz - 6 GHz	3,000	160
6 GHz - 8 GHz	400	170
8 GHz - 12 GHz	1,230	230
12 GHz - 18 GHz	730	190
18 GHz - 40 GHz	600	150

(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 percent 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 400 MHz, the conducted susceptibility current must be at least 30 mA.

(3) 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 percent depth or greater.

(4) From 400 MHz to 8 gigahertz (GHz), use radiated susceptibility tests at a minimum of 150 V/m peak with pulse modulation of 0.1 percent duty cycle with 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 percent.

(5) From 400 MHz to 8 GHz, use radiated susceptibility tests at a minimum of 28 V/m peak with 1 kHz square wave modulation with 90 percent depth or greater. This signal must be switched on and off at a rate of 1 Hz with a duty cycle of 50 percent.

(d) Equipment HIRF Test Level 2.

(1) From 10 kHz to 400 MHz, use conducted susceptibility tests with CW and 1 kHz square wave modulation with 90 percent depth or greater. The conducted susceptibility current must start at a minimum of 0.6 mA at

10 kHz, increasing 20 dB per frequency decade to a minimum of 30 mA at 500 kHz.

(2) From 500 kHz to 400 MHz, the conducted susceptibility current must be at least 30 mA.

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

(4) From 400 MHz to 8 GHz, use radiated susceptibility tests at a minimum of 150 V/m peak with pulse modulation of 4 percent 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 percent.

(e) Equipment HIRF Test Level 3. Test level 3 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 4.

(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 400 MHz, use conducted susceptibility tests at a minimum of 7.5 mA.

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

PART 25 — AIRWORTHINESS STANDARDS: TRANSPORT CATEGORY AIRPLANES

4. The authority citation for part 25 continues to read as follows:

Authority: 49 U.S.C. §§ 106(g), 40113, 44701, 44702, 44704.

5. Add § 25.1317 to subpart F to read as follows:

§ 25.1317 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 airplane must be designed and installed so that—

(1) Each function is not adversely affected during and after the time the airplane is exposed to HIRF environment I, as described in appendix K to this part;

(2) Each electrical and electronic system automatically recovers normal operation, in a timely manner, after the airplane is exposed to HIRF environment I, as described in appendix K to this part, unless the system's recovery conflicts with other operational or functional requirements of the system; and

(3) Each electrical and electronic system is not adversely affected during and after the time the airplane is

exposed to HIRF environment II, as described in appendix K to this part.

(b) Each electrical and electronic system that performs a function whose failure would significantly reduce the capability of the airplane or the ability of the flightcrew to cope with adverse operating conditions must be designed and installed so the system is not adversely affected when the equipment providing these functions is exposed to equipment HIRF test level 1, 2, or 3, as described in appendix K to this part.

(c) Each electrical and electronic system that performs a function whose failure would reduce the capability of the airplane or the ability of the flightcrew to cope with adverse operating conditions must be designed and installed so the system is not adversely affected when the equipment providing these functions is exposed to equipment HIRF test level 4, as described in appendix K to this part.

6. Add appendix K to part 25 to read as follows:

Appendix K to Part 25– HIRF Environments and Equipment HIRF Test Levels

This appendix specifies the HIRF environments and equipment HIRF test levels for electrical and electronic systems under § 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 as follows :

Table I — HIRF Environment I

FREQUENCY	FIELD STRENGTH (V/M)	
	PEAK	AVERAGE
10 kHz - 100 kHz	50	50
100 kHz - 500 kHz	50	50
500 kHz - 2 MHz	50	50
2 MHz - 30 MHz	100	100
30 MHz - 70 MHz	50	50
70 MHz - 100 MHz	50	50
100 MHz - 200 MHz	100	100
200 MHz - 400 MHz	100	100
400 MHz - 700 MHz	700	50
700 MHz - 1 GHz	700	100
1 GHz - 2 GHz	2,000	200
2 GHz - 4 GHz	3,000	200
4 GHz - 6 GHz	3,000	200
6 GHz - 8 GHz	1,000	200
8 GHz - 12 GHz	3,000	300
12 GHz - 18 GHz	2,000	200
18 GHz - 40 GHz	600	200

(b) HIRF environment II is specified as follows:

Table II – HIRF Environment II

FREQUENCY	FIELD STRENGTH (V/M)	
	PEAK	AVERAGE
10 kHz - 100 kHz	20	20
100 kHz - 500 kHz	20	20
500 kHz - 2 MHz	30	30
2 MHz - 30 MHz	100	100
30 MHz - 70 MHz	10	10
70 MHz - 100 MHz	10	10
100 MHz - 200 MHz	30	10
200 MHz - 400 MHz	10	10
400 MHz - 700 MHz	700	40
700 MHz - 1 GHz	700	40
1 GHz - 2 GHz	1,300	160
2 GHz - 4 GHz	3,000	120
4 GHz - 6 GHz	3,000	160
6 GHz - 8 GHz	400	170
8 GHz - 12 GHz	1,230	230
12 GHz - 18 GHz	730	190
18 GHz - 40 GHz	600	150

(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 percent 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 400 MHz, the conducted susceptibility current must be at least 30 mA.

(3) 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 percent depth or greater.

(4) From 400 MHz to 8 gigahertz (GHz), use radiated susceptibility tests at a minimum of 150 V/m peak with pulse modulation of 0.1 percent duty cycle with 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 percent.

(5) From 400 MHz to 8 GHz, use radiated susceptibility tests at a minimum of 28 V/m peak with 1 kHz square wave modulation with 90 percent depth or greater. This signal must be switched on and off at a rate of 1 Hz with a duty cycle of 50 percent.

(d) Equipment HIRF Test Level 2.

(1) From 10 kHz to 400 MHz, use conducted susceptibility tests with CW and 1 kHz square wave modulation with 90 percent depth or greater. The conducted susceptibility current must start at a minimum of 0.6 mA at

10 kHz, increasing 20 dB per frequency decade to a minimum of 30 mA at 500 kHz.

(2) From 500 kHz to 400 MHz, the conducted susceptibility current must be at least 30 mA.

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

(4) From 400 MHz to 8 GHz, use radiated susceptibility tests at a minimum of 150 V/m peak with pulse modulation of 4 percent 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 percent.

(e) Equipment HIRF Test Level 3. Test level 3 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 4.

(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 400 MHz, use conducted susceptibility tests at a minimum of 7.5 mA.

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

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PART 27 — AIRWORTHINESS STANDARDS: NORMAL CATEGORY ROTORCRAFT

7. The authority citation for part 27 continues to read as follows:

Authority: 49 U.S.C. §§ 106(g), 40113, 44701, 44702, 44704.

8. Add § 27.1317 to subpart F to read as follows:

§ 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) Each function is not adversely affected during and after the time the rotorcraft is exposed to HIRF environment I, as described in appendix D to this part;

(2) Each electrical and electronic system automatically recovers normal operation, in a timely manner, after the rotorcraft is exposed to HIRF environment I, as described in appendix D to this part, unless this conflicts with other operational or functional requirements of that system;

(3) Each electrical and electronic system is not adversely affected during and after the time the rotorcraft is exposed to HIRF environment II, as described in appendix D to this part; 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 to this part.

(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 flightcrew to cope with adverse operating conditions must be designed and installed so the system is not adversely affected when the equipment providing these functions is exposed to equipment HIRF test level 1, 2, or 3, as described in appendix D to this part.

(c) Each electrical and electronic system that performs a function whose failure would reduce the capability of the rotorcraft or the ability of the flightcrew to cope with adverse operating conditions, must be designed and installed so the system is not adversely affected when the equipment providing these functions is exposed to equipment HIRF test level 4, as described in appendix D to this part.

9. Add appendix D to part 27 to read as follows:

Appendix D to Part 27– HIRF Environments and Equipment HIRF Test Levels

This appendix specifies the HIRF environments and equipment HIRF test levels for electrical and electronic systems under § 27.1317. The field strength values for the HIRF environments and laboratory 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 as follows ow:

Table I — HIRF Environment I

FREQUENCY	FIELD STRENGTH (V/M)	
	PEAK	AVERAGE
10 kHz - 100 kHz	50	50
100 kHz - 500 kHz	50	50
500 kHz - 2 MHz	50	50
2 MHz - 30 MHz	100	100
30 MHz - 70 MHz	50	50
70 MHz - 100 MHz	50	50
100 MHz - 200 MHz	100	100
200 MHz - 400 MHz	100	100
400 MHz - 700 MHz	700	50
700 MHz - 1 GHz	700	100
1 GHz - 2 GHz	2,000	200
2 GHz - 4 GHz	3,000	200
4 GHz - 6 GHz	3,000	200
6 GHz - 8 GHz	1,000	200
8 GHz - 12 GHz	3,000	300
12 GHz - 18 GHz	2,000	200
18 GHz - 40 GHz	600	200

(b) HIRF environment II is specified as follows:

Table II – HIRF Environment II

FREQUENCY	FIELD STRENGTH (V/M)	
	PEAK	AVERAGE
10 kHz - 100 kHz	20	20
100 kHz - 500 kHz	20	20
500 kHz - 2 MHz	30	30
2 MHz - 30 MHz	100	100
30 MHz - 70 MHz	10	10
70 MHz - 100 MHz	10	10
100 MHz - 200 MHz	30	10
200 MHz - 400 MHz	10	10
400 MHz - 700 MHz	700	40
700 MHz - 1 GHz	700	40
1 GHz - 2 GHz	1,300	160
2 GHz - 4 GHz	3,000	120
4 GHz - 6 GHz	3,000	160
6 GHz - 8 GHz	400	170
8 GHz - 12 GHz	1,230	230
12 GHz - 18 GHz	730	190
18 GHz - 40 GHz	600	150

(c) HIRF environment III is specified as follows:

Table III – HIRF Environment III

FREQUENCY	FIELD STRENGTH (V/M)	
	PEAK	AVERAGE
10 kHz - 100 kHz	150	150
100 kHz - 500 kHz	200	200
500 kHz - 2 MHz	200	200
2 MHz - 30 MHz	200	200
30 MHz - 70 MHz	200	200
70 MHz - 100 MHz	200	200
100 MHz - 200 MHz	200	200
200 MHz - 400 MHz	200	200
400 MHz - 700 MHz	730	200
700 MHz - 1 GHz	1,400	240
1 GHz - 2 GHz	5,000	250
2 GHz - 4 GHz	6,000	490
4 GHz - 6 GHz	7,200	400
6 GHz - 8 GHz	1,100	170
8 GHz - 12 GHz	5,000	330
12 GHz - 18 GHz	2,000	330
18 GHz - 40 GHz	1,000	420

(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 percent 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 400 MHz, the conducted susceptibility current must be at least 30 mA.

(3) 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 percent depth or greater.

(4) From 400 MHz to 8 gigahertz (GHz), use radiated susceptibility tests at a minimum of 150 V/m peak with pulse modulation of 0.1 percent duty cycle with 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 percent.

(5) From 400 MHz to 8 GHz, use radiated susceptibility tests at a minimum of 28 V/m peak with 1 kHz square wave modulation with 90 percent depth or greater. This signal must be switched on and off at a rate of 1 Hz with a duty cycle of 50 percent.

(e) Equipment HIRF Test Level 2.

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

(2) From 500 kHz to 400 MHz, the conducted susceptibility current must be at least 30 mA.

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

(4) From 400 MHz to 8 GHz, use radiated susceptibility tests at a minimum of 150 V/m peak with pulse modulation of 4 percent 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 percent.

(f) Equipment HIRF Test Level 3. Test level 3 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.

(g) Equipment HIRF Test Level 4.

(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 400 MHz, use conducted susceptibility tests at a minimum of 7.5 mA.

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

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PART 29 — AIRWORTHINESS STANDARDS: TRANSPORT CATEGORY ROTORCRAFT

10. The authority citation for part 29 continues to read as follows:

Authority: 49 U.S.C. §§ 106(g), 40113, 44701, 44702, 44704.

11. Add § 29.1317 to subpart F to read as follows:

§ 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) Each function is not adversely affected during and after the time the rotorcraft is exposed to HIRF environment I, as described in appendix E to this part;

(2) Each electrical and electronic system automatically recovers normal operation, in a timely manner, after the rotorcraft is exposed to HIRF environment I, as described in appendix E to this part, unless this conflicts with other operational or functional requirements of that system;

(3) Each electrical and electronic system is not adversely affected during and after the time the rotorcraft is exposed to HIRF environment II, as described in appendix E to this part; 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 to this part.

(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 flightcrew to cope with adverse operating conditions must be designed and installed so the system is not adversely affected when the equipment providing these functions is exposed to equipment HIRF test level 1, 2, or 3, as described in appendix E to this part.

(c) Each electrical and electronic system that performs such a function whose failure would reduce the capability of the rotorcraft or the ability of the flightcrew to cope with adverse operating conditions must be designed and installed so the system is not adversely affected when the equipment providing these functions is exposed to equipment HIRF test level 4, as described in appendix E to this part.

12. Add appendix E to part 29 to read as follows:

Appendix E to Part 29— HIRF Environments and Equipment HIRF Test Levels

This appendix specifies the HIRF environments and equipment HIRF test levels for electrical and electronic systems under § 29.1317. The field strength values for the HIRF environments and laboratory 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 as follows:

Table I — HIRF Environment I

FREQUENCY	FIELD STRENGTH (V/M)	
	PEAK	AVERAGE
10 kHz - 100 kHz	50	50
100 kHz - 500 kHz	50	50
500 kHz - 2 MHz	50	50
2 MHz - 30 MHz	100	100
30 MHz - 70 MHz	50	50
70 MHz - 100 MHz	50	50
100 MHz - 200 MHz	100	100
200 MHz - 400 MHz	100	100
400 MHz - 700 MHz	700	50
700 MHz - 1 GHz	700	100
1 GHz - 2 GHz	2,000	200
2 GHz - 4 GHz	3,000	200
4 GHz - 6 GHz	3,000	200
6 GHz - 8 GHz	1,000	200
8 GHz - 12 GHz	3,000	300
12 GHz - 18 GHz	2,000	200
18 GHz - 40 GHz	600	200

(b) HIRF environment II is specified as follows:

Table II – HIRF Environment II

FREQUENCY	FIELD STRENGTH (V/M)	
	PEAK	AVERAGE
10 kHz - 100 kHz	20	20
100 kHz - 500 kHz	20	20
500 kHz - 2 MHz	30	30
2 MHz - 30 MHz	100	100
30 MHz - 70 MHz	10	10
70 MHz - 100 MHz	10	10
100 MHz - 200 MHz	30	10
200 MHz - 400 MHz	10	10
400 MHz - 700 MHz	700	40
700 MHz - 1 GHz	700	40
1 GHz - 2 GHz	1,300	160
2 GHz - 4 GHz	3,000	120
4 GHz - 6 GHz	3,000	160
6 GHz - 8 GHz	400	170
8 GHz - 12 GHz	1,230	230
12 GHz - 18 GHz	730	190
18 GHz - 40 GHz	600	150

(c) HIRF environment III is specified as follows:

Table III – HIRF Environment III

FREQUENCY	FIELD STRENGTH (V/M)	
	PEAK	AVERAGE
10 kHz - 100 kHz	150	150
100 kHz - 500 kHz	200	200
500 kHz - 2 MHz	200	200
2 MHz - 30 MHz	200	200
30 MHz - 70 MHz	200	200
70 MHz - 100 MHz	200	200
100 MHz - 200 MHz	200	200
200 MHz - 400 MHz	200	200
400 MHz - 700 MHz	730	200
700 MHz - 1 GHz	1,400	240
1 GHz - 2 GHz	5,000	250
2 GHz - 4 GHz	6,000	490
4 GHz - 6 GHz	7,200	400
6 GHz - 8 GHz	1,100	170
8 GHz - 12 GHz	5,000	330
12 GHz - 18 GHz	2,000	330
18 GHz - 40 GHz	1,000	420

(d) <u>Equipment HIRF Test Level 1</u>.

(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 percent 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 400 MHz, the conducted susceptibility current must be at least 30 mA.

(3) 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 percent depth or greater.

(4) From 400 MHz to 8 gigahertz (GHz), use radiated susceptibility tests at a minimum of 150 V/m peak with pulse modulation of 0.1 percent duty cycle with 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 percent.

(5) From 400 MHz to 8 GHz, use radiated susceptibility tests at a minimum of 28 V/m peak with 1 kHz square wave modulation with 90 percent depth or greater. This signal must be switched on and off at a rate of 1 Hz with a duty cycle of 50 percent.

(e) <u>Equipment HIRF Test Level 2</u>.

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

(2) From 500 kHz to 400 MHz, the conducted susceptibility current must be at least 30 mA.

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

(4) From 400 MHz to 8 GHz, use radiated susceptibility tests at a minimum of 150 V/m peak with pulse modulation of 4 percent 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 percent.

(f) Equipment HIRF Test Level 3. Test level 3 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.

(g) Equipment HIRF Test Level 4.

(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 400 MHz, use conducted susceptibility tests at a minimum of 7.5 mA.

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

Issued in Washington, DC, on

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DRAFT

August 24, 2000

U.S. Department of Transportation

Federal Aviation Administration

Advisory Circular

Subject: The Certification of Aircraft Electrical and Electronic Systems for Operation in the High Intensity Radiated Fields (HIRF) Environment

Date: XX/XX/00

Initiated by: XXX-XXX

AC No: 20-xxx

Change:

1. PURPOSE. This advisory circular (AC) provides information and guidance concerning an acceptable means, but not the only means, of showing compliance with Title 14, Code of Federal Regulations (14 CFR) §§ 23.1308, 25.1317, 27.1317, and 29.1317, regarding the operation of electrical and electronic systems on an aircraft when the aircraft is exposed to an external high intensity radiated fields (HIRF) environment. This AC is not mandatory nor does it constitute a regulation; an applicant may elect an alternative means of compliance acceptable to the Federal Aviation Administration (FAA).

2. FOCUS. This AC applies to all applicants seeking issuance of a type certificate (TC), an amended type certificate (amended TC), or a supplemental type certificate (STC) under Parts 23, 25, 27, and 29 for the initial approval of a new type of aircraft, a change in an aircraft type design, or the use of an existing piece of equipment or system on an aircraft that previously has not used that equipment or system.

3. RELATED MATERIAL.

a. Sections 23.901, 25.901, 27.901, and 29.901, Installation; §§ 23.903, 25.903, 27.903, and 29.903, Engines; §§ 23.1301, 25.1301, 27.1301, and 29.1301, Function and Installation; §§ 23.1309, 25.1309, 27.1309, and 29.1309, Equipment, Systems, and Installations; §§ 23.1308, 25.1317, 27.1317, and 29.1317, High Intensity Radiated Fields (HIRF) Protection; §§ 23.1329, 25.1329, 27.1329, and 29.1329, Automatic Pilot System; §§ 23.1431, 25.1431, and 29.1431, Electronic Equipment; and §§ 23.1529, 25.1529, 27.1529, and 29.1529, Instructions for Continued Airworthiness.

b. Joint Aviation Requirements (JAR) 23, 25, 27, and 29. Copies of these documents may be purchased from Global Engineering Documents, 15 Inverness Way East, Englewood, Colorado 80152-5776; domestic calls: 1-800-854-7179; international calls: 1-303-397-7956; facsimile: 1-303-397-2740; electronic mail: global@ihs.com.; and web site: http://www.global.ihs.com.

c. AC 23.1309-1C, Equipment, Systems, and Installations in Part 23 Airplanes; and AC 25.1309-1A, System Design and Analysis. Copies of these documents may be purchased from the Superintendent of Documents, P.O. Box 371954, Pittsburgh, Pennsylvania 15250-7954; telephone: 1-202-512-1800; facsimile: 1-202-512-2250; web site: http://bookstore.gpo.gov.

d. RTCA/DO-160, Environmental Conditions and Test Procedures for Airborne Equipment, Revision D or later. Copies of this document may be purchased from RTCA, Inc., 1140 Connecticut Avenue SW., Suite 1020, Washington, DC 20036. This document is technically equivalent to EUROCAE ED-14. Anywhere there is a reference to RTCA/DO-160, EUROCAE ED-14 may be used.

e. European Organization for Civil Aviation Equipment (EUROCAE) Copies of these documents may be purchased from EUROCAE, 17 Rue Hamelin, F-75783, Paris, Cedex 16, France.

(1) EUROCAE ED-XX, "Guide to Certification of Aircraft in a High Intensity Radiated Field (HIRF) Environment." ED-XX and SAE ARP 5583, referenced below, are technically equivalent and either document may serve as the "Users Guide" referred to in this AC.

(2) EUROCAE ED-14 revision D or later. This document is technically equivalent to RTCA/DO-160. Anywhere there is a reference to RTCA/DO-160, EUROCAE ED-14 may be used.

f. Society of Automotive Engineers (SAE). Copies of the following documents may be obtained from SAE, 400 Commonwealth Drive, Warrendale, Pennsylvania 15096-0001; web site: http://www.sae.org.

(1) SAE ARP 5583 "Guide to Certification of Aircraft in a High Intensity Radiated Field (HIRF) Environment," Draft.

(2) SAE ARP 4754, "Certification Considerations for Highly-Integrated or Complex Aircraft Systems," November 1996.

(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 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 radio frequency (RF) energy from radar, radio, television, and other ground-based, shipborne, or airborne RF transmitters. The User's Guide provides a detailed description of the derivation of these HIRF environments.

5. DEFINITIONS. For the purposes of this AC, the following definitions apply:

a. Attenuation. A 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).

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

c. Continued Safe Flight and Landing. The capability for continued controlled flight and landing at a suitable location, possibly using emergency procedures, but without requiring exceptional pilot skill or strength. Some aircraft damage may be associated with a failure condition during flight or upon landing.

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

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

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

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

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

i. Equipment Electrical Interface. The 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.

j. External High Intensity Radiated Fields Environment. The electromagnetic RF fields at the exterior of an aircraft.

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

l. High Intensity Radiated Fields (HIRF). The electromagnetic environment that exists from the transmission of high power RF energy into free space.

m. HIRF Vulnerability. The 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 a HIRF environment.

n. Immunity. The 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.

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

p. 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.

q. Margin. The 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.

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

s. Radio Frequency (RF). A 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.

t. Reflection Plane. Conducting plate that reflects RF signals.

u. Similarity. The 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.

v. Susceptibility. The property of a piece of equipment that describes its capability to function acceptably when subjected to unwanted electromagnetic energy.

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

x. System. A 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 many pieces of equipment and wire bundles.

y. Transfer Function. The 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.

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

6. APPROACHES TO COMPLIANCE.

a. General. The following activities should be elements of a HIRF certification program. The iterative application of these activities is left to the applicant and adherence to the sequence shown is not necessary. The applicant should—

(1) Identify the systems to be assessed;

(2) Establish the applicable external HIRF environment;

(3) Establish the test environment for installed systems;

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

(5) Verify compliance with HIRF certification requirements.

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 §§ 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/or 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 all normal aircraft operating modes, stages of flight, and operating conditions; all failure conditions and their subsequent effect on aircraft operations and the flightcrew; and any corrective actions required.

(2) Safety Assessment. A safety assessment related to HIRF should 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 AC are similar to those used in AC 23.1309-1C and AC 25.1309-1A, 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. The failure classifications "minor" and "no safety effect" used in AC 23.1309-1C and AC 25.1309-1A are not used in this AC. 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 23.1309-1C, AC 25.1309-1A, SAE ARP 4754, 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 rotorcraft/airplane	Catastrophic	A
Each electrical and electronic system that performs a function whose failure would significantly reduce the capability of the rotorcraft/airplane or the ability of the flightcrew to cope with adverse operating conditions	Hazardous	B
Each electrical and electronic system that performs such a function whose failure would reduce the capability of the	Major	C

rotorcraft/airplane or the ability of the flightcrew to cope with adverse operating conditions		

(3) Failure Conditions. 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 used for aircraft HIRF certification 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 - 100 kHz	50	50
100 kHz - 500 kHz	50	50
500 kHz - 2 MHz	50	50
2 MHz - 30 MHz	100	100
30 MHz - 70 MHz	50	50
70 MHz - 100 MHz	50	50
100 MHz - 200 MHz	100	100
200 MHz - 400 MHz	100	100
400 MHz - 700 MHz	700	50
700 MHz - 1 GHz	700	100
1 GHz - 2 GHz	2,000	200
2 GHz - 4 GHz	3,000	200
4 GHz - 6 GHz	3,000	200
6 GHz - 8 GHz	1,000	200
8 GHz - 12 GHz	3,000	300
12 GHz - 18 GHz	2,000	200
18 GHz - 40 GHz	600	200
In this table, the higher field strength applies at the frequency band edges.		

Table 3 — HIRF ENVIRONMENT II

FREQUENCY	FIELD STRENGTH (V/M)	
	PEAK	AVERAGE
10 kHz - 100 kHz	20	20
100 kHz - 500 kHz	20	20
500 kHz - 2 MHz	30	30
2 MHz - 30 MHz	100	100
30 MHz - 70 MHz	10	10
70 MHz - 100 MHz	10	10
100 MHz - 200 MHz	30	10
200 MHz - 400 MHz	10	10
400 MHz - 700 MHz	700	40
700 MHz - 1 GHz	700	40
1 GHz - 2 GHz	1,300	160
2 GHz - 4 GHz	3,000	120
4 GHz - 6 GHz	3,000	160
6 GHz - 8 GHz	400	170
8 GHz - 12 GHz	1,230	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.		

Table 4 — HIRF ENVIRONMENT III

FREQUENCY	FIELD STRENGTH (V/M)	
	PEAK	AVERAGE
10 kHz - 100 kHz	150	150
100 kHz - 500 kHz	200	200
500 kHz - 2 MHz	200	200
2 MHz - 30 MHz	200	200
30 MHz - 70 MHz	200	200
70 MHz - 100 MHz	200	200
100 MHz - 200 MHz	200	200
200 MHz - 400 MHz	200	200
400 MHz - 700 MHz	730	200
700 MHz - 1 GHz	1,400	240
1 GHz - 2 GHz	5,000	250
2 GHz - 4 GHz	6,000	490
4 GHz - 6 GHz	7,200	400
6 GHz - 8 GHz	1,100	170
8 GHz - 12 GHz	5,000	330
12 GHz - 18 GHz	2,000	330
18 GHz - 40 GHz	1,000	420
In this table, the higher field strength applies at the frequency band edges.		

d. Establish the Test Environment for Each System.

(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, reradiation 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 HIRF environments I, II, or III, as applicable. The attenuation is aircraft- and zone-specific and should be established by aircraft test, analysis, or similarity. Further details are in paragraph 10 of this AC.

(3) Level B Systems. The internal RF environments for level B systems are defined in appendix J to Part 23, appendix K to Part 25, appendix D to Part 27, and appendix E to Part 29, as applicable, as equipment HIRF test levels 1, 2, and 3. Further details are in paragraph 10 of this AC.

(4) Level C Systems. The internal RF environment for level C systems is defined in appendix J to Part 23, appendix K to Part 25, appendix D to Part 27, and appendix E to Part 29, as applicable, as equipment HIRF test level 4. Further details are in paragraph 10 of this AC.

e. Apply the Appropriate Test Requirements. Table 5 summarizes the relationship between the aircraft performance requirements in the HIRF regulations, and the HIRF environments and test levels.

Table 5 - HIRF Certification Requirements Summary

HIRF Failure Condition from §§ 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 airplane/rotorcraft must be designed and installed so that–	Each function is not adversely affected during and after the time	the airplane/rotorcraft	is exposed to HIRF environment I.
	Each electrical and electronic system automatically recovers normal operation, in a timely manner after … unless this conflicts with other operational or functional requirements of that system	the airplane/rotorcraft	is exposed to HIRF environment I.
	Each electrical and electronic system is not adversely affected during and after	the airplane/rotorcraft	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 airplane/rotorcraft or the ability of the flightcrew to cope with adverse operating conditions 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, 2, or 3.
Each electrical and electronic system that performs such a function whose failure would reduce the capability of the	the system is not adversely affected when	the equipment providing these functions	is exposed to equipment HIRF test level 4.

airplane/rotorcraft or the ability of the flightcrew to cope with adverse operating conditions must be designed and installed so that—			

f. Verification of Compliance with the Certification Requirements.

(1) General. Verification of compliance with the HIRF certification requirements should be shown by evidence that the internal HIRF environment at equipment interfaces and enclosures does not exceed the equipment's or system's HIRF test levels.

(2) Pass/Fail Criteria. The specific HIRF compliance pass/fail criteria for each system, related to the applicable HIRF regulation performance criteria, should be established by the applicant and approved by the FAA. The means for monitoring system performance relative to these criteria also should be established by the applicant and approved by the FAA. 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, that could adversely affect system performance. This should include failures that could negate any built-in redundancy within the system or could influence more than one system performing the same function.

7. MARGINS. A margin may be necessary to account for uncertainties involved in analyses and test measurements. A margin normally is not required for analyses or measurements that are based on proven data. Where data have limited background for substantiation, a margin may be required depending on the available justifications. The User's Guide contains a detailed description of margins.

8. AIRCRAFT TYPE CERTIFICATIONS. The design and verification data to support a submission for a TC, amended TC, or STC should be acquired through a logical and traceable procedure. The procedure should begin with the definition stage, where the system requirements are generated and defined, and end with demonstration of compliance with system requirements. HIRF compliance considerations should be included as a part of the certification plan.

9. 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 the FAA for approval before being implemented. If the aircraft, system, or installation design changes after FAA approval, a revised HIRF compliance plan should be submitted to the FAA for approval. The HIRF compliance plan should include the following:

(1) A HIRF compliance plan summary;

(2) Identification of the aircraft systems, with classification based on the safety assessment as it relates to HIRF;

(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) A HIRF compliance test plan should include the objectives, both at equipment and system level, 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 and should not list only the test items and intended test locations. The test plan should include the following information:

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 and frequency bands,

6. Pass/fail criteria, and

7. The test schedule and test location.

(b) The test plan should cover the level A, B, or C systems and equipment. Level A systems may require both a laboratory and an installed-on-aircraft test. Level A display systems may require an integrated system rig test, in addition to a generic attenuation assessment. Level B or level C systems and equipment may require only equipment bench 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. A HIRF compliance analysis plan should include the objectives, both at the system and equipment level, for generating data to support HIRF compliance verification. Comprehensive modeling and analysis for RF field coupling to aircraft systems and structures is an emerging technology; therefore, the analysis plan should be coordinated with the FAA 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.

c. Compliance Reports. One or more compliance reports may be necessary to document the results of 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. Any supporting rationale related to any observed deviations from system performance during testing also should be provided.

(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 modeling uncertainty.

(3) <u>Similarity Reports</u>. The 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. Any significant differences should be identified, along with the assessment of the impact of these differences on HIRF compliance.

d. <u>Major Elements of Compliance Verification</u>.

(1) Various methods are available to aid in demonstrating HIRF compliance. These methods are described in the following paragraphs and represent those that have evidence of practical application and are acceptable to the FAA. Figures 1 and 2 outline the possible steps to HIRF compliance for systems requiring level A, B, or C HIRF certification.

(2) Other HIRF compliance techniques may be considered to demonstrate system performance in the HIRF environment, but should be approved by the FAA before their use.

Figure 1 — Routes to HIRF Compliance

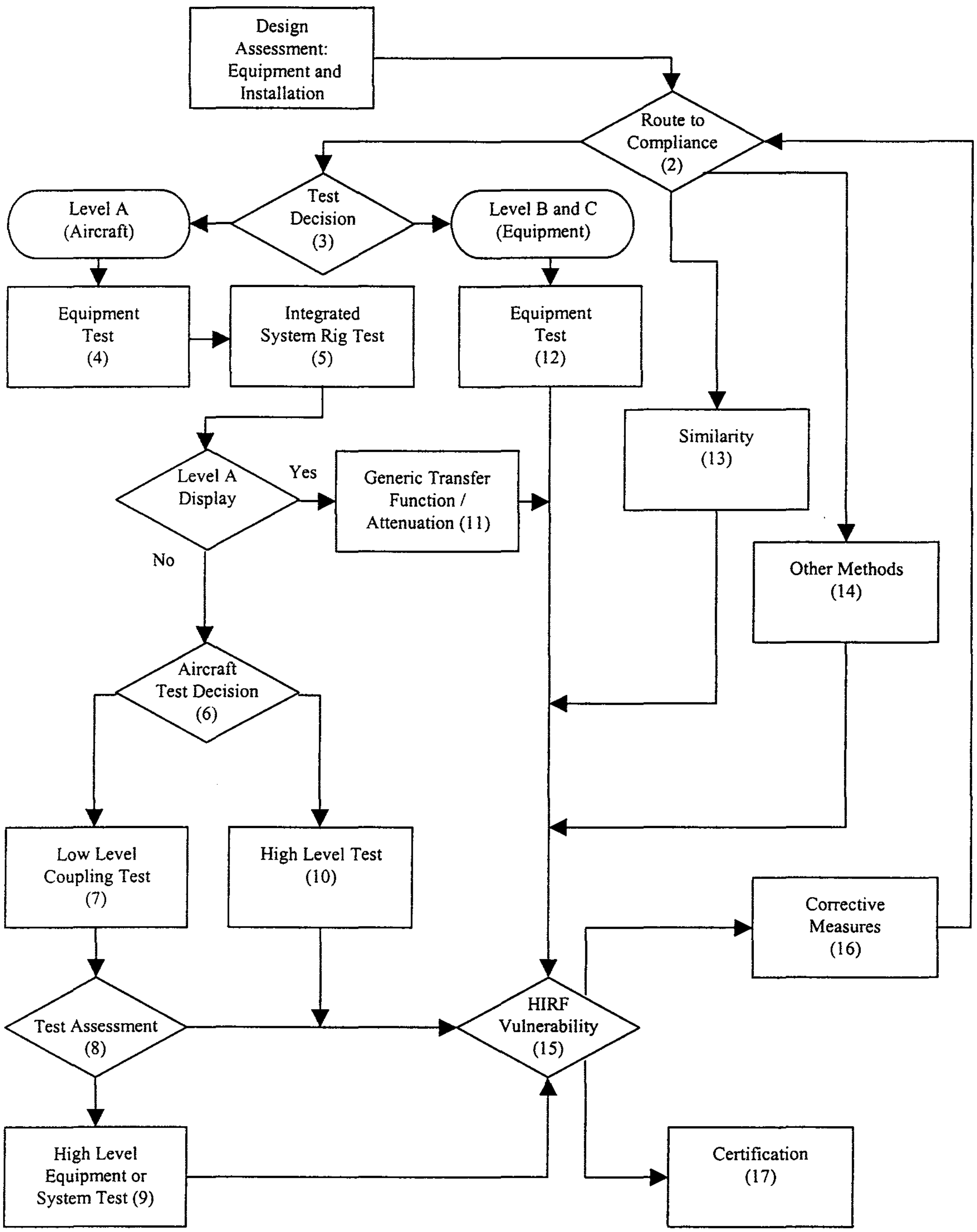
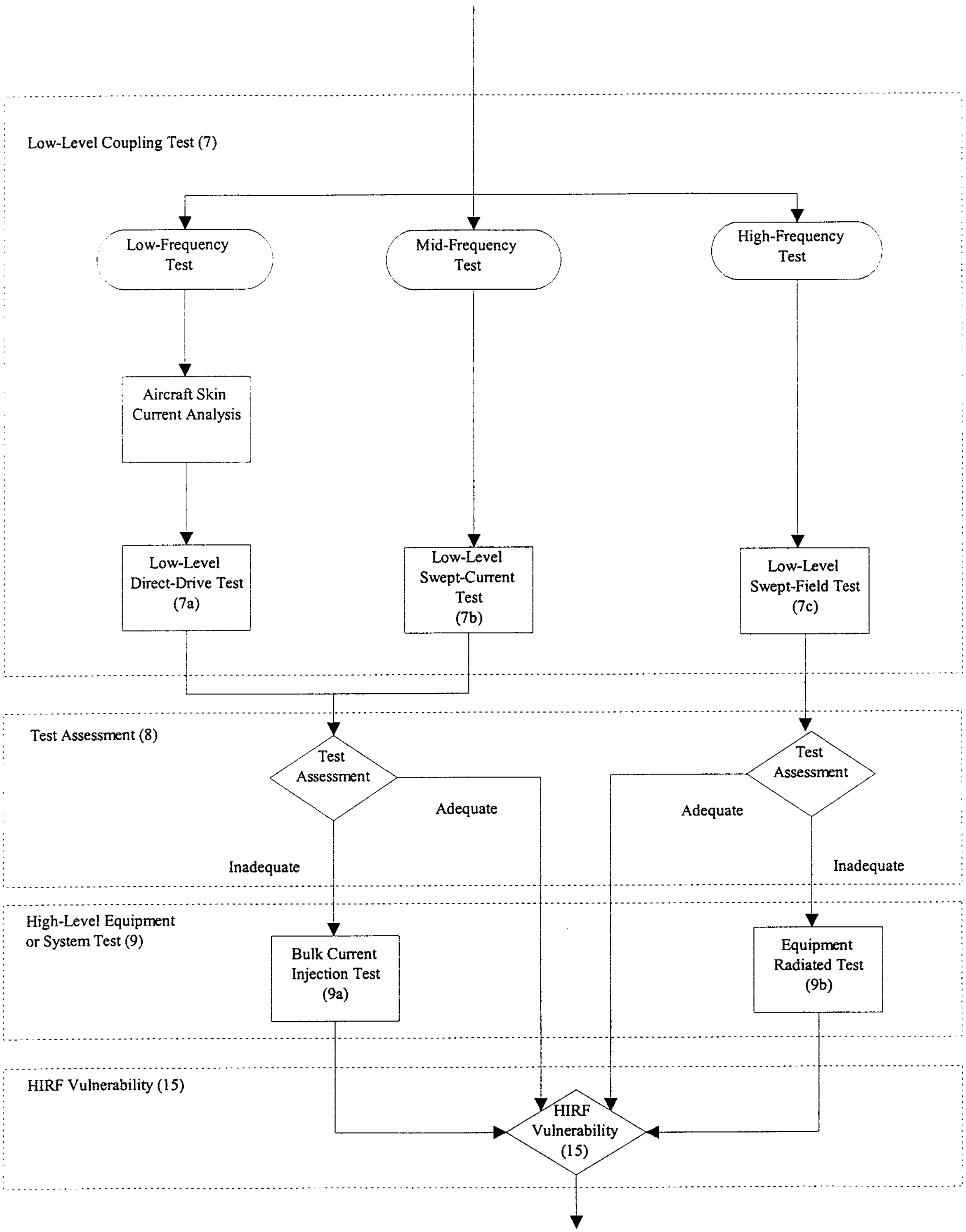


Figure 2 – Routes to HIRF Compliance (Steps 7 through 9)



10. STEPS TO HIRF COMPLIANCE.

a. Step 1 – Design Assessment: Equipment and Installation.

(1) The initial step in HIRF compliance is to determine the HIRF environment to which the aircraft, equipment, or system should be exposed. The equipment or system failure condition classification should be determined from a safety assessment. According to the system failure condition classification, the system will be designated as level A, B, or C. The HIRF environment to which the aircraft, equipment, or system will be exposed is based on whether the system is designated as level A, B, or C.

(2) Because equipment or system tests may occur before aircraft-level testing and before the actual internal HIRF environment is known, the equipment or system test levels should be selected based on an estimate of the expected internal HIRF environment.

b. Step 2 – Route to Compliance. The route to be taken for HIRF compliance will vary depending on whether the system was designated as level A, B, or C. The decision should be made whether to use test (step 3), similarity (step 13), or other methods (step 14), including analysis for HIRF compliance verification.

c. Step 3 – Test Decision. Level A systems will require an aircraft assessment and should proceed to step 4. Level B and C systems will require equipment testing and should proceed to step 12.

d. Step 4 – Equipment Test.

(1) The radiated and conducted RF susceptibility test procedures of RTCA/DO-160, revision D or later, section 20, or equivalent, may be used to build confidence in the equipment's performance before conducting integrated system rig testing in step 5. The equipment should be tested in accordance with the test levels (wire bundle currents and RF field strengths) of RTCA/DO-160, revision D or later, or to a level derived from the analysis of the aircraft and equipment installation for a given external HIRF environment.

(2) Equipment development testing may be used to augment the compliance test submission where appropriate. If equipment that was not subject to the equipment qualification testing of paragraph 10.d.(1) above is used within the system to be tested, then the HIRF compliance certification may be achieved by step 5, and step 4 may be omitted.

e. Step 5 – Integrated System Rig Test.

(1) A radiated and conducted RF susceptibility test on an integrated system rig should be performed for level A systems.

(2) If the results of the tests conducted on an integrated system rig are comparable to the results obtained in step 7 and characterize the equipment's or system's final installation in the aircraft, high-level tests on equipment or systems in step 9 may not be required.

(3) The physical installation of the equipment or system in the integrated system rig assembly should be similar to that used in the aircraft. For example, the bonding and grounding of the system, the wiring harness detail, and the relative position of the elements to each other and the ground plane should match closely the equipment's or system's installation on the aircraft to be certificated.

(4) The internal HIRF environment should be determined by using analysis, previous coupling/attenuation data from similar aircraft types, or, for level A display systems only, the generic transfer function/attenuation curves in appendix 1 to this AC.

(5) A method of comparing the integrated system rig test of step 5 with the internal RF current or RF fields measured during the low-level coupling test of step 7 should be defined to show that the internal RF environment is lower than the equipment or system test levels in step 15, HIRF vulnerability. This method should be included in the HIRF compliance plan. The method should enable a direct comparison between the equipment or system test level and the aircraft internal HIRF environment at the equipment or system location, in terms of field strength (>100 megahertz (MHz)) and current (<400 MHz). The comparison method should ensure that—

(a) The laboratory test configuration includes all significant aspects of the aircraft installation considered necessary in the demonstration process for that portion of the system to be certified.

(b) The system is tested in an operational state with the input sensors operational. The input sensors may be simulated by test sets, provided the test sets accurately represent the terminating impedance of the sensor. Additionally, the sensors should be evaluated individually and shown to meet the HIRF requirements with respect to their locations.

(c) The test procedures used and test levels employed are selected to simulate the conditions created by the aircraft internal HIRF environment when the aircraft operates in the appropriate external HIRF environment. Suitable test procedures are described in detail in the User's Guide. BCI tests should be used from 10 kHz to 400 MHz, and radiated susceptibility testing should be used from 100 MHz to 18 GHz.

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

(7) Standard RTCA/DO-160, revision D or later, equipment tests normally are not sufficient to show HIRF compliance for step 5. However, if the requirements of paragraphs 10.e.(5)(a), (b), and (c) above are met, then the standard integrated system rig tests can be used.

f. Step 6 – Aircraft Test Decision.

(1) Various aircraft test procedures are available, recognized, and accepted for collecting data for HIRF compliance verification. The two main approaches to aircraft testing are the low-level coupling test (step 7) and the high-level test (step 10). Low-level coupling involves measuring the airframe attenuation and confirming that the integrated system rig test levels reflect the internal HIRF environment measured. The high-level equipment field-illumination test involves radiating the aircraft at test levels equal to the applicable external HIRF environment as provided in paragraph 6.c. of this AC.

(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 HIRF compliance testing proposed in figure 2 may be more suitable for testing large aircraft than the high-level equipment field-illumination test in step 10, which requires illumination of the entire aircraft with the external HIRF environment.

g. Step 7 — Low-Level Coupling Test.

(1) General.

(a) The low-level coupling test involves three different tests, briefly described below, 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 and should be discussed with and approved by the FAA before being used.

(b) The low-level direct-drive test (step 7a) and the low-level swept-current test (step 7b) are used for frequencies below 400 MHz, and the low-level swept-field test (step 7c) is used for frequencies above 400 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.

(c) Low-level coupling tests should cover the frequency range of 10 kHz to 18 GHz.

(2) Step 7a — Low-Level Direct-Drive Test. Low-level direct-drive tests should be used to measure the transfer function between the skin current and individual equipment wire bundle currents. This test is typically used in the frequency range from 10 kHz to the first airframe resonance. 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 (see the User's Guide) such that the three-dimensional model can then be used to derive a representation of the aircraft's skin current pattern for a given external HIRF environment. 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 aircraft or equipment wire bundles are measured with a current probe and normalized to the external unit 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 fuselage shielding.

(3) Step 7b – Low-Level Swept-Current Test.

(a) The low-level swept-current test involves illuminating the aircraft with an 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 0.5 MHz to 400 MHz. The transfer function is resonant in nature and is dependent on both the aircraft structure and the equipment or 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) Transmit antennas should be placed at four separate positions around the aircraft, typically the nose, tail, and each wing. The aircraft should be illuminated by one antenna at a time with both horizontally and vertically polarized swept frequency fields, and the currents induced on the aircraft wire bundles should be measured. The ratio between the induced wire bundle current and the illuminating antenna field strength should be calculated and normalized to 1 V/m. This calculation should provide the transfer function in terms of induced current per unit external field strength that can then be extrapolated to the required HIRF field strength by multiplying the induced current at 1 V/m by the external HIRF field strength. The extrapolated HIRF currents for all measurement configurations for each aircraft wire bundle being assessed should be overlaid and a worst-case induced current profile should be produced. These current profiles should be compared with the induced current measured during the tests in step 5 or step 9. When compared with the current measured during tests in step 5, the comparison may not show equivalence because of changes in equipment or system installation, for example, wire bundle lengths, screening and bonding, wire bundle composition, or differences between equipment qualification and aircraft test levels.

(c) 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 0.05 MHz to 0.5 MHz, 0.5 MHz to 30 MHz, and 30 MHz to 100 MHz. This comparison should be broken into discrete frequency ranges because the resonance may differ between equipment test and aircraft test levels.

(4) <u>Step 7c – Low-Level Swept-Field Test</u>. 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. See the User's Guide for detailed low-level swept-field test procedures.

h. <u>Step 8 – Test Assessment</u>.

(1) At this point, the internal RF fields and wire bundle currents produced by the appropriate external HIRF environment should be known based on the measurements made in step 7. These measurements should be compared with the test levels used in step 5.

(2) Step 9a should be performed on the aircraft or a representative system integration rig if the above comparison shows that—

(a) Significant configuration differences were identified between the integrated system rig used for conducted RF susceptibility testing in step 5, and the actual aircraft system installation;

(b) The conducted RF susceptibility test levels used in step 5 were too low when compared with the aircraft-induced currents measured in step 7; or

(c) Potential HIRF susceptibility may exist.

(3) Step 9b should be performed on systems installed on the aircraft or a representative integrated system rig if the above comparison shows that—

(a) Significant configuration differences were identified between the integrated system rig used for radiated RF susceptibility testing in step 5, and the actual aircraft system installation;

(b) The RF fields used in step 5 were too low when compared with the aircraft internal fields measured in step 7; or

(c) Potential HIRF susceptibility may exist.

(4) If the measurements made in step 5 are comparable to those made in step 7, then step 9 may be omitted and step 15 should be performed next.

i. Step 9 – High-Level Equipment or System Test.

(1) General. The various procedures that should be used in this step are described briefly below. Detailed descriptions are available in the User's Guide. Other techniques may be valid, but should be proposed in the HIRF compliance plan and approved by the FAA before use.

(2) Overlap Procedures. The high-level test procedures are typically divided at 400 MHz. The division at 400 MHz is not definitive but rather depends on when RF penetration of the equipment case becomes a factor. It is therefore necessary to overlap the two procedures described below to ensure the primary coupling route is tested.

(3) Step 9a – Bulk Current Injection Test.

(a) High-level wire bundle bulk current injection (BCI) should be used at frequencies below 400 MHz to measure the current at equipment malfunction or equipment test levels when RF currents are injected into the equipment wiring via a current transformer.

(b) The system should be tested using the test levels determined in step 7a or step 7b. Each wire bundle in the system should be injected and the induced wire bundle current measured. If a wire bundle branches, then each relevant wire branch containing system wiring should be tested.

(c) To ensure the systems under test are tested when operating at their maximum sensitivity, each system should be operational and the aircraft or integrated system rig should be placed in various simulated operating modes. Simultaneous multi-bundle BCI may be necessary on systems where, for example, there are redundant/multichannel architectures.

(d) The test time should be minimized by using only the modulation to which the system under evaluation is most sensitive. See the User's Guide for guidance on modulation selection and suggested default modulations and dwell times.

(4) Step 9b – Equipment Radiated Test.

(a) High-level equipment radiated susceptibility tests should be used at frequencies greater than 100 MHz. The equipment should be installed on the aircraft. The internal RF field in the vicinity of the equipment under evaluation should be determined using the transfer function or attenuation measured in step 7 and the appropriate external HIRF environment. The equipment under evaluation should be radiated by this HIRF environment using antennas inside the aircraft in the vicinity of the equipment. The radiating antenna should be far enough away to ensure the total volume of the equipment and that at least half a wavelength of the wiring is simultaneously and uniformly illuminated during the test.

(b) The test time should be minimized by using only the modulation to which the system under evaluation is most sensitive. See the User's Guide for guidance on modulation selection and suggested default modulations and dwell times.

j. Step 10 – High-Level Test.

(1) General.

(a) The high-level test requires the generation of RF fields external to an aircraft at a level equal to the applicable external HIRF environment.

(b) At frequencies below 400 MHz, the aircraft and the radiating antenna should be separated to ensure the aircraft is illuminated uniformly by the external HIRF environment. Typically, four radiating antenna positions should be used, illuminating the nose, tail, and each wingtip. The aircraft should be illuminated by one antenna at a time, with both horizontally and vertically polarized fields. The RF field should be calibrated by measuring the RF field strength in the center of the test volume before the aircraft is placed there.

(c) 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. Relevant apertures on the bottom and top of the aircraft should be illuminated by using reflection planes.

(d) 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.

(e) The test time should be minimized by using only the modulation to which the system under evaluation is most sensitive. The User's Guide provides guidance on modulation selection and suggested default modulations and dwell times.

(2) Aircraft High-Level Direct-Drive Test. As an alternative to testing at frequencies below the first airframe resonance, it is possible to inject high-level currents directly into the airframe using the techniques similar to those described in step 7. 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 aircraft resonant frequency, is advantageous because it is possible to test all systems simultaneously.

k. Step 11 – Generic Attenuation (Level A Display Systems).

(1) Level A displays involve functions for which the pilot will be within the loop through pilot/system information exchange. For level A display systems, the aircraft attenuation data may be determined by analysis 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 require a more rigorous HIRF compliance verification program.

(2) The test levels required in Step 5 may be derived from the generic transfer function and attenuation curves for the different types of aircraft. Acceptable transfer function curves for calculating the test levels are given in appendix 1 to this AC. Appendix 1 to this AC also contains guidelines for selecting the proper generic attenuation curve. These curves show the envelope of the peak currents that might be expected to be induced in the generic types of aircraft in an external HIRF environment of 1 V/m. The peak current levels should be multiplied linearly by the appropriate external HIRF environment to provide the test levels within the limits described in the User's Guide.

(3) The internal HIRF environment would be, in V/m, 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 relevant external HIRF environment reduced by a factor of 10 in terms of electric field strength.

(4) The internal HIRF environments also can be measured using on-aircraft low-level coupling measurements of the actual equipment installation. This procedure should provide more accurate information to the user, and the test levels may be lower than the generic curves, as the generic curves are worst-case estimates.

l. <u>Step 12 - Equipment Test (for Level B and Level C Systems)</u>.

(1) <u>General</u>. Level B or level C systems do not require the same degree of HIRF compliance testing as level A systems. Level B or level C systems do not require aircraft-level testing; standard RTCA/DO-160, revision D or later, test procedures, using suitably defined equipment or system test levels, should be used. The test limits used should depend on whether the system is categorized as level B or level C. When applying modulated signals, the test levels are given in terms of the peak of the test signal as measured by a rms-indicating spectrum analyzer's peak detector. See the User's Guide for more details on modulation.

(2) Level B Systems. Equipment HIRF test level 1, 2, or 3 from the HIRF regulation must be used for level B systems. Test Category R in RTCA/DO-160 revision D, section 20, is the same as equipment HIRF test levels 1 and 2. Equipment HIRF test levels 1, 2, and 3 from appendix J to Part 23, appendix K to Part 25, appendix D to Part 27, and appendix E to Part 29, as applicable, are repeated here for convenience.

(a) Equipment HIRF Test Level 1.

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

2. From 500 kHz to 400 MHz, the conducted susceptibility current must be at least 30 mA.

3. 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 percent depth or greater.

4. From 400 MHz to 8 gigahertz (GHz), use radiated susceptibility tests at a minimum of 150 V/m peak with pulse modulation of 0.1 percent duty cycle with 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 percent.

5. From 400 MHz to 8 GHz, use radiated susceptibility tests at a minimum of 28 V/m peak with 1 kHz square wave modulation with 90 percent depth or greater. This signal must be switched on and off at a rate of 1 Hz with a duty cycle of 50 percent.

(b) Equipment HIRF Test Level 2.

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

2. From 500 kHz to 400 MHz, the conducted susceptibility current must be at least 30 mA.

3. From 100 MHz to 400 MHz, use radiated susceptibility tests at a minimum of 20 V/m peak with CW and 1 kHz square wave modulation with 90 percent depth or greater.

4. From 400 MHz to 8 GHz, use radiated susceptibility tests at a minimum of 150 V/m peak with pulse modulation of 4 percent 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 percent.

(c) Equipment HIRF Test Level 3. Test level 3 is HIRF environment II reduced by acceptable aircraft transfer function and attenuation curves. Testing must cover the frequency band of 10 kHz to 8 GHz. Generic aircraft transfer function and attenuation curves shown in appendix 1 to this AC are acceptable for determining equipment HIRF test level 3.

(3) Level C Systems. Equipment HIRF test level 4 should be used to test level C systems. Category T in RTCA/DO-160, revision D, section 20, is the same as equipment HIRF test level 4. Equipment HIRF test level 4 from appendix J to Part 23, appendix K to Part 25, appendix D to Part 27, and appendix E to Part 29, as applicable, is repeated here for convenience.

(a) 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.

(b) From 500 kHz to 400 MHz, use conducted susceptibility tests at a minimum of 7.5 mA.

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

m. Step 13 – Similarity.

(1) General. The rules for applying similarity as a means of compliance vary according to the equipment/system failure condition classification.

(2) Level A Systems.

(a) Systems previously certified on one aircraft model may be certified by similarity in another aircraft model as described below. Similarity is not applicable for level A systems consisting of new equipment designs installed in an aircraft with a new design. Systems previously certified on an aircraft model may be transferred to other aircraft models. Each system considered for certification by similarity needs to be assessed independently even if it may use equipment and installation techniques that have been the subject of a previous certification.

(b) The system used as the basis for certification by similarity must have been certified previously for HIRF on another aircraft model. Certification by similarity requires a comparison of both equipment and installation differences that could adversely effect HIRF susceptibility. An assessment of a new system installation should consider the differences that could affect the internal HIRF environment of the system and its wiring, such as the following:

_1._ The aircraft type, equipment locations, airframe construction, and apertures that could affect attenuation for the external HIRF environment;

_2._ The equipment interfaces, wiring, grounding, bonding, connectors, and wire-shielding practices; and

_3._ The line replaceable units that comprise the system.

(c) If the assessment finds only minimal differences between previously certified installations and the installation to be certified, similarity may be used as the basis for certification without the need for additional tests providing there are no unresolved in-service HIRF problems. If there is uncertainty about the effects of the differences, additional tests and analysis should be conducted as necessary and appropriate to resolve the open issues. The amount of testing to be undertaken should be commensurate with the degree of change identified between the immediate system and its application and those items tested previously. If significant differences are found, similarity should not be used as the basis for certification.

(3) Level B or Level C Systems. Certification by similarity often is more appropriate for level B or level C systems than for level A systems and can be achieved by demonstrating that the equipment is similar to equipment that has previously met the HIRF test levels appropriate to its assessed failure condition classification as defined in step 12.

n. Step 14 - Other Methods.

(1) Other methods for HIRF compliance verification include modeling, analysis, and combinations of any method given in the other steps. Comprehensive modeling and analysis for RF field coupling to the aircraft structure is an emerging technology; therefore, modeling and analysis alone currently are not adequate for showing HIRF compliance for level A systems and should be augmented by testing.

(2) Analytical models representative of the aircraft and transfer function characteristics of the equipment or system installation may be used in conjunction with supporting test data to provide HIRF compliance verification. Any data submitted should take into account the quality of the model and provide the model's assumed accuracy and the margins established by such an assessment. The margins should depend heavily on the quality of the data base used in the model. Significant testing, including aircraft level testing, may be required to support the submission. Models capable of providing detailed system performance assessments related to systems performing level A functions generally are not currently accepted, but accepted practices may develop in the future.

(3) In some situations, the steps outlined in this AC may not be suitable or new technologies may emerge that offer an alternative approach. In such cases, discussions with the FAA should be held early in the certification process.

o. Step 15 - HIRF Vulnerability.

(1) The primary intent of the HIRF vulnerability assessment should be to verify that all the functional requirements of the system are met when subjected to the internal HIRF environment generated as a result of the aircraft's or system's exposure to the applicable external HIRF environments. The pass/fail criteria defined in the test plan should be used for this assessment.

(2) HIRF susceptibilities that were not anticipated or defined in the test plan pass/fail criteria may be found during aircraft, system, or equipment 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. The applicant should provide to the FAA for approval an assessment of and supporting rationale for any modifications to the pass/fail criteria.

(3) If the level A system passed the required tests when exposed to HIRF environment I or III, as applicable, with no adverse effects, then additional testing in HIRF environment II is not required.

(4) The system safety assessment may show that the functions performed by the systems do not have the same failure condition classification throughout all phases of flight. Therefore, the HIRF environment appropriate to the sensitive phase of flight should be used for the HIRF vulnerability assessment.

(5) The HIRF vulnerability analysis documentation should include all observed effects, assumptions, and assessments to show compliance with the HIRF requirements.

(6) Tests for the HIRF environments above 18 GHz are not required if data and design analysis show the integrated system rig tests results 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.

(7) 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 the FAA. Future modifications of the minimum performance standards should reflect HIRF performance requirements.

p. Step 16 – Corrective Measures. If the equipment or system fails to satisfy the HIRF vulnerability assessment of step 15, corrective action should be taken. Any changes or modifications to the equipment or system and/or its installation may generate the need for retesting. The relevant equipment or system qualification testing of RTCA/DO-160 and/or the aircraft testing, in whole or in part, may need to be repeated to satisfy the requirements of the HIRF compliance submission.

q. Step 17 - Certification. The applicant should submit the test results and compliance report to the cognizant FAA 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 §§ 23.1529, 25.1529, 27.1529, and 29.1529, as appropriate. When dedicated protection devices or specific techniques are required to provide the protection for an equipment or system installation, periodic maintenance, special tests, and HIRF protection assurance requirements or techniques should be defined to ensure protection integrity is not degraded in service.

b. The use of devices that may degrade over time because of corrosion, fretting, flexing cycles, or other causes should be avoided. Whenever possible, dedicated replacement times should be identified. Aircraft or system modifications should be assessed for the impact any changes will have on the HIRF protection level. This assessment should be based on analysis and/or measurement.

c. The techniques and time intervals for evaluating or monitoring the integrity of the equipment's or system's HIRF protection should be defined. Built-in test equipment, resistance measurements, continuity checks of the entire system, or other means should be identified to provide assurance of the system integrity. The User's Guide provides further information on these topics.

[Insert Appropriate Name]
[Insert Appropriate Title]

APPENDIX 1 – GENERIC TRANSFER FUNCTION/ATTENUATION CURVES

1. GENERIC TRANSFER FUNCTION CURVES.

a. Suitable transfer functions for calculating the BCI test levels are given in figures A-1 through A-5. These are derived generic transfer functions acquired by tests on a significant number of aircraft, with the test results processed to establish a 95 percent population probability.

b. The curves are normalized to a 1 V/m HIRF environment and may be multiplied linearly by the external HIRF environment to establish the BCI test level requirements in the frequency range up to 400 MHz.

c. These generic curves are for wiring bundles running within the airframe with no additional protection such as that provided by conduits or raceways. In the compliance submission, the added protection such measures provide should be demonstrated if a lower test level is considered more representative.

2. GENERIC ATTENUATION CURVES.

a. Figure A-6 shows the generic attenuation curves that can be used for predicting the internal HIRF environment at the location of the equipment over the frequency band 100 MHz to 18 GHz. This predicted internal HIRF environment then provides the test level for the radiated susceptibility test.

b. Guidance on the use of these curves is given below:

(1) CAT Y. This attenuation curve can be used when the equipment under consideration is located in very severe electromagnetic environments, defined as areas with unprotected nonconductive composite structures, areas where there is no guarantee of structural bonding, and other open areas where no shielding is provided. This attenuation curve also may be used when a broad range of installations is to be covered.

(2) Cat W. This attenuation curve can be used when the equipment under consideration is located in severe electromagnetic environments, defined as areas outside the fuselage such as wings, fairings, wheel wells, pylons, and control surfaces where minimal shielding is provided. This attenuation curve is not appropriate for equipment installations more appropriately described by the definition of a Cat Y location.

(3) <u>Cat V</u>. This attenuation curve can be used when the equipment under consideration is contained entirely within a moderate electromagnetic environment, defined as the fuselage of a metallic aircraft or composite aircraft demonstrating equivalent shielding effectiveness. Examples of such an environment are avionics bays not enclosed by bulkheads, cockpit areas, and locations with large apertures, such as doors without EMI gaskets, windows, and access panels. Current-carrying conductors in this environment, such as hydraulic tubing, control cables, wire bundles, and metal wire trays, are not necessarily electrically grounded at bulkheads. This attenuation curve is not appropriate for equipment installations more appropriately described by the CAT W and CAT Y locations.

(4) <u>CAT U</u>. This attenuation curve can be used when the equipment under consideration is contained entirely within a partially protected environment, defined as the fuselage of a metallic aircraft or composite aircraft demonstrating equivalent shielding effectiveness. Wire bundles in this environment passing through bulkheads should have shields terminated at the bulkhead connector. Wire bundles should be installed close to the ground plane and take advantage of other inherent shielding characteristics provided by metallic structures. Current-carrying conductors, such as hydraulic tubing, cables, and metal wire trays should be grounded electrically at all bulkheads. This attenuation curve is not appropriate for equipment installations more appropriately described by the definition of CAT V, W, and Y locations.

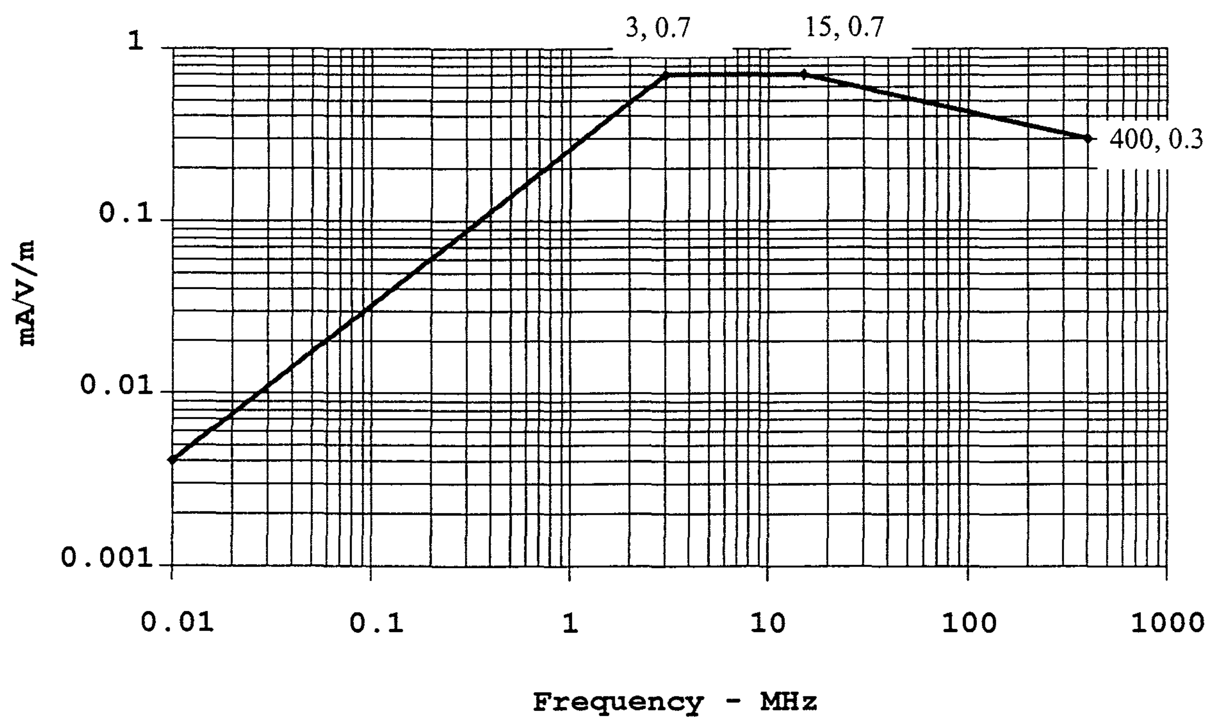
(5) <u>CAT T</u>. This attenuation curve can be used when the equipment under consideration, all interfaces to and from equipment, and the wire bundles are contained entirely within a well-protected environment, defined as an electromagnetically enclosed area. This attenuation curve is not appropriate for equipment installations more appropriately described by the definitions of CAT U, V, W, and Y locations.

c. Different attenuation curves may be appropriate for different frequency ranges. For example, CAT Y may be used for the frequency range of 100 MHz to 400 MHz, Cat W for the frequency range of 400 MHz to 1 GHz, and CAT V for the frequency range of 1 GHz to 18 GHz.

d. Airframe manufacturers can produce their own generic transfer function and attenuation curves based on measurements on their aircraft models and use these in their compliance submission in place of the generic curves specified in this appendix. This would be advantageous because they will provide a more accurate reflection of the true internal environment for their aircraft.

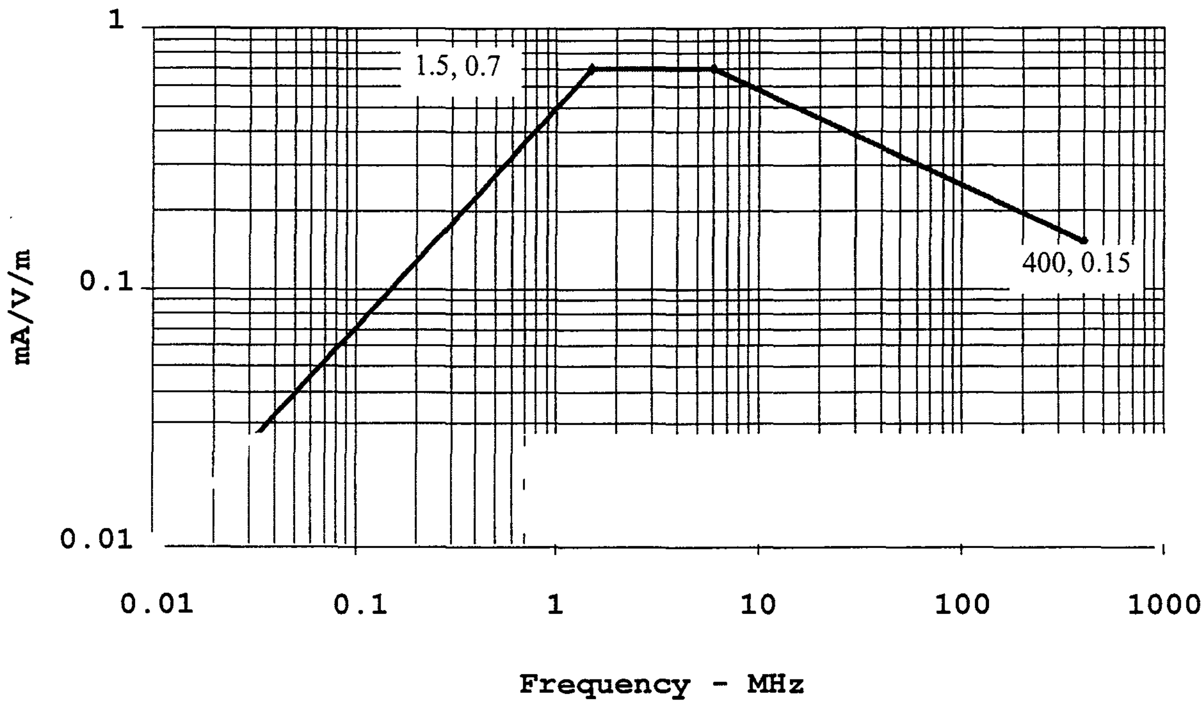
e. The User's Guide should be consulted for details on the use of generic curves.

FIGURE A-1 — Generic Transfer Function - Airplane



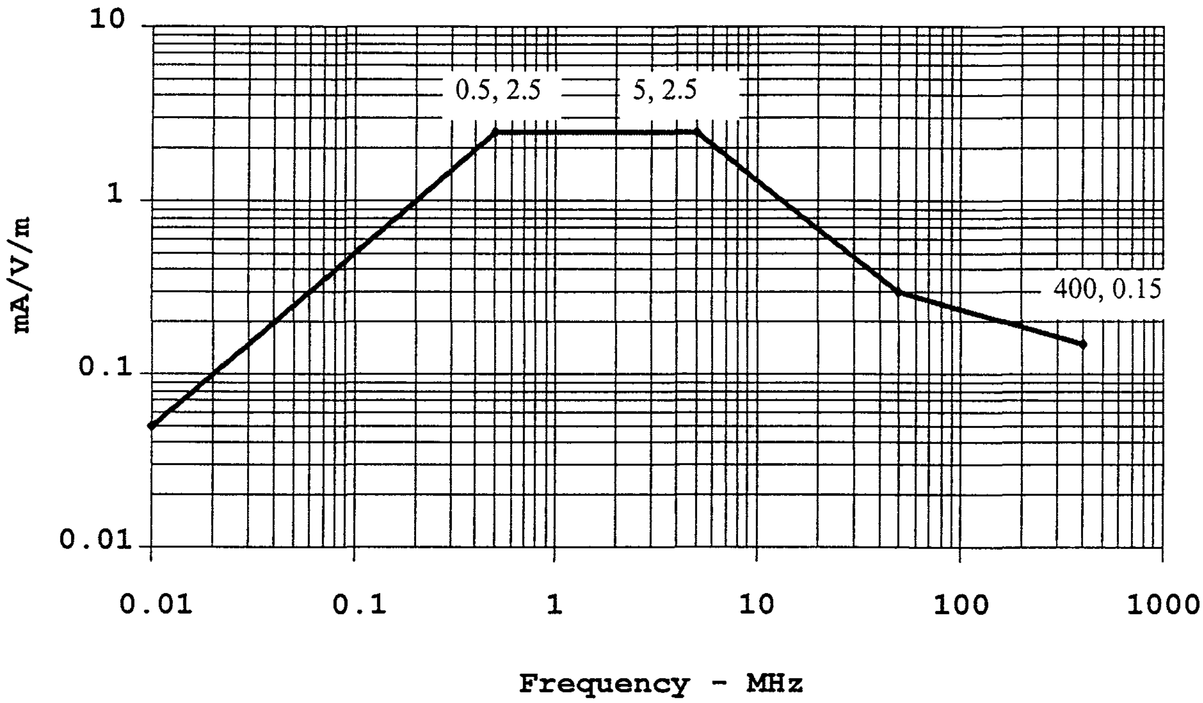
Generic transfer function curve normalized to 1 V/m for an airplane with a fuselage length of <25m.

FIGURE A-2 – Generic Transfer Function - Airplane



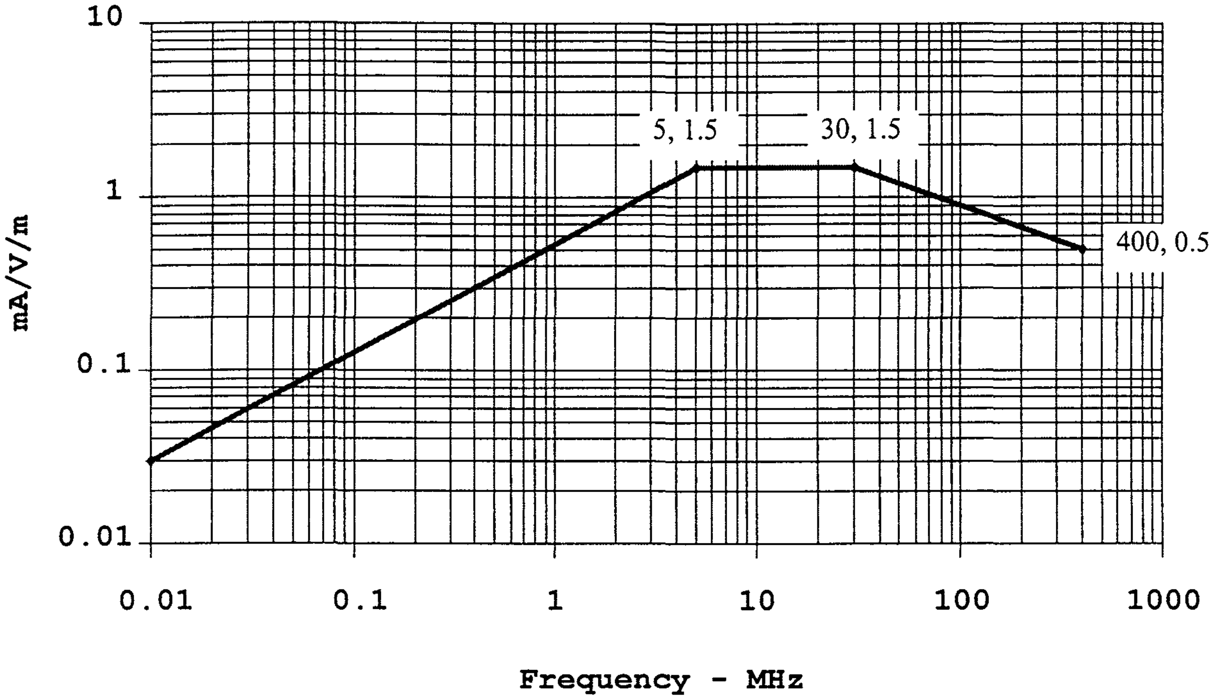
Generic transfer function curve normalized to 1 V/m for an airplane with a fuselage length of >25m and <50m.

FIGURE A-3 — Generic Transfer Function - Airplane



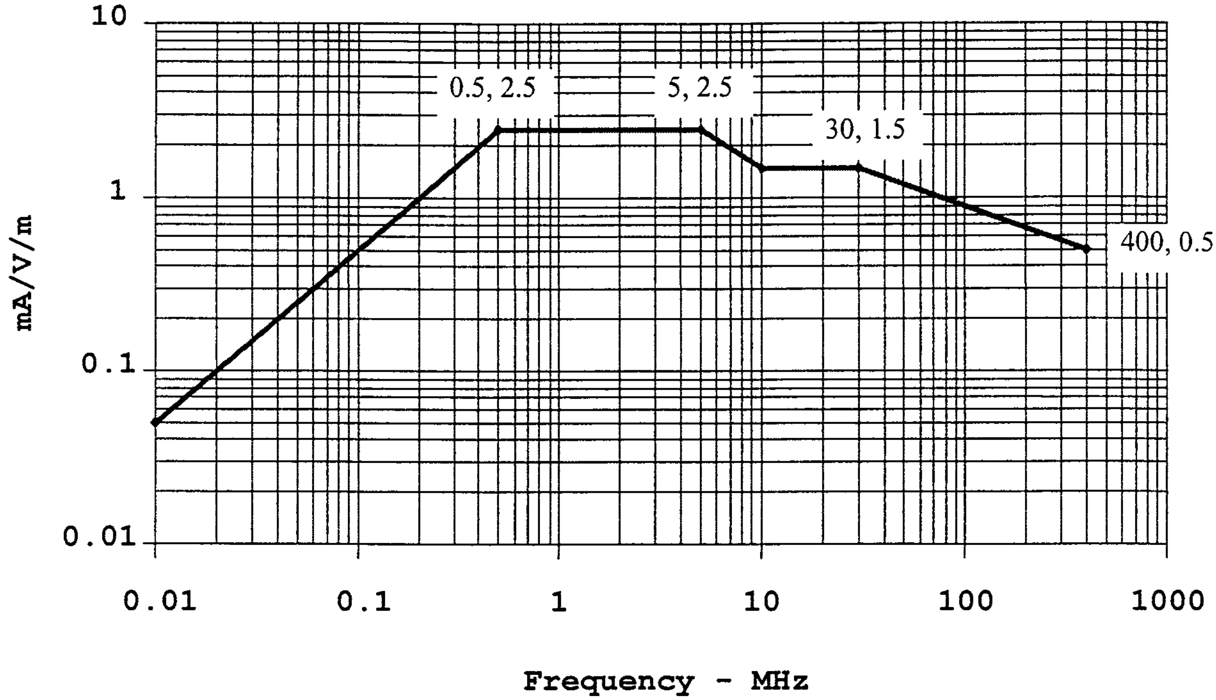
Generic transfer function curve normalized to 1 V/m for an airplane with a fuselage length of >50m.

FIGURE A-4 — Generic Transfer Function - Rotorcraft



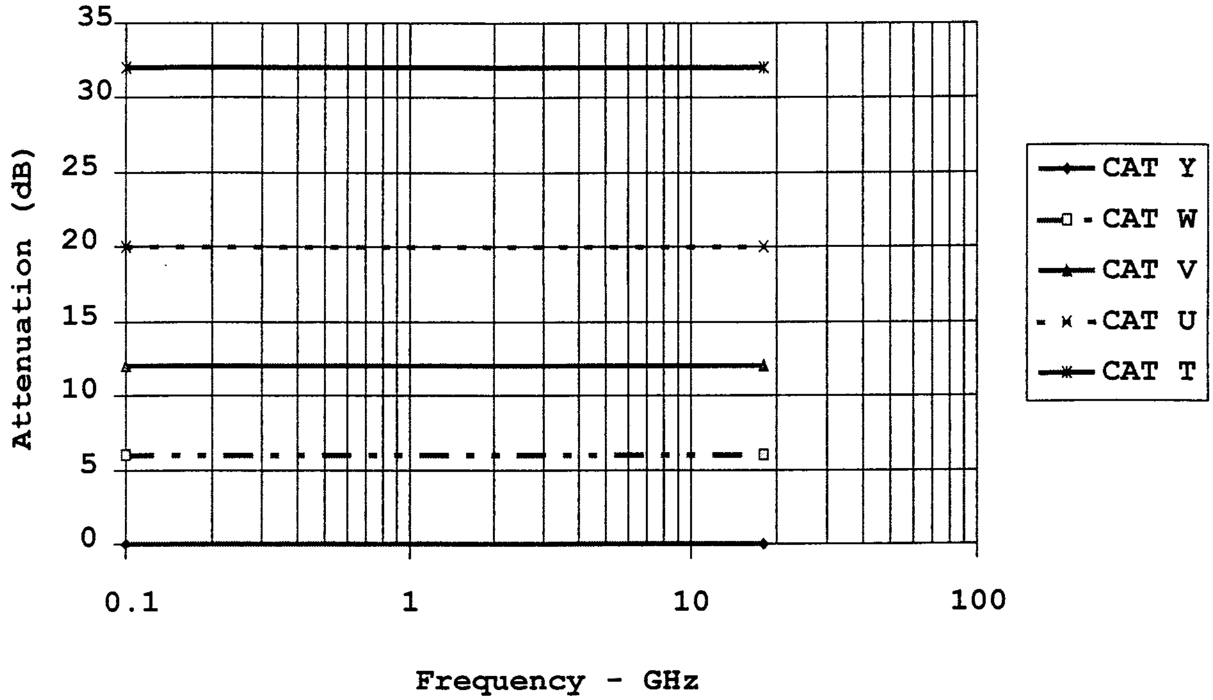
Generic transfer function curve normalized to 1 V/m for a rotorcraft.

FIGURE A-5 — Generic Transfer Function - All Aircraft



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

FIGURE A-6 — GENERIC ATTENUATION CURVES — All Aircraft



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14 CFR Parts 23, 25, 27 and 29

High-Intensity Radiated Fields (HIRF) Protection for Aircraft Electrical and Electronic Systems; Final Rule

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Parts 23, 25, 27, and 29

[Docket No. FAA–2006–23657; Amendment Nos. 23–57, 25–122, 27–42, and 29–49]

RIN 2120–AI06

High-Intensity Radiated Fields (HIRF) Protection for Aircraft Electrical and Electronic Systems

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Final rule.

SUMMARY: This final rule amends FAA regulations by adding airworthiness certification standards to protect aircraft electrical and electronic systems from high-intensity radiated fields (HIRF). This action is necessary due to the vulnerability of aircraft electrical and electronic systems and the increasing use of high-power radio frequency transmitters. This action is intended to create a safer operating environment for civil aviation by protecting aircraft and their systems from the adverse effects of HIRF.

DATES: These amendments become effective September 5, 2007.

FOR FURTHER INFORMATION CONTACT: Richard E. Jennings, Aircraft Certification Service, Aircraft Engineering Division, AIR–130, Federal Aviation Administration, 470 L'Enfant Plaza, Suite 4102, Washington, DC 20024; telephone (202) 385–4562; e-mail *Richard.Jennings@faa.gov.*

SUPPLEMENTARY INFORMATION:

Availability of Rulemaking Documents

You can get an electronic copy of this final rule using the Internet by:

(1) Searching the Department of Transportation's electronic Docket Management System (DMS) Web page (*http://dms.dot.gov/search*);

(2) Visiting the FAA's Regulations and Policies Web page at *http://www.faa.gov/regulations_policies/*; or

(3) Accessing the Government Printing Office's Web page at *http://www.gpoaccess.gov/fr/index.html.*

You can also get a copy by sending a request to the Federal Aviation Administration, Office of Rulemaking, ARM–1, 800 Independence Avenue SW., Washington, DC 20591, or by calling (202) 267–9680. Make sure to identify the amendment number or docket number of this rulemaking.

Small Business Regulatory Enforcement Fairness Act

The Small Business Regulatory Enforcement Fairness Act (SBREFA) of 1996 requires the FAA to comply with small entity requests for information or advice about compliance with statutes and regulations within its jurisdiction. If you are a small entity and you have a question regarding this document, you may contact a local FAA official or the person listed under **FOR FURTHER INFORMATION CONTACT**. You can find out more about SBREFA on the Internet at *http://www.faa.gov/regulations_policies/rulemaking/sbre_act/*.

Authority for This Rulemaking

The FAA's authority to issue rules regarding aviation safety is found in Title 49 of the United States Code. Subtitle I, Section 106 describes the authority of the FAA Administrator. Subtitle VII, Aviation Programs, describes in more detail the scope of the agency's authority. This rulemaking is promulgated under the authority described in Subtitle VII, Part A, Subpart III, Section 44701(a)(1). Under that section, the FAA is charged with prescribing regulations to promote safe flight of civil aircraft in air commerce by prescribing minimum standards in the interest of safety for appliances and for the design, material, construction, quality of work, and performance of aircraft, aircraft engines, and propellers. By prescribing standards to protect aircraft electrical and electronic systems from high-intensity radiated fields, this regulation is within the scope of the Administrator's authority.

I. Background

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 electrical and electronic systems.

Although the HIRF environment did not pose a significant threat to earlier generations of aircraft, in the late 1970s designs for civil aircraft were first proposed 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 involving civil aircraft with flight-critical electrical and electronic systems have also brought attention to the need to protect these critical systems from high-intensity radiated fields.

Further, the need to protect these systems in aircraft has increased substantially in recent years because of—

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

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

(3) 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;

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

(5) The increased severity of the HIRF environment due to an increase in the number and power of RF transmitters; and

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

Recognizing the need to address the vulnerability of aircraft electrical and electronic systems to HIRF, the FAA published a notice of proposed rulemaking (NPRM) on February 1, 2006 (71 FR 5553). The NPRM includes a description of the HIRF-related incidents that provided some of the impetus for this rulemaking. It also includes a description of the collaborative efforts the FAA undertook in developing these rule changes. We encourage interested readers to refer to the NPRM for additional information.

The comment period for the NPRM closed on May 2, 2006. We received thirty comments from twelve commenters. The commenters include two aviation industry associations, two avionics equipment manufacturers, one engine manufacturer, two airplane manufacturers and five individual commenters.

II. Discussion of the Rule

This final rule amends the airworthiness standards for normal, utility, acrobatic, and commuter category airplanes certificated under part 23; transport category airplanes certificated under part 25; normal category rotorcraft certificated under part 27; and transport category rotorcraft certificated under part 29. Under the rule, applicants for certification of aircraft under these parts are required to demonstrate that any 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—

(1) Each function is not adversely affected during and after the time the aircraft is exposed to a specifically

designated HIRF environment (HIRF environment I);

(2) 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, unless this conflicts with other operational or functional requirements of that system; and

(3) Each electrical and electronic system is not adversely affected during and after the aircraft is exposed to a less severe, but more commonly encountered HIRF environment (HIRF environment II).

HIRF environment I sets forth test and analysis levels that are used to demonstrate that an aircraft and its systems meet basic HIRF certification requirements. HIRF environment I represents the range of electromagnetic field strengths that an aircraft could encounter during its operational life. HIRF environment II is an estimate of the electromagnetic field strengths more likely to be encountered in the airspace above an airport or heliport at which routine departure and arrival operations take place.

The rule also contains specific provisions for rotorcraft that differ from those applicable to airplanes. The rule requires rotorcraft to meet additional HIRF certification standards because rotorcraft operating under visual flight rules (VFR) do not have to comply with the same minimum safe altitude restrictions for airplanes specified in § 91.119 and, therefore, may operate closer to RF transmitters. Accordingly, any electrical and electronic system that performs a function required during operation under VFR and whose failure would prevent the continued safe flight and landing of the rotorcraft must be designed and installed so that the function is not adversely affected during and after the time the rotorcraft is exposed to a specified HIRF environment unique to rotorcraft (HIRF environment III).

HIRF environment III presents worst-case estimates of the electromagnetic field strength in the airspace in which VFR rotorcraft operations are permitted. Rotorcraft operating under instrument flight rules (IFR), however, normally have to comply with more restrictive altitude limitations and, therefore, electrical and electronic systems with functions required for IFR operations must not be adversely affected when the rotorcraft is exposed to HIRF environments I and II.

This final rule also establishes equipment HIRF test levels for electrical and electronic systems. It requires each electrical and electronic system that performs a function whose failure would significantly reduce the capability of the aircraft or the ability of the flightcrew to respond to an adverse operating condition to be designed and installed such that it is not affected adversely when the equipment providing the function is exposed to equipment HIRF test level 1 or 2. HIRF test level 1 allows an applicant to use an industry standard test method for compliance. HIRF test level 2 allows an applicant to use equipment test levels developed for the specific aircraft being certificated. Either of these test levels may be used to demonstrate HIRF protection.

Additionally, the final rule requires each electrical and electronic system that performs a function whose failure would reduce (but not significantly) the capability of the aircraft or the ability of the flightcrew to respond to an adverse operating condition to be designed and installed such that it is not affected adversely when the equipment providing these functions is exposed to equipment HIRF test level 3. HIRF test level 3, like HIRF test level 1, allows an applicant to use an industry standard test method for compliance that is not as rigorous as that specified by HIRF test levels 1 or 2. HIRF environments I, II, and III, and equipment HIRF test levels 1, 2, and 3 are found in the appendices to the parts revised by this rule.

The rule also includes provisions that provide relief from the new testing requirements for equipment previously certificated under HIRF special conditions issued in accordance with § 21.16. These provisions permit the installation of an electrical or electronic system that performs a function whose failure would prevent the continued safe flight and landing of the aircraft, if an applicant can show that the system continues to comply with previously issued HIRF special conditions. This relief, however, will only be available for a five-year period and will only apply to equipment certificated under HIRF special conditions issued before December 1, 2007. To obtain this relief an applicant must be able to—

(1) Provide evidence that the system was the subject of HIRF special conditions issued before December 1, 2007;

(2) Show that there have been no system design changes that would invalidate the HIRF immunity characteristics originally demonstrated under the previously issued HIRF special conditions; and

(3) Provide the data used to demonstrate compliance with the HIRF special conditions under which the system was previously approved.

Reference Material

For further information on the development of the HIRF environments, consult the Naval Air Warfare Center Aircraft Division (NAWCAD) Technical Memorandum, Report No. NAWCADPAX–98–156–TM, High-intensity Radiated Field External Environments for Civil Aircraft Operating in the United States of America (Unclassified), dated November 12, 1998. A copy of the NAWCAD Technical Memorandum is available in the docket for this final rule.

Related Activity

When we published the HIRF NPRM on February 1, 2006, we also announced the availability of a draft Advisory Circular (describing a method for applicants to comply with the proposed HIRF standards (71 FR 5570). We have revised the draft AC based on the comments we received. You can get copies of the final AC 20–158, ''The Certification of Aircraft Electrical and Electronic Systems for Operation in the High Intensity Radiated Fields (HIRF) Environment'', from the FAA's Regulatory and Guidance Library (RGL) at the Web site: *http://www.airweb.faa.gov/rgl.* On the RGL Web site, click on ''Advisory Circulars.''

A. Revision of Proposed HIRF Test Levels

1. Deletion of Proposed HIRF Test Level 1

In the NPRM, we proposed to include four specific equipment HIRF test levels for electrical and electronic systems. Each electrical and electronic system that performs a function whose failure would significantly reduce the capability of the aircraft or the ability of the flightcrew to respond to an adverse operating condition was required to be designed and installed so the system is not adversely affected when the equipment providing those functions is exposed to equipment HIRF test levels 1, 2, or 3. Additionally, we proposed that equipment be exposed to HIRF test level 4 for those functions that would cause any reduction in the capability of the aircraft or the ability of the flightcrew to respond to an adverse operating condition.

RTCA, Inc. Special Committee 135, which develops HIRF test procedures for aircraft equipment, recommended deleting one of the proposed equipment HIRF test levels included in the appendices to the proposed regulations. Comments from Boeing, GAMA, and an individual commenter also supported this change.

The commenters noted that proposed § 23.1308(b) would require each electrical and electronic system that performs a function whose failure would significantly reduce the capability of the airplane or the ability of the flightcrew to respond to an adverse operating condition to be designed and installed so the system is not adversely affected when the equipment providing the function is exposed to equipment HIRF test level 1, 2, or 3. Proposed §§ 25.1317(b), 27.1317(b), and 29.1317(b) also contained corresponding provisions.

The commenters noted that the amplitudes and modulations defined in equipment HIRF test levels 1 and 2 were similar, but not identical. HIRF test level 1 specified the use of a pulse modulated waveform with 150 volts per meter (V/m) amplitude and 0.1 percent duty cycle, along with a square wave modulated waveform with 28 V/m amplitude and 50 percent duty cycle, for frequencies from 400 megahertz (MHz) to 8GHz. Test level 2 used a pulse modulated waveform 150 V/m amplitude and 4 percent duty cycle, but no square wave modulated waveform in the same frequency range. The commenters also noted that compliance with proposed § 23.1308(b) and corresponding provisions would be more consistent if only one of the two definitions of test amplitude and modulation were included in the regulations. RTCA, Inc. Special Committee 135 also noted that eliminating one equipment test level would help standardize equipment tests and minimize confusion in selecting the appropriate equipment test level. Both RTCA and an individual commenter recommend that this single test level conform to the proposed requirements in equipment HIRF test level 2.

The FAA agrees with these comments and has eliminated proposed equipment HIRF test level 1 from the appendices to parts 23, 25, 27, and 29. We have renumbered the remaining test levels accordingly in the final rule. Equipment HIRF test levels 2, 3, and 4 in the proposed rule have therefore become test levels 1, 2, and 3, respectively, in the final rule. We have also revised §§ 23.1308(b), 25.1317(b), 27.1317(b), and 29.1317(b) to refer to equipment HIRF test levels 1 and 2. Additionally, we have revised §§ 23.1308(c), 25.1317(c), 27.1317(c), and 29.1317(c) to refer to equipment HIRF test level 3. Equipment HIRF test levels are specified in paragraphs (c), (d), and (e) of Appendix J to Part 23; paragraphs (c), (d), and (e) of Appendix L to Part 25; paragraphs (d), (e), and (f) of Appendix D to Part 27; and paragraphs (d), (e), and (f) of Appendix E to Part 29.

2. Revision of Conducted Current Susceptibility Test Requirements

RTCA, Inc. Special Committee 135 also recommended changes to the conducted current susceptibility test requirements in proposed equipment HIRF test levels 1, 2, and 4. These equipment HIRF test requirements define the amplitude and modulation of radio frequency current that equipment and its wiring must be exposed to in a laboratory to demonstrate that equipment is immune to HIRF.

RTCA, Inc. Special Committee 135 stated that it has worked with the Aviation Rulemaking Advisory Committee (ARAC) Electromagnetic Effects Harmonization Working Group (EEHWG) to define equipment HIRF test requirements. The Special Committee stated that the changes it proposes would modify conducted radio frequency current amplitude to make the conducted radio frequency current decrease linearly with frequency so that the radio frequency current at 400 MHz would be one tenth the current at 30 MHz. The Special Committee asserted that this change would make the test levels more consistent with values measured on aircraft. HIRF tests on aircraft show that the conducted radio frequency current decreases above a certain frequency, and that this frequency depends on the size of the aircraft.

The FAA generally agrees with RTCA's comment, however, data used to develop the HIRF AC shows the current decreases logarithmically with frequency. Therefore, the FAA has changed the conducted current amplitude in proposed equipment HIRF test levels 2 and 4 (test levels 1 and 3 in the final rule) so that the conducted current decreases at 20 decibel (dB) per frequency decade starting at 40 MHz and continuing to 400 MHz. This change results in a current at 400 MHz that is one tenth the current at 40 MHz and simplifies the procedures necessary to show compliance with equipment HIRF test levels. Since the FAA is not adopting proposed HIRF test level 1 (as discussed earlier in this preamble), no additional changes have been made to the final rule in response to this comment.

B. Effect of the Rule on Systems That Have Demonstrated Compliance With Previously Issued HIRF Special Conditions

In the NPRM, the FAA proposed that the HIRF certification requirements would apply to all electrical and electronic systems designed and installed in an aircraft for which the new rules constitute part of its certification basis. In their comments, the General Aviation Manufacturers Association (GAMA) and Rockwell Collins expressed general support for the rule yet stated that a number of systems have been installed on aircraft that have demonstrated compliance with HIRF special conditions issued pursuant to § 21.16. The commenters assert that when application is made for certification of equipment in an aircraft and that same equipment has already been found to be in compliance with HIRF special conditions issued for another aircraft, the test requirements set forth in the proposal would impose significant costs with little additional safety benefit. Another commenter, Meggitt/S–TEC, expressed similar concerns.

The commenters recommend that systems previously installed on an aircraft should be considered compliant with the HIRF protection requirements of the rule if those systems have been found to meet existing HIRF special conditions when installed on another aircraft.

The FAA agrees that there are a number of systems installed under HIRF special conditions that have a proven service history and that compliance with the rule, as originally proposed, would require additional testing and costs. In an effort to address this concern, the FAA has revised the rule to permit the installation of an electrical or electronic system that performs a function whose failure would prevent the continued safe flight and landing of the aircraft, if it can be shown that the system to be installed continues to comply with HIRF special conditions issued before December 1, 2007. This relief is contained in paragraph (d) of each section of the rule and is limited to a five-year period.

To utilize this relief from the general requirements of the rule, an applicant must: (1) Provide evidence that the system was the subject of previously issued HIRF special conditions; (2) show that there have been no system design changes that would invalidate the HIRF immunity characteristics originally demonstrated under the previously issued HIRF special conditions; and (3) provide the data used to demonstrate compliance with the HIRF special conditions under which the system was previously approved.

Upon issuance of this rule, the FAA does not foresee the need to issue special conditions, like those previously issued for HIRF, to include special conditions permitting equipment evaluations in a laboratory environment using test levels of 100 V/m (200 V/m for VFR rotorcraft). Therefore, if an installation cannot meet the requirements of paragraph (d), the installation will need to comply with the HIRF certification requirements specified in paragraph (a).

Paragraph (d)(1) requires an applicant to provide objective evidence that the system was the subject of HIRF special conditions that were issued before December 1, 2007. In meeting subparagraph (d)(1), it is not essential that the HIRF special conditions be issued for the same make and model of aircraft, but only that they were used as the basis for showing HIRF compliance for the electrical or electronic system intended for the specific installation. After the rule becomes effective, the FAA generally will no longer use special conditions as a means for an applicant to show protection from the HIRF environment for new equipment installation certifications. The date specified in paragraph (d)(1), however, provides a sufficient time period beyond the effective date of the rule to allow applicants to use HIRF special conditions that are currently being developed as part of a new installation's certification basis to be processed and issued.

Paragraph (d)(2) requires the applicant to show that there have been no system design changes that would invalidate the HIRF immunity characteristics originally demonstrated under previously issued HIRF special conditions. If a change has been made to the system, and the change cannot be substantiated through analysis as having no impact on the previously demonstrated HIRF immunity characteristics, the system must comply with the general requirements of the rule as specified in paragraph (a) of each section.

Paragraph (d)(3) requires the applicant to provide the data used to demonstrate compliance with HIRF special conditions. The term ''data'' includes, but is not limited to, items such as the HIRF certification/ qualification test report used to demonstrate compliance; installation instructions, as appropriate, to support HIRF immunity of the system; and instructions for continued airworthiness (ICA) to maintain the integrity of the system's demonstrated HIRF immunity. To assist prospective applicants, Appendix 2 of AC 20–158 provides guidance on one means, but not the only means, of complying with these provisions.

Although these revisions will affect aircraft intended for certification under parts 23, 25, 27 and 29, the FAA believes that the changes will primarily afford relief to persons installing equipment in aircraft intended for certification under part 23. The FAA estimates that as many as 30–35% of the applicants that apply for installation of a Level A system in aircraft certificated under part 23 will be seeking approval of equipment that has been shown to comply with previously issued HIRF special conditions (a Level A system is a system that performs a function whose failure would prevent the continued safe flight and landing of an aircraft, such as a flight display system certificated for IFR operations or a full authority digital engine control (FADEC) system). Such systems have been shown to meet appropriate certification standards and, based on comments received, the FAA believes that the burden associated with re-testing this equipment to the new certification standards is not justified by a corresponding benefit.

In determining the extent of the relief that could be provided, the FAA sought clarification of GAMA's earlier comment. GAMA noted that if the FAA were to accept its comment to consider equipment previously certified under HIRF special conditions as compliant with the proposed HIRF requirements, it may not be feasible for the FAA to make such a provision open-ended. GAMA stated that if the FAA were to establish a specific time period during which such equipment would be considered compliant, that determination should give full consideration to the technological life of the product. The FAA concurs with this recommendation. We have therefore provided applicants with a five-year period during which equipment shown to comply with previously issued HIRF special conditions will be considered to meet the requirements of this rule. This decision was based on a number of factors.

Due to the dynamic and highly competitive nature of the current avionics industry, new avionics models are being rapidly introduced into the marketplace in response to public demand. As special conditions for HIRF generally will no longer be issued after the effective date of the rule, it will become increasingly difficult to find new equipment in compliance with previously issued HIRF special conditions. Equipment manufacturers will therefore not be able to take advantage of the provisions of new paragraph (d), and the equipment will have to meet the general requirements of the rule. The FAA also believes that major design changes will, in most cases, necessitate retesting of previously approved equipment in accordance with the general provisions of the rule, again significantly decreasing the number of systems that will be able to use the provisions of paragraph (d) within a short period of time.

Additionally, avionics manufacturers now compete in a global marketplace. Many foreign civil aviation authorities are adopting airworthiness standards similar to those found in paragraphs (a), (b), and (c) of each section added by the rule, but are not adopting airworthiness standards which contain provisions similar to those contained in paragraph (d) of those sections. Manufacturers intending to market their equipment for installation on aircraft registered in countries other than the United States will therefore need to ensure compliance with the general provisions of the rule to export their products.

Technological advances and the necessity for manufacturers to comply with standards established by foreign aviation authorities to globally market their products will require that newer systems comply with the general test standards established by the final rule. The FAA therefore believes that the relief permitted by the revision, while of immediate benefit to manufactures, will neither be practical nor warranted within five years after the effective date of the rule, and has limited the relief to that period accordingly.

C. Applicability of HIRF Requirements

1. Applicability of HIRF Requirements to Aircraft Certificated Under Part 23

Thielert Aircraft engines commented on the HIRF Risk Analysis report used in the regulatory evaluation (DOT/FAA/AR–99/50). This risk analysis forms the basis of the benefits analysis in the FAA's regulatory evaluation. According to Thielert, a comparison of estimated HIRF risks for transport category airplanes (table 9 of the report) with estimated HIRF risks for non-transport category aircraft, including Part 23 small airplanes (table 10 of the report), shows that HIRF risks are higher for transport category airplanes. Thielert therefore believes the proposed HIRF protection requirements for small airplanes should not be the same as those proposed for transport category airplanes. Additionally, Thielert believes that table 10 of the report indicates the proposal provides a decreased level of safety for airplanes certificated under Part 23.

The FAA does not agree with Thielert's contentions. The HIRF Risk Analysis report shows that the HIRF requirements provide a substantial HIRF risk reduction for both transport category airplanes and non-transport category aircraft, including small airplanes certificated under Part 23, even when compared to existing HIRF special conditions (page 13 of the report).

The FAA agrees, however, that both tables 9 and 10 of the report could be misconstrued. With regard to the data used to evaluate the HIRF risk to transport category airplanes, a crucial component affecting the risk analysis is the aircraft's position with respect to an emitter's location. HIRF protection requirements are predicated on various minimum (i.e., safe) distances between aircraft and emitters. Inconsistencies in the values for transport category aircraft in table 9 noted by Thielert can be attributed to inaccuracies in recording aircraft position data due to the normal variability inherent in radar tracking. When the minimum distance assumptions on which the rule is based are taken into account, only a few flights in the analysis were exposed to field strengths that exceeded the rule's certification levels. As these discrepancies are likely the result of the normal variability inherent in determining an aircraft's position using radar, there was no evidence that HIRF certification levels were exceeded for flights involving transport category aircraft (in the Denver and Seattle study areas).

The same positional inaccuracies are also the probable cause of the inconsistent results in table 10 of the analysis that were noted by the commenter. To account for this possible error, the FAA's benefits analysis was conducted using data from table 11 of the report to obtain the number of flights that exceeded the various protection (or comparison) levels. Similar to the results of the analysis for transport category aircraft, the risk analysis for part 23 aircraft shows that the HIRF requirements provide a substantial risk reduction compared to existing HIRF special conditions. The FAA's risk-avoidance analysis for part 23 airplanes does, however, differ from that for part 25 airplanes in that it combines information from an actual HIRF incident with the theoretical analysis of the Risk Analysis study. That incident was the basis of the finding in the benefits analysis of greater risk for part 23 airplanes.

The report also includes a detailed discussion of how to interpret the information presented in tables 9 and 10. It clearly states that the proposed HIRF requirements reduce the risk of HIRF-related accidents by a factor of 3.5 compared to the existing HIRF special conditions for non-transport category airplanes, which include small airplanes certificated under Part 23 (page 16). Thus, the report supports the benefits of the rule for non-transport category aircraft, which includes small airplanes certificated under Part 23.

2. Applicability of the Requirements to Airplane-Level Functions

Boeing Commercial Airplanes requested a change to proposed § 25.1317(a)(1). The proposed section stated ''Each electrical and electronic system that performs a function whose failure would prevent the continued safe flight and landing of the airplane must be designed and installed so that *the function* is not adversely affected during and after the time the airplane is exposed to HIRF environment I . * * *'' (Emphasis added). In the commenter's view, the phrase ''the function'' should be changed to ''the airplane-level function'' since only top-level functions may be observable in multi-system integrated avionics configurations where several systems can contribute to correct operation of an airplane-level function.

The FAA disagrees with the comment. The wording of proposed § 25.1317(a)(1) is consistent with the wording of existing § 25.1316, which governs system lightning protection. The FAA has taken a similar approach in addressing protection from lightning and HIRF as both constitute external environmental hazards to an aircraft. A failure of a system as a result of lightning or HIRF would have an identical effect on the operation of the aircraft, and the FAA believes that their failure effects should therefore be treated similarly. For this reason, we did not make the requested change to the final rule.

3. Limiting § 25.1317(a)(2) and Corresponding Requirements to Functions, Rather Than Systems Whose Failure Would Prevent Safe Flight and Landing of the Aircraft

Boeing Commercial Airplanes requested clarification of proposed § 25.1317(a)(2) which states ''Each electrical and electronic system that performs a function whose failure would prevent the continued safe flight and landing of the airplane must be designed and installed so that *the system* automatically recovers normal operation, in a timely manner, after the airplane is exposed to HIRF environment I * * *.'' (Emphasis added). The commenter requested clarification that the expectation of automatic recovery of an electrical or electronic system is limited to functions whose failure would prevent safe flight and landing. Other functions may not be required to return to ''normal operation,'' which is interpreted to mean the ability to perform functions to the extent necessary to continue safe flight and landing, not necessarily full functional performance and redundancy.

The FAA agrees with Boeing. The requested change clarifies the rule's intent that an automatic recovery of an electrical or electronic system be limited to those functions whose failure would prevent safe flight and landing. We have therefore changed the wording of final § 25.1317(a)(2) to state that ''The system automatically recovers normal operations *of that function,* in a timely manner. * * *'' (Emphasis added). We have also made corresponding changes to final §§ 23.1308(a)(2), 27.1317(a)(2), and 29.1317(a)(2).

4. Expanding the Scope of the HIRF Protection Requirements to Equipment Whose Failure Does Not Have Safety Consequences

An individual commenter recommended that equipment required by FAA certification or operating regulations should be subject to this rulemaking even though failure of that equipment would not have safety consequences.

The FAA does not agree with the commenter. The FAA's general approach to system safety is to define requirements based on the hazard consequences of system failures. This rulemaking follows the FAA's longstanding system safety approach to aircraft design and defines requirements based on their impact on overall aircraft safety. For example, this approach is followed in 14 CFR 25.1309, which provides general aircraft equipment, systems, and installation safety requirements. The EEHWG, which developed the recommendations upon which the NPRM is based, specifically recommended that the rule apply only to systems with failure classifications that are major, hazardous, or catastrophic. The FAA notes that this final rule does not preclude any aircraft or avionics manufacturer or supplier from testing equipment not subject to the rule for susceptibility to HIRF effects using the standards contained in the rule.

D. Continued Airworthiness Requirements

One individual commenter expressed general support for the NPRM, but was concerned that the cost of maintaining aircraft airworthiness after aircraft delivery should be considered in the regulatory evaluation for the rulemaking.

The FAA agrees with the commenter. The regulatory evaluation includes costs for both designing and installing HIRF protection, as well as costs for maintaining this protection over the service life of the aircraft. The EEHWG collected this cost data from aircraft and avionics manufacturers and provided this information to the FAA for inclusion in the regulatory evaluation. We believe the commenter's concerns have been addressed in the rulemaking process.

E. Concerns Regarding the Ability of the HIRF Certification Standards To Afford Adequate Protection of Aircraft

An individual commenter expressed general support for the proposal, but had a concern about ''a flight that went down off Long Island a few years back.'' The commenter questioned whether the proposed standards will sufficiently protect aircraft. Two commenters urged the FAA to include standards in this final rule to protect aircraft from an electromagnetic pulse (EMP) generated by a nuclear weapon or some other EMP-based disabling device.

We believe the first commenter is referring to the crash of TWA Flight 800, which broke up in flight off Long Island, New York on July 17, 1996. The investigation of the accident was conducted by the National Transportation Safety Board (NTSB). The NTSB in its Aircraft Accident Report (NTSB/AAR–00/03) did not find that the probable cause of the accident was related to HIRF effects. As discussed in the notice, the FAA has worked extensively with aircraft and equipment manufacturers, foreign civil aviation authorities and engineers who have an extensive knowledge of the HIRF environment in its efforts to develop the protection regulations for the HIRF environment found in this rule. This rule is based to a significant degree upon their detailed recommendations and for these reasons, the FAA believes that the commenter's concern is not warranted.

In response to concerns regarding EMP protection, the FAA notes that the EEHWG participants who assisted the agency in developing the HIRF NPRM were familiar with issues related to EMP. The aircraft protection requirements for lightning and HIRF provide some inherent protection from EMP. However, EMP generated from a nuclear or other device is not part of the normal HIRF environment. The FAA considers protection of aircraft from the hazards of EMP generated by such devices to be beyond the scope of this rulemaking effort.

F. Use of Similar HIRF Protection Requirements for Systems With Major and Hazardous Failure Conditions

An individual commenter recommends that the HIRF requirements for systems with major failure conditions should meet the same equipment HIRF test levels as systems with hazardous failure conditions. The commenter believes that this is the general practice of most aircraft manufacturers and that such a requirement would provide additional protection against the effects of portable electronic devices (PEDs) that may transmit during flight. These PEDs include mobile phones and two-way pagers.

The FAA agrees, in part, with the commenter. Radiated emissions from PEDs on aircraft are a growing concern, and FAA has requested RTCA, Inc., through Special Committee 202 to investigate PED emissions (both intentional and unintentional emitters) and their possible impact on required aircraft electronic systems. However, the hazards related to radiated fields generated by PEDs are not considered part of the external HIRF environment encountered by an aircraft, and consideration of their effects is therefore beyond the scope of this rulemaking. Such effects would have to be addressed by a separate rulemaking activity when Special Committee 202 completes its assigned task. In addition, the FAA has reviewed certification plans that indicate many manufacturers do not require systems with major failure conditions to meet the same equipment HIRF test levels as systems with hazardous failure conditions. Therefore, we have not made any changes to this final rule based on the comment.

G. Harmonization of HIRF Certification Standards

Thielert Aircraft Engines commented that the European Aviation Safety Agency (EASA) classified the consequence of a failure of their reciprocating engine as major or hazardous, while the FAA has required HIRF tests that assume the engine failures are catastrophic. Thielert commented that this decision has not fulfilled the intent to harmonize HIRF standards because the FAA requires more expensive HIRF tests on Thielert's FADEC systems than EASA does. Thielert states that the FAA HIRF compliance requirements are more expensive to comply with because the engine and engine electronic controls must be tested when they are installed on an airplane rather than prior to any installation. Based on these concerns, Thielert proposed changes to § 23.1308(a) that would eliminate the need for the more expensive airplane tests.

The FAA does not agree with the changes proposed by Thielert. The HIRF regulations neither define the specific failure classification for particular aircraft systems nor establish requirements used to classify any particular system. The failure classification must be established by the certification applicant and agreed on by the FAA for the specific aircraft and system being certified. Once a specific failure classification has been established, the HIRF regulations set forth in the final rule only specify those requirements that must be met for that specific failure classification. In fact, EASA currently issues HIRF Certification Review Items (CRI) (equivalent to the FAA's special conditions) that use the same approach as that generally set forth in the rule. The example provided by Thielert is not a consequence of the proposed HIRF regulations, but rather a difference in classification of failure severity.

Additionally, this final rule, with the exception of the provisions contained in paragraph (d) of each section, is consistent with current EASA practices. The FAA, however, does recognize that for an aircraft to be exported it may not be acceptable to a foreign authority if a system installed on the aircraft has been certificated in accordance with the provisions of paragraph (d) of each section of the final rule.

H. Addition of Explanatory Note to HIRF Environment Tables

A note was added to each HIRF Environment table in the appendices to this rule. The note states that, ''In this table, the higher field strength applies at the frequency band edges.'' Although not included in the proposal, this note was included in the draft AC that was the subject of a Notice of Availability published in the **Federal Register** (71 FR 5570) on February 1, 2006 concurrent with the notice for this rule. During the public comment period of the draft AC, we received no comments with regard to this note. The note was added to standardize testing and to remove any ambiguity when applying field strength values at frequency band edges.

III. Regulatory Notices and Analyses

Paperwork Reduction Act

The Paperwork Reduction Act of 1995 (44 U.S.C. 3507(d)) requires that the

FAA consider the impact of paperwork and other information collection burdens imposed on the public. An agency may not collect or sponsor the collection of information, nor may it impose an information collection requirement unless it displays a currently valid Office of Management and Budget (OMB) control number. We have determined that there are no new information collection requirements associated with this amendment.

International Compatibility

In keeping with U.S. obligations under the Convention on International Civil Aviation, it is FAA policy to comply with International Civil Aviation Organization (ICAO) Standards and Recommended Practices to the maximum extent practicable. The FAA has determined that there are no ICAO Standards and Recommended Practices that correspond to these regulations.

Economic Evaluation, Regulatory Flexibility Determination, International Trade Impact Assessment, and Unfunded Mandates Assessment

Changes to Federal regulations must undergo several economic analyses. First, Executive Order 12866 directs that each Federal agency shall propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs. Second, the Regulatory Flexibility Act of 1980 (Pub. L. 96–354) requires agencies to analyze the economic impact of regulatory changes on small entities. Third, the Trade Agreements Act (Pub. L. 96–39) prohibits agencies from setting standards that create unnecessary obstacles to the foreign commerce of the United States. In developing U.S. standards, this Trade Act requires agencies to consider international standards and, where appropriate, that they be the basis of U.S. standards. Fourth, the Unfunded Mandates Reform Act of 1995 (Pub. L. 104–4) requires agencies to prepare a written assessment of the costs, benefits, and other effects of proposed or final rules that include a Federal mandate likely to result in the expenditure by State, local, or tribal governments, in the aggregate, or by the private sector, of $100 million or more annually (adjusted for inflation with base year of 1995). This portion of the preamble summarizes the FAA's analysis of the economic impacts of this final rule. We suggest readers seeking greater detail read the full regulatory evaluation, a copy of which we have placed in the docket for this rulemaking.

In conducting these analyses, FAA has determined that this final rule: (1) Has benefits that justify its costs; (2) is not an economically ''significant regulatory action'' as defined in section 3(f) of Executive Order 12866; (3) is not ''significant'' as defined in DOT's Regulatory Policies and Procedures; (4) will not have a significant economic impact on a substantial number of small entities; (5) will not create unnecessary obstacles to the foreign commerce of the United States; and (6) will not impose an unfunded mandate on state, local, or tribal governments, or on the private sector by exceeding the threshold identified above. These analyses are summarized below.

Who Is Affected by This Rulemaking

Manufacturers of transport category airplanes will incur no incremental costs; manufacturers of transport category rotorcraft and non-transport category aircraft will incur varying costs.

Occupants in, and operators of, affected aircraft receive safety benefits.

Assumptions and Standard Values

- *Discount rate:* 7%.
- *Period of analysis:* Costs are based on a 10-year production period and benefits are based on 25-year operating lives of newly-certificated aircraft.
- *Value of statistical fatality avoided:* $3 million.
- *Benefits/costs are evaluated from two perspectives:* (1) The 'base case'—a comparison of the costs and benefits concomitant with current industry practice to those associated with meeting the rule's requirements, and (2) the 'regulatory case'—a comparison of the costs and benefits of complying with current U.S. special conditions to those associated with meeting the rule. Current industry practice for manufacturers of all airplanes certificated under part 25, for manufacturers of the majority of aircraft certificated under parts 23 and 29, and for manufacturers of a sizeable minority of part 27 rotorcraft, is to comply with the European Aviation Safety Agency's (i.e., EASA's, as noted earlier in this preamble) HIRF interim policy, which, with the exception of the provisions of paragraph (d) of each section, is equivalent to the rule. On the other hand, manufacturers of the remaining aircraft (some aircraft certificated under parts 23 and 29 and most rotorcraft certificated under part 27) currently manufacture their aircraft to meet U.S. special conditions, which are not as stringent as the provisions in this final rule. These affected aircraft manufacturers will experience additional costs under the rule.
- The rule is assumed to be nearly 100 percent effective in preventing HIRF-related accidents.

Alternatives Considered

Although earlier and current special condition levels of HIRF protection were considered, EASA's HIRF interim policy (formerly Joint Aviation Authorities (JAA) policy) was selected for this rule because of both the proven high levels of protection demonstrated and the potential cost savings associated with adoption of substantially harmonized U.S. and European HIRF-requirements.

Costs and Benefits of the Rule

Costs

ESTIMATED PRESENT VALUE COSTS

[$millions over a 10-year period]

	Current practice to rule	Special conditions to rule
Part 23 certificated airplanes	$21.8	$72.8
Part 25 certificated airplanes	0	308.1
Part 27 certificated rotorcraft	1.5	2.0
Part 29 certificated rotorcraft	5.3	26.6
Total estimated costs	28.6	409.5

In the first column (or, the base case, which reflects actual costs to industry), there are no additional HIRF-protection costs for manufacturers of airplanes certificated under part 25 and for manufacturers of the majority of aircraft certificated under parts 23 and 29, since most U.S. large manufacturers have produced these aircraft to comply with current EASA HIRF interim policy standards (generally equivalent to the requirements in this final rule) to market their aircraft in Europe. There are moderate incremental costs for manufacturers of the remaining portion of aircraft certificated under parts 23 and 29 and relatively lower costs for the majority of rotorcraft certificated under part 27 that do not currently meet EASA's HIRF interim policy standards either because (1) their aircraft do not yet have complex electronic systems installed or (2) they have chosen not to market their aircraft outside the United States. This ''current practice to rule'' is the base perspective in this analysis. The total estimated ten-year costs of $28.6 million (the sum of column one) represent the true incremental impact on the industry.

However, most manufacturers of aircraft certificated under parts 23, 25, 27, and 29 believe that U.S. special conditions afford sufficient protection from HIRF. Therefore, in the second column (or, the regulatory case, ''special conditions to rule''), the FAA shows the incremental compliance costs between the current U.S. special conditions (essentially equivalent to industry's self-determined protection) and the rule's more stringent requirements. These regulatory costs equal $409.5 million, and represent the costs for more robust HIRF protection that industry would not have voluntarily incurred.

Benefits

Estimated benefits of this rule are the accidents, incidents, and fatalities avoided as a result of increased protection from HIRF-effects provided to electrical and electronic systems. Quantified benefits are partly based on a study titled ''High-Intensity Radiated Fields (HIRF) Risk Analysis,'' by EMA Electro Magnetic Applications, Inc. of Denver, CO. (DOT/FAA/AR–99/50, July 1999). The complete study is available in the docket for this rulemaking. Using the study's risk analysis results for airplanes certificated under parts 23 and 25 and FAA accident/incident data for rotorcraft certificated under parts 27 and 29, the FAA calculated the difference between the expected number of accidents under the new standards versus those expected under current U.S. special conditions.

ESTIMATED PRESENT VALUE BENEFITS

[$millions over a 34-year period]

	Current practice to rule	Special conditions to rule
Part 23 certificated airplanes	$37.1	$123.5
Part 25 certificated airplanes	0	3,683.9
Part 27 certificated rotorcraft	33.3	44.4
Part 29 certificated rotorcraft	17.7	88.6
Total estimated benefits	88.1	3,940.4

Following FAA's rationale as stated in the cost section earlier, column one (the base case) in the benefits table above shows incremental benefits of $88.1 million resulting from averted accidents in future compliant parts 23, 27, and 29 aircraft. Part 25 airplanes already meet similar EASA standards, hence no additional benefits attributable to part 25 airplanes accrue to society. Column two in the table presents the regulatory case; it shows the additional benefits associated with going from industry's self-determined protection standards (or current special conditions) to the new HIRF standards. Total regulatory incremental benefits equal $3,940.4 million and represent the value of avoiding the following numbers of accidents over the 34-year analysis period:

(1) Part 23 airplanes, 24 accidents; (2) part 25 airplanes, 22 accidents; (3) part 27 rotorcraft, 41 accidents, and (4) part 29 rotorcraft, 14 accidents. The FAA believes that, based on the aforementioned risk assessment, the predicted accidents could occur absent the new HIRF standards in this rule if manufacturers of all airplanes certificated under part 25, manufacturers of the majority of aircraft certificated under parts 23 and 29, and manufacturers of a sizeable minority of part 27 rotorcraft, choose in the future not to market their aircraft abroad and therefore no longer meet EASA's enhanced HIRF requirements (but rather meet only current less stringent U.S. special conditions).

Comments to the Docket on Costs and Benefits

Although there were no comments directly criticizing FAA's cost estimates, GAMA, Rockwell Collins, and Meggitt/S–TEC were concerned that companies which previously installed electrical systems in aircraft pursuant to HIRF special conditions could experience significant additional testing costs, with little additional safety benefit, if those systems required re-certification before installation on other aircraft. A comment from Thielert questioned the efficacy of the risk analysis, which is the basis of the benefits analysis in FAA's regulatory evaluation. Thielert believes the HIRF requirements for small airplanes certificated under part 23 should not be the same as those for transport category airplanes certificated under part 25. The FAA's detailed response to these comments is discussed earlier in this preamble and in the full regulatory evaluation (available in the docket to this rulemaking). Although the FAA has revised the final rule in response to the comments, the benefit and cost estimates remain the same.

Summary of Costs and Benefits (at Present Value)

For a ten-year period, the incremental costs of meeting the new requirements versus current industry practice equal $28.6 million and the associated benefits are $88.1 million, for a benefit-to-cost ratio of 3.1 to 1. Alternatively, the incremental costs of meeting the new requirements versus current U.S. special conditions equal $409.5 million and the benefits are $3,940.4 million, for a benefit-to-cost ratio of 9.6 to 1. From either perspective, this rule is clearly cost-beneficial.

Regulatory Flexibility Determination

The Regulatory Flexibility Act of 1980 (Pub. L. 96–354) (RFA) establishes ''as a principle of regulatory issuance that agencies shall endeavor, consistent with the objective of the rule and of applicable statutes, to fit regulatory and informational requirements to the scale of the businesses, organizations, and governmental jurisdictions subject to regulation. To achieve this principle, agencies are required to solicit and consider flexible regulatory proposals and to explain the rationale for their actions to assure that such proposals are given serious consideration.'' The RFA covers a wide range of small entities, including small businesses, not-for-profit organizations and small governmental jurisdictions.

Agencies must perform a review to determine whether a rulemaking action will have a significant economic impact on a substantial number of small entities. If an agency determines that it will, the agency must prepare a regulatory flexibility analysis as described in the RFA. However, if an agency determines that a proposed or final rule is not expected to have a significant economic impact on a substantial number of small entities, section 605(b) of the RFA provides that the head of the agency may so certify and a regulatory flexibility analysis is not required. The certification must include a statement providing the factual basis for this determination, and the reasoning should be clear.

The FAA believes that this final rule will not have a significant economic impact on a substantial number of small entities for the following reasons:

As noted in the regulatory evaluation and preamble to the NPRM, this rule will affect manufacturers of aircraft intended for certification under parts 23, 25, 27, and 29. For manufacturers, the RFA considers a small entity to be one with 1,500 or fewer employees. None of the part 25 or part 29 manufacturers has 1,500 or fewer employees; consequently, none is considered a small entity. There are, however, currently about four part 27 (utility rotorcraft) and ten part 23 (small non-transport category airplanes) manufacturers, who have fewer than 1,500 employees and are considered small entities.

Based on a sampling of the affected small manufacturers of parts 23 and 27 aircraft, the incremental costs are expected to represent significantly less than one percent of the typical small manufacturer's annual revenues; these compliance costs do not constitute a significant economic impact. There were no comments to the docket disputing this finding.

Therefore, as the FAA Administrator, I certify that this rule will not have a significant economic impact on a substantial number of small entities.

International Trade Impact Assessment

The Trade Agreements Act of 1979 prohibits Federal agencies from engaging in any standards or related activities that create unnecessary obstacles to the foreign commerce of the United States. Legitimate domestic objectives, such as safety, are not considered unnecessary obstacles. The statute also requires consideration of international standards and where appropriate, that they be the basis for U.S. standards. The FAA has assessed the potential effect of this final rule and determined that it is in accord with the Trade Agreements Act in that it uses European standards as the basis for United States regulation.

Unfunded Mandates Reform Act

Title II of the Unfunded Mandates Reform Act of 1995 (Pub. L. 104–4) requires each Federal agency to prepare a written statement assessing the effects of any Federal mandate in a proposed or final agency rule that may result in an expenditure of $100 million or more (adjusted annually for inflation since the base year 1995) in any one year by State, local, and tribal governments, in the aggregate, or by the private sector; such a mandate is deemed to be a ''significant regulatory action.'' The FAA currently uses an inflation-adjusted value of $128.1 million in lieu of $100 million. This final rule does not contain such a mandate. The requirements of Title II do not apply.

Executive Order 13132, Federalism

The FAA has analyzed this final rule under the principles and criteria of Executive Order 13132, Federalism. We determined that this action will not have a substantial direct effect on the States, or the relationship between the national Government and the States, or on the distribution of power and responsibilities among the various levels of government, and therefore does not have federalism implications.

Environmental Analysis

FAA Order 1050.1E identifies FAA actions that are categorically excluded from preparation of an environmental assessment or environmental impact statement under the National Environmental Policy Act in the absence of extraordinary circumstances. The FAA has determined this rulemaking action qualifies for the categorical exclusion identified in paragraph 308(c)(1) and involves no extraordinary circumstances.

Regulations That Significantly Affect Energy Supply, Distribution, or Use

The FAA has analyzed this final rule under Executive Order 13211, Actions Concerning Regulations that Significantly Affect Energy Supply, Distribution, or Use (66 FR 28355, May 18, 2001). We have determined that it is not a ''significant energy action'' under the executive order because it is not a ''significant regulatory action'' under Executive Order 12866, and it is not likely to have a significant adverse effect on the supply, distribution, or use of energy.

List of Subjects

14 CFR Part 23

Air transportation, Aircraft, Aviation safety, Certification, Safety.

14 CFR Part 25

Air transportation, Aircraft, Aviation safety, Certification, Safety.

14 CFR Part 27

Air transportation, Aircraft, Aviation safety, Certification, Rotorcraft, Safety.

14 CFR Part 29

Air transportation Aircraft, Aviation safety Certification, Rotorcraft, Safety.

The Amendment

■ In consideration of the foregoing, the Federal Aviation Administration amends Chapter I of Title 14, Code of Federal Regulations as follows:

PART 23—AIRWORTHINESS STANDARDS: NORMAL, UTILITY, ACROBATIC, AND COMMUTER CATEGORY AIRPLANES

■ 1. The authority citation for part 23 continues to read as follows:

Authority: 49 U.S.C. §§ 106(g), 40113, 44701, 44702, and 44704.

■ 2. Add § 23.1308 to subpart F to read as follows:

§ 23.1308 High-intensity Radiated Fields (HIRF) Protection.

(a) Except as provided in paragraph (d) of this section, each electrical and electronic system that performs a function whose failure would prevent the continued safe flight and landing of the airplane must be designed and installed so that—

(1) The function is not adversely affected during and after the time the airplane is exposed to HIRF environment I, as described in appendix J to this part;

(2) The system automatically recovers normal operation of that function, in a timely manner, after the airplane is exposed to HIRF environment I, as described in appendix J to this part, unless the system's recovery conflicts with other operational or functional requirements of the system; and

(3) The system is not adversely affected during and after the time the airplane is exposed to HIRF environment II, as described in appendix J to this part.

(b) Each electrical and electronic system that performs a function whose failure would significantly reduce the capability of the airplane or the ability of the flightcrew to respond to an adverse operating condition must be designed and installed so 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 J to this part.

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

(d) Before December 1, 2012, an electrical or electronic system that performs a function whose failure would prevent the continued safe flight and landing of an airplane may be designed and installed without meeting the provisions of paragraph (a) provided—

(1) The system has previously been shown to comply with special conditions for HIRF, prescribed under § 21.16, issued before December 1, 2007;

(2) The HIRF immunity characteristics of the system have not changed since compliance with the special conditions was demonstrated; and

(3) The data used to demonstrate compliance with the special conditions is provided.

■ 3. Add appendix J to part 23 to read as follows:

Appendix J to Part 23—HIRF Environments and Equipment HIRF Test Levels

This appendix specifies the HIRF environments and equipment HIRF test levels for electrical and electronic systems under § 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 (volts/meter)	
	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
GHz–2 GHz	2,000	200
2 GHz–6 GHz	3,000	200
6 GHz–8 GHz	1,000	200
8 GHz–12 GHz	3,000	300
12 GHz–18 GHz	2,000	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 (volts/meter)	
	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	1,300	160
2 GHz–4 GHz	3,000	120
4 GHz–6 GHz	3,000	160
6 GHz–8 GHz	400	170
8 GHz–12 GHz	1,230	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 percent 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 percent 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 percent 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 percent.

(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.

PART 25—AIRWORTHINESS STANDARDS: TRANSPORT CATEGORY AIRPLANES

■ 4. The authority citation for part 25 continues to read as follows:

Authority: 49 U.S.C. §§ 106(g), 40113, 44701, 44702, 44704.

■ 5. Add § 25.1317 to subpart F to read as follows:

§ 25.1317 High-intensity Radiated Fields (HIRF) Protection.

(a) Except as provided in paragraph (d) of this section, each electrical and electronic system that performs a function whose failure would prevent the continued safe flight and landing of the airplane must be designed and installed so that—

(1) The function is not adversely affected during and after the time the airplane is exposed to HIRF environment I, as described in appendix L to this part;

(2) The system automatically recovers normal operation of that function, in a timely manner, after the airplane is exposed to HIRF environment I, as described in appendix L to this part, unless the system's recovery conflicts with other operational or functional requirements of the system; and

(3) The system is not adversely affected during and after the time the airplane is exposed to HIRF environment II, as described in appendix L to this part.

(b) Each electrical and electronic system that performs a function whose failure would significantly reduce the capability of the airplane or the ability of the flightcrew to respond to an adverse operating condition must be designed and installed so the system is not adversely affected when the equipment providing these functions is exposed to equipment HIRF test level 1 or 2, as described in appendix L to this part.

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

(d) Before December 1, 2012, an electrical or electronic system that performs a function whose failure would prevent the continued safe flight and landing of an airplane may be designed and installed without meeting the provisions of paragraph (a) provided—

(1) The system has previously been shown to comply with special conditions for HIRF, prescribed under § 21.16, issued before December 1, 2007;

(2) The HIRF immunity characteristics of the system have not changed since compliance with the special conditions was demonstrated; and

(3) The data used to demonstrate compliance with the special conditions is provided.

■ 6. Add appendix L to part 25 to read as follows:

Appendix L to Part 25—HIRF Environments and Equipment HIRF Test Levels

This appendix specifies the HIRF environments and equipment HIRF test levels for electrical and electronic systems under § 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 (volts/meter)	
	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	2,000	200
2 GHz–6 GHz	3,000	200
6 GHz–8 GHz	1,000	200
8 GHz–12 GHz	3,000	300
12 GHz–18 GHz	2,000	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 (volts/meter)	
	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	1,300	160
2 GHz–4 GHz	3,000	120
4 GHz–6 GHz	3,000	160
6 GHz–8 GHz	400	170
8 GHz–12 GHz	1,230	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 percent 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 percent 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 percent 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 percent.

(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.

PART 27—AIRWORTHINESS STANDARDS: NORMAL CATEGORY ROTORCRAFT

■ 7. The authority citation for part 27 continues to read as follows:

Authority: 49 U.S.C. §§ 106(g), 40113, 44701, 44702, 44704.

■ 8. Add § 27.1317 to subpart F to read as follows:

§ 27.1317 High-intensity Radiated Fields (HIRF) Protection.

(a) Except as provided in paragraph (d) of this section, 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 to this part;

(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 to this part, unless this conflicts with other operational or functional requirements of that system;

(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 to this part; 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 to this part.

(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 flightcrew to respond to an adverse operating condition must be designed and installed so the system is not adversely affected when the equipment providing these functions is exposed to equipment HIRF test level 1 or 2, as described in appendix D to this part.

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

(d) Before December 1, 2012, an electrical or electronic system that performs a function whose failure would prevent the continued safe flight and landing of a rotorcraft may be designed and installed without meeting the provisions of paragraph (a) provided—

(1) The system has previously been shown to comply with special conditions for HIRF, prescribed under § 21.16, issued before December 1, 2007;

(2) The HIRF immunity characteristics of the system have not changed since compliance with the special conditions was demonstrated; and

(3) The data used to demonstrate compliance with the special conditions is provided.

■ 9. Add appendix D to part 27 to read as follows:

Appendix D to Part 27—HIRF Environments and Equipment HIRF Test Levels

This appendix specifies the HIRF environments and equipment HIRF test levels for electrical and electronic systems under § 27.1317. The field strength values for the HIRF environments and laboratory 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 (volts/meter)	
	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	2,000	200
2 GHz–6 GHz	3,000	200
6 GHz–8 GHz	1,000	200
8 GHz–12 GHz	3,000	300
12 GHz–18 GHz	2,000	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 (volts/meter)	
	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	1,300	160
2 GHz–4 GHz	3,000	120
4 GHz–6 GHz	3,000	160
6 GHz–8 GHz	400	170
8 GHz–12 GHz	1,230	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) HIRF environment III is specified in the following table:

TABLE III.—HIRF ENVIRONMENT III

Frequency	Field strength (volts/meter)	
	Peak	Average
10 kHz–100 kHz	150	150
100 kHz–400 MHz	200	200
400 MHz–700 MHz	730	200
700 MHz–1 GHz	1,400	240
1 GHz–2 GHz	5,000	250
2 GHz–4 GHz	6,000	490
4 GHz–6 GHz	7,200	400
6 GHz–8 GHz	1,100	170
8 GHz–12 GHz	5,000	330
12 GHz–18 GHz	2,000	330
18 GHz–40 GHz	1,000	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 percent 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 percent 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 percent 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 percent.

(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.

PART 29—AIRWORTHINESS STANDARDS: TRANSPORT CATEGORY ROTORCRAFT

■ 10. The authority citation for part 29 continues to read as follows:

Authority: 49 U.S.C. §§ 106(g), 40113, 44701, 44702, 44704.

■ 11. Add § 29.1317 to subpart F to read as follows:

§ 29.1317 High-intensity Radiated Fields (HIRF) Protection.

(a) Except as provided in paragraph (d) of this section, 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 to this part;

(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 to this part, unless this conflicts with other operational or functional requirements of that system;

(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 to this part; 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 to this part.

(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 flightcrew to respond to an adverse operating condition must be designed and installed so the system is not adversely affected when the equipment providing these functions is exposed to equipment HIRF test level 1 or 2, as described in appendix E to this part.

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

(d) Before December 1, 2012, an electrical or electronic system that performs a function whose failure would prevent the continued safe flight and landing of a rotorcraft may be designed and installed without meeting the provisions of paragraph (a) provided—

(1) The system has previously been shown to comply with special conditions for HIRF, prescribed under § 21.16, issued before December 1, 2007;

(2) The HIRF immunity characteristics of the system have not changed since compliance with the special conditions was demonstrated; and

(3) The data used to demonstrate compliance with the special conditions is provided.

■ 12. Add appendix E to part 29 to read as follows:

Appendix E to Part 29–HIRF Environments and Equipment HIRF Test Levels

This appendix specifies the HIRF environments and equipment HIRF test levels for electrical and electronic systems under § 29.1317. The field strength values for the HIRF environments and laboratory 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 (volts/meter)	
	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	2,000	200
2 GHz–6 GHz	3,000	200
6 GHz–8 GHz	1,000	200
8 GHz–12 GHz	3,000	300
12 GHz–18 GHz	2,000	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 (volts/meter)	
	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	1,300	160
2 GHz–4 GHz	3,000	120
4 GHz–6 GHz	3,000	160
6 GHz–8 GHz	400	170
8 GHz–12 GHz	1,230	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) HIRF environment III is specified in the following table:

TABLE III.—HIRF ENVIRONMENT III

Frequency	Field strength (volts/meter)	
	Peak	Average
10 kHz–100 kHz	150	150
100 kHz–400 MHz	200	200
400 MHz–700 MHz	730	200
700 MHz–1 GHz	1,400	240
1 GHz–2 GHz	5,000	250
2 GHz–4 GHz	6,000	490
4 GHz–6 GHz	7,200	400
6 GHz–8 GHz	1,100	170
8 GHz–12 GHz	5,000	330
12 GHz–18 GHz	2,000	330

TABLE III.—HIRF ENVIRONMENT III—Continued

Frequency	Field strength (volts/meter)	
	Peak	Average
18 GHz–40 GHz	1,000	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 percent depth or greater. The conducted susceptibility current must start at a minimum of 0.6 milliamperes (mA) at 10 kHz, increasing 20 decibel (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 percent 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 percent 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 percent.

(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.

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Marion C. Blakey,

Administrator.

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