

AEROSPACE RECOMMENDED PRACTICE

ARP60493™

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Guide to Civil Aircraft Electromagnetic Compatibility (EMC)

RATIONALE

This document provides guidance for demonstrating that electrical and electronic systems installed on civil aircraft can operate without adversely affecting, or without being affected by, the operation of other aircraft electrical and electronic systems. It includes guidance for defining appropriate electromagnetic compatibility requirements for the electrical and electronic equipment. It also includes methods for aircraft electromagnetic compatibility analysis and tests.

ARP60493 has been reaffirmed to comply with the SAE Five-Year Review policy.

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1. SCOPE

This guide provides detailed information, guidance, and methods for demonstrating electromagnetic compatibility (EMC) on civil aircraft. This guide addresses aircraft EMC compliance for safety and functional performance of installed electrical and electronic systems. The EMC guidance considers conducted and radiated electromagnetic emissions and transients generated by the installed electrical and electronic systems which may affect other installed electrical and electronic systems on the aircraft. Application of appropriate electrical and electronic equipment EMC requirements are discussed. Methods for aircraft EMC tests and analysis are described. This guide does not address aircraft compatibility with the internal electromagnetic environments of portable electronic devices (PED) or with the external electromagnetic environments, such as high-intensity radiated fields (HIRF), lightning, and precipitation static.

1.1 Purpose

This document provides technical guidance that can be used to demonstrate that aircraft electrical and electronic systems are electromagnetically compatible with other aircraft systems, that is, inter-system electromagnetic compatibility. This guide may be applied to new aircraft and modifications to existing aircraft. The electromagnetic compatibility demonstrations apply to all aircraft electrical and electronic systems, including power distribution systems, electrical generating systems, electronic engine control systems, electronic flight control systems, navigation, communication, flight reference systems, and passenger entertainment and convenience systems. The term 'systems' refers to electrical and electronic equipment; interconnecting power, signal, and control wiring; indicators; control panels; sensors; and software. This document emphasizes the EMC demonstrations required to achieve appropriate aircraft safety, but can also be used to demonstrate acceptable performance for any aircraft electrical and electronic system. The approach for achieving aircraft EMC includes appropriate system design, qualification, and installation. This document only addresses aircraft inter-system electromagnetic compatibility. For other electromagnetic environments, reference the appropriate regulations, requirements, standards, and guides. To avoid confusion with other electromagnetic environments and to provide a means of readily identifying the engineering associated with these regulations, the term 'electromagnetic compatibility' will be used along with the abbreviation EMC in this document.

Prior to the publication of this document, there were no standard methods defined for demonstrating electromagnetic compatibility on civil aircraft, resulting in a wide range of compliance techniques. This document standardizes the EMC demonstration approaches and methods to ensure common application of regulations, consistent evaluation of the results, and confidence in the overall safety of the aircraft.

2. REFERENCES

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1 Applicable Documents

2.1.1 EUROCAE Publications

Available from EUROCAE Secretariat, 102 rue Etienne Dolet, 92240 Malakoff, France, Tel: +33 1 40 92 79 30, www.eurocae.net.

EUROCAE/ED-14G, "Environmental Conditions and Test Procedures for Airborne Equipment", May 2011

EUROCAE/ED-118, "Report on Electromagnetic Compatibility Between Passenger Carried Portable Electronic Devices (Peds) and Aircraft Systems", November 2003

2.1.2 RTCA Publications

Available from RTCA, Inc., 1150 18th Street, NW, Suite 910, Washington, DC 20036, Tel: 202-833-9339, www.rtca.org.

RTCA/DO-160G, "Environmental Conditions and Test Procedures for Airborne Equipment", December 8, 2010

RTCA/DO-307, "Aircraft Design and Certification for Portable Electronic Device (PED) Tolerance", October 11, 2007

RTCA/DO-313, "Certification Guidance for Installation of Non-Essential, Non-Required Cabin Systems and Equipment", October 2, 2008

RTCA/DO-357, "User Guide: Supplement to DO-160G", December 16, 2014

RTCA/DO-363, "Guidance for the Development of Portable Electronic Devices (PED) Tolerance for Civil Aircraft", December 15, 2016

2.1.3 U.S. Military Specifications and Standards

Copies of these documents are available online at <http://quicksearch.dla.mil>.

MIL-STD-461G, "Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment", December 11, 2015

MIL-STD-464C, "Electromagnetic Environmental Effects Requirements for Systems", December 1, 2010

MIL-STD-704F, "Aircraft Electric Power Characteristics", December 30, 2008

MIL-STD-810G, "Environmental Engineering Considerations and Laboratory Tests", October 31, 2008

2.1.4 FAA Publications

Available from Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591, Tel: 866-835-5322, www.faa.gov.

FAA Order 8100.4C, "Type Certification", December 20, 2011

FAA Advisory Circular 20-158A, "The Certification of Aircraft Electrical and Electronic Systems for Operation in the High-intensity Radiated Fields (HIRF) Environment", May 30, 2014

FAA Advisory Circular 20-168, "Certification Guidance for Installation of Non-Essential, Non-Required Aircraft Cabin Systems & Equipment (CS&E)", July 22, 2010

FAA Advisory Circular 21-16G, "RTCA Document DO-160 versions D, E, F, and G, "Environmental Conditions and Test Procedures for Airborne Equipment", June 22, 2011

FAA Advisory Circular 23.1309-1E, "System Analysis and Assessment for Part 23 Airplane", November 17, 2011

FAA Advisory Circular 25-7C, "Flight Test Guide For Certification Of Transport Category Airplanes", October 16, 2012

FAA Advisory Circular 25.1353-1A, "Electrical Equipment and Installations", October 22, 2007

FAA Advisory Circular 25.1701-1, "Certification of Electrical Wiring Interconnection Systems on Transport Category Airplanes", December 4, 2007

2.2 Abbreviations

dB	Decibel
GHz	Gigahertz
kHz	Kilohertz
MHz	Megahertz

2.3 Acronyms

AC	Alternating current
ATA	Air Transport Association
CAD	Computer aided design
CFR	Code of Federal Regulations
COMM	Aircraft communication radio
CS	Certification specifications
CW	Continuous wave
DAL	Design assurance level
DC	Direct current
EASA	European Aviation Safety Agency
EED	Electro-explosive device
EM	Electromagnetic
EMC	Electromagnetic compatibility
EMI	Electromagnetic interference
ESD	Electrostatic discharge
FCC	Federal Communications Commission
HF	High frequency
HIRF	High-intensity radiated field
ICA	Instruction for continued airworthiness
LISN	Line impedance stabilization network
MOM	Method-of-moments
MOPS	Minimum operational performance standards
NAV	Aircraft navigation radio
PED	Portable electronic device
PMA	Parts manufacturer approval
P-static	Precipitation static
RBW	Resolution bandwidth
RF	Radio frequency
STC	Supplemental type certificate
TC	Type certificate
TCCA	Transport Canada Civil Aviation
TSO	Technical standard order
TSOA	Technical standard order authorization
USD	United States dollars
VHF	Very high frequency
VOR	VHF omni range

3. AIRCRAFT EMC CONCEPTS

Modern aircraft, in an ever increasing manner, rely extensively on electrical and electronic equipment to perform functions on the aircraft, ranging from functions with catastrophic failure effects to the no safety failure effects of in-flight entertainment equipment. Regardless of the function performed, the equipment and its interconnecting wiring will unavoidably generate and be exposed to various types of electrical transients, electrical and magnetic fields, and spurious noise, spanning over a wide range of frequencies and amplitudes.

Throughout this document, the term EMC is used when referring to the goal of aircraft system compatibility. The term electromagnetic interference (EMI) is used only when referring to undesirable effects that occur when EMC has not been achieved.

While offending electromagnetic transients and fields can be produced by sources outside of the aircraft (e.g., lightning, HIRF, precipitation static (P-Static)), or by devices carried onto the aircraft (e.g., PEDs or transmitting portable electronic devices), this document will only deal with emissions from equipment installed within the aircraft, referred to as inter-system EMC in [3.1](#). Interoperability between radio systems (antenna to antenna coupling) is out of the scope of this document.

The requirements to perform EMC testing are derived from the airworthiness regulations and are specifically enunciated by various guidance documents. The specific text varies somewhat between the regulations. However, they all dictate that electrical and electronic equipment, when installed on board an aircraft, be capable of being simultaneously operated without adverse effects to the aircraft.

Equipment qualification is normally accomplished via laboratory testing using an accepted test standard such as RTCA/DO-160 and EUROCAE/ED-14, to demonstrate adequate electromagnetic transient immunity, radio frequency (RF) immunity, and electromagnetic emissions characteristics. Although equipment may be qualified to certain emission and susceptibility categories, equipment qualification alone may not be sufficient to demonstrate aircraft electromagnetic compatibility.

Ultimately, the aircraft manufacturer or system installer applying for certification must show that the aircraft design complies with the airworthiness regulations. Therefore, an aircraft EMC test or analysis should be performed to demonstrate compatibility or to reveal any EMI issues for evaluation of their effects on the aircraft. An aircraft EMC test can be accomplished via ground testing, flight testing, or a combination of both with the primary objective being to reveal any EMI while observing the behavior or measuring the response of the selected system when operating other systems installed on the aircraft, and vice versa.

The extent of this testing or analysis should reflect the complexity of the change and the impact it can have on safety. For example, a simple test might be accomplished for a relatively simple supplemental type certificate (STC) involving changes to equipment whose functions and failure thereof have no impact on safety and has been shown to not be a source of EMI, whereas a more complex test is required for a new aircraft type certificate (TC) where numerous electrical and electronic systems perform functions whose malfunction or failure seriously impact safe operation of the aircraft.

3.1 Inter-System EMC

EMC between installed aircraft systems is the most basic element of electromagnetic concerns and is often referred to as inter-system EMC. The various equipment and systems should be designed and installed so that operation of any one unit or system of units will not adversely affect the simultaneous operation of any other equipment or system on the aircraft.

Inter-system EMC is influenced by:

- Structural material and electromagnetic shielding design,
- Equipment design, location, installation, and bonding/grounding, and
- Cable shielding, shield terminations, wire separation, and routing.

Any modification of the above could have an impact on electromagnetic interaction between equipment or systems onboard. Therefore, an aircraft level demonstration by test and/or analysis should be performed to prove that modifications do not introduce adverse EMI.

3.2 Characteristics of Electromagnetic Emissions

It is necessary to control electromagnetic sources onboard the aircraft to avoid adverse interference to equipment and systems necessary for continued safe flight and landing and to satisfy customer-specific requirements.

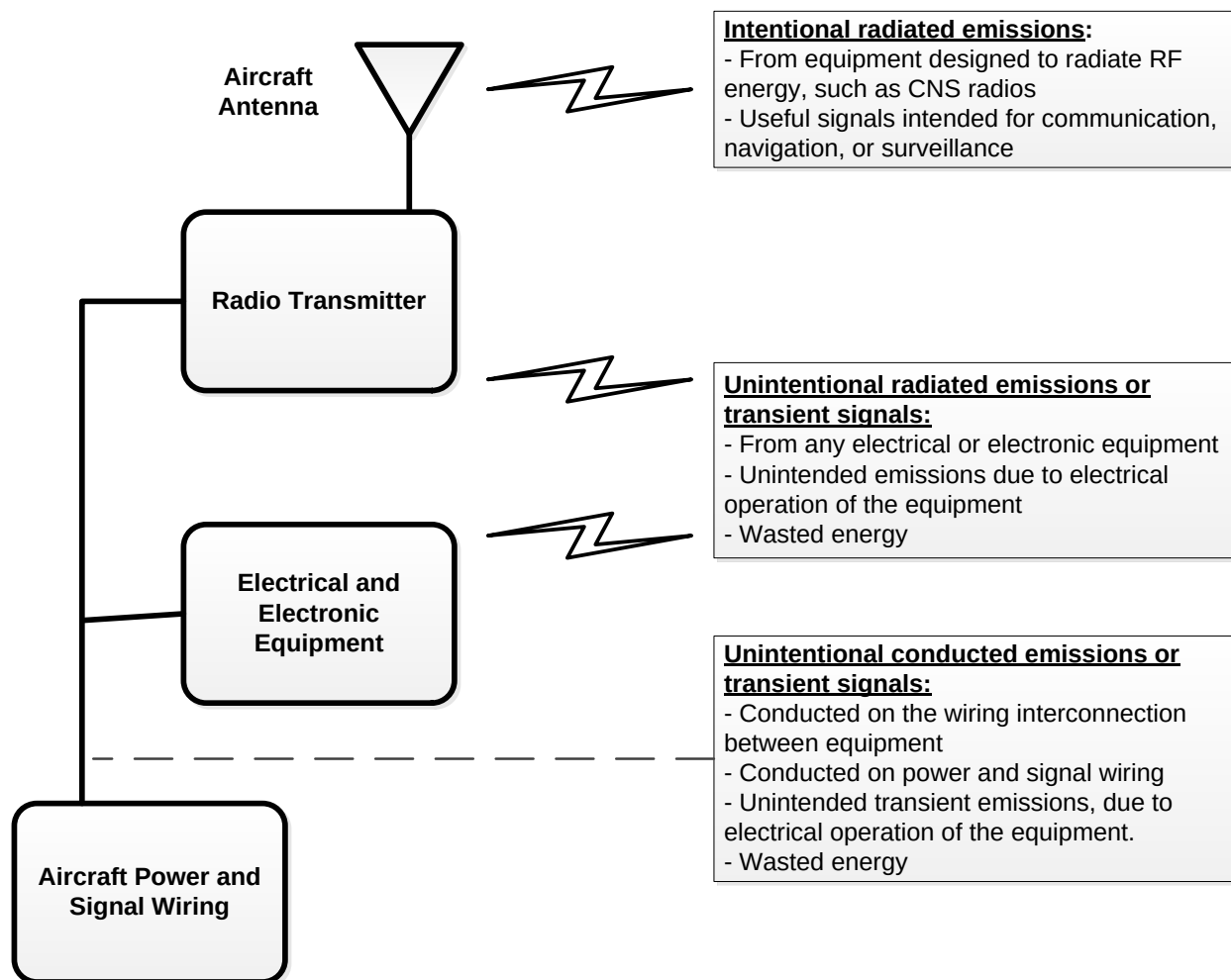
All electrical/electronic equipment are a source of some level of unintentional radiated and conducted RF emissions or spurious transient signals. These unintentional RF emissions and spurious transient signals result from the operation of internal electrical/electronic equipment and propagate via radiation or through the aircraft power, signal, or data wiring. Many equipment radiate some level of intentional RF emissions for communication or navigation purposes. These intentional RF emissions are classified as narrowband signals.

Table 1 describes some characteristics of these signals and Figure 1 illustrates the different types of radiated and conducted RF emissions.

Table 1 - Characteristics of electromagnetic emissions

Inter-System Emissions Environment	Waveform Type	Coupling *
Intentional Emissions	<u>Narrowband signal from communication, navigation, or surveillance radio transmitters:</u> - Pulse, continuous wave (CW) and modulated - Wide frequency range (from 2 MHz up to 18 GHz) and high field strengths	Radiated
Unintentional Emissions and Spurious Transient Signals	<u>Broadband signals from any operating electrical/electronic equipment :</u> - Transients (switching, relays, engine ignition operation, electrostatic discharge (ESD), etc.) - From slow to very fast waveforms <u>Narrowband signals from any operating electrical/electronic equipment :</u> - CW and modulated (oscillators, clock, power harmonics, RF, etc.) - Very wide frequency range (from a few Hz up to some GHz)	Radiated and Conducted

* Coupling is the mode by which the electromagnetic energy propagates from the source to the victim.

**Figure 1 - Example of RF emission (radiated or conducted)**

Radiated emission coupling to antennas is called front door coupling. The interfering radiated emission can be out of band or in band for the aircraft radio receivers. The coupling of radiated emissions to the aircraft radio antennas occurs primarily through aircraft windows and via door and access panel seams.

Radiated emission coupling to equipment and wiring is called back door coupling.

The coupling paths represent the different mechanisms for the emitted signals to couple to the aircraft systems and are illustrated in Table 2.

Table 2 - Potential coupling path should be considered

Emission Type	Coupling Path	Coupling Type
Intentional Radiated Emissions (useful signals)	Coupling through the radio antennas	Front Door
	Direct coupling to equipment	Back Door
	Coupling to equipment input and wires	Back Door
Unintentional Radiated Emissions (spurious emissions)	Coupling through the radio antennas	Front Door
	Direct coupling to equipment	Back Door
	Coupling to equipment input and wires	Back Door
Conducted Spurious Emissions	Coupling to equipment inputs	Back Door
	Cross talk (wire to wire coupling)	Back Door

4. AIRCRAFT EMC REGULATIONS AND GUIDANCE

4.1 Aircraft EMC Regulations

No regulations specifically use the words “electromagnetic compatibility”, except for two sections related to rotorcraft external load attachment release systems in parts 27 and 29.

In general, since aircraft electrical and electronic systems are normally operated simultaneously, effects of one system on the other systems should be considered as foreseeable operating conditions under regulations such as §23.1309(a) which says: “The airplane equipment and systems must be designed and installed so that: (1) Those required for type certification or by operating rules perform as intended under the airplane operating and environmental conditions, including the indirect effects of lightning strikes.” [Amendment 23-62].

Similarly, aircraft electrical and electronic systems are normally operated simultaneously, so effects of one system on the other systems should be considered under regulations such as §25.1431(c) which says: “Radio and electronic equipment, controls, and wiring must be installed so that operation of any one unit or system of units will not adversely affect the simultaneous operation of any other radio or electronic unit, or system of units, required by this chapter.” [Amendment 25-113]

Several of the regulations use the phrase ‘adversely affect’. For example, §23.1309(a)(2) says: “The airplane equipment and systems must be designed and installed so that: ... (2) Any equipment and system does not adversely affect the safety of the airplane or its occupants, or the proper functioning of those covered by paragraph (a)(1) of this section.” [Amendment 23-62]. In the context of these regulations, adverse effects are those effects that are related to the safety of the aircraft and its occupants.

Other regulations, such as §27.1301(d) [Original Issue] which says: “Each item of installed equipment must— ... (d) Function properly when installed.” have been invoked to require the certification applicant demonstrate aircraft system electromagnetic compatibility. These regulations should not be applied for aircraft EMC certification, because there are some aircraft systems that can be affected by interference from other systems but result in no safety effects.

The US FAA regulations, the European Aviation Safety Agency (EASA) certification specifications, and Transport Canada Civil Aviation (TCCA) certification standards have very similar requirements for demonstrating aircraft EMC.

Other authorities have similar regulations and may also differ in requirements. The certification applicant is responsible for determining the appropriate regulations for their project.

FAA 14 CFR 23, EASA CS-23, TCCA Chapter 523

- 14 CFR 23.2500 Airplane level systems requirements
- CS-23.1309, Chapter 523.1309 Equipment, systems, and installations; sections (a)(1), (b), and (e)
- 14 CFR 23.1431, CS-23.1431, TCCA 523.1431 Electronic equipment; section (b)

FAA 14 CFR 25, EASA CS-25, TCCA Chapter 525

- 14 CFR 25.1309, TCCA 525.1309 Equipment, systems, and installations; sections (a) and (e)
- CS-25.1309 Equipment, systems, and installations; sections (a)(1) and (a)(2)
- 14 CFR 25.1353, CS-25.1353, TCCA 525.1353 Electrical equipment and installations; section (a)
- 14 CFR 25.1431, CS-25.1431, TCCA 525.1431 Electronic equipment; sections (c) and (d)
- 14 CFR 25.1707, CS-25.1707, TCCA 525.1707 Electrical Wiring Interconnection Systems (EWIS) section (b)

FAA 14 CFR 27, EASA CS-27, TCCA Chapter 527

- 14 CFR 27.865, CS-27.865, TCCA 527.865 External loads; section (b)(3)
- 14 CFR 27.1309, CS-27.1309, TCCA 527.1309 Equipment, systems, and installations; section (a)
- 14 CFR 27, CS-27 /Chapter 527 Appendix B Airworthiness Criteria for Helicopter Instrument Flight; section VIII. The basic equipment and installation must comply with §29.1431

FAA 14 CFR 29, EASA CS-29, TCCA Chapter 529

- 14 CFR 29.865, CS-29.865, TCCA 529.865 External loads; section (b)(3)
- 14 CFR 29.1309, CS-29.1309, TCCA 529.1309 Equipment, systems, and installations; section (a) and (g)
- 14 CFR 29.1353, CS-29.1353, TCCA 529.1353 Electrical equipment and installations; section (a)
- 14 CFR 29.1431, CS-29.1431, TCCA 529.1431 Electronic equipment; section (b)

4.2 Regulatory Guidance on Electromagnetic Compatibility

Early aviation authority guidance for aircraft EMC was very general, and in some cases ineffective. For example, now cancelled FAA Advisory Circular 25-10, "Guidance for Installation of Miscellaneous, Non-Required Electrical Equipment", included the following guidance: "Operate communications and navigation equipment on at least one low, high and mid-band frequency." The electronic systems used in aircraft now have potential sources of RF emissions from electronic oscillators and clocks that are very narrowband and stable. Therefore, operating multi-channel communication and navigation radio receivers at one low, high, and mid-band frequency would be unlikely to find radio interference that occurs at a specific frequency.

More recently, AC 20-168, "Certification Guidance for Installation of Non-Essential, Non-Required Aircraft Cabin Systems & Equipment (CS&E)", provides guidance for aircraft EMC demonstrations by referring to RTCA/DO-313. RTCA/DO-313, "Certification Guidance for Installation of Non-Essential, Non-Required Cabin Systems and Equipment", includes Appendix C, "Electromagnetic Compatibility Ground/Flight Test Guidelines for Installed CS&E Equipment". AC 25.1701-1 "Certification of Electrical Wiring Interconnection Systems on Transport Category Airplanes" notes that EMC should be considered when designing electrical wiring installations, particularly for wire separation.

Advisory Circular 25.1353-1A provides the following guidance in section 5.a:

- a. Section 25.1353(a). The following sources of interference should be considered when demonstrating compliance to the requirements of § 25.1353(a):
 1. Conducted and radiated interference caused by electrical noise generation from apparatus connected to the bus bars.
 2. Coupling between electrical wires or between wires and aircraft antenna coax cables.
 3. Malfunctioning of electrically-powered apparatus.
 4. Parasitic currents and voltages in the electrical distribution and grounding systems, including the effects of lightning currents or static discharge.
 5. Different frequencies between generating or other systems.

The regulations in 14 CFR 25.1353(a), EASA CS 25.1353(a) and TCCA standard 525.1353(a) do not address “malfunctioning electrically-power apparatus”. Demonstrating compliance to item 5.a.(3) “Malfunctioning of electrically-powered apparatus” has generally been limited to demonstrating that circuit protection devices, such as circuit breakers, can be operated without adverse effects to other electrical systems. This demonstration is particularly important for aircraft with composite structure, a specific grounding network, and high power electrical sources and electrical loads. For these aircraft, common ground coupling between equipment and inductive coupling between wires can result when electrical faults occur.

Specific policy has been published for rotorcraft EMC. Advisory Circulars 27-1B and 29-2C include several sections that refer to EMI and EMC. For example, AC 27-1B section AC 27.865B and AC 29-2C section AC 29.865B for external loads provide guidance on EMC demonstrations. These advisory circulars refer to EMI tests for electronic equipment in sections AC 27.1309 and AC 29.1309 for equipment, systems, and installations. AC 29-2C refers to EMI in section AC 29.1353 on electrical equipment and installations and section AC 29.1431 for electronic equipment. Other references to electromagnetic compatibility and interference are in the miscellaneous guidance sections of ACs 27-1B and 29-2C. The sections in ACs 27-1B and 29-2C that refer to EMC and interference provide very general guidance on the methods for demonstrating compliance with the applicable regulations.

A Special Airworthiness Information Bulletin SW-10-43 addresses potential EMIs with required aviation radios caused by non-aviation transmitters installed in rotorcraft. The concern of this bulletin is that non-aviation radios may be capable of transmitting directly on RFs reserved for aviation. In addition, these radios are capable of generating harmonics while transmitting that creates interference with and adversely affects the operation of required communication, navigation, and surveillance equipment in the rotorcraft.

FAA Advisory Circular 21-16G provides guidance on the use of RTCA/DO-160 to show compliance with certain airworthiness requirements.

5. DESIGN CONSIDERATIONS

The electrical and electronic systems and equipment should be designed and installed on the aircraft in a manner that will not be susceptible to, nor create, any unacceptable EMI. The complexity and interference risk of these systems and equipment when installed should be evaluated during the design phase and adequate features planned and incorporated in the equipment and their installation. These systems and equipment should be tested for EMC to ensure adverse effects are unlikely.

The electrical and electronic systems and equipment should be designed considering all foreseeable operating conditions; including the consideration of the worst-case installation configuration for all aspects of design, installation, operation, and maintenance.

The systems and equipment should be designed and certified appropriate for the location in which they will be installed and operated on the aircraft. The aircraft size, type, passenger capacity, and mission will impact the systems and equipment operation and EMI.

5.1 General Equipment Qualification Process

Electrical and electronic equipment and components should be designed and qualified to determine their appropriateness for all foreseeable conditions in which they will be installed and operated. Guidelines relating to proper category or severity selection are given in [Section 7](#).

5.2 General Installation Qualification Process

Systems and equipment should be designed and installed on aircraft in a manner to minimize the susceptibility and any adverse effects on other systems by considering the aircraft's specific environment, systems configurations, functions, malfunctions, discrepancies, and failure conditions. To mitigate the EMI and their adverse effects, adequate shielding, electrical interconnection wiring systems routing, separation, and segregation should be incorporated in design and installation of the electrical and electronic systems and equipment on the aircraft. In addition to complying with the applicable regulations and using appropriate industry standards, the certification applicant should ensure that the original equipment manufacturer's processes, procedures, and assumptions are not violated and are used to the extent possible.

6. AIRCRAFT EMC PROCESS

The aircraft certification applicant is responsible for showing compliance and providing instructions for maintaining the requirements set forth for EMC as defined by 14 CFR for parts 23, 25, 27, and 29. The applicant will typically establish aircraft and equipment requirements, pass criterion, qualification and verification tests, and a certification report. When evaluating aircraft scope of changes, Figure 2 provides generalized concepts of the level of rigor (exhaustive) versus the scope of the change.

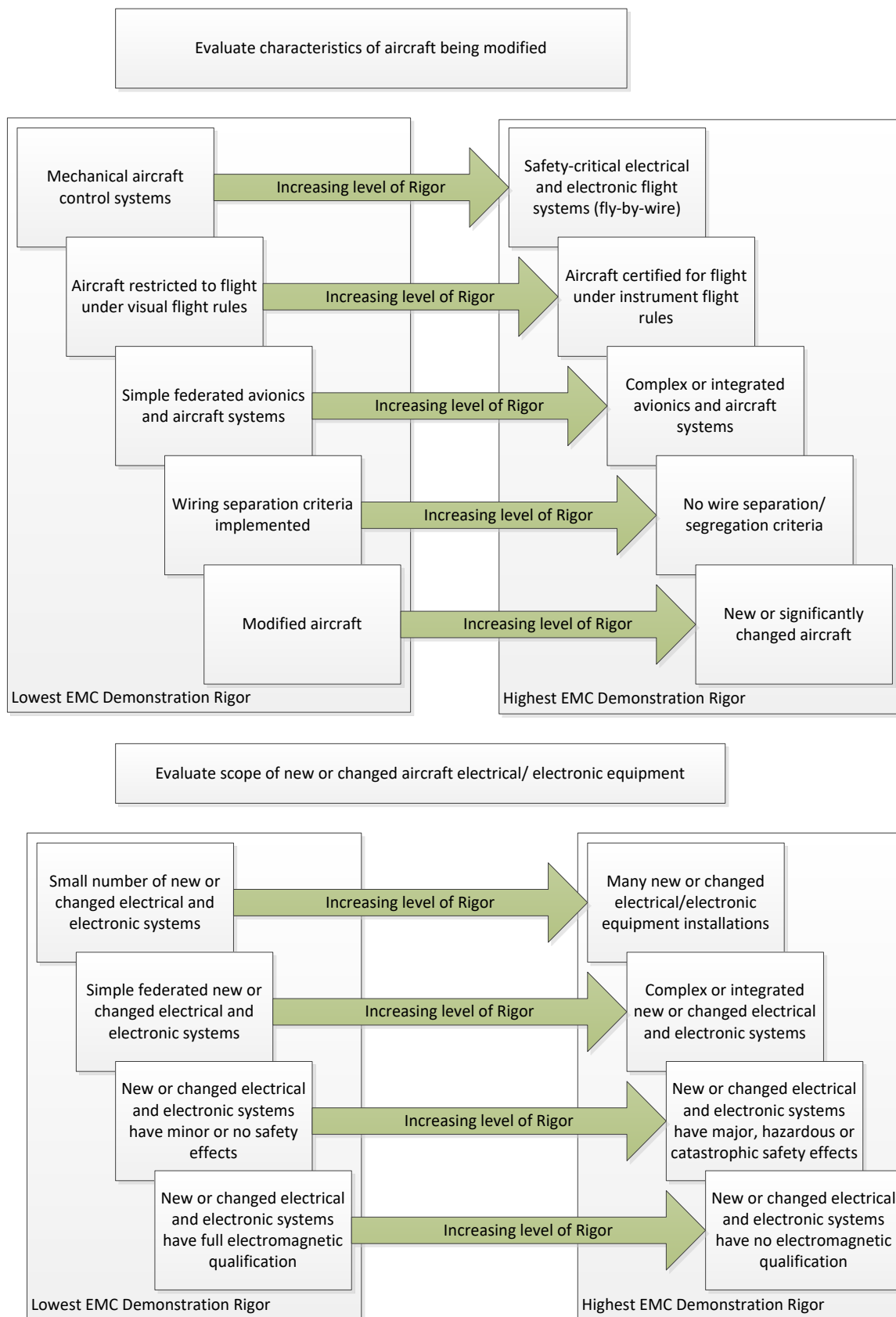


Figure 2 - Scope of change versus level of rigor

The evaluation of EMC is required for all aircraft projects ranging from:

- New aircraft TC or derivative aircraft, where full evaluation of the front door and back door effects of all the systems being installed is required,
- Evaluation of a complex modification to the aircraft and/or system, which will be a subset of what is accomplished on a new or derivative aircraft, and
- Simple modification(s) that may involve a fairly straight forward analysis, with no additional requirement for compliance.

In the beginning, at a high level, you should evaluate the parameters of the project and determine what level of effort is required for the type certification. The flow diagram in Figure 3 provides the general approach for the three categories: New or Derivative Aircraft, Complex Change to Existing Aircraft, and Simple Change to Existing Aircraft. A description of each category is provided in the sub sections below for making the decision on which flow diagram to follow.

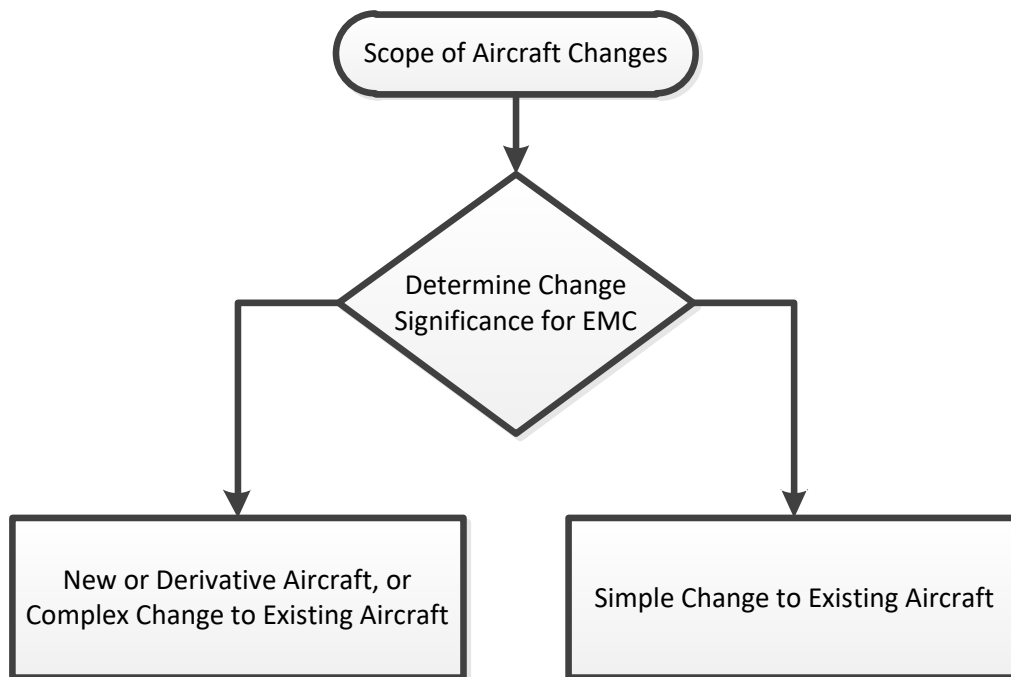


Figure 3 - Determining scope of change

6.1 New or Derivative Aircraft and Complex Change to Existing Aircraft

The certification of a new or derivative aircraft is complex and involves multiple disciplines, of which EMC compliance is a critical part, beginning well in advance of the actual construction of the aircraft. To ensure compliance to EMC requirements, it is critical that the certification applicant develop a compliance methodology that addresses all aspects of compliance. This begins with the fundamental understanding of the means of compliance, such as test, analysis, and similarity. Figure 4 provides a flow diagram of steps to consider for EMC for new or derivative aircraft or for complex changes to existing aircraft.

Successful EMC compliance begins in the early stages of the design in two major areas: Equipment qualification and aircraft protection design.

Equipment qualification should consider equipment susceptibility (immunity to audio noise, transients, surges, RF, etc.) and equipment emissions (electrical harmonics on power lines, RF spurious emissions, etc.). Typically, these qualification requirements are based on various industry standards, such as MIL-STD-461, RTCA/DO-160, or EUROCAE/ED-14; however, many companies develop and apply their own standards.

In all of these standards, requirements are typically based upon equipment location, equipment installation, level of equipment protection, and/or level of emission control required for the specific application.

The results of the equipment qualification is then documented and results approved by the proper engineering representative. This documentation is then utilized as a critical component during the final stages of the compliance demonstration.

More in depth discussion of equipment qualification aspects and controls are provided in [Section 7](#).

EMC aircraft protection design involves design controls that should be used to ensure proper operation of the equipment and control of the 'victim/source' relationship. These design controls involve the proper application of engineering design features, such as electrical bonding (ensuring both direct current (DC) and RF bonding), proper wire shield termination techniques (ensuring low impedance path to ground for RF signals), proper wire bundle separation techniques (minimizing cross coupling between sources and victims), proper wire bundle routing techniques (reducing the magnetic coupling by reducing the inductive loop characteristics), and proper specification of wire type (ensuring proper shielding).

Equipment should be qualified properly using the same engineering specifications used to design and build wire bundles and install equipment to ensure, not only the original certification process but also the ability, later in the life of the aircraft, to update, modify, and requalify equipment to a known baseline. It is just as critical that the various specifications, such as wire bundle separation/routing, electrical bonding, shield terminations, etc., be incorporated into the engineering drawings and properly reviewed and approved by engineering ensuring proper type design of the installation.

All aircraft level activities are typically overseen by the aviation authority or delegated representatives.

The final validation of the aircraft design to show compliance to the applicable certification requirements is an aircraft EMC demonstration. Though aircraft EMC demonstrations are usually performed toward the end of the aircraft development cycle, planning and development of the tasks associated with validation and compliance, such as detail test plans, similarity assessments and analysis, should occur well in advance. Development of similarity assessments and analysis (that might reduce total testing) and detail planning of various matrixes (for monitoring the performance of systems while operating other systems in the aircraft) should both be coordinated with certification authorities to assure agreement on the means of compliance chosen by the certification applicant.

In depth discussion of the full aircraft EMC demonstration process is provided in [Section 8](#).

After the aircraft EMC demonstration, the results and compliance summary should be documented.

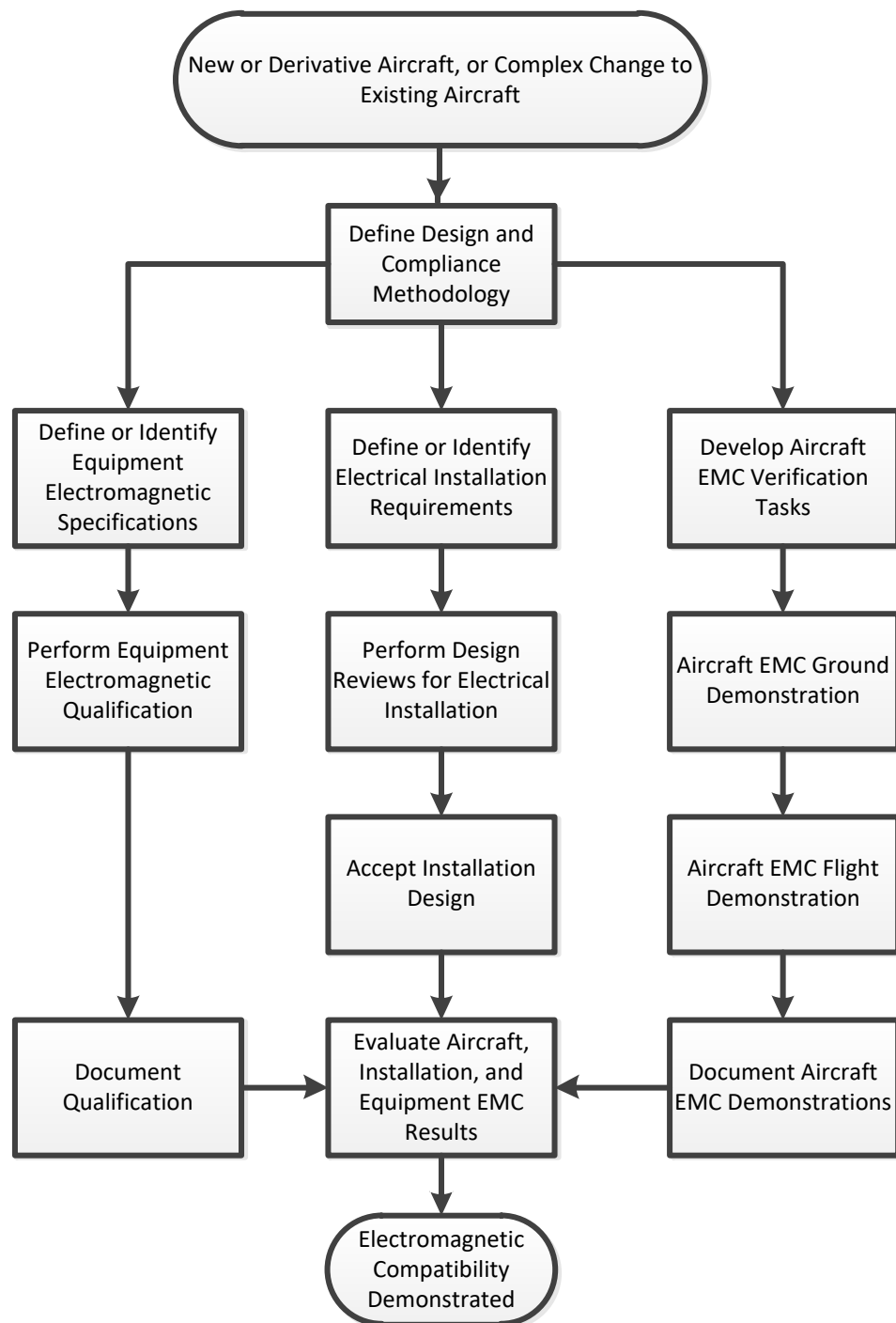


Figure 4 - Flow diagram for new derivative or complex change to existing aircraft