CLC(SG)819

Edition 05

REPORT ON CIVIL AIRCRAFT AND INCORPORATED EQUIPMENT COVERING THE TECHNICAL SPECIFICATIONS AND RELATED CONFORMITY ASSESSMENT PROCEDURES, REGIONAL OR INTERNATIONAL, IN RELATION TO ELECTROMAGNETIC COMPATIBILITY

Issue, 5 October 2000

The conclusions and recommendations made in chapter 8 of the Report on civil aircraft and incorporated equipment covering the technical specifications and related conformity assessment procedures, regional or international, in relation to Electromagnetic Compatibility, were endorsed by the CENELEC Technical Board at the 105th BT meeting (Luzern, 3-5 October 2000, decision D105/156).

INTRODUCTION

At its 79th meeting in June 1999, the Committee on “Standards and Technical Regulations” (Committee 98/34, former 83/189) approved a mandate to CEN, CENELEC and ETSI for the preparation of harmonized standards under the EMC Directive 89/339/EEC covering the essential EMC requirements for aircraft and aeronautical equipment, including the preparation of an intermediate report, which should refer to existing national and international specifications and practices applied in the current technical situation, which may already satisfy the EMC Directive.

In September 1999, the CENELEC Technical Board accepted the proposed mandate M/282 and invited its Central Secretariat to pave the way for the intermediate report through exploratory contacts with CEN, ETSI, the Commission, AECMA, EUROCAE, JAA and the relevant international organizations (FAA, RTCA).

An ad hoc EMC Aircraft and Aeronautical Interest Group (EMC/AAIG) was set up and held three exploratory meetings under the convenorship of CENELEC CS, during which the different aspects of aircraft and aeronautical equipment in relation to the EMC Directive were examined and an agreement was reached on the draft outline of this report. Two drafting groups, one under the auspices of JAA and one set up by EUROCAE, have turned the draft outline into a preliminary version of the report.

On the occasion of its July 2000 meeting, the CENELEC Technical Board welcomed the progress made by the EMC/AAIG and invited them to finalize their work on the “intermediate” report in time for presentation at the October 2000 meeting of the Technical Board.

Two further EMC/AAIG meetings were held during the summer months to agree on the final version of the report, worked out by a small editing group, convened by AECMA.

EXECUTIVE SUMMARY

The purpose of the report is to show how the aircraft safety is addressed and how the aircraft interacts with the EMC environment. In order to achieve this goal, the report is divided into eight chapters, i.e.:

General

Aircraft certification requirements

Aircraft certification process

Aircraft operation and EMC requirements

Aircraft emissions

Aircraft immunity

Portable electronic devices

Conclusions

In chapter 1 “General”,

the purpose is to describe Aviation Safety Principles and to present the International context. The basic principle is that an aircraft is only allowed to fly if it has been designed, manufactured, operated and maintained in accordance with the relevant regulations and if its crew is also qualified in accordance with the relevant regulations.

The international context is provided by the International Civil Aviation Organisation (ICAO). ICAO has developed 18 annexes to the Chicago Convention (1944) which are the basis for Member States Regulations. Annex 8 (Airworthiness) is particularly relevant in the EMC context.

In chapter 2 "Aircraft certification requirements",

the purpose is to describe certification requirements (procedural and technical) using as examples JAR-21 and JAR-25 (JAR: Joint Aviation Requirement), after an introduction to the Joint Aviation Authorities (JAA).

JAR-21 (Certification Procedures for Aircraft and Related Products and Parts) applies to all aspects of design and manufacture. It prescribes procedural requirements for the issue of Type Certificates (TCs) and changes to TCs, for the issue of standard Certificate of Airworthiness (C of A) and the issue of Export Airworthiness Approvals. It describes procedural requirements for the approval of certain parts and appliances. It describes rules governing the holders of certificates or approvals mentioned above. The procedural requirements and rules are applicable to products and parts designed in JAA countries and in non-JAA countries.

Finally it defines procedural requirements for approval of organisations (Design and Production Organisations). However, these are applicable only to organisations under the jurisdiction of JAA Countries, which include all European Union member states.

Technical Airworthiness Codes such as JAR-25 (Large Aeroplanes) contain requirements in relation to performance; handling qualities; structural strength; design and construction; powerplant installation; systems and equipment; manuals and limitations.

It should be kept in mind that aircraft certification is only the starting point for safety. Operations and maintenance of aircraft are also regulated. Flight crew must possess valid licences.

In chapter 3 "Aircraft certification process",

the purpose is to define the two elements of Type Certification (technical findings; legal findings) and to outline the four phases of the technical findings (definition of applicable requirements; definition of means of compliance; demonstration of compliance by the applicant and acceptance by the Authority; final report). This chapter gives also a broad overview of the two JAA certification processes: Joint Multi-national Team process; Joint Local Team process. It concludes with a comparison between the Aviation Certification Process and the EU Global approach to conformity assessment.

In chapter 4 "Aircraft operations and EMC requirements",

justification is provided to consider aircraft as a very specific environment with regard to EMC requirements. Safety is a major objective in aircraft design and certification, hence the essential requirements regarding EMC within the aircraft itself are directly embedded in the safety requirements. Several airworthiness codes exist covering all the types of fixed wings and rotorcraft, each of these codes have general and specific EMC requirements.

Aircraft operations are also controlled through the international regulations. Three major phases of flight have been considered in this report: the aircraft parked or taxiing, the aircraft taking off or landing and the aircraft in its navigation phase. During these various phases the aircraft is always significantly separated from its outside environment according to safety regulations, except in the phase where the aircraft is on the ground at the airport. This last situation leads to separation distances between the aircraft and the airport environment that could be of the same magnitude as the typical separation distance used in the EN 50081-2 (30 meters). Therefore the aircraft at airport represents the worst case to be analyzed in particular in relation to aircraft emission. In this specific case two situations have been considered:

Aircraft handling where the separation distance could be in some cases smaller that the EN selected distance;

Other airport activities where the separation distance is always larger than the EN selected distance.

In the case of aircraft handling, it must be noted that the compatibility between the relevant activities and the aircraft itself is achieved through special and local practices. Therefore the airport must also be considered as a specific environment.

In chapter 5 "Aircraft emissions",

an analysis supported by test data is done to assess both radiated and conducted aircraft emissions.

As regards the radiated emission, two methods are used:

The first considers the radiated emission limit required for each piece of the electrical equipment of an aircraft as specified by the civil aeronautic technical specification EUROCAE ED14, and applies correction factors to take into account all parameters necessary for the comparison to the EN 50081-2 such as: quasipeak versus peak measurement, measurement bandwidth, measurement distances, effect of multiple equipment working together, aircraft attenuation.

The second assesses the maximum field radiated by an aircraft based on the field limits which would cause disturbance to the aircraft receivers used for navigation and communication.

The radiated emission values obtained from the two methods are compared to the EN 50081-2 limit and are found to be lower.

To complement the analysis above, measurements on a large civil aircraft are presented that confirm the results of the analysis.

As regards the aircraft conducted emission there is no direct electrical link between the aircraft and the public power supply network. But even if the aircraft power system is analyzed, the conducted emission limit specified by EUROCAE ED14 is lower than the EN 50081-2 limit.

It is then concluded that any aircraft satisfies the EMC EN 50081-2 emission limit with the existing civil standards and procedures.

In Chapter 6 "Aircraft immunity",

the purpose is to describe the Certification Process to demonstrate an aircraft's immunity to the electromagnetic environment. This chapter discusses how this process has evolved, and the definition of the HIRF (High Intensity Radiated Fields) environment and the resulting immunity test procedures.

It concludes by showing that the essential requirements of the EMC Directive for immunity are covered by current aircraft immunity certification requirements.

In chapter 7 "Portable electronic devices",

the existing Joint Aviation Requirement JAR OPS 1.110 which restricts use of portable electronic devices on aircraft, and the similar US aviation regulation FAR 91.21 (Federal Aviation Regulation), are discussed. The key issues are protecting the sensitive aircraft radio receivers and protecting critical aircraft electronic control systems. Studies have been performed in Europe and the US to assess and quantify the electromagnetic effects from portable electronic devices. These studies showed that the risk of radio interference from portable electronic devices exists, but is relatively low. This chapter focuses on the very high assurance required for aviation safety, which results in operational restrictions on the use of portable electronic devices which are not intentional transmitters on board aircraft. This also results in the requirement prohibiting the use of intentional transmitters during aircraft operation. This approach provides high safety assurance, by taking advantage of existing aircraft system protection, existing limits from portable electronic device electromagnetic emissions, and operational restrictions on using portable electronic devices on aircraft, which all contribute to limit potential interference effects from portable electronic devices. The assessment in this chapter shows that the existing aviation regulations adequately address potential interference from portable electronic devices.

Chapter 8 "Conclusions"

addresses the following:

The comparative analysis developed in this report shows that the requirements of the EMC Directive 89/336/EEC are satisfied by the certification requirements and processes for civil aircraft and incorporated equipment.

These certification requirements and processes will be ultimately harmonized by the Council Regulation 3922/91 and its successor. This harmonization process must be encouraged and as far as possible accelerated.

Based on the two above statements, it is recommended to exclude civil aircraft and incorporated equipment from the scope of the EMC Directive, taking the opportunity of the current process of revision of this Directive, to avoid duplicating certification procedures.

Moreover there is no need to establish a standardization programme as proposed by mandate M/282.

All of the procedures, practices and technical specifications associated with aircraft certification and EMC mentioned in this report are under continual review in order to evolve with changes affecting civil aircraft and incorporated equipment.

* * *

TABLE OF CONTENTS

Chapter 1 GENERAL

1.1 Aviation Safety Principles

The purpose of this chapter is to describe the principles for Aviation Safety and to present the international context (ICAO).

Aviation and specifically aviation safety have been right from the beginning highly regulated. This may be explained as follows:

- Flying is not a natural activity for mankind. Public confidence in that mode of transport must be established.

Aviation is also a powerful weapon of war. There are numerous examples in the past of bombers and transport airplanes developed from the same design.

- Sovereignty of States over their airspace is a fundamental principle.

Some regulations were written even before World War One (WWI), when aviation was still basically a sport.

The development of Air Transport after WWI led to the signature of the first Convention for Air Navigation in 1919. (CINA: Conference Internationale de la Navigation Aerienne). Also most of the western countries set up Authorities and developed detailed regulations in the mid twenties.

The basic principle regulating the safety of one flight can be expressed as follows:

An aircraft is only allowed to fly if it has been designed, manufactured, operated and maintained in accordance with relevant regulation and if its crew is also qualified in accordance with relevant regulations. Such principle is usually incorporated in high level regulations. It is also necessary to develop safety regulations for Air Transport Infrastructure (airports, navigation aids) and for Air Navigation Services.

The required level of safety depends on size, complexity and kind of operation of the aircraft. Kind of operation means for example Commercial Air Transportation; Aerial Work, Private Aviation… The highest level of safety is required for large aircraft operated in Commercial Air Transportation. Less stringent level of safety is required for small private aircraft.

This difference between public and private use exists also in other modes of transportation.

It should be well understood that aviation safety is a shared responsibility between Authorities, Operators, Manufacturers, Crews…. The Authorities are responsible for Aviation Safety Regulations (i.e. developing, adopting, and enforcing regulations); the others have the primary responsible to comply with Aviation Safety Regulations.

Due to this shared responsibility, development of Aviation Safety Regulations should involve interested parties (manufacturers, operators, crews, maintenance organisations….).”

Lessons learned from experience is a very important element of aviation safety. Accidents and serious incidents are analysed by independent investigation boards with the objective to define the causes and propose safety recommendations. These recommendations, together with the information obtained through incident reporting systems (mandatory and voluntary) are used to improve requirements

Historically the purpose of aviation safety regulations was to protect people on the ground. Due to the development of Commercial Air Transportation and social legislation, the purpose is now to protect people on the ground, crews and passengers.

1.2 International Civil Aviation Organisation

Aviation is international by nature, especially in Europe. Therefore international conventions were developed in the 1920s (CINA; Warsaw Convention…).

In 1944, in view that international relations will re-start after the war, the Chicago Convention was signed. Its purpose is as follows:

The "governments agreed on certain principles and arrangements in order that international civil aviation may be developed in a safe and orderly manner and that international air transport services may be established on the bases of equality of opportunity and operated soundly and economically".

The Convention established the International Civil Aviation Organisation (ICAO). This Convention which comprises around 100 articles has now been signed by more than 180 countries.

The Convention establishes that states have complete and exclusive sovereignty over their airspace (art. 1).

The Convention also establishes in its article 5 the right of non-scheduled flights (make flight into or in transit non-stop and stop for technical purposes).

Article 6 describes how scheduled services may be allowed.

Article 7 gives the right to states to refuse cabotage.

Article 5 to 7 address what is known as the five freedoms.

Article 33 requires States to recognise as valid licenses, Certificates of Airworthiness that have been issued in accordance to requirements that are equal or above the minimum standards defined in the Convention.

The minimum standards of Article 33 are defined in Article 37. Article 37 states that States undertake to co-operate to ensure the highest practicable degree of uniformity in *inter alia* regulations. To achieve this, Article 37 envisages that ICAO will adopt and amend international standards and recommended practices. These international standards and recommended practices are included in ICAO Annexes.

There are 18 annexes among which Annex 1 (licensing), Annex 6 (operations); Annex 8 (airworthiness)

As indicated in Article 33, national requirements may not be less stringent than the international standards.

National requirements may of course include the recommended practices. ICAO however allows states to notify differences (in particular when the national requirements are less stringent than the international standards) but in that case other states are not obliged to recognise licenses, Certificates of Airworthiness…

In the context of this document, it is useful to describe in more details Annex 8 "Airworthiness":

- Part I Definitions
- Part II Administration
- Part III Aeroplanes
- Part IV Helicopters

States can only issue a Certificate of Airworthiness for which it intends to claim recognition in accordance to Article 33 if the certificate is based on detailed airworthiness requirements complying with those included in Part III or IV. JAR-25 (see below) is one example of detailed airworthiness requirements.

If the design features of the aircraft render any of the standards of Part III or IV not applicable, the State may consider variations providing an equivalent level of safety. These variations are the Special Conditions of JAR-21 (see below).

The proof of compliance with appropriate airworthiness requirements is the Certificate of Airworthiness.

The State of Registry (i.e. where the aircraft is registered) shall adopt requirements to ensure the continued airworthiness of the aircraft during its service life. The continuing airworthiness of the aircraft is determined by the State of Registry.

However there is a special role of the State of Design (i.e. the state having jurisdiction on the organisation responsible for the Type Design).

The State of Design shall inform other States of any information found necessary for the continuing airworthiness of the aircraft. These include the Airworthiness Directives of JAR-21 (see below).

Other States should adopt or assess such information.

In order that the necessary data is available, States of Registry and States of Design shall ensure that systems exist for reporting, collecting and evaluating incidents.

Part III and IV contain objective standards such as Flight, Structures, Design and Construction, Equipment…. which will also be found in detailed airworthiness requirements.

This chapter has described the principles for Aviation Safety and has given a broad overview of the ICAO Convention and in particular of its Annex 8.

Chapter 2 CERTIFICATION REQUIREMENTS

The purpose of this Chapter is to describe certification requirements (procedural and technical) using as examples JAR-21 and JAR-25. This chapter will also given an overview of the JAA System.

JAR-21 defines the certification process for aircraft and related products and parts. It defines administrative and procedural requirements to obtain for example Type Certificates.

JAR-25 defines technical requirements to obtain a Type Certificate for Large Aeroplanes.

The principles used in these two JARs can also be found in other Airworthiness Codes.

2.1 The Joint Aviation Authorities (JAA)

The Joint Aviation Authorities (JAA) are a co-operative body for Aviation Safety of 33 Member Authorities, 13 of which being Candidate Members.

JAA are an associated body of the European Civil Aviation Conference (ECAC). ECAC membership is a prerequisite to JAA membership. All European Union Member States are also members of JAA.

The JAA remit relates to the following:

- Design and Manufacture, Operation and Maintenance of civil Aircraft and related products and parts,
- Licensing of flight crews,
- Noise and emissions of aircraft and engines.

The JAA operate under two fundamental documents:

- The JAA Arrangements of 1990 (or Cyprus Arrangements): These Arrangements, signed at the level of Member Authorities, envisage technical co-operation but does not envisage transfer of legal responsibilities, In particular, through the Arrangements, Member Authorities are committed to adopt, as soon as possible, the structure of JARs as their sole codes.
- EU Regulation 3922/91 relative to technical harmonisation in the field of Aviation: This Regulation strengthens the commitments of Member Authorities but for 15 of them only. In particular, when a JAR is adopted by the European Union, then this JAR becomes automatically the sole code for these 15 Authorities.

The JAA overall objective can be summed up as follows:

- Ensure a high consistent level of safety within its members,
- Set up a cost effective Aviation Safety System to avoid undue burden for the Aviation Industry.
- Contribute to free circulation of products, persons and services,
- Promote the JAA System world-wide.

More specifically the JAA have recently adopted an aim for safety which reads:

The JAA aim at continuously improving its effective Aviation Safety System in order to reduce the number of accidents and the number of fatalities irrespective of the growth of Air Traffic.

Under this objective and aim, the JAA have three main functions:

- Develop, Adopt and Maintain Joint Aviation Requirements (JARs),
- Jointly Implement these JARs and develop, adopt and maintain Joint Implementation Procedures (JIPs) to that effect.
- Standardise (i.e. ensure that JARs are implemented in a consistent manner) implementation of JARs within their Member Authorities.

The JAA have adopted 27 JARs; 60 aircraft and related products have been certified/validated in accordance with JIPs; 3000 Maintenance Organisations in Europe and World-wide have been approved/accepted in accordance with JAR-145 (Approval of Maintenance Organisations). These activities have led to significant co-operation with the European Commission, the US Federal Aviation Administration, EUROCONTROL, EUROCAE, CEN/CENELEC/ETSI and SAE (Society of Automotive Engineers (USA)).

However, the JAA have reached their limits. It should be replaced by a Community EASA (European Aviation Safety Authority/Agency).

2.2 Certification procedures for aircraft and related products and parts (JAR-21)

2.2.1 Definitions

Airworthy:

An aircraft is airworthy when it conforms with an approved design and is in condition for safe operations.

Certification:

The Authority performs two actions:

Technical findings: check compliance with regulations

Legal findings: issue of certificates, approval or licenses.

Products:

JAR-21 defines as products only aircraft, engines and propellers.

2.2.2 Purpose and applicability of JAR-21

JAR-21 prescribes procedural requirements for the issue of Type Certificates (TC) and changes to TC, the issue of standard Certificates of Airworthiness (C of A) and the issue of export airworthiness approvals .

It also describes procedural requirements for the approval of certain parts and appliances.

It also describes rules governing the holders of Certificates or Approvals mentioned above.

These procedural requirements and rules are applicable to products and parts designed in JAA countries and to products and parts designed in non-JAA countries.

JAR-21 defines procedural requirements for approval of organisation (Design and Production Approvals), however these are applicable only to organisation under the jurisdiction of JAA countries.

In other words JAR-21 will be applicable to the design and manufacture industry as a whole.

It was developed step by step starting by future JAA products and parts, then adding future non-JAA products and parts and finally adding already nationally certificated products and parts (JAA and non-JAA). Ultimately future products and parts and all existing products and parts will be covered by JAR-21.

Non-JAA products and parts are addressed in JAR-21 Subpart N which is a self contained “JAR-21” for such products and parts.

2.2.3 General Principles of JAR-21

JAR-21 recognises the central role of the Type Certificate holder (i.e. Airbus Industries for Airbus products, Boeing Company for Boeing products). This role could be summed up as acting as a “good father” for the products.

JAR-21 introduces a concept of mandatory approvals for organisations under the jurisdiction of JAA states.

Organisations approvals are consistently used within the JAA System.

The rationale for organisation approvals is to ensure that such organisations have the expertise and competence to perform their job. Organisation approvals also reduce the risk of human errors as such errors may be induced by company culture.

To simplify an organisation approval addresses the following:

- Personnel requirements: they should be trained and qualified. Some specific post holders may be required.
- Requirements for procedures.
- Requirements for facilities and tools.

Requirements for a quality system: It should ensure that procedures are constantly reviewed and improved through audits.

JAR-21 contains two organisation approvals:

- Design Organisation Approval (DOA).
- Production Organisation Approval (POA).

Both grant privileges to their holders.

JAR-21 brings a consistent approach to the activities under its scope. For example, it envisages links between design and production organisations. Another example is that production requirements are identical be it for products or parts.

Finally JAR-21 is compatible with JAA single technical investigation procedures (see Chapter 3).

2.2.4 Design of aircraft and related products

2.2.4.1 Type Certificates

JAR-21 Subparts B and NB define the condition to obtain a Type Certificate.

The issue of a Type Certificate requires that the product complies with its applicable requirements and that, for JAA applicants only, a Design Organisation Approval has been obtained (acceptable alternatives must be found for non-JAA applicants) and the applicant will be able to discharge its responsibilities.

Therefore the TC is based both on technical and administrative conditions.

The applicable requirements can be summed up as follows:

- the applicable JAR at the date of application (i.e. JAR-25 for Large Aeroplanes, JAR-29 for Large Rotorcraft) and
- any necessary special conditions.

It should be noted that an applicant may always elect to comply to later requirements (i.e. later than the date of application).

Special Conditions are used when the design contains novel features or envisage unusual operations compared to those on which the JAR is based.

Special Conditions can also be notified when experience with comparable design shows that unsafe conditions can exist. For example, Special Conditions are raised for EMC.

The requirements contained in the Special Condition should ensure that an equivalent level of safety to the one of the applicable JAR is met.

Compliance with applicable requirements can be met literally or using equivalent safety finding procedures.

In the latter case, requirements are not met literally but compensating factors are found.

To sum-up, applicable requirements are the applicable JAR modified by any Special Condition or elect to comply and compliance may be found either literally or through equivalent safety finding procedures.

As JARs are detailed requirements based on a certain state of the art, this allows for controlled flexibility to accommodate new technologies.

It should be noted that Design Organisation Approvals are not required for simple design (e.g. Sailplanes, 4-seater Touring Aeroplanes….)

Two responsibilities of the TC holder should be highlighted:

- the set up of a system to collect, analyse incidents and propose corrective actions.
- the development of manuals for continuing airworthiness.

2.2.4.2 Changes to Type Certificates

Today these are two categories of changes to TC in JAR-21 (minor and major changes). In a very near future there will be four categories: minor, major non-significant, major significant and substantial.

Minor changes are changes which have no appreciable effect on weight, balance, structural strength, reliability, operational characteristics or other characteristics affecting the airworthiness of the product.

Minor changes may be proposed by any person or organisation.

The applicable requirements are the ones of the original TC.

Minor changes are either approved directly by the Authority or by an approved Design Organisation.

JAR-21 Subparts D and ND address minor changes.

Major changes are all other changes not classified as minor.

Major changes can be subdivided in:

non-significant

significant

A change that meets one of the following criteria is automatically considered significant:

- general configuration or principles of construction of the product to be changed do not remain valid
- assumptions used for the certification of the product to be changed do not remain valid.

Major changes may be proposed by the TC holders using Subpart D or ND procedures or by Supplemental Type Certificate Holders using Subpart E or NE procedures.

The applicable requirements for major non-significant are the ones for the original TC.

The applicable requirements for major significant are the ones at the time of application of the change except for non affected parts and areas and except for affected parts and areas, when the applicant can show that compliance with requirements applicable at the date of application do not contribute materially to safety or is impractical.

Applicable requirements for major-significant changes are defined by a top down approach.

Major changes are approved by the Authority.

Substantial changes are changes in design, configuration, power, limitations, or weigh that are so extensive that a substantially complete investigation of compliance with applicable requirements is required. This means a new Type Certificate and this is addressed by JAR-21 Subpart B and NB.

Supplemental Type Certificates are addressed by Subpart E and NE.

JAA applicants must have a design organisation approval (except for simple design).

Acceptable alternatives must be found for non-JAA applicants.

A link may be required between the STC holder and the TC holder.

Responsibilities of STC holders are broadly comparable to those of TC holders.

2.2.5 Production of Aircraft and Related Products

A certificate of Airworthiness should be issued for aircraft by the Authority (see Subpart H and NH of JAR-21).

All other products and parts receive an Airworthiness Release document issued usually by an approved production organisation. (see Subpart K and NK of JAR-21).

JAA organisations should receive a Production Organisation Approval (POA) in accordance to JAR-21 Subpart G. For non-JAA organisations, acceptable alternatives to POA should be found.

POA have the privilege to obtain a C of A from the Authority without further showing and to issue Airworthiness Release certificates without further showing.

A link is required between production organisations and design organisations. POA is the "normal" way to produce products and parts for JAA organisations. However, in some specific cases such as production of a limited number of aircraft, production may be done without a POA (see JAR-21 Subpart F). There are no privileges in Subpart F.

2.2.6 Design and Production of Parts

Subpart K and Subpart NK of JAR-21 envisages only four routes to approve parts:

- In conjunction with Type Certification or with change to Type Certificates procedures.
- Where applicable, under the JTSO authorisation procedures of Subparts O or NO of JAR-21.
- Where applicable under the Joint parts Approvals procedures of Subpart P of JAR-21. For non-JAA parts, acceptable alternatives must be found.
- In the case of standards parts (e.g. nuts, bolts,…), in accordance with established industry (e.g. CEN, SAE…) or Government Specifications.

JTSOs are Joint Technical Standard Orders. Such authorisations can be issued for equipment such as radio transmitters, life-vests, altimeters, airborne collision avoidance systems… There is no definitive criteria to define eligible equipment. JTSO is an approval of the design of equipment and a Production Approval (POA) for its manufacturers.

For some equipment for which the specification contains qualitative design requirements of significance to airworthiness, a DOA is required for its designer. Today only Auxiliary Power Units (APUs) are included in that category.

JTSO specification can be found in JAR-TSO. This JAR-TSO can be described as a catalogue of specifications.

Joint Part Approval is also an approval of the design of the part and a Production Approval (POA) for its manufacturers.

JPA is applicable to replacement parts and to modification parts. However in the case of a modification part (i.e. the design of the part has been changed when for a replacement part there is no design change), the change must be a minor change.

The difference between JTSO and JPA is that a JTSO authorisation is independent from the aircraft the equipment will be installed on whereas a JPA is linked to a specific product type.

2.2.7 Design and Production of repairs to Aircraft and Related Products and Parts

JAR-21 requirements (Subpart M) needs to be finalised, however the general principle should be:

- The design of a repair must be approved.
- The production of the material needed for a repair must be done in an approved manner.
- The installation of a repair must be done by an approved organisation.

2.2.8 Export of Aircraft and Related Products and Parts

The Authority issues an Export Certificate for an Aircraft (see JAR-21 Subpart L). Other products and parts except standard parts receive an authorised Release Certificate issued usually by an POA.

2.2.9 Import of Aircraft and Related products and parts

In order to maximise the use of the non-JAA Authority airworthiness system and to ensure equal treatment with JAA Products and Parts, JAR-21 introduces a concept of an "arrangement" with that non-JAA Authority which will enable the JAA to find acceptable alternatives to the procedures used for JAA products.

As mentioned in para 2.1.2 requirements applicable to imported Product and Parts are included in a Subpart N which is a self contained JAR-21 modified to introduce the concept of arrangement.

2.3. Technical Airworthiness Codes

Such codes exist for Very Light Aeroplanes (JAR-VLA); for Sailplanes and powered Sailplanes (JAR-22); for Large Aeroplanes (JAR-25); for small Rotorcraft (JAR-27); for large Rotorcraft (JAR-29); for Engines (JAR-E); for Propellers (JAR-P); for Auxiliary Power Units (JAR-APU) and for Equipment (JAR-TSO).

The structures of such codes are different between aircraft and engines/propellers/

APUs/equipment.

The structure which is presented below is relevant to airworthiness codes for aircraft:

- Performances (e.g. climb gradients one engine inoperative) and handling qualities (e.g. static and dynamic stability, control forces…).
- Structure (gusts envelope, manoeuvres envelope, fatigue requirements)
- Design and Construction (e.g. emergency evacuation provisions; fire protection…)
- Powerplant Installation (e.g. uncontained powerplant failure, fuel and oil system requirements)
- Systems and Equipment (e.g. systems safety analyses; requirements for electrical, hydraulic and pneumatic systems; required equipment for flight and navigation)
- Manuals and limitations (e.g. speed limitations, flight manual, continued airworthiness manual…).

The requirements usually prevent unsafe conditions (e.g. performance requirements with one engine inoperative). However some have been written to limit the consequences of such unsafe conditions (e.g. emergency evacuation provisions to allow passengers escaping after a minor crash).

Requirements may be performance oriented (e.g. there must be an inverse relationship between the probability of a failure and its consequences) or may impose design constraints (e.g. number and types of emergency exist versus number of passengers).

2.4 Relations with other requirements

Aircraft certification is only the starting point for safety.

As described in Chapter 1 para 1.1 aircraft operation and maintenance are also regulated. Flight crew must obtain licenses.

Today JARs only regulate Commercial Transportation (JAR-OPS 1 and 3). Commercial Air Transportation Operators receive an organisation approval (the AOC: Air Operator Certificate).

JAR-OPS Subpart M describes the responsibilities of AOC holders in terms of maintenance.

Maintenance for Commercial Air Transportation must be performed by approved maintenance organisations (JAR-145).

The AOC holders aeroplane maintenance programme is based on the one developed by the aircraft designer and must be approved by the Authority.

AOC holders shall ensure the airworthiness of the aeroplane and the serviceability of both operational and emergency equipment. This includes:

- Accomplishment of pre-flight equipment.
- Rectifications of defects and damages.
- Accomplishments maintenance in accordance with the approved aeroplane maintenance programme.
- Analysis of the effectiveness of the above programme.
- Accomplishment of Airworthiness Directives.
- Accomplishment of modifications.

The AOC holder shall ensure that the Certificate of Airworthiness of each aeroplane its operates remains valid.

This Chapter has described JAR-21, has outlined the procedural requirements to obtain Type Certificated an Changes to Type Certificates. It has also given an overview of the approval of parts and equipment, in particular JTSOs and JPAs. Production requirements have also be addressed. The situation on Repairs, Import and Expert has also been briefly addressed.

The Chapter has also described JAR-25, in particular its various subparts. The Chapter has ended by a description of the relations with other JARs such as Operations and Maintenance JARs.

Chapter 3 TYPE CERTIFICATION PROCESS

The purpose of this Chapter is to describe the Aircraft Type Certification Process. It concentrate on Type Certification for clarity purposes and also because the description of the process is valid for all States. it also provide3s a comparison with the EU global approach to conformity assessment.

3.1 The Aviation Type Certification Process

Aircraft Type Certification covers two distinct elements:

- Technical findings that the aircraft complies with the technical requirements. There are four phases in this process. Technical findings are done by Authority employees or by people or organisation nominated by the Authority.
- Legal findings which are the end of the Type Certification process and consist in the issue by the Authority of the appropriate Type Certificate

The 4 phases of the technical findings can be summed up as follows:

- the definition of an the agreement on the Type Certification Basis 9see para 2.2.4a: The applicable requirements),
- the definition and the agreement on the proposed means of compliance with the requirements. means of compliance can be flight or ground tests; analysis inspections, etc.
- the demonstration of compliance by the applicant (e.g. Airbus, Boeing, etc) and the acceptance of the demonstration by the Authority,
- the final phase (final report), issue of Type Certificate.

The JAA Joint Implementation Procedures ensures that technical findings are only done once to the satisfaction of its 33 member Authorities which in turn issue their legal findings (33 Type Certificates).

There are two JAA Joint Implementation Procedures:

- Joint Multinational Team Procedure
- Joint Local Team Procedures.

The first one is used for complex products (e.g. large aeroplanes; large rotorcraft) A multinational team is set up to do the technical findings. The second one is used for simpler products (e.g. sailplanes; small rotorcraft). A team made of employees of one JAA Authority do the technical findings. This Authority must be a-priori agreed by the JAA as a Primary Certificating Authority following an investigation of its resources, procedures, experience, etc. these two approaches have been agreed for pragmatic reasons taking into account complexity of the product, technical competence and resources of Authorities and the burden put on Industry.

3.2 Comparison with the EU global approach to conformity assessment

3.2.1 The new approach to directives (Main Principles)

In this new approach, directives only notify <u>essential requirements for safety</u> (or other requirements in the general interest) with which products put on the market should conform and therefore benefit of free circulation.

The drawing up of <u>technical specifications</u> necessary to ensure conformity to the essential requirements is entrusted to <u>organisations competent in the standardisation area</u> (e.g. CEN, CENELEC, ETSI).

These technical requirements are <u>not mandatory.</u> National Authorities are obliged to recognize that <u>products conformity to these technical specifications are presumed to conform</u> with the essential requirements.

Two conditions are needed for the operation of such system:

- The technical specification offer a guarantee of quality with regard to the “essential requirements”
- Public authorities keep intact their responsibilities for safety.

3.2.2 Main elements to be included in a Directive

These main elements are:

- Scope
- General clause for placing on the market
- Essential requirements
- Free movement clause
- Means of proof of conformity and effects
- Management of the list of standards
- Safeguard clause
- Means of attestation of conformity; although the general idea is that manufacturers be offered a wide range of means, the choice may be limited (even removed) according to the nature of products and hazards covered by the Directive
- Standing Committee
- Tasks and operation of the Committee

Note: 3.2.1 and 3.2.2 are largely inspired by the text of the annex II to council resolution of 7 May 1989 on a new approach to technical harmonisation and standards.

3.2.3 Conformity assessment procedures in the Technical Harmonisation Directives (general guidelines)

The objective of conformity assessment procedures is to enable authorities to ensure that products placed on the marked conform to the requirements expressed in Directives, in particular with regard to health and safety.

Conformity assessment procedures can be divided in modules which relate to design and/or production.

Both design and production should be assessed.

The range of choices open to manufacturers should be as wide as possible and at the same time remain compatible with the level of safety required for the product.

Member states will notify bodies for the purpose of operating the modules (Notified bodies). Notified bodies must have the technical qualification required by the directives.

3.2.4 Modules for conformity assessment

These modules are:

1) internal production control;

2) EC type examination;

3) conformity to type;

4) production quality assurance;

5) product verification;

6) product quality assurance;

7) unit verification;

8) full quality assurance.

1, 7, and 8 cover both design and production.

3, 4, 5, and 6 are normally related to production and should be used in conjunction with 2, al though for the product of very simple design and production can be used on their own.

4, 5, and 8 requires quality systems from the manufacturer.

3.2.5 Comparison between Aircraft Type Certification and EU modules

3.2.5.1 EC Type Examination is quite comparable to the Aircraft Type Certification for simple products.

In the EC Type Examination the manufacturer submit to the notified body.

– Technical documentation

– Type

The notified body:

– Ascertain conformity with essential requirements

– Carries out tests if necessary

– Issues EC Type-examination certificate

In the aviation system, the authority plays the role of the notified body. However it ascertains conformity with detailed airworthiness codes.

3.2.5.2 Full Quality Assurance

In this module both design and production are covered.

Relative to design, the manufacturer operates an approved quality system for design; the notified body carries out the surveillance of the quality system and in specific directives verifies the conformity of design and issues EC design examination certificates.

This is quite comparable to the issue of a Type Certificate to a manufacturer holding a Design Organisation Approval (DOA contain a quality system). The Authority plays the role of the notified body.

Relative to production, the manufacturer operates an approved quality system for production and testing, declares conformity, affixes the CE marking, the Notified body carries out the surveillance of the Quality System. This is quite comparable to the Aviation System (POA = Production Organisation Approval). The POA holder can obtain without further showing the certificate of airworthiness for aircraft and can issue directly the Airworthiness Release document for other products. The Authority plays the role of the notified body.

Note: The comparison made here is also valid for the module “production quality assurance”.

Note: Paragraph 3.2.3 and 3.2.5 are largely inspired from the text of the annex to council decision of 13 Dec. 1990 concerning the modules for the various phases of the conformity assessments procedures which are intended to be used in the technical harmonisation directives.

Chapter 4 AIRCRAFT OPERATIONS AND EMC REQUIREMENTS

4.1 Aircraft considered as a specific environment

According to articles 4 and 7 of the EMC Directive (89/336/EEC), demonstration that the EMC essential requirements have been met can be achieved by the application of harmonised standards. The generic standards recognise two types of environments: “residential, commercial and light industrial” and “industrial”, used in most harmonised product standards. It is important to recognise that aircraft cannot be associated with any of these generic environments and must be considered as a specific environment. Indeed the two main drivers in aircraft design are the flight safety for all aircraft operation types and its suitability to serve the requirements of the air transport industry (e.g. the quality of service at the passenger level).

Therefore, as a matter of priority, all choices in aircraft design and production as well as avionics equipment selection and integration focus on safety: This is the major objective of the aircraft certification exercise. Nevertheless the other issues that could be qualified “commercial” are also contributing at a high level in aircraft design and aircraft avionics integration in order to satisfy the air transport industry commercial requirements.

For these main reasons the individual liberty for the passenger must be constrained on board aircraft by the two objectives presented above (e.g. no usage of portable electronics devices during critical phases of flight). So the aircraft environment is by definition a very strictly controlled one that takes into account all the limitations and restrictions imposed to fulfil the objectives described above.

It is essential to recognise this fact in order to understand the justification of the rationale that will be presented in chapters 5 and 6. Furthermore to complement these inherent restrictions justified by the objectives above aircraft operations are also strictly controlled through civil aviation regulations like the Rules of Air described in Annex 2 of the ICAO Chicago Convention. In particular all aircraft must respect the altitude restriction to protect the habitation area according to their size (e.g. overflying a small city is restricted to a minimum height of 150 meters). These minimum separations distances must be used when assessing the impact of aircraft emissions on aircraft’s external environment for the appropriate phases of flight in chapter 5.

4.2 The aircraft operations and the associated phases of flight

In this section we discuss the operational phases of aircraft operations and identify the potential issues regarding the conformity with the EMC Directive.

There are considered to be three distinct phases of operation for fixed wing aircraft, associated with;

i) Phase1, aircraft at parking or taxiing on the ground, within the boundaries of the airport,

ii) Phase 2, landing and takeoff, in which the airport boundary is crossed at low altitude,

iii) Phase 3, high altitude flight, outside the airport boundary.

4.2.1 Ground Operations

During this phase, involving the aircraft either at its parking place (gate or open parking) or taxiing within the airport boundary, the issues associated with the EMC performance of the aircraft must be considered in relation to the airport RF environment itself.

4.2.1.1 Parked aircraft

When the aircraft is parked, a number of activities could take place in the close vicinity of the aircraft. However since the aircraft is designed and tested to meet a very severe immunity requirement, aircraft immunity during this phase operations is not considered a problem with respect to the EMC Directive immunity requirements (see **Chapter 6** on the aircraft immunity**)**.

Concerning emission, the minimum distance that could separate the aircraft from those equipment or installation that are directly involved in the aircraft handling could be less than the 30 meters value that has been taken as the reference value to compare the aeronautical technical specifications fixing emission limits with the EMC standards (EN 50081-2). But in this case the harmonised coexistence of the aircraft and its supportive system and services is managed under airport management rules according to which every operator accept the constraints generated by the others without a real impact on those activities. For the others systems or installations that are more associated to wider business or industrial activities the separation distances are always larger than 30 meters, distance for which the analysis and comparison have been made (see chapter 5).

4.2.1.2 Taxiing aircraft

While taxiing the aircraft comes within proximity of other equipment and the issues of immunity and emissions must be addressed. For the same reason than expressed above the immunity aspects are well covered by the applicable regulations.

Concerning emissions during this phase of flight, due to the clearance that are applicable to protect the aircraft from collision with obstacles or other vehicles, the separation distance is much larger than 30 meters, therefore the comparison of the requirements compared at 30 meters represents a virtual case while in the reality the separation distance is usually above 50 meters.

4.2.3 Take off and final landing Phase Operations

During this phase, the aircraft crosses the airport boundary fence and passes through the RF energy generated by the airport deliberate transmitters and the background ambient environment due to the inadvertent from the airport and civil equipment in the surrounding area (i.e. housing estates, factories etc.).

The airport environment associated with its deliberate transmitters is used extensively to derive the Immunity Environment for aircraft during landing and taking off and this is explained in detail in Chapter 6 on this document. This environment is extremely hostile and more severe than the Generic Immunity levels called up by **EN 50082-2,** as explained above. Consequently, the immunity requirement is well covered in the certification process of any aircraft (see chapter 6).

Concerning the emissions aspects it must be noted that during this phase of flight the minimum distance separation between the aircraft and other system or users is fixed by international ICAO rules and these distances are usually greater than 100 meters for safety reasons (the installation or users are considered as obstacles. Therefore the comparison conducted in chapter 5 being based on a minimum separation of 30 meters is very conservative one that provide in real world a significant margin.

4.2.4 Navigation Phase Operations

During this phase, the aircraft is operating at altitudes well away from other civil equipment and this is not considered an area of operation that comes within the requirements of the EMC Directive.

Proximity to other flying aircraft is addressed in the derivation of the EMC environment for immunity levels.

Since aircraft move around the world the immunity environment has taken account of 500, 000 transmitters world-wide, that it is likely to encounter.

4.3 The different classes of aircraft and their technical Airworthiness codes.

This section is describing the various aircraft classes and their associated airworthiness codes. Furthermore, this section is providing the essential requirements contained in these respective airworthiness codes that are covering EMC matters. They are dealing with the certification process itself, the documentation called up in support of this process and the control of EMC during development.

4.3.1 Aircraft classification (with equivalent FAR title where appropriate)

4.3.1.1 JAR 22 Sailplanes and powered sailplanes

This JAR-22 prescribes minimum airworthiness standards for the issue of type certificates, and changes to those certificates, for sailplanes and powered sailplanes in the utility U and aerobatics A categories:-

Sailplanes the maximum weight of which does not exceed 750 kg;

(1) Single engined (spark or compression ignition) powered sailplanes the design value W/b^2 (weight to $span^2$) of which is not greater than 3 (W[kg], b[m]) and the maximum weight of which does not exceed 850 kg; and

(2) Sailplanes and powered sailplanes the number of occupants of which does not exceed two.

4.3.1.2 JAR 23 Normal, Utility, Aerobatics and Commuter category Aeroplanes

(Equivalent FAR part 23 - Normal, Utility, Acrobatic and Commuter category Airplanes)

This code prescribes airworthiness standards for the issue of type certificates, and changes to those certificates, for:-

(1) Aeroplanes in the normal, utility and aerobatic categories that have a seating configuration, excluding the pilot seat(s), of nine or fewer and a maximum certificated take-off weight of 5670 kg (12,500 lb) or less; and

(2) Propeller -driven twin engined aeroplanes in the commuter category that have a seating configuration, excluding the pilot seat(s), of nineteen or fewer and a maximum certificated take-off weight of 8618 kg (19,000 lb) or less

4.3.1.3 JAR 25 Large Aeroplanes

(Equivalent FAR part 25 - Transport Category Airplanes)

This code prescribes airworthiness standards for the issue of type certificates, and changes to those certificates, for Large Turbine-powered Aeroplanes.

4.3.1.4 JAR 27 Small Rotorcraft

(Equivalent FAR part 27 - Normal Category Rotorcraft)

This code prescribes airworthiness standards for the issue of type certificates, and changes to those certificates, for small rotorcraft with maximum weights of 2730 kg (6000 pounds) or less.

4.3.1.5 JAR 29 Large Rotorcraft

(Equivalent FAR part 29 - Transport Category Rotorcraft)

This code prescribes airworthiness standards for the issue of type certificates, and changes to those certificates, for large rotorcraft.

Note: This JAR-29 is subdivided into category A and B, dependant on number passengers (nine or less passengers or ten or more passengers) and also weight (greater than 9072 kg [20,000 pounds] or less than 9072 kg [20,000 pounds].

4.3.1.6 JAR-VLA Very Light Aeroplanes

This JAR-VLA prescribes airworthiness standards for issuance of a type certificate, and changes to that type certificate, for an aeroplane with a single engine (spark- or compression-ignition) having not more than two seats, with a Maximum Certificated Take-off Weight of not more than 750 kg and a stalling speed in the landing configuration of not more than 45 knots (CAS). The approval to be for day-VFR only

4.3.2 Airworthiness Codes with EMC implications

The following is a list of the JAR codes with EMC implications for the part 22, 23, 25, 27, 29 and VLA aircraft. Equivalent FARs contain the same general requirements. Where the JAR code quoted is an extract of the relevant this is highlighted.

Note: That the HIRF requirements eg JAR 23.1317, 25.1317, 27.1317 and 29.1317 have not yet formally incorporated into relevant JARs (or equivalent FARs). Advisory material is available and aircraft have been certificated using special conditions and in accordance with an interim policy.

4.3.2.1 JAR 22 Sub part F Equipment (General)

JAR 22.1301 Function and Installation

Each item of required equipment must:

(1) be of a kind and design appropriate to its intended function;

(2) be labelled as to its identification, function, or operating limitations, or any applicable combination of these factors;

(3) be installed according to limitations specified for that equipment; and

(4) function properly when installed.

Instruments and other equipment may not in themselves, or by their effect upon the sailplane, constitute a hazard to safe operation.

4.3.2.2 JAR 23 Sub part F Equipment (General)

JAR 23.1301 Function and Installation

Each item of installed equipment must:

(1) be of a kind and design appropriate to its intended function;

(2) be labelled as to its identification, function or operating limitations, or any applicable combination of these factors;

(3) be installed according to limitations specified for that equipment;

Function properly when installed.

JAR 23.1309 - Equipment, Systems And Installations (extract)

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

4.3.2.3 JAR 25 Sub part F Equipment

JAR 25.1301 Function and installation

Each item of installed equipment must:

(1) be of a kind and design appropriate to its intended function;

(2) be labelled as to its identification, function, or operating limitations, or any applicable combination of these factors. (See ACJ 25.1301(b).)

(3) be installed according to limitations specified for that equipment; and

(4) function properly when installed.

JAR 25.1309 Equipment, systems and installations (extract)

The equipment, systems, and installations whose functioning is required by the JAR and national operating regulations must be designed to ensure that they perform their intended functions1 under any foreseeable operating conditions. (See AMJ 25.1309 and ACJ No. 2 to JAR 25.1309.). However, systems used for non-essential services need only comply so far as is necessary to ensure that the installations are neither a source of danger in themselves nor liable to prejudice the proper functioning of any essential service.

In showing compliance with sub-paragraphs (a) and (b) of this paragraph with regard to system and equipment design and installation, critical environmental conditions including vibration and acceleration loads, handling by personnel and where appropriate fluid pressure effects, must be considered. For power generation, distribution and utilisation equipment required by or used for certification, the ability to provide continuous safe service under foreseeable environmental conditions may be shown by environmental tests, design analysis or reference to previous comparable service experience on other aeroplanes.

JAR 25.1353 Electrical equipment and installations (extract)

Electrical 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 electrical unit or system essential to the safe operation. Any electrical interference likely to be present in the aeroplane must not result in hazardous effects upon the aeroplane or its systems except under extremely remote conditions. (See ACJ 25.1353 (a).)

JAR 25.1431 Electronic equipment

In showing compliance with JAR 25.1309 (a) and (b) with respect to radio and electronic equipment and their installations, critical environmental conditions must be considered.

Radio and electronic equipment must be supplied with power under the requirements of JAR 25.1355 (c).

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 JAR-25.

(d) Electronic equipment must be designed and installed such that it does not cause essential loads to become inoperative, as a result of electrical power supply transients or transients from other causes.

JAR 25X899 Electrical Bonding and Protection Against Lightning and Static Electricity

(see also ACJ 25X899)

The electrical bonding and protection against lightning and static electricity systems must be such as to:

(1) protect the aeroplane, including its systems and equipment, against the dangerous effects of lightning discharges.

(2) prevent dangerous accumulation of electro-static charge.

(3) minimise the risk of electrical shock to crew, passengers and servicing personnel and also to maintenance personnel using normal precautions, from the electricity supply and distribution system.

(4) provide an adequate electrical return path under both normal and fault conditions, on aeroplanes having earthed electrical systems.

Reduce to an acceptable level interference from these sources with the functioning of essential electrically-powered or signalled services. (See also JAR 25.1351 (b) (4) and JAR 1431 (c).

JAR 25.581 Lightning Protection

(a) The aeroplane must be protected against catastrophic effects from lightning. (See JAR 25X899 and ACJ 25.581.).

(b) For metallic components, compliance with sub-paragraph (a) of this paragraph may be shown by:

  (1) bonding the components properly to the airframe, or

  (2) designing the components so that a strike will not endanger the aeroplane.

(c) For non-metallic components, compliance with sub-paragraph (a) of this paragraph may be shown by:

  (1) designing the components to minimise the effect of a strike, or

  (2) incorporating acceptable means of divert the resulting electrical current so as not to endanger the aeroplane.

JAR 25.953 Fuel System Lightning Protection

The fuel system must be designed and arranged to prevent the ignition of fuel vapour within the system (see ACJ 25.954) by:

(a) direct lightning strikes to areas having a high probability of stroke attachment.

(b) swept lightning strokes to areas where swept strokes are highly probably.

(c) corona and streamering at fuel vent outlets.

Draft JAR 25.1317 High Intensity Radiated Fields (HIRF) Protection (see AC-XXX/AMJ-XXX)

(a) The aircraft systems, equipment and installations considered separately and in relation to other systems must be designed and installed so that:

  (1) each function, whose failure may prevent the continued safe flight and landing of the aircraft, is not adversely affected when the aircraft is exposed to the Certification HIRF environment as defined in AC-XXX/AMJ-XXX. After the aircraft is exposed to the Certification HIRF environment, each affected system that performs these functions automatically recovers normal operation unless this conflicts with other operational or functional requirements of that system.

  (2) each system that performs a function whose failure may prevent the continued safe flight and landing of the aircraft is not adversely affected when the aeroplane is exposed to the Normal

HIRF environment, as defined in AC-XXX/AMJ-XXX.

(3) each system that performs a function, whose failure may cause large reductions in the capability of the aircraft or the ability of the crew to cope with adverse operating conditions, is not adversely affected when the equipment is exposed to a equipment level test as defined in AC-XXX/AMJ-XXX.

(4) each system that performs a function, whose failure may reduce the capability of the aircraft or the ability of the crew to cope with adverse operating conditions is not adversely affected when the equipment providing these functions is tested as defined in AC-XXX/AMJ-XXX.

While this standard is in draft the requirements of HIRF are taken account of through the raising of “special conditions”, for each aircraft type.

4.3.2.4 JAR 27 Subpart F - Equipment

JAR 27.1301 Function and installation

Each item of installed equipment must:

(1) be of a kind and design appropriate to its intended function;

(2) be labelled as to its identification, function, or operating limitations, or any applicable combination of these factors;

(3) be installed according to limitations specified for that equipment; and

(4) function properly when installed.

JAR 27.1309 Equipment, systems, and installations

The equipment, systems, and installations [whose functioning is required by this JAR-27] must be designed and installed to ensure that they perform their intended functions under any foreseeable operating condition.

The equipment, systems, and installations of a multi-engine rotorcraft must be designed to prevent hazards to the rotorcraft in the event of a probable malfunction or failure.

The equipment, systems, and installations of single-engine rotorcraft must be designed to minimise hazards to the rotorcraft in the event of a probable malfunction or failure.

4.3.2.5 JAR 29 Subpart F - Equipment

JAR 29.1301 Function and Installation

Each item of installed equipment must:

(1) be of a kind and design appropriate to its intended function;

(2) be labelled as to its identification, function, or operating limitations, or any applicable combination of these factors;

(3) be installed according to limitations specified for that equipment; and

(4) function properly when installed.

JAR 29.1309 Equipment, Systems, and Installations (extract)

The equipment, systems, and installations whose functioning is required by this JAR-29 must be designed and installed to ensure that they perform their intended functions under any foreseeable operating condition.

In showing compliance with sub-paragraphs (a) and (b) of this paragraph with regard to the electrical system and to equipment design and installation, critical environmental conditions must be considered. For electrical generation, distribution and utilisation equipment [required by or used in complying with this JAR-29, except equipment covered by Joint Technical] Standard Orders containing environmental test procedures, the ability to provide continuous, safe service under foreseeable environmental conditions may be shown by environmental tests, design analysis, or reference to previous comparable service experience on other aircraft.

JAR 29.1353 Electrical Equipment and Installations (extract)

Electrical 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 electrical unit or system essential to safe operation.

JAR 29.1431 Electronic Equipment

Radio communication and navigation installations must be free from hazards in themselves, in their method of operation, and in their effects on other components, under any critical environmental conditions.

Radio communication and navigation 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 any applicable JAR or operating rule.

4.3.2.6 JAR-VLA Subpart F -- Equipment - General

JAR-VLA 1301 - Function And Installation

Each item of installed equipment must:

(1) be of a kind and design appropriate to its intended function;

(2) be labelled as to its identification, function, or operating limitations, or any applicable combination of these factors;

(3) be installed according to limitations specified for that equipment; and

(4) function properly when installed.

JAR-VLA 1309 - Equipment, Systems, And Installations

The equipment, systems, and installations must be designed to minimise hazards to the aeroplane in the event of a probable malfunction or failure.

JAR-VLA 1431 - Electronic Equipment

Electronic equipment and installations must be free from hazards in themselves, in their method of operation, and in their effects on other components.

4.3.3 Other Supporting EMC Documents.

A AC/AMJ 20.1317

The Advisory Circular/Advisory Material Joint AC/AMJ 20.1317 addresses the certification of Aircraft Electrical Systems in the High Intensity Radiated Fields (HIRF) environment. It provides additional information in support of the JAR 25.1317. In section 3 it identifies those sections of the JAR standards which underpin the application of EMC requirements throughout development.

The AC/AMJ addresses the following areas:

i) The Purpose, Scope and Background,

ii) Approaches to Compliance for HIRF,

iii) Major Elements of Compliance Verification,

iv) Maintenance, Quality Control, Repair and Modification,

v) The External HIRF Environment.

B The AC/AMJ 20.1317 User Guide

The AC/AMJ 20.1317 document is supported by an extensive and detailed, "User Guide for AC/AMJ 20.1317", written by the Electromagnetic Environment Hazard Working Group committee of ARAC.

The document addresses in detail:

i) The HIRF environment,

ii) Practical Design Considerations for HIRF,

iii) Approaches to Compliance with HIRF requirements,

iv) Demonstration of Compliance with HIRF requirements for:

  a) control functions Level A (catastrophic)

  b) display functions Level A (catastrophic)

  c) all functions at Level B (hazardous/severe major)

v) Maintenance, Repair and Modifications of HIRF performance.

C EUROCAE ED-14D (RTCA DO-160D).

"Environmental Conditions and Test Procedures for Airborne Equipment".

Sections described below, which address the EMC requirements for aircraft, are called up in the AC/AMJ 20.1317 and the User Guide. They describe detailed test EMC requirements and test methods for each of the phenomena listed:

i) section 15, "Magnetic Effect",

ii) section 16, "Power Input",

iii) section 17, "Voltage Spike",

iv) section 18, "Audio Frequency Conducted Susceptibility-Power Inputs",

v) section 19, "Induced Signal Susceptibility",

vi) section 20, "Radio Frequency Susceptibility (Radiated and Conducted)",

vii) section 21, "Emission of Radio Frequency Energy",

viii) section 22, "Lightning Induced Transient Susceptibility",

ix) section 23, "Lightning Direct effects",

x) section 25, "Electrostatic Discharge".

Where distinctions are necessary for the type of aircraft (e.g. rotor craft), these are contained in the standard.

D EUROCAE ED-81

"Certification of Aircraft Electrical/Electronic Systems for the Indirect Effects of Lightning". This document was produced by the EUROCAE WG-31 and the SAE Committee AE4L and addresses the following aspects of Indirect Lightning Effects:

i) Purpose/Scope,

ii) Related Information,

iii) Approaches to Compliance,

iv) Effects of Induced Transients,

v) Margins and Verification Methods,

vi) Major Elements of Compliance,

vii) Maintenance and Surveillance.

This document also makes reference to the following documents:

- Section 1309 of FAR/JAR Parts 23, 25, 27 and 29;
- Section 22 of DO-160C/ED-14C, change notice 2;
- ACJ 29.610, "Lightning and Static Electricity Protection (Interpretative Material and Acceptable Means of Compliance);
- JAR 27.610 and JAR 29.610.

4.4 Airport environment

Airports are composed of a large variety of environments with significant differences according to their size, level of traffic and degree of peripheral activities (typically large airports are more and more a high concentration of various industrial activities linked to a certain degree with the multi-modal dimension of transport). Whilst small airports could easily be classified as equivalent to the industrial environment, a number of medium size and large airports are not realistically assimilated to such a typical environment.

It must be noted that one of the objectives of the EMC Directive is to provide a friendly environment through the mutual respect of all participants. This is de facto governing the airport general management on the basis that the main mission of an airport is to be an interface of exchange of passengers and goods using the air transportation (in the last twenty years airports have evolved from this basic function to a much more broader function covering a large range of industrial and services activities). So the airport environment is governed by the need to secure its core business activity that is air traffic handling.

Airports could be considered as a controlled specific environment. A survey of an airport's typical EMC environment has been made in the frame of the activity on High Intensity Radiated Fields (HIRF) (see Chapter 6). This exhaustive and intensive survey provides the input to define a typical airport environment that would be used in the analysis of the scenario presented in this chapter.

Measurements on some airports have been performed in order to characterise the typical RF spectrum that can be expected on a large airport. These measurements have been used in the identification of the principle sources of RF interference that could be found on an airport in the context of the HIRF activities.

The airport electromagnetic environment is generated by the various communication, navigation and radar transmitters based at the airport or in the surrounding area. During the discussions between EUROCAE and SAE defining the HIRF requirements for civil aircraft, the airport environment had to be defined. The resulting environment is an estimate of the electromagnetic field strength level in the airspace on and about airports/heliports in which routine departure and arrival operations take place. This estimate considers the operational characteristics of the high peak power microwave transmitters, which typically do not operate continuously at the maximum output power levels.

Chapter 5 AIRCRAFT EMISSIONS

This chapter focuses on emission, both conducted and radiated.

Section 5.1 describes the historical and technical reasons that have lead the aircraft certification authorities to address the Electromagnetic Compatibility issues during the aircraft certification process.

Section 5.2 describes how the Electromagnetic Compatibility of an aircraft is achieved in the current certification process.

Section 5.3 provides a comparison between:

- the emissions limits of the electrical/electronic equipment of an aircraft based upon EUROCAE/RTCA standards and the emissions limits of the aircraft itself considered as a single apparatus,
- and the limits of EN 50081-2 (Generic Emission limits for the industrial environment).

Section 5.4 provides a first conclusion on technical compliance of the aircraft certification process with the EMC directive objectives regarding emissions.

5.1 History of requirements

The first EMC (or as they were then known “Radio Interference”) specifications applicable to aircraft were published by the military in the early 1940’s. These early EMC specifications were designed to protect radio communication equipment from the impact of on-board electrically generated interference from such items as the electrical power system. These early specifications were designed to measure the emissions from equipment only and the test consisted of placing a long wire antenna inside the length of the aircraft fuselage and measuring the induced voltage. These early specifications contained no limits and no susceptibility tests.

With the advent of sensitive semiconductor based avionics equipment, the vulnerability of these avionics systems to EM fields generated from the on-board communication and radar transmitters became of concern and susceptibility tests were incorporated into the standards. The US military in 1950 published the first conventional EMC Standard: MIL-I-6181. This standard contained both emission and susceptibility testing and limits. The emission limits were based on in-flight measurements made on internal aircraft environments and the threshold of existing receiver sensitivities. In Europe similar military standards were published and a series of in-flight measurements were undertaken by the UK to validate these emission limits.
The first US civil aircraft equipment environmental standard was published in June 1968 as an RTCA document (DO138). This document contained both emissions and susceptibility EMC requirements.

The first European civil aircraft equipment environmental specification was published in 1975 as a EUROCAE document (“Environmental Conditions and Test Procedures for Airborne Electronic /Electrical Equipment and Instruments”). It was produced in conjunction with the US committee RTCA SC123 and took into account work being undertaken by ISO/TC 20/SC1 & SC5. This document contained both emissions and susceptibility test requirements tailored to the on-board environment. In 1975, the US published similar requirements in the first issue of RTCA DO160 which superseded DO138.

In Europe, in January 1980, EUROCAE published a new document which also covered these aspects (ED14A). A word for word identical document was published in the USA by RTCA SC135 known as DO160A. Since then these documents have been regularly simultaneously updated. The emission limits were adapted to take into account improved receiver sensitivities and changes in the nature of the interference being generated by new onboard electronic systems using digital technology. In the last revision of DO160/ED14 (Revision D), the emission limits were reduced by 10dB in the aircraft’s receiver bands to provide additional protection for new generation avionics radio and navigation systems. Both DO 160 and ED14 have been maintained to the present time to be word for word identical.

In addition to these requirements placed on equipment emission contained in DO160/ED14, careful control of the equipment installation in the aircraft has to be undertaken to ensure that there is no desensitisation problems with the onboard receivers. Consequently, care has to be taken with the location of equipment, aircraft antennas and cable bundle runs. The final aircraft installation is subject to a customer acceptance test by energising all onboard systems.

5.2 Certification procedures rationale

5.2.1 Introduction.

The certification procedures for controlling the aircraft emissions use the following steps:

a) identification of applicable requirements from the regulatory side and from airframe manufacturers directives,

b) demonstration of compliance to these requirements through tests performed at equipment/system level, followed by interoperability tests on first installation on the aircraft.

These two steps are described in the following sections.

5.2.2 Applicable requirements

The applicable requirements, covering emissions, are extracted from:

a) the regulatory codes described in Section 5.2.2.1 “Airworthiness requirements”

b) the airframe manufacturer directives described in Section 5.2.2.2 “Design requirements”

5.2.2.1 Airworthiness Requirements

JARs, and the equivalent FARs, require control of EMC between aircraft systems and ensure suitable for use in the intended operating environment. The detailed requirements regarding emissions are contained in the various JAR codes (JAR 22, 23, 25, 27, 29 and VLA), as described in section 4.3.3.

5.2.2.2 Design Requirements

The JARs are primarily driven by safety considerations. Aircraft manufacturers apply these requirements to the electrical/electronic equipment fitted to the aircraft.

However, manufacturers apply additional internal directives that improve the internal EMC performance of an aircraft. This requires the following:

a) by selecting the EMC emissions specification to be applied to all equipment to be installed in the aircraft.

   Emission measurements have to be in accordance with EUROCAE ED14 procedures and the emission limits selected from the categories identified in ED 14. The appropriate category is selected by considering the equipment position and utilisation in the aircraft.

   When no existing category is really suitable, manufacturers may define a specific one (generally based on ED-14/DO-160 methods but with possible additional requirements or lower emission limits) or military standards (e.g. MIL-STD-461), where appropriate.

   This results in a specific contractual requirement for each piece of equipment.

b) by considering all the issues associated with the installation of the equipment in the aircraft**.**

   Based on past experience and state of the art knowledge, the aircraft manufacturer and equipment manufacturer specifies requirements, procedures and any mitigation to ensure that the equipment is installed correctly. For example, due account is taken to ensure equipment does not emit above a level that would cause interference to radio receiving equipment (e.g. navigation and communication systems).

5.2.3 Tests

To demonstrate compliance with the appropriate JARs and design requirements the following two steps are taken:

a) Equipment/system qualification tests

Emissions tests are carried out, typically using DO160/ED14 Chapter 21 (or other agreed specifications as noted in 5.2.2), based on the selected categories.

b) Aircraft interoperability tests

To ensure equipment installed correctly on the aircraft, whole aircraft interoperability EMC tests are carried out, generally on the first such installation, to ensure inter-system EMC, typically as follows:

GROUND TESTS

Tests are conducted with the aircraft engines running, and with all electrical equipment operating (those that are usually operated on the ground).

All radio and navigation equipment should be operated over their full range of operating frequencies to establish that the level of interference does not affect the performance of any other system.

FLIGHT TESTS

Tests are conducted with all electrical equipment operating (those that are usually operated in flight).

All radio and navigation equipment should be operated over a limited number of frequencies (due to operational limitations) to establish that the level of interference does not affect the performance of any other system.

5.3 Comparison of aircraft electromagnetic emission characteristics with EN 50081-2

5.3.1 Objective

The objective of this section is to compare the electromagnetic emission characteristics of an aircraft (levels and frequency bands) with those specified in the EN 50081-2 “Generic Emission limits for the industrial environment”. This EN has been selected to support the comparison considering that its levels are the most stringent among the EN used in industrial environment to demonstrate compliance with the EMC Directive.

This generic emission standard generalises the limits existing in the product family standards EN 55011 and EN 55022.

The two following sections (5.3.2 “Aircraft radiated emissions” and 5.3.3 “Aircraft conducted emissions”) make an assessment of the level of radiated and conducted emissions from the aircraft and compare these levels to the EN levels.

5.3.2 Aircraft radiated emissions

5.3.2.1 Method of analysis

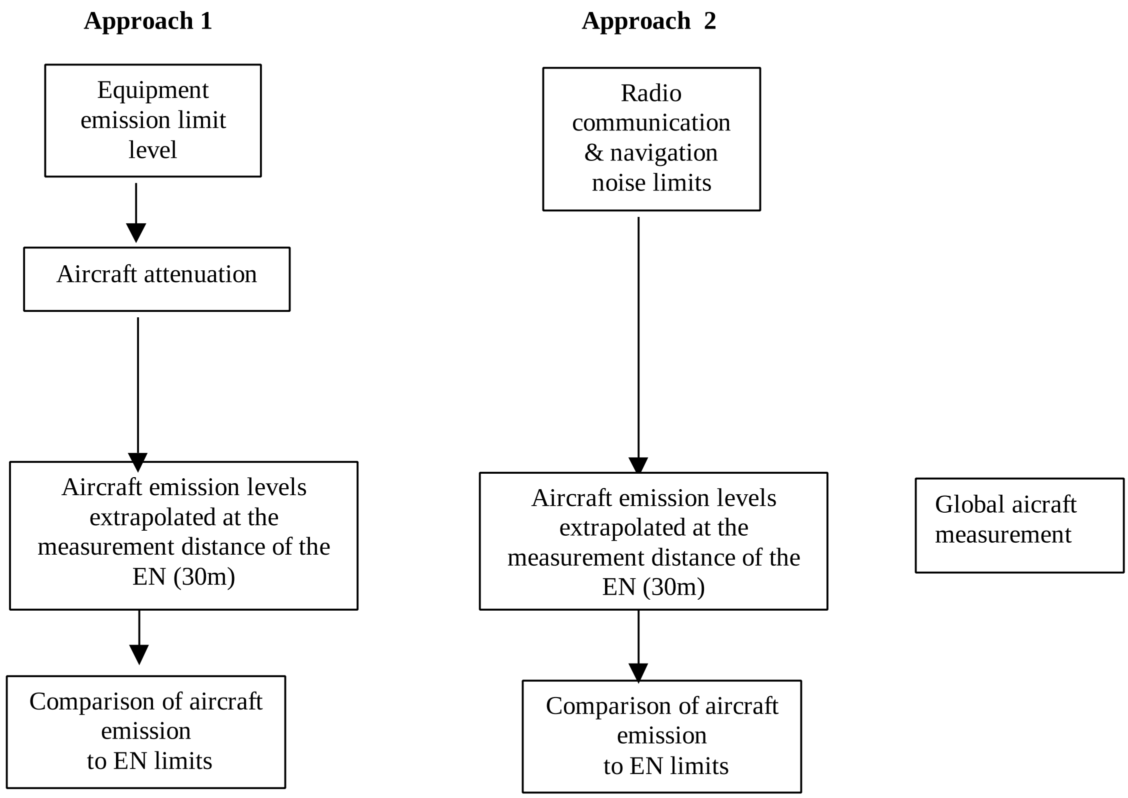
The intent of this section is to give values (order of magnitude) of the electromagnetic field that can be radiated from an aircraft and then to make comparison with the EN by taking account of correction factors where appropriate (see section 5.3.2.2.2).

This comparison with the EN is using two complementary approaches:

- a comparison of the emission levels quoted in aeronautical technical specifications,
- a comparison of emission levels derived from the susceptibility characteristics of some safety critical receivers.

The reason that leads to this twofold comparison is that the first comparison method, approach 1, is not precise enough. Therefore approach 2, is necessary to support the basic comparison using a completely independent approach.

In addition practical radiated emission measurements are presented in section 5.3.2.4 to support this demonstration.



5.3.2.2 Approach 1: Direct comparison of radiated emission levels from equipment specification with EN limits

5.3.2.2.1 Equipment specifications identification

5.3.2.2.1.1 EUROCAE ED14 specification

ED 14 introduces several equipment categories that correspond to the equipment location and/or criticality of operation. The existing categories (as contained in section 21 of ED14D) are:

<u>Category B</u>

This category is intended primarily for equipment where interference should be controlled to tolerable levels.

Category L

This category is defined for equipment and interconnected wiring located in areas far from apertures of the aircraft (such as windows) and far from radio receiver's antenna. This category may be suitable for equipment and associated interconnecting wiring located in the electronics bay of an aircraft.

Category M

This category is defined for equipment and interconnected wiring located in areas where apertures are em significant and not directly in view of radio receiver's antenna. This category may be suitable for equipment and associated interconnecting wiring located in the passenger cabin or in the cockpit of a transport aircraft.

Category H

This category is defined for equipment located in areas which are in direct view of radio receiver's antenna. This category is typically applicable for equipment located outside the aircraft.

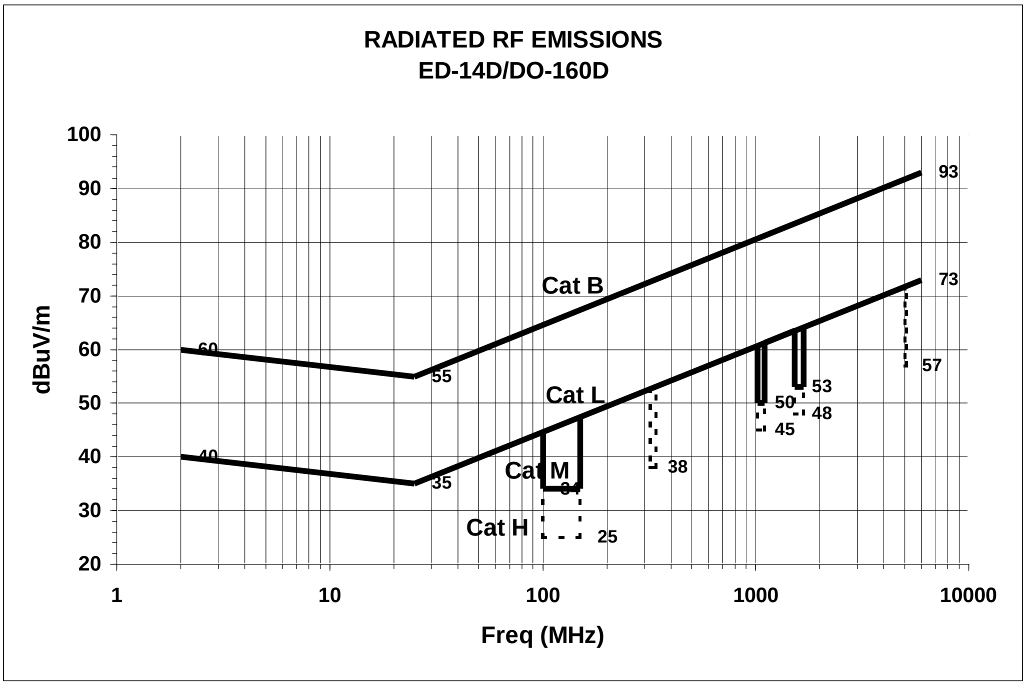
Note: Older versions of ED-14 identified other categories (A and Z). An equivalence could be derived between these old categories and the current ones.

Frequency ranges (MHz)	ED-14D Sec. 21 Cat. L (Used where interference free operation is required)	ED-14D Sec. 21 Cat. B (Used where interference can be controlled/tolerated)	ED-14D Sec. 21 Cat. M (For equipment in cockpit and cabin)	ED-14D Sec. 21 Cat. H (For equipment with no aircraft attenuation)
30 - 41	36	56	36	36
41 - 68	38	58	38	38
68 - 88	41	61	41	41
88 - 100	43	63	43	43
100 - 150	**43**	**63**	**34**	**25**
150 - 174	43	63	43	43
174 - 216	49	69	49	49
216 - 230	50	70	50	50
230 - 300	51	71	51	51
300 - 310	51	71	51	51
310 - 330	51	71	51	38
330 - 470	51	71	51	51
470 - 760	56	76	56	56
760 - 960	60	80	60	60
960 - 1000	62	82	62	62

Table 1/5

Emission limits (Levels given in dB µV/m measured at 1 meter)

The following figure is the graphical presentation of table 1/5



5.3.2.2.1.2 European Norm EN 50081-2

The Radiated Emission limits specified in this EN are described in the following table.

EN 50081-2 - Radiated emissions (quasi-peak)

frequency bands	Measured at 30 metres distance
30 - 230 MHz	30 dB µV/m
230 MHz - 1 GHz	37 dB µV/m

Table 2/5

5.3.2.2.2 Correction factors to apply before comparison

For radiated emissions both the EN and ED14 use similar test methodology. However measurements are made under different conditions, environments, heights, detectors, rotations, bandwidths and distances. Consequently before a comparison of the various specification limits can be made, correction factors potentially influencing it, need to be defined for the extrapolation process. These are:

- quasi peak versus peak measurements
- differences in measurement bandwidth
- adjustments due to different measurement distances
- effect of multiple equipment working together where each has been tested individually
- attenuation of the aircraft installation

a) quasi peak versus peak measurement

The Quasi Peak detector relaxes the level indication for impulsive, incoherent or low frequency modulated noise by adding a longer time constant than the peak detector. The quasi peak measurement will always be lower than the peak measurement, but, in practice, there is very little measurement difference between Quasi peak and Peak readings for pulse repetition rates above 100Hz. For the purposes of this comparison exercise it is concluded that there would be no significant differences due to the detector types and Peak detection used in ED14 will always give the highest and therefore the worst case result.

b) differences in measurement bandwidth

Any correction factors resulting from the different measurement bandwidths used will only apply to coherent broadband noise whose bandwidth is greater than the measurement bandwidth. As shown in Table 3/5 below, the bandwidths used for testing to the EN standards is virtually the same as ED14 for measurements from 400 MHz to 1 GHz and therefore no allowance is necessary. Below 400 MHz the factor is roughly 10 times from 150KHz to 400MHz.

Frequency Bands	ED14	EN
0.15 - 30MHz	1KHz	9KHz
30 - 400MHz	10KHz	120KHz
400 - 1000MHz	100KHz	120KHz
1000 – 6000MHz	1MHz	1MHz

Table 3/5

In practice, the interference measured in this frequency range could be a mixture of all types, including narrow band, impulsive and broadband noise, with impulsive and broadband noise more likely to be encountered at lower frequencies. Consequently, if the measurement bandwidth is changed by a factor of 10 as shown above the measured level could be affected by a factor between 1 and 10. However considering that narrow band noise is preponderant, no allowance has been made in the extrapolation process for differences in measurement bandwidth.

c) distance of measurements for radiated emission

The main differences on the measurement methods are in the distance required between the tested device and the measurement antenna. The commonly used distances for EN are 30 metres, 10 metres and 3 metres. The ED14 aeronautical standard specifies a distance of 1 metre.

Basically the aeronautical standard ED14, refers to internal electromagnetic compatibility inside an aircraft and furthermore inside an electronic bay. This results in doing emission measurement at 1 metre from the EUT (Equipment Under Test), inside closed anechoic or reverberating chambers with the EUT mounted on a conductive bench which is bonded to the ground plane.

The EN deal with electromagnetic compatibility between several apparatus not necessarily installed in close proximity. These are measured at distances between 3 metres to 30 metres on open area test sites on a non-conductive bench but over a ground plane.

This distance is an important factor as regards the wave impedance of the radiated fields and the coupling between the antenna and the EUT and/or the ground.

When the field source is located far from the measuring antenna, it is possible to consider that the wave impedance would be very close to the free space impedance (120Ω) because the far field conditions are met. Therefore, it is correct to extrapolate the measured field at a given distance to a greater distance by using a proportional law (1/r field evolution where r is the distance between the field source and the observation point).

On the other hand, when the field source is located close to the measurement antenna (with respect to the wavelength), the near field condition applies. The field evolution involves other terms proportional to $1/r^2$ or $1/r^3$. Therefore, the proportional extrapolation gives only an approximation of the correct field value.

The best way to compare the standards is to extrapolate the required levels to the greatest distance value using a simple proportional law. This approach would give more severe values than using a rigorous approach which integrates all the propagation factors ($1/r^2$ and $1/r^3$). There are two main factors that affect this approach:

- Interaction of the EUT with the conductive bench.

Whilst the height at which products are tested to the civil and aeronautical standards is roughly the same, the conductive bench used for the ED14 tests is bonded to the shielded enclosure wall and hence the ground plane reference.

This is not the case in the EN where the EUT is placed on a non conductive bench. The civil set up is likely to give a worst case above, say, 100MHz compared to a ED14 measurement, due to the destructive effects on the radiated field from to the ground plane and shielded enclosure.

- Close proximity of measurement antenna to EUT and ground plane

This effect is known not to follow the proportional law for measurement distances less than 10 metres due to coupling effects between the EUT, measurement, antenna and ground plane. This of course becomes more noticeable as the measurement distance decreases.

For example, moving the measurement distance from 3 metres to 10 metres, on an open area test site, could give measured values at 10 metres anywhere from 3 to 12 dB lower than at 3 metres. The theoretical value assuming1/r law is 10dB. This is due to many different effects, such as height search, EUT size and cable layout. In our experience a figure of 5 to 6dB is more common. This factor should be used instead of the theoretical extrapolation factor when comparing specification limits at 3 metres and 10 metres.

What the total factor might be for extrapolating from 1metre to 10metres or 30metres is difficult to predict with any certainty. However, because some effects give factors in one sense and others in the opposite sense it has been assumed that the 1/r law would be the best compromise when extrapolating from 1 metre to 10 metres or 30 metres for the purpose of this comparison.

d) Emission of an apparatus composed by pieces each of one satisfying the standard

When comparing, the emissions of one piece of electrical equipment which complies with a standard, to the emissions of other compliant apparatus in close proximity the cumulative effects of the emissions of each piece of equipment needs consideration.

This question applies since we are interested in the emission limits from an aircraft but only have the emission limits of each electronic box which is embodied within the aircraft.

It is very unlikely that the emissions of several pieces of equipment together would be at the same frequency and with the same phase (i.e. the probability that the emission is in phase is identical to the probability that the emission is in opposite phase).

The following example shows that there is no strong cumulative effect.

- Radiated emission measurements undertaken inside the electronic bay at 1metre from the rack containing all the electronics of an Airbus A310 show that in the band around 200MHz (limit 49 dBµV/m), a field lower than 50 dB µV/m is experienced. In this band each piece of the electronic equipment emits less than 49 dB µV/m. (see Table 1/5)

It is very unlikely that the emissions of several pieces of equipment together would be at the same frequency and with the same phase (i.e. the probability that the emission is in phase is identical to the probability that the emission is in opposite phase)

e) Attenuation of the aircraft

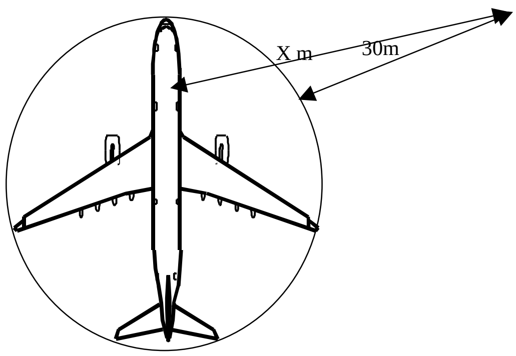
The equipment being installed on the aircraft, some attenuation of the radiated emission field is gained by the aircraft itself; this attenuation is dependant on its location within the aircraft and can vary between the following values:

- 0 dB if the equipment is installed on the skin of the aircraft or close to an electromagnetic aperture,
- 60dB if the equipment is installed inside dedicated enclosure.

For example a typical value of 20dB attenuation is measured for a civil aeroplane

f) Correction factors to be applied

Whilst it is recognised that all of the above factors affect the extrapolation, only the attenuation factors have been applied. The extrapolation to 30 metres uses the 1/r law. Taking account of all factors, this approach is conservative and enables a useful comparison to be made of the emission limit values.



5.3.2.2.3 Direct limits comparison per aircraft types

In order to take into account some attenuation factor caused by the aircraft itself, a segregation has been made between fixed wing aircraft and helicopters.

5.3.2.2.3.1 Fixed wing aircraft

The analysis part by part of the aeroplane shows (ANNEX 2) that the worst case is created by the equipment installed on the skin of the aircraft (ED14 Cat H) or by the equipment installed inside the cabin that does not comply with ED14 Cat M (ED14 Cat B). Generally only equipment compliant with ED14 Cat M are installed in the cabin. A extra attenuation of 12 dB has been used in the extrapolation for equipment associated with ED14 Cat B and M to take into account the effect of the aircraft itself.

The following table compares the levels corresponding to Category M, H and B to the EN levels after extrapolation:

Frequency bands (MHz)	**Aircraft radiated emission extrapolated at 30m applied to ED14 Cat B cabin equipment (peak)**	**Aircraft radiated emission extrapolated at 30m applied to ED14 Cat M cabin equipment (peak)**	**Aircraft radiated emission extrapolated at 30m applied to ED14 Cat H external equipment (peak)**	**EN 50081-2 Radiated emissions (quasi-peak) at 30 m**
30 - 41	*12*	-8	6	30
41 - 68	*14*	-6	8	30
68 - 88	*17*	-3	11	30
88 - 100	*18*	-2	13	30
100 -150	*18*	-8	-5	30
150 - 174	*18*	-2	13	30
174 - 216	*25*	5	19	30
216 - 230	*26*	6	20	30
230 - 300	*27*	7	21	37
300 - 310	*27*	7	21	37
310 - 330	*27*	7	7	37
330 - 470	*27*	7	21	37
470 - 760	*32*	12	26	37
760 - 960	*36*	16	30	37
960 - 1000	*38*	16	32	37

Table 4/5

Levels given in dB µV/m

From this analysis it appears that the fixed wing aircraft radiated emission is always well below the EN limits.

5.3.2.2.3 Helicopters

The electrical/electronic equipment installed on helicopter satisfies the most severe category of ED14 (Cat C or D), and even reinforced emission limit requirements.

The reason for that is that :

- most of the location of avionics on helicopter are very open area (nose, cockpit, cabin partly or fully composite skin)
- helicopters are small aircraft , the proximity of receivers sensor such as radio-communication or navigation antenna make this characteristic a critical one for the success of the system integration.

Typically a usual requirement for helicopter equipment will be Cat H of ED14 and the worst acceptable case would be Cat L of ED14.

Due to the above statement no extra attenuation from the aircraft is used in the extrapolation.

The following table shows the resulting helicopter emission levels and compares them to the EN levels.

Frequency bands (MHz)	**Helicopter radiated emission extrapolated at 30m applied to ED14 Cat L equipment (peak)**	**Helicopter radiated emission extrapolated at 30m applied to ED14 Cat H external equipment (peak)**	**EN 50081-2 Radiated emissions (quasi-peak) at 30 m**
30 - 41	6	6	30
41 - 68	8	8	30
68 - 88	11	11	30
88 - 100	11	11	30
100 - 150	11	-5	30
150 - 174	13	13	30
174 - 216	19	19	30
216 - 230	20	20	30
230 - 300	21	21	37
300 - 310	21	21	37
310 - 330	21	8	37
330 - 470	21	21	37
470 - 760	26	26	37
760 - 960	30	30	37
960 - 1000	32	32	37

Table 5/5

Levels given in dB µV/m

From this analysis it appears that the helicopter radiated emission is always well below the EN limits.

5.3.2.2.4 Conclusion from the first comparison approach

It appears from the analysis undertaken that in most case there is a margin of 10 dB in average of extra protection if compare with the EN limits values. Nevertheless in a limited number of cases this margin could be less down to 0 dB for one of them.

5.3.2.3 Approach 2: Emission limits derived from the susceptibility requirements of the Radio communication and Radio-Navigation systems

5.3.2.3.1 Description of the method

This method determines the maximum radiated emission levels generated within the cabin by any equipment that can be tolerated by the critical receiving equipment (Radio-communication or radio-navigation receivers) on the aircraft.

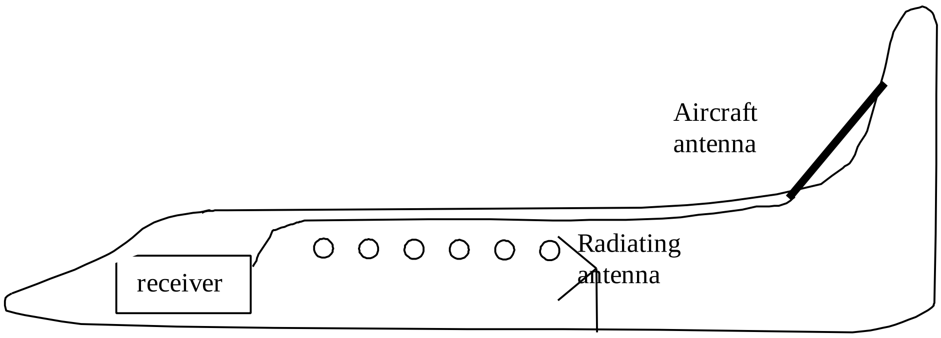
Because it is not acceptable that the aircraft own equipment disturbs the aircraft essential and critical equipment, the limits derived by this method cannot be violated.

These levels derived from the above method have been extrapolated to 30m from the aircraft to be compared to the EN.

This assessment has been done using data experimentally measured on Airbus aeroplane. But the level obtained is only dependant on the antenna/receiver characteristics. Consequently, the resulting levels can be applied to all aircraft types assuming that the Radio-communication or radio-navigation receivers are based on the same technical specifications (e.g. EUROCAE MOPS ED 23).

Description:

0- For several location of the equipment on the aeroplane, the transfer function between the voltage measured at the input of the receivers and the radiated electric field from an equipment in the cabin has been determined. This transfer function is called “path loss transfer function” (Tf). It is expressed in dB µV / V/m. This is described by the figure that follows:



1- For each receiver type (radio-communication or radio-navigation), the sensitivity and the immunity level has been determined.

2- Using the measurement method described above, a table presenting for each equipment locations, the maximum tolerable radiated field has been elaborated. This has been done for several types of aircraft (A320, A330/A340).

3- For each aircraft type a worst case location has been identified.

4- Because the same radiating equipment (not dependent from the aircraft type) could be fitted on the various types of aircraft, the worst case has been selected (the minimum value of the radiated field). As a consequence any radiated field above this value will be prohibited in the certification process in the considered frequency band.

5- This worst case radiated field has been extrapolated at 30m external to the aircraft. A 12 dB attenuation has been taken into account to reflect the attenuation effect of the aircraft (see Annex 2).

5.3.2.3.2 Analysis

The assessment of the allowable field radiated emission of an equipment inside a large aircraft has determined using :

- coupling measurements at aircraft level, using a calibrated field source located inside the airframe, and the antenna port of the receivers ;
- the sensitivity or susceptibility levels of the radio-communication and radio-navigation receivers considered at the antenna port of the receiver in the presence of a desired signal ; these levels have been determined by test.

With the following notations :

T'f : path loss transfer function in V/V/m ;

V's : immunity voltage of the receiver in V ;

E's : field limit for the radiating equipment measured at 1 metre in V/m,

Because, by definition of the path loss transfer, **V's= T'f** x **E's** [Giving V=(V/v/m)*(v/m)] the electric field limit is**:**

E's = V's/T's (1)

Change of unity:

To understand the measurement results which are given in dB the following unity change has been done

Tf is expressed in dB µV / V/m , then **Tf** (dB µV / V/m) = 20 Log**T'f**(V/V/m) + 120;

Vs is expressed in dB µV, then **Vs** (dB µV = 20 Log**V's**(V) + 120 ;

Es is expressed in dB µV/m, then **Es** (dB µV/m) = 20 Log**E's**(V/m) + 120;

From formula (1) it comes:

20 Log**E's**(V/m) = 20 Log**V's**(V) - 20 Log**T'f**(V/V/m)

and from the above unity change:

Es (dB µV/m) **= Vs** (dB µV) **- Tf** (dB µV / V/m) **+ 120**

It is important to notice that no margin has been introduced in these levels to cover some evaluation inaccuracies or some scatter in receiver susceptibility levels.

These limits depend on the frequency range, on the location of the equipment inside the aircraft and on the aircraft type.

The following paragraphs give the measurement/analysis results for each receiver frequency range, for several locations inside the cabin and for two aircraft type.

The concerned system receivers are the following:

The **HF com** is an amplitude modulated receiver in the 2MHz-30MHz band used for audio communication,

The **Marker** is a 75 MHz receiver used to receive on ground beacon emission; tree beacons are located on the longitudinal runway axis,

The **VHF com** is an amplitude modulated receiver in the 118MHz-137MHz band used for audio communion and for some data between the aircraft and the on ground operator base.

The **ILS** as Instrument Landing System receivers (Loc and Glide) are used to receive the emission, in the 108 – 335 MHz band, of dedicated emitters located on the edges of the runway for lateral and vertical guidance for landing.

The **VOR** (VHF Omni-directional Range) is a receiver in the 108 MHz - 118 MHz used to receive the emission of on ground beacons located far from airfield for navigation;

The **DME** (Distance Measuring Equipment) is a receiver in the 962 MHz – 1,212GHz used to receive the emission of on ground beacons located far from airfield for navigation; the system gives an estimate of the distance of the aircraft from the beacon.

The **ATC/TCAS** (Air Traffic Management and Traffic Collision Avoidance System) receiver is the receiving part of the system which receive data from ground and from other aircraft.

The **GPS** is the public Ground Positioning System receiver at 1,575 GHz which receives the emission of the GPS satellite.

The **SAT com** is a satellite receiver in the 1,530 – 1,559 GHz used mainly for communication

Receiver reference immunity level

The immunity level of each receiver has been determined either by test (VHF, ILS, VOR, DME) and/or following the technical specification (ARINC/RTCA requirements). This immunity level has been determined considering the minimum sensitivity level, the minimum ratio signal/noise and the system response to the receiver output.

Receiver	**Frequency band**	**Immunity Level dB µV**	**Means for immunity level assessment**
HF Com.	2 MHz - 30 MHz	6 dB µV	From minimum sensitivity and signal/noise EUROCAE requirement (MOPS)
Marker	75 MHz	32 dB µV	From minimum sensitivity and signal/noise ARINC requirement
VHF Com.	118 MHz - 137 MHz	6 dB µV	From test and from minimum sensitivity and signal/noise EUROCAE requirement (MOPS)
ILS-Loc.	108,1 MHz - 112 MHz	-3 dB µV	From test and from minimum sensitivity and signal/noise RTCA requirement (DO199)
VOR	108 MHz - 118 MHz	-3 dB µV	From test and from minimum sensitivity and signal/noise RTCA requirement (DO199)
ILS-G/S	329 MHz - 335 MHz	8 dB µV	From test and from minimum sensitivity and signal/noise RTCA requirement (DO199)
DME	962 MHz - 1,212 GHz	24 dB µV	From test and from minimum sensitivity and signal/noise RTCA requirement (DO199)
ATC/TCAS	1,090 GHz	27 dB µV	Conservative Immunity Level from system analysis
GPS	1575,42 MHz	-19 dB µV	From ARINC requirement
SAT/COM	1530 MHz - 1559 MHz	12 dB µV	From RTCA requirement (DO210 Part A)

Table 6/5

Operational receiving frequency range, Immunity levels of aircraft radio-communication and radio-navigation receivers

The **Tf** : path loss transfer function (dB µV / V/m) ; is given in the following two tables for both Airbus A330 and A320

Receiving Antenna	**Source antenna location**	**Approx. distance**	**Tf** (µV/V/m)	**Tf** (dB µV/V/m)
Marker	**Door** - Against vertical seam - Worst location	4,5 meters	183	45,2490
Marker	**PAX seat** - Close to the window - Worst location	4 meters	320	50,1029
VHF 1	**Cockpit** - Close to front windshield - Worst location	8 meters	5350	74,5670
VHF 1	**Cockpit** - Pilot work table - Usual location	7,8 meters	1230	61,7981
VHF 3	**Door** - Against vertical seam - Worst location	19,5 meters	6500	76,2582
VHF 1	**Door** - 50 cm from the vertical seam - Usual location	3,5 meters	1650	64,3496
VHF 3	**PAX seat** - Close to the window - Worst location	9 meters	1900	65,575
VHF 3	**PAX seat** - seat table - Usual location	8,8 meters	1000	60
VOR	**Cockpit** - Pilot work table - Usual location	59 meters	115	41,2139
VOR	**Door** - Against vertical seam - Worst location	14 meters	1500	63,5218
VOR	**PAX seat** - Close to the window - Worst location	17 meters	470	53,4419
VOR	**PAX seat** - seat table - Usual location	17 meters	120	41,5836
ILS - Loc	**Cockpit** - Close to front windshield - Worst location	3,5 meters	6000	75,563
ILS - Loc	**Cockpit** - Pilot work table - Usual location	3,5 meters	1650	64,3496
ILS - Loc	**Door** - Against vertical seam - Worst location	6 meters	4050	72,1491
ILS - Loc	**Door** - 50 cm from the vertical seam - Usual location	5 meters	585	55,3431
ILS - Loc	**PAX seat** - Close to the window - Worst location	8,5 meters	620	55,8478
ILS - Loc	**PAX seat** - seat table - Usual location	8,3 meters	190	45,575
ILS - G/S	**Cockpit** - Close to front windshield - Worst location	3,5 meters	3150	69,9662
ILS - G/S	**Cockpit** - Pilot work table - Usual location	3,5 meters	790	57,9525
ILS - G/S	**Door** - Against vertical seam - Worst location	5,5 meters	1650	64,3496
ILS - G/S	**Door** - 50 cm from the vertical seam - Usual location	4,8 meters	920	59,2757
ILS - G/S	**PAX seat** - Close to the window - Worst location	7,5 meters	550	54,8072
ILS - G/S	**PAX seat** - seat table - Usual location	13,5 meters	325	50,2376
DME	**PAX seat** - Close to the window - Worst location	4,8 meters	205	46,2350
DME	**PAX seat** - seat table - Usual location	5 meters	< 150	43,5218
ATC	**Cockpit** - Close to front windshield - Worst location	11,5 meters	245	47,7833
ATC	**PAX seat** - Close to the window - Worst location	4,5 meters	610	55,7065
ATC	**PAX seat** - seat table - Usual location	6,3 meters	< 200	46,0205
TCAS	**PAX seat** - Close to the window - Worst location	5 meters	305	49,6859

Table 7/5

Worst and usual TF evaluated for A330 radio-communication and radio-navigation receivers

Receiving Antenna	**Source antenna location**	**Approx. distance**	**Tf** (µV/V/m)	**Tf** (dB µV/V/m)
Marker	**PAX seat** - Close to the window - Worst location	9 meters	590	55,4170
VHF 1	**Cockpit** - Close to front windshield - Worst location	4,5 meters	4500	73,0642
VHF 1	**Cockpit** - Pilot work table - Usual location	4 meters	4400	72,8690
VHF 3	**Door** - Against vertical seam - Worst location	7,5 meters	6100	75,7065
VHF 1	**Door** - 50 cm from the vertical seam - Usual location	2,5 meters	2700	68,6272
VHF 1	**PAX seat** - Close to the window - Worst location	10,5 meters	4150	72,3609
VHF 1	**PAX seat** - seat table - Usual location	2,5 meters	1400	62,9225
VOR	**Door** - Against vertical seam - Worst location	9 meters	1550	63,806
VOR	**PAX seat** - Close to the window - Worst location	20,25 meters	450	53,0642
VOR	**PAX seat** - seat table - Usual location	10 meters	170	44,6089
ILS - Loc	**Cockpit** - Close to front windshield - Worst location	2 meters	2000	66,0205
ILS - Loc	**Cockpit** - Pilot work table - Usual location	2,5 meters	2200	66,8484
ILS - Loc	**Door** - Against vertical seam - Worst location	4,5 meters	2500	67,9588
ILS - Loc	**Door** - 50 cm from the vertical seam - Usual location	4,5 meters	925	59,3228
ILS - Loc	**PAX seat** - Close to the window - Worst location	8 meters	1125	61,0230
ILS - Loc	**PAX seat** - seat table - Usual location	7 meters	700	56,9019
ILS - G/S	**Cockpit** - Close to front windshield - Worst location	2 meters	2400	67,6042
ILS - G/S	**Cockpit** - Pilot work table - Usual location	2,5 meters	1400	62,9225
ILS - G/S	**Door** - Against vertical seam - Worst location	4,5 meters	1200	61,5836
ILS - G/S	**Door** - 50 cm from the vertical seam - Usual location	4,5 meters	900	59,0848
ILS - G/S	**PAX seat** - Close to the window - Worst location	12,5 meters	2100	66,4443
ILS - G/S	**PAX seat** - seat table - Usual location	7 meters	1100	60,8278
DME	**PAX seat** - Close to the window - Worst location	14 meters	360	51,1260
DME	**PAX seat** - seat table - Usual location	10 meters	< 150	43,5218
ATC	**Cockpit** - Close to front windshield - Worst location	6,5 meters	220	46,8484
ATC	**PAX seat** - Close to the window - Worst location	4 meters	600	55,5630

Table 8/5 :

Worst and usual TF evaluated for A320 radio-communication and radio-navigation receivers

By considering that the same radiating equipment must be compliant with the requirement associated with the various aircraft type, the worst case between the two aircraft family has been taken (minimum radiating level)

To be independant of its location inside the aircraft the equipment must not emit more than the minimum values which is obtained for the greatest Tf

The result is given in the following Table 9/5

Receiver	**Extended Frequency Range**	**Tf A330/340** (dB µV/V/m)	**Tf A320** (dB µV/V/m)	**Tf Max** (dB µV/V/m)	**Vs** (dB µV)	**Es = Vs - Tf + 120** (dB µV/m)
HF Com.	1 MHz - 35 MHz	72,1*	68*	68	6	58
Marker	70 MHz - 80 MHz	50,1	55,4	55,4	32	96,6
VHF Com.	115 MHz - 140 MHz	76,3	75,7	76,3	6	49,7
ILS-Loc.	105 MHz - 115 MHz	72,15	68	72,15	-3	44,85
VOR	105 MHz - 120 MHz	63,5	53,1	63,5	-3	53,5
ILS-G/S	325 MHz - 340 MHz	70	67,6	70	8	58
DME	950 MHz - 1,25 GHz	46,2	51,1	51,1	24	92,9
ATC/TCAS	1,08 GHz - 1,1 GHz	55,7	55,6	55,7	27	91,3
GPS	1,55 GHz - 1,6 GHz	55,7*	55,6*	55,7	-19	45,3
SAT/COM	1,6 GHz - 1,7 GHz	55,7*	55,6*	55,7	12	76,3

* When no measurement of the Tf was done, the value of a very similar antenna for the same frequency band has been selected

Table 9/5

Summary : Maximum path loss transfer Tf Max

Immunity level

Maximum allowed field of an equipment inside the aircraft

5.3.2.3.3 Comparison

The extrapolated limits at 30 metres of the aircraft (32 dB) are compared with the EN limits in the frequency bands that have been analysed. In this extrapolation a correction factor of 12 dB has been selected to take into account the attenuation effect of the aircraft.

The results are presented in a graphical way below

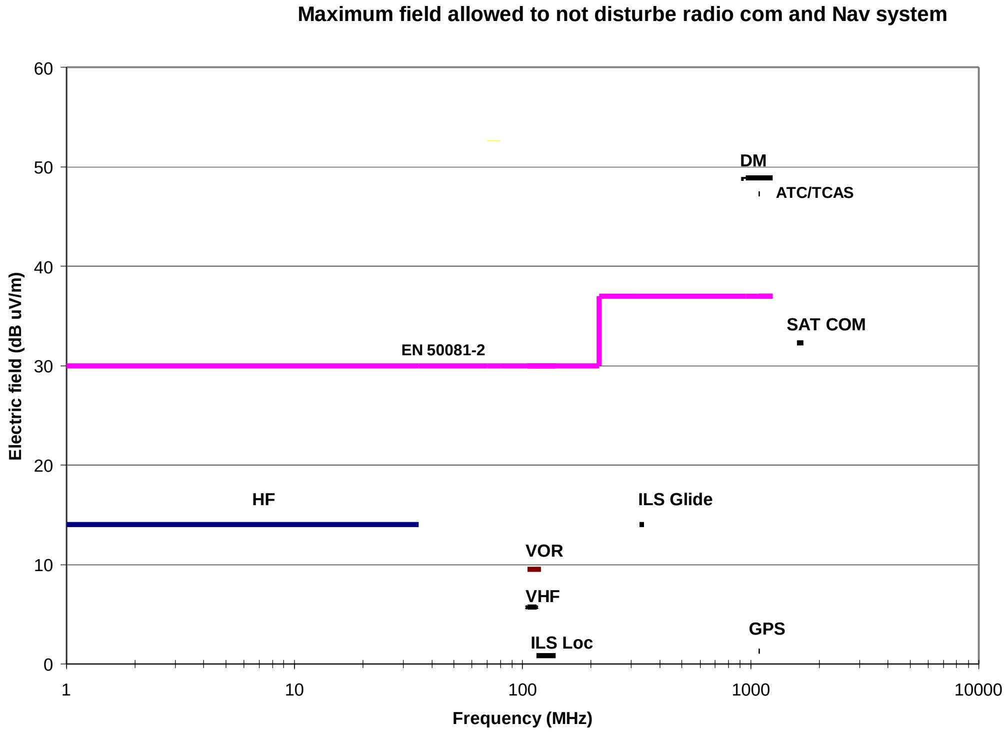


Figure 10/5

5.3.2.3.4 Conclusion of approach 2

The curve presented above indicates that the EN requirements are met with some margin except for the DME and ATC/TCAS. However the lower limits for the GPS and SAT COM would drive the emission limits.

This assessment, limited to the frequency bands associated with the radio-communication and radio-navigation system for which the emission is lower than the EN requirements, confirmed the conclusion of the analysis resulting from approach 1.

The acceptable field levels within the aircraft are driven by the lowest limit because it is not possible to design to control the interference field levels in narrow frequency bands and specific locations.

The above assessment has been done using data resulting from specific measurements on Airbus aircraft. Nevertheless the results and the conclusions could be generalised to other aircraft types due to the fact that the worst case has been selected that relates primarily on the radio-communication and radio-navigation receivers performances that are common to every aircraft (EUROCAE MOPS).

These results could also be applied to helicopters for the same reason.

5.3.2.4 Global Aircraft Radiated Emission Measurements

5.3.2.4.1 Airbus A320 Measurements

Here after some measurements of the global radiated emission of an A320 on ground are reported.

The aircraft was on the Aerospatiale plant at Toulouse. The idea being to get some very rough emission value, no special precautions were taken: no frequency control of the plant, the aircraft was powered by on ground power supply and the engines were not running.

The first configuration (Figure 11/5) is the radiated field emission measured at 1m from the nose of the aircraft at the cockpit windshield height (about 4m).

The second configuration (Figure 12/5) is the same measurement but at 10m from the nose on the axis of the aircraft.

For each of the above configuration two measurements were done:

- one with the aircraft not powered (blue curve on the figures)
- the second with the aircraft powered and all the electrical/electronic systems running (red curve of the figures)

Remark: the measured noise level appears to be different in the two following graphics. This is due to the fact that different measurements bandwidth has been used in the two tests. This does not change the conclusion concerning the maximum values that are narrow band.

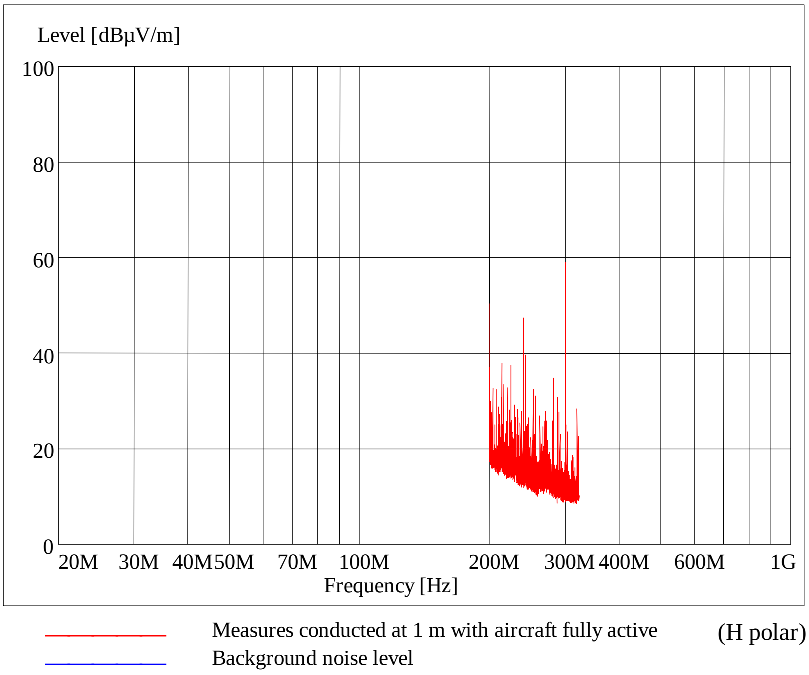


Figure 11/5

Radiated emission at 1m from the nose of the aircraft at the same height than the windshield (4m).

Blue curve : environment of the plant
Red curve : environment of the plant + the aircraft

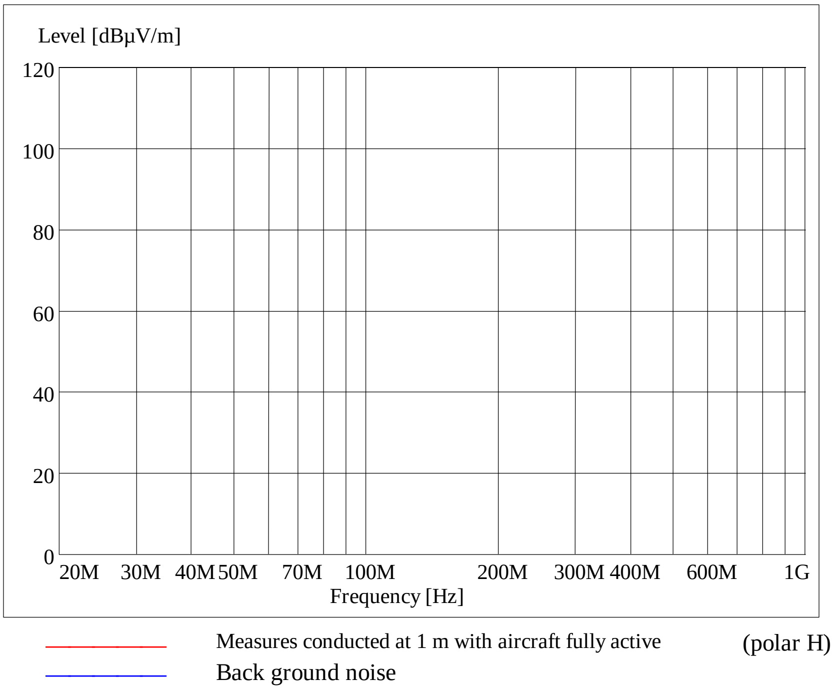


Figure 12/5

Radiated emission at 10m from the nose of the aircraft at the same height than the windshield (4m).

Blue curve : environment of the plant
Red curve : environment of the plant + the aircraft

The following conclusion can be deduced from the curves:

- the emission is characteristic of narrow band emission
- there is no basic identifiable difference between the aircraft powered or not . This clearly shows that the electromagnetic environment of the plant is much higher than the aircraft electromagnetic emission even at one meter from the cockpit.
- At 1m some emission slightly above the noise can be seen between 350 MHz and 400MHz. The level is about 20dB µV/m.
- at some frequencies, for example in the band 87MHz-108MHz the aircraft works as a reflector the external emission being reinforced at 1m if compared with 10m

These measurements, even they are not at all exhaustive, confirm the conclusion derived from the two previous approaches.

5.3.2.5 Radiated emission synthesis

The route 2, which is based on the sensitivity of the radio communication and navigation system, used to asses the radiated emission limit of an aircraft, shows that, in the frequency band of radio communication and navigation system, this limit is below the EN Limit.

The analysis done on the route 1 for some aircraft shows that it is unlikely that outside the radio communication and navigation system frequency band the behaviour of the aircraft would be different.

As a summary of the two routes it can be concluded that an aircraft radiates electromagnetic field lower than the one specified by the EN 50081-2 for industrial environment.

This is confirmed by some measurements of the radiated field of aircraft.

5.3.3 Conducted emission on the power supply

5.3.3.1 EN Conducted emission limits

The EN conducted emission limits are given in EN 50081-2 as per the following table 13/5

Frequency	**Limits**
0,15 – 0,50 MHz	79 dB µV Quasi peak 66 dB µV average
0,50 – 5 MHz	73 dB µV Quasi peak 60 dB µV average
5 MHz – 30 MHz	73 dB µV Quasi peak 60 dB µV average

Table 13/5

EN 50081-2 Conducted emission

5.3.3.2 Comparison between the EN 50081-2 and ED14 conducted emission limits

The only possible electrical link between the aircraft and other external system is, on ground, connection to external power supply.

This power is supplied to the aircraft by fixed or mobile installation. This power supply is providing a 115V/400 Hz current specific for aircraft.

The aircraft is never directly connected to the industrial or public power supply network.

Therefore the conducted emission of an aircraft through this link will have no impact on the external world. It is not an external EMC issue and as such, no extra requirement is needed .

Nevertheless, the comparison between the EN 50081-2 and the ED14 limits is presented in the table below.

Frequency bands (MHz)	**EN 50081-2 Limits**	**ED14 Sec. 21 Supply**
0,15 - 0,5	79 dB µV Quasi peak 66 dB µV average	62 to 56 µV peak narrow band
0,5 - 1,7	73 dB µV Quasi peak 60 dB µV average	56 to 51 µV peak narrow band
1,7 - 5	73 dB µV Quasi peak 60 dB µV average	51 to 46µV peak narrow band
5 - 30	73 dB µV Quasi peak 60 dB µV average	46 µV peak narrow band

Table 14/5

Conducted emission limits

If we consider the aircraft as a single apparatus, all the aircraft electrical equipment could be functioning when the aircraft is plugged to its power supply; every piece of equipment can emit the conducted emission limit specified above.

The limit specified for one equipment is nearly 20dB below the EN 50081-2 limit; then it is very unlikely that the aircraft emits above the EN limit.

In conclusion, although the aircraft is never directly connected to the industrial and public power network because all its electrical equipment must be powered by 115V/400Hz, the above comparison shows that it is very unlikely that the aircraft emits above the EN 50081-2 limit.

5.4 Conclusion

The analysis conducted in this section aiming to compare the emission limits (conducted and radiated) that typically associated with an aircraft considered as a single apparatus with the emission limits specified in the EN 50081-2, indicates that, with realistic assumptions, an aircraft considered as a single apparatus, emits lower conducted and radiated emissions than the limits specified by EN 50081-2.

Chapter 6 AIRCRAFT IMMUNITY

In the certification process, the immunity requirement is the most important aspect for the overall EMC of the aircraft. The reason for this is because of the safety implication inherent with the increasing use of electronics in flight safety critical areas such as flight and engine control.

The levels and test procedures have been developed by the responsible international aerospace committees to ensure safe flight and landing. These levels have been derived from studies of the external (HIRF) and internal EM environments. This section discusses the history of the development of the immunity requirements, the development of the HIRF environment and the resulting immunity test procedures and provides a conclusion.

6.1 History of requirements

6.1.1 Overview

Right from the beginning the susceptibility requirements for the civil community were based on protecting the on-board equipment from the fields generated by the aircraft's own transmitters such as radio and radar. It was not until the HIRF requirements became a factor that the levels for susceptibility testing were raised to take into account the external environment. However in these early days, electronics did not control safety critical functions such as flight or engine control. The requirements for equipment to be immune to a level of RF fields was in these early days based on customer pressure as electronics did not perform safety critical functions. It was only in the 80's with such aircraft as Airbus that the safety aspects and HIRF became a factor.

The Civil Aviation Authority (CAA) initially raised concerns for the integrity of civil fly-by-wire aircraft in July 1985. This was followed by independent radio frequency (RF) environment surveys undertaken early in 1986 which culminated in a special condition attached to the certification interim policy imposed on the Airbus A320 for high energy RF (HERF) as it was then.

Since those earlier days various committees and working groups were set up following at least two international meetings held to present results and further the work both in Europe and in the USA. These two international meetings were held in the USA in September 1987 and in the UK during March 1988.

The various working groups spent the next six years establishing agreed distance assumptions and hence values of the electric field strengths from 500,000 transmitters in the frequency band 10 kHz to 40 GHz.

In 1993 the Electromagnetic Effects Harmonisation Working Group (EEHWG) was set up by the Aviation Rulemaking Advisory Committee (ARAC) Transport Aircraft and Engine Issues Group (TAEIG) to make recommendations to the TAEIG concerning HIRF and lightning requirements. These activities culminated in the production of harmonised documents including the AC/AMJ (Advisory Circular)/(Advisory Material Joint), NPRM/NPA (Notice of Proposed Rule Making)/ (Notice of Proposed Amendment) and the Users manual/User's guide which are scheduled for completion during 2000.

During the period of the development of the HIRF requirements, changes have been made to DO160 and ED14 to take into account the need to provide suitable susceptibility tests to confirm the immunity of on-board electronic systems to external RF transmitters – HIRF. The first version to contain upgraded limits and test procedures as a result of the HIRF requirements was the 'C' edition. Since then there have been 3 amendments to the C version containing increased immunity requirements and improved test techniques and in 1998 the current "D" revision was issued. As the HIRF environments have now been finalised a revision to DO160D/ED14D is currently being produced for publication later this year with susceptibility test limits reflecting all the HIRF environments with test levels up to 6850V/m depending on system functional criticality and aircraft type:

Functional Criticality	Requirement
Level A	Test level to be selected based on expected environment with allowance made for expected coupling and attenuation. A range of test levels defined in DO160/ED14. For Level A control functions validation of level selected by means of an aircraft test required.
Level B	Test level defined in DO160/ED14 Cat U
Level C	Test level defined in DO160/ED14 Cat T
Level D	Level determined by market pressure
Level E	Level determined by market pressure

Table 1/6

The test levels for HIRF related test requirements for safety critical systems have to a large extent been developed by measuring the coupling into a range of different aircraft types.

For non safety critical systems the test levels defined by the airframer or avionics company are determined by market pressures, for instance if the in-flight entertainment system failed to work in normal aircraft cruise condition through interference, passenger pressure would ensure that sales of such systems would become nil.

6.1.2 Derivation of HIRF Requirements

The earliest record that has been unearthed in connection with the relatively recent activities relating to HIRF is a letter from the FAA to the SAE AE4R committee in which the following is an excerpt;

“The Purpose of this letter is to request that the SAE-AE4 committee co-ordinate with the Federal Aviation Administration (FAA) in the development of procedures and guidance material which can be used during the aircraft certification process.

The FAA in co-operation with the United Kingdom Civil Aviation Authority and the French Service Technique des Constructions Aeronautique are conducting research associated with the susceptibility of avionic systems in high energy radio frequency (RF) fields.

The three agencies are in the process of developing proposed requirements and standards concerning the effects of transmitted RF energy on critical flight control and avionics systems aboard modern aircraft. This problem has been intensified by the trend towards increased power levels from high energy ground radiation systems, increased utilisation of sensitive micro-electronic critical flight control systems, and the reduced electromagnetic protection provided by advanced technology airframe materials…”

This letter was dated Autumn 1982 (it is considered that this was incorrectly dated and should read 1985) and included in the presentation by Mr Stan Schneider of Boeing Airplane Company, during the second international conference held in the UK during March 1988.

The various civil aviation authorities identified that a potential incompatibility might exist between an increased power output from various ground based emitters on the one hand and sensitive critical flight controls and avionics systems in overall composite aircraft skins, on the other.

Within the same time-scale, July 1985, concern was raised by the civil aviation authority (CAA) for the integrity of future fly-by-wire civil aircraft and in early 1986 independent if environment surveys were undertaken by specialists associated with the FAA, CAA and the French Direction Générale de l’Aviation Civile (DGAC).

From an assessment of the UK and French RF environmental data a special condition was applied to the A320 aircraft in March 1987, this being the first civil European fly-by-wire aircraft.

6.1.3 International activities

During May 1987 a meeting was held in London involving the FAA, DGAC and CAA to exchange measured and calculated results and to plan a common regulatory approach. The common approach involved the development of requirements and standards concerning the effects of transmitted RF energy in critical flight control and avionics systems installed in modern aircraft. The perceived problem has been exacerbated by the trend toward increased power levels from ground based radiation systems and the reduced electromagnetic protection provided by advanced composite airframes.

RF susceptibility standards appeared inadequate to assume aircraft system immunity from the RF threat. It was considered appropriate that, since aircraft are required to fly throughout the world, an international RF susceptibility standard was required.

Within the USA the FAA attempted to address the problem and define the radiation energy levels, in terms of far field electric field, in co-operation with the Electromagnetic Compatibility Analysis Centre (ECAC) by surveying all civil and military ground and airborne high energy RF sources. From this survey the FAA developed a worse case envelope for large transport aircraft (Part 25) and ECAC wrote a document "Guidelines for developing maximum peak and average field strength envelope graphs for aircraft" to ensure conformity in the development of an international electromagnetic environmental standard. This document was subsequently supplemented by a "Note on the computation of the electric field amplitude in the near field region" by P Bonamour (Aerospatiale) and J Verpoorte (NLR).

To gain support at the international level an "International meeting on susceptibility of avionics systems in high energy radio frequency fields" was held in Crystal City, Washington, Virginia, USA on 22-23rd September 1987.

The achieved aim of this, the first of two such gatherings was:

a) To present the results of the environmental surveys.

b) To present the paper by Alexander Gross.

c) To encourage other nations besides the US, UK and French to submit and present environmental data.

Sixty-five specialists attended the meeting. At the conclusion of the two-day meeting it was agreed to set up a second meeting in the UK during the following year.

The second and final international meeting was held under the same banner in Brighton UK during 21-22nd March 1988.

The format was largely the same as the first meeting but with the addition of detailed discussions on the various committees, technical working groups and international co-ordination that were already in place or could be put in place to co-ordinate the activity. The activity was previously known as High Energy Radiated Fields (HERF), an acronym already in existence concerned with High Energy Radiation to Fuels.

It was at this meeting attended by 53 persons, including the author, that the way ahead for the various committees and working groups was agreed.

The aims and objectives agreed upon at the meeting included the following;

a) In the short term

   To issue interim policy material to certification directorates that can be read as a basis for special conditions.

b) In the middle term

   (i) To use an agreed internationally recognised RF 'Threat' envelope as a basis to review and update the Federal Aviation Regulations (FARs) and Joint Aviation Requirements (JARs) for parts 23,25,27,29,33 and 35.

   (ii) To use the expertise of industry technical organisations such as SAE, EUROCAE and RTCA to develop standards that can be referenced in Advisory Circulars (ACs) and Technical Standard Orders (TSOs).

c) In the long term

(i) To develop maintenance criteria to assess the continued airworthiness of aircraft/systems to HIRF.

(ii) To monitor status of transmitters to ensure viability of the HIRF envelopes.

(iii) To monitor developments in aircraft shielding.

From 1987 to 1993 two groups were involved with HIRF namely the SAE AE4R, Aircraft Radiated Environment Sub-committee in the USA and The European Organisation for Civil Aviation Equipment (EUROCAE) WG-33, High Intensity Radiated Fields, in Europe.

On the US side the sub-committee was divided into three panels. These were:

Panel 1 – Data Accuracy – chaired originally by Mr R Rogers.

Panel 2 – Design Approval – chaired by Mr C Kendall

Panel 3 – Test and Analysis Methods – chaired by Mr F Heather.

In Europe the three equivalent bodies were:

Sub group 1 – Data Accuracy – chaired by Mr R Hathaway

Sub group 2 – Design Approval – chaired by Mr A Quet and later Mr R.Butler

Sub group 3 – Test and Analysis – chaired by Mr G Jackson and later by Dr.N.J.Carter.

To aggravate, or simplify, the problems of agreement on the way forward, some European members were also members of both the SAE AE4 committee and the SAE AE4R sub committee, attending the various panel meetings on a regular basis. A reciprocal arrangement existed for US members to attend EUROCAE WG33 meetings by invitation.

In March 1993, the electromagnetic effects harmonisation working group (EEHWG) was established by the ARAC, Transport Aircraft and Engine Issues Group (TAEIG) previously Transport Airplane and Engine Subcommittee (TAES) in response to the public announcement by the FAA in the US Federal Register, Vol 57, no 239 dated December 1992. The EEHWG was chartered with making recommendations to the TAEIG concerning the FAA disposition of the HIRF and lightning requirements.

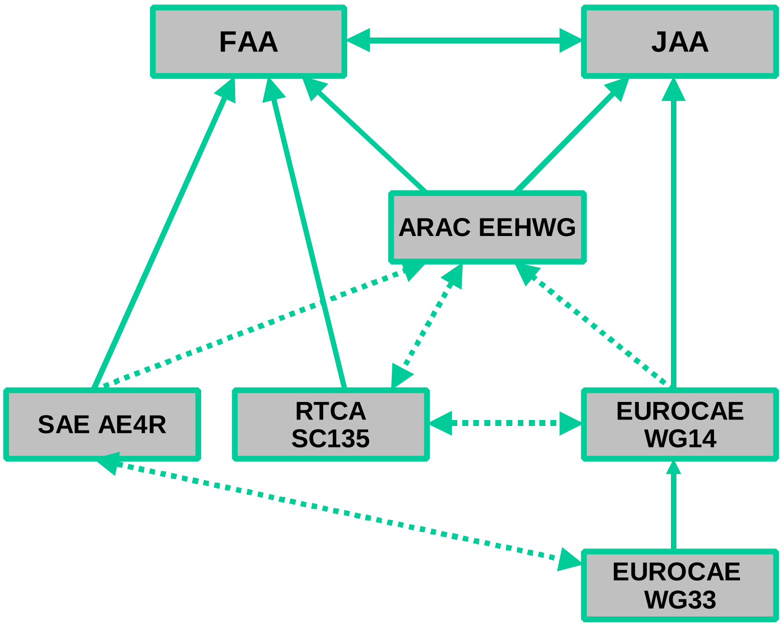
The EEHWG, once ‘settled in’ consisted of seven task groups in addition to all attending the main unified meetings.

The task groups were as follows:

Task Group 1	-	Lightning
Task Group 2	-	Terms of reference
Task Group 3	-	Economic analysis requirements
Task Group 4	-	Documentation
Task Group 5	-	FAA Internal team (not part of ARAC or EEHWG but counted as a task group)
Task Group 6	-	Probability
Task Group 7	-	Maintenance

From the initial meeting until the present most of those that attended the SAE and EUROCAE became members of the EEHWG plus some additional attendees so by the 16th EEHWG meeting (1998) there were some 93 persons attending. Of those 93, 53 were members, not observers etc, and of the members approximately 36 were active participants.

The figure below gives an indication of the complexity of the interaction between these committees:



The HIRF task involved the development of new requirements for aircraft exposed to high intensity radiated field (HIRF) as related to FAR parts 23, 25, 27, 29, 33 and 35, as appropriate. This task supplemented the efforts by RTCA, SAE, EUROCAE and FAA/JAA during the period of 1987 to 1992. The EEHWG took the reports prepared by the SAE and EUROCAE and converted them into harmonised ACs/AMJs and a User Manual/User Guide. The EEHWG also took the FAA NPRM and the JAA NPA HIRF materials and converted them into a harmonised NPRM/NPA document.

The EEHWG need to create harmonised NPRM/NPA documents for each part of the FAR required an expansion of the scope of the HIRF environments from just Part 25 to Parts 23, 25, 27 and 29 Aircraft. The chilled but not frozen Part 25 environment needed to be updated to include Part 23 commuter and general aviation airplanes and Part 27 and 29 for Rotorcraft. The assumptions for the various types of fixed wing aircraft and rotorcraft had to be adjusted for the inclusion of visual flight rules and the corresponding flight envelope of the aircraft (i.e. hovering and vertical landing/takeoff).

The EEHWG concentrated all it's effort on harmonising the various documents. The environments remained chilled up until June 1997. The EEHWG did evaluate ways of reducing the HIRF levels by considering probability of encounter for aircraft operating near land based and ship based HIRF emitters. The FAA contracted the support of Dr Rod Perala (Electromagnetic Applications) to analyse this concept and conduct statistical studies for land based emitters. It was the conclusion of EEHWG that probability of encounter could not be used to predict the HIRF environments for land based emitters. Pat Scott of Honeywell was tasked by the EEHWG to analyse the ship based emitters. The EEHWG reviewed his study and made changes to the assumptions that resulted in changes to the ship to aircraft separation as shown in the paragraph 6.2.1.1.

The international HIRF environment finally included the following specific environments:

- Fixed Wing Aircraft Severe HIRF environment
- Aircraft certification HIRF environment, and
- Aircraft Normal HIRF environment
- Rotorcraft Severe environment

6.2 The HIRF Environment

6.2.1 SEVERE HIRF Environment

The Severe HIRF environment is the electromagnetic field strength level in the airspace in which flight operations are permitted (see table 2/6).

Distance Criteria for the Calculation of the Fixed Wing Severe HIRF Environment

The Fixed Wing Severe environment considers transmitters in the following groups and aircraft to transmitter distances:

(a) Airport Environment:

  (i) 250 feet, slant range, for fixed transmitters within a 5 nautical mile boundary around the runway with the exception of airport surveillance radar and air route surveillance radar. For these two radar types a 500 foot, slant range distance was used.

  (ii) 50 feet, direct range, for mobile transmitters, including transmitters on other aircraft, and 150 feet direct range for aircraft's weather radar.

(b) Non-airport ground transmitters:

  (i) 500 feet, slant range, for fixed transmitters beyond a 5 nautical mile boundary around the airport runway.

  (ii) Aircraft were assumed to be at a minimum flight altitude of 500 feet above local terrain and avoiding all obstructions, including transmitter antennas, by 500 feet being the International Civil Aviation Organisation (ICAO) aircraft minimum obstruction clearance for Visual Flight Rules (VFR).

(c) Shipboard transmitters: 350 feet slant range. (This distance value changed at the 14th EEHWG (Bridgeport) meeting to 500 feet slant range.)

(d) Air-to-air transmitters:

  (i) 500 feet direct range for non-interceptor aircraft with all transmitters operational.

  (ii) 100 feet direct range for interceptor aircraft with only non-hostile transmitters operational.

FREQUENCY	FIELD STRENGTH (V/M)	
	PEAK	AVERAGE
10 kHz - 100 kHz	50	50
100 kHz - 500kHz	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 - 200MHz	90	30
200 MHz - 400MHz	70	70
400 MHz - 700MHz	730	80
700 MHz - 1 GHz	1400	240
1 GHz - 2 GHz	3300	160
2 GHz - 4 GHz	4500	490
4 GHz - 6 GHz	7200	300
6 GHz - 8 GHz	1100	170
8 GHz - 12 GHz	2600	330
12GHz - 18 GHz	2000	330
18GHz - 40 GHz	1000	420

Table 2/6

6.2.2 Certification HIRF Environment (I)

The Certification HIRF environment (now known as Environment I) is a subset of the Fixed Wing Severe HIRF environment, which has been established as an estimate of the electromagnetic field strength levels which could be encountered. The Certification environment is shown in Table 3/6. This estimate considers the operational characteristics of the high peak power microwave transmitters, which typically do not operate continuously at the maximum output power levels. This estimate has also rounded the levels to the nearest single significant digit, given the known variability associated with the environment calculations.

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	2000	200
2 GHz - 4 GHz	3000	200
4 GHz - 6 GHz	3000	200
6 GHz - 8 GHz	1000	200
8 GHz - 12 GHz	3000	300
12GHz - 18 GHz	2000	200
18GHz - 40 GHz	600	200

Table 3/6

6.2.3 Normal HIRF Environment (II)

The Normal HIRF environment (now known as Environment II) is an estimate of the electromagnetic field strength level in the airspace on and about airports/heliports in which routine departure and arrival operations take place. The Normal environment is shown in the Table 4/6 below. This estimate considers the operational characteristics of the high peak power microwave transmitters, which typically do not operate continuously at the maximum output power levels. This estimate has also rounded the levels, given the known variability associated with the environment calculations.

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	1300	160
2 GHz - 4 GHz	3000	120
4 GHz - 6 GHz	3000	160
6 GHz - 8 GHz	400	170
8 GHz - 12 GHz	1230	230
12GHz - 18 GHz	730	190
18GHz - 40 GHz	600	150

Table 4/6

6.2.4 Rotorcraft Severe HIRF Environment (III)

The Rotorcraft Severe HIRF environment (now known as Environment III) is derived from a worst case estimate of the electromagnetic field strength levels in the airspace in which rotorcraft flight operations are permitted. The Rotorcraft Severe HIRF environment considers both the likelihood of encountering the worst case estimated environment, and the technology and operation of the transmitters and aircraft systems in the HIRF environment. This environment is shown in the Table 5/6:

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	1400	240
1 GHz - 2 GHz	5000	250
2 GHz - 4 GHz	6000	490
4 GHz - 6 GHz	7200	400
6 GHz - 8 GHz	1100	170
8 GHz - 12 GHz	5000	330
12GHz - 18 GHz	2000	330
18GHz - 40 GHz	1000	420

Table 5/6

6.3 Immunity Procedures rationale

Aerospace immunity testing throughout the world is designed to ensure that equipment performs its intended function throughout all phases of aircraft operation in the defined EM environment agreed world-wide. Two environments exist in which avionics equipment has to operate namely:

- that generated by the on-board systems, such as load switching transients, electrical power generation, communication transmitters and radar..
- that generated by sources external to the aircraft such as from ground or ship borne communication transmitters and radars (HIRF) and lightning.

These EM environments couple into the avionics systems via power supply wiring, interconnecting cables, or direct penetration of the equipment cases.

The test procedures have been developed to exercise these various coupling routes. Both time domain transient test procedures (for load switching transients and lightning) and frequency domain test procedures (for HIRF etc) are used in the evaluation.

The equipment under test is stressed to the appropriate test level by either:

- directly injecting the test signal into its wiring
- or by irradiating the EUT and associated wiring with the test signal by means of an antenna.

The test levels used vary depending on the functional criticality of the EUT and the expected electromagnetic environment.

The procedures used have been internationally agreed between EUROCAE and RTCA SC135 and were originally based on those procedures used for military aerospace although they have been refined to meet the requirements of the civil community. One of the driving factors in the current test procedures used in the latest version of DO160/ED14 is the need to simulate the harsh EM environment generated by HIRF with equivalent test levels of up to 6800V/m being required. The primary procedures used are:

Time Domain Environments:

- Injection of the appropriate time domain waveform between the ground and the equipment case. Used for lightning to simulate the ground voltage drop between the various equipment in a system. The lightning current passing through the aircraft skin causes this voltage difference between the various equipment.
- Injection of the appropriate transient waveform into power supply lines, both common mode and differentially, to simulate load switching transients coupling to the equipment via the power supply bus-bars.
- Induction of the appropriate transient waveform into interconnecting cables by means of a cable wrapped around the interconnecting cable to simulate crosstalk from an adjacent cable conducting a large transient.

Frequency Domain Environments

- Injection of the appropriate test level into power lines, both common mode and differentially by means of a current transformer at low frequencies and a current probe at higher frequencies.
- Induction of the appropriate test level into interconnecting cables by means of a cable wrapped around the interconnecting cable to simulate crosstalk from an adjacent cable. This is used at audio frequencies.
- Injection into the interconnecting cables by the use of a current probe the appropriate test level. This is used to simulate coupled RF currents for other onboard systems and at higher levels those resulting from HIRF. This technique is commonly known as the bulk current injection (BCI) technique.
- Irradiation of the EUT and wiring at the appropriate EM field level from an antenna, either in “free field “ conditions in an anechoic or semi-anechoic chamber or in a reverberation chamber. This latter technique is used to develop the high fields required for HIRF testing.

Specifications

For civil aerospace there are two primary equipment EMC standards:

- In Europe ED14 produced by EUROCAE. In addition, EUROCAE have produced ED90 which is a Users Guide to ED14.
- In the USA DO160 produced by RTCA.

Representatives from both committees attend each others meeting with the aim of ensuring the documents are technically identical. Both these standards cover all environmental effects as seen in the table below. A description of any section relating to electromagnetic effects is provided in the table.

Section	Content	Purpose
15	Magnetic Effects	This test determines the dc magnetic fields generated by the equipment to assist the installer in choosing the proper location of the equipment.
16	Power Input	This section defines test conditions and procedures for 115 V ac, 26V dc and 14 Vdc electrical power applied to the terminals of the equipment under test. It covers power supply effects such as over and under voltage, frequency and voltage modulation, interrupts and surges.
17	Voltage Spike	This test determines whether the equipment can withstand the effects of voltage spikes arriving at the equipment on its power leads, either ac or dc.
18	Audio Frequency Conducted Susceptibility – Power Inputs	This test determines whether the equipment will accept frequency components of a magnitude normally expected when the equipment is installed in the aircraft. These frequency components are normally harmonically related to the power source fundamental frequency.
19	Induced Signal Susceptibility	This test determines whether the equipment interconnect circuit configuration will accept a level of induced voltages caused by the installation environment. This Section relates specifically to interfering signals related to the power frequency and its harmonics, audio frequency signals and electrical transients that are generated by other on-board equipment or systems and coupled to sensitive circuits within the EUT through its interconnecting wiring.
20	Radio Frequency Susceptibility (Radiated and Conducted)	These tests determine whether equipment will operate within performance specifications when the equipment and its interconnecting wiring are exposed to a level of RF modulated power, either by a radiated RF field or by injection probe induction onto the power lines and interface circuit wiring.
22	Lightning Induced Transient Susceptibility	These test methods and procedures apply idealised waveforms to verify the capability of equipment to withstand the effects of lightning induced transients.
23	Lightning Direct Effects	The tests described in this section are intended to determine the ability of externally mounted electrical and electronic equipment to withstand the direct effects of lightning strike.

Table 6/6

6.4 Conclusions

The procedure to demonstrate the immunity of aircraft and associated systems during all phases of flight show compliance with the essential requirements of the EMC directive. The safety objective of the certification process is to demonstrate that the aircraft has a defined low probability of upset (including all causes) when operating in its expected environment. This probability is based on the safety criticality of the system being considered.

The certification process is demonstrating that the aircraft has an adequate level of intrinsic immunity to electromagnetic disturbance to enable it to operate as intended.

Chapter 7 PORTABLE ELECTRONIC DEVICES

7.1 Existing requirements

The discussion of electromagnetic emissions and immunity in chapters V and VI deal with systems and equipment installed in the aircraft. The electromagnetic compatibility of these systems and equipment is demonstrated and validated during the aircraft certification process. Passengers and crewmembers may also carry portable electronic devices on board the aircraft, which are not certified as part of the aircraft. Portable electronic devices may be unintentional electromagnetic radiators, such as laptop computers, personal video players, electronic games, audio CD and cassette players, or one-way pagers. Or, these devices may be intentional electromagnetic radiators, such as cellular telephones, two-way pagers, personal communication radios, amateur radio transceivers, or computers with RF data links.

The current regulatory approach for assuring safe aircraft operation relies upon restricting use of these devices on aircraft. The Joint Aviation Requirements include JAR-OPS 1.110, which states:

JAR-OPS 1.110 Portable Electronic Devices

An operator shall not permit any person to use, and no person shall use, on board an aeroplane a portable electronic device that can adversely affect the performance of the aeroplane's systems and equipment.

This JAR requirement is very similar to other national aircraft regulations. For example, the US regulation in FAR 91.21 states:

FAR § 91.21 Portable electronic devices.

(a) Except as provided in paragraph (b) of this section, no person may operate, nor may any operator or pilot in command of an aircraft allow the operation of, any portable electronic device on any of the following U.S.-registered civil aircraft:

  (1) Aircraft operated by a holder of an air carrier operating certificate or an operating certificate; or

  (2) Any other aircraft while it is operated under IFR.

(b) Paragraph (a) of this section does not apply to--

  (1) Portable voice recorders;

  (2) Hearing aids;

  (3) Heart pacemakers;

  (4) Electric shavers; or

  (5) Any other portable electronic device that the operator of the aircraft has determined will not cause interference with the navigation or communication system of the aircraft on which it is to be used.

(c) In the case of an aircraft operated by a holder of an air carrier operating certificate or an operating certificate, the determination required by paragraph (b)(5) of this section shall be made by that operator of the aircraft on which the particular device is to be used. In the case of other aircraft, the determination may be made by the pilot in command or other operator of the aircraft.

As in the JAR 1.110, this is an operating requirement for aircraft, not a an aircraft certification requirement. These requirements make the aircraft operator responsible for controlling the use of portable electronic devices on aircraft.

7.2 Studies on Aircraft Interference from Portable Electronic Devices

The need for high assurance of electromagnetic compatibility between portable electronic devices and aircraft systems has resulted in three major studies to consider the potential effects of portable electronic devices on board aircraft. RTCA in the US produced report DO-119 in April, 1963. As a result of this report, the US FAA adopted Federal Aviation Regulation 91.19, which was similar to the current US FAR 91.21.

In 1983, RTCA Special Committee 156 produced a second report which considered the effects of portable electronic devices on board aircraft. This special committee produced RTCA report DO-199, "Potential Interference to Aircraft Electronic Equipment from Devices Carried Aboard", dated September 1988.

More recently, the US FAA requested RTCA to investigate issues associated with potential electromagnetic interference from portable electronic devices on aircraft. RTCA Special Committee 177 produced the RTCA report DO-233, "Portable Electronic Devices Carried on Board Aircraft", dated August 1996. This report evaluated electronic devices with intentional and unintentional electromagnetic radiation. The special committee evaluated the risk of portable electronic devices interfering with aircraft radios, displays, and controls. The risk evaluation used a statistical analysis similar to other aircraft safety analyses.

The special committee focused on the potential interference between portable electronic devices and the aircraft radio communication, navigation and surveillance receivers. These aircraft radio receivers can be very sensitive and operate in frequency bands from 190 kHz to 9.45 GHz. The special committee measured RF emissions from a large number of portable electronic devices. They then measured path loss between locations in the aircraft where portable electronic devices may be used, and the aircraft radio receiver antennas. With this information along with the aircraft radio receiver sensitivity, the committee could estimate the likelihood of interference between portable electronic devices and the aircraft radio receivers.

The committee also studied the likelihood of portable electronic device RF emissions interfering directly with aircraft electronic and electrical systems, through the system boxes and wiring, not through the radio receiver antennas. The study showed that portable electronic device RF emissions, with the normal immunity of aircraft electronic and electrical systems, made electromagnetic interference very unlikely. The committee also evaluated the risk of interference from handheld radios, such as cellular telephones. Again, the study was for interference to aircraft electronic and electrical systems, through the system boxes and wiring, not through the radio receiver antennas. And again, the study showed a reasonable margin between the radio transmitted signal and the normal immunity of aircraft electronic and electrical systems.

The special committee concluded that the probability of interference from portable electronic devices is low, with today's standards for aircraft electromagnetic immunity. However, the special committee stated that even a low probability of a significant interference event during a critical phase of flight may be considered unacceptable. Therefore, the committee felt that, as a practical matter, use of portable electronic devices should be prohibited during critical phases of flight, such as takeoff and landing.

A recent study by the UK Civil Aviation Authority assessed interference from portable telephones. The report from this study, "Interference Levels in Aircraft at Radio Frequencies Used by Portable Telephones", dated May 2, 2000, quantified the electric field strength generated by portable telephones inside aircraft. The report estimated the expected field strength levels that aircraft avionics will be exposed to from portable telephones. The report recommended that regulatory authorities continue to prohibit use of portable telephones on board aircraft while engines are operating. The report also recommended a minimum field strength level that aircraft avionics should meet. These recommendations will be harmonized in the aviation electromagnetic effects rulemaking harmonization working group.

7.3 Rationale for Existing Requirements

Portable electronic devices meet the appropriate EMC standard for the class of device in the country where the electronic device was purchased. These standards specify maximum electromagnetic emission levels, and for electronic devices on the market in the EU, minimum electromagnetic immunity levels. The standards apply to the electronic device as designed and manufactured, and when properly installed and maintained and used for the purposes intended. These standards provide assurance that "the electromagnetic disturbance it (the device) generates does not exceed a level allowing radio and telecommunications equipment and other apparatus to operate as intended;" (from EC Directive 89/336/EEC Article 4(a)). However, the EMC standards for residential, commercial and light industry apparatus, or for information technology equipment, give a presumption of conformity for EMC compatibility, but do not guarantee electromagnetic compatibility in all conditions and circumstances.

This is illustrated in a statement within the US FCC regulations for digital devices (47 CFR Sec. 15.15 General technical requirements.)

(c) Parties responsible for equipment compliance should note that the limits specified in this part will not prevent harmful interference under all circumstances. Since the operators of part 15 devices are required to cease operation should harmful interference occur to authorized users of the radio frequency spectrum, the parties responsible for equipment compliance are encouraged to employ the minimum field strength necessary for communications, to provide greater attenuation of unwanted emissions than required by these regulations, and to advise the user as to how to resolve harmful interference problems …

For aircraft, the electromagnetic compatibility constraints must be related to the consequences of the failure due to interference. For example, requirements for large aeroplane equipment and systems in JAR 25.1309(b) states "The aeroplane systems and associated components, considered separately and in relation to other systems, must be designed so that - (1) The occurrence of any failure condition which would prevent the continued safe flight and landing is extremely improbable, …" This is a much higher standard of certainty than is required for consumer electronics electromagnetic compatibility.

There are practical examples that illustrate the different level of electromagnetic compatibility assurance for consumer electronic devices than for electrical and electronic equipment installed on aircraft. A common example is a consumer finds interference on a channel of their home television. Typically, the consumer begins to turn off household appliances to determine which one is causing the interference. If the source of the interference cannot be found in the home, the consumer may complain to the authorities. The solution is then typically separating the offending electrical appliance from the television, or turning off the offending electrical appliance. In general, consumers accept that interference is possible, even from devices that meet appropriate standards, but expect that occurrences of interference will be infrequent and result only in inconvenience and irritation.

This is quite different than the consequences of interference from portable electronic devices to aircraft radio receivers. Here, the interference may interfere with safety-related communication, or degrade aircraft navigation accuracy. The consequences here can range from inconvenient to catastrophic.

7.4 Maintenance and Modification of Portable Electronic Devices

There are significant differences between the approach to maintenance and modification of consumer portable electronic devices, and aircraft-installed electronics. These differences also influence the approach to controlling use of portable electronic devices on board aircraft.

Aircraft installed electrical and electronic equipment must meet electromagnetic compatibility requirements at the time of aircraft certification. But the aircraft and installed electrical and electronic equipment must also meet stringent requirements for maintenance and modification over the life of the aircraft. The aircraft manufacturer must define maintenance requirements that will assure that the electromagnetic emissions and susceptibility are not adversely affected by aging, environmental conditions, wear, and damage.

Any modifications performed on the aircraft and installed electrical and electronic equipment must also meet the certification requirements, including electromagnetic compatibility.

This is significantly different than requirements for portable electronic devices. The portable electronic devices meet electromagnetic compatibility standards in their original manufactured condition. There are seldom any substantial requirements for maintaining the electromagnetic characteristics of these portable electronic devices, particularly for damage or environmental conditions which may degrade the electromagnetic emissions or susceptibility. Many portable electronic devices may be modified after original compliance with electromagnetic compatibility requirements, by adding peripheral devices or new internal components.

This difference in approach provides far less confidence in electromagnetic compatibility for portable electronic devices than for aircraft-installed electrical and electronic equipment.

7.5 Consequences of Interference from Portable Electronic Devices

The key issue related to portable electronic devices and aircraft radio receivers and systems is not strictly the electromagnetic emissions and immunity standards. The key issue is the level of assurance required to have confidence in safe aircraft operation. Therefore, use of portable electronic devices on aircraft is controlled not just by electromagnetic emissions and immunity requirements, but also by operational controls on using portable electronic devices on aircraft. This two-part approach provides the high assurance of safe aircraft operation required by regulatory authorities and the public.

Chapter 8 CONCLUSIONS

8.1 Present Aircraft EMC requirements

The comparative analysis developed in this report shows that the requirements of the EMC Directive 89/336 are satisfied by the certification requirements and processes for civil aircraft and incorporated equipment.

These certification requirements and processes will be ultimately harmonized by the Council Regulation 3922/91 and its successor. This harmonization process must be encouraged and as far as possible accelerated.

Based on the two above statements, its is recommended to exclude civil aircraft and incorporated equipment from the scope of the EMC Directive taking the opportunity of the current process of revision of this Directive, to avoid duplicating certification procedures.

Moreover there is no need to establish a standardization programme as envisaged by the mandate.

8.2 Future Trends for Aircraft EMC requirements

There are several trends that will affect the future potential for aircraft system electromagnetic interference. These trends are:

a) Proliferation of handheld computing, communication and entertainment electronics, which will include RF voice and data transmission, RF local area network interfaces imbedded in devices, and faster clock and data rates.

b) More comprehensive HIRF protection on aircraft systems.

c) Transition to more sophisticated, higher frequency aircraft RF communication, navigation and surveillance systems, and decommissioning earlier-generation RF communication and navigation systems.

The trend toward more comprehensive HIRF protection on critical and essential aircraft systems has and will continue to mitigate the direct effects of interference from portable electronic devices. New aircraft and new aircraft system installations will provide very effective protection against interference that may couple into system wiring or directly to the aircraft system electronics.

The future proliferation of complex handheld portable electronic devices, particularly with wireless RF interfaces, could adversely affect aircraft radio receivers. However, in the future, this will be mitigated by use of more sophisticated aircraft RF systems. The existing generation of aircraft RF systems such as ADF, ILS, VOR and VHF communication use relatively simple amplitude modulation schemes. Aircraft RF systems now being implemented or planned use much more sophisticated modulation schemes that are generally more tolerant to interference. For example, even though the GPS receivers are very sensitive, the receivers use spread spectrum techniques and signal quality monitors. These reject simple interference, or else notify when the system performance is degraded, so that the pilot or aircraft navigation system would not be given false data. The existing generation of aircraft RF systems such as ADF, ILS, VOR and VHF communication will be progressively complemented and ultimately replaced by higher precision, higher data capacity RF systems that, on the one hand use modulation less susceptible to simple RF interference and on the other hand could produce more wider out of band background noise.

In light of these trends, the aircraft RF interference environment will become more complex. But this complex RF environment is being considered during aircraft and aircraft system design. The aircraft regulatory authorities, including JAA, continue to monitor these trends, and update requirements when appropriate. For example, there are new programs to install wireless RF networks into the aircraft, that allow passengers and crew to use handheld devices to communicate through this network. These issues are addressed through the existing JAA regulatory process of Certification Review Items (CRI), similar to the US FAA issue papers and special conditions. Certification and operating rules are updated when necessary to account for new understanding of issues.

The system for “lessons learned from experience” described in 1.1 is instrumental for such updates.

In addition, Authorities are considering to introduce processes to systematically address future hazards. These processes identify changes affecting the Aviation System and analyse selected changes to reveal future hazards. An example of such processes, still in the development phase, is the Future Hazards activity of the JAA Safety Strategy Initiative.

* * *

ANNEX 1

EMC international standards or specifications

Based on the result of a survey, three types of standards or regulations have been analysed and compared together and with the ED14 specifications. They are **CISPR international standards**, **EN standards (European norms)**, and **FCC (US regulations)**. Specific national standards such as GOST (Russia) have not been considered because the information about their applicability is not available at the time of publication of this report.

A1.1 CISPR Standards

The CISPR is an international standards committee in the IEC framwork that makes recommendations for the control of electromagnetic emissions (conducted and radiated limits) and for relevant test methods. The CISPR standards cannot be enforced by this committee and there is no authorized certification mark to be affixed to the successfully tested device.

However, the CISPR is the basis for a lot of regional or national regulations.

There are several CISPR publications, each of them being applicable to a specific category of equipment :

CISPR 11 : Industrial, Scientific and Medical equipment, for example:

CISPR 13 : Sound and Television broadcast receivers and associated equipment (including video tape for example)

CISPR 22 : Information Technology Equipment

The emissions limits required by each of these standards have been summarised in the following tables. Radiated and conducted emissions have been considered.

Generally speaking, Class A equipment is for non - domestic equipment. Class B equipment is for equipment which is intended for domestic use in residential areas, the limits being more stringent to provide protection for broadcast reception (the interfering device is likely to be closer to any receiver than for non - domestic use).

CISPR 11 - Radiated emissions (quasi-peak)

Standard	CISPR 11	CISPR 11
Class	A (Non - domestic)	B (Domestic)
Measurement distance	30 metres	10 metres
30 - 230 MHz	30 dB µV/m	30 dB µV/m
230 MHz - 1 GHz	37 dB µV/m	37 dB µV/m

CISPR 11 - Conducted emissions (quasi-peak)

Standard	CISPR 11	CISPR 11
Class	A (Non - domestic)	B (Domestic)
150 kHz - 500 kHz	79 dB µV	66 - 56 dB µV
500 kHz - 5 MHz	79 dB µV	56 dB µV
5 MHz - 30 MHz	73 dB µV	60 dB µV

CISPR 13 - Radiated emissions (quasi-peak)

Standard	CISPR 13	CISPR 13	CISPR 13
Category	TV set and video tape Channels below 300 MHz	TV set and video tape Channels above 3 GHz	FM receivers
Measurement distance	3 metres	3 metres	3 metres
Local oscillator	57 dB µV/m	56 dB µV/m	60 dB µV/m
30 - 300 MHz	52	NA	52
300 MHz - 1 GHz	56	56	56

CISPR 13 - Conducted emissions (quasi-peak)

Standard	CISPR 13
Category	TV set and video tape FM receivers
150 kHz - 500 kHz	66 - 56 dB µV
500 kHz - 5 MHz	56 dB µV
5 MHz - 30 MHz	60 dB µV

CISPR 22 - Radiated emissions (quasi-peak)

Standard	CISPR 22	CISPR 22
Class	A (Non - domestic)	B (Domestic)
Measurement distance	30 metres	10 metres
30 - 230 MHz	30 dB µV/m	30 dB µV/m
230 MHz - 1 GHz	37 dB µV/m	37 dB µV/m

CISPR 22 - Conducted emissions (quasi-peak)

Standard	CISPR 22	CISPR 22
Class	A (Non - domestic)	B (Domestic)
150 kHz - 500 kHz	79 dB µV	66 - 56 dB µV
500 kHz - 5 MHz	79 dB µV	56 dB µV
5 MHz - 30 MHz	73 dB µV	60 dB µV

A1.2 EN (EuroNorm) Standards

EN are produced by the European standardisation bodies (CENELEC, CEN, and ETSI) and are de facto the main standards in Europe, through their transposition in identical national standards in Europe.

The EN standards are are very often used to ensure the presumption of conformity to the European directives (translated in national regulations).

Apart from the two generic emission standards, there are many EMC emission product standards, each of them being applicable to a specific category of equipment. The publications of particular interest as regards the limitation of the electromagnetic emissions are in most cases identical to the CISPR ones. The EN references are the following with the cross reference to the CISPR standard :

EN 55011 <-> CISPR 11 : Industrial, Scientific and Medical equipment

EN 55013 <-> CISPR 13 : Sound and Television broadcast receivers and associated equipment (including video tape for example)

EN 55014 <-> CISPR 14 : Electrical motor operated equipment and thermal appliances

EN 55022 <-> CISPR 22 : Information Technology Equipment

Category definitions and emission levels are the same than those given by the corresponding CISPR publication ; refer to the tables relating to the CISPR standards.

Note that in chapter 5.3 (where a comparison is done between EN and RTCA/DO160 standard) the limit value of the generic standard *50081-2* which are identical to those of EN 55011 and to CISPR 11 for the most usual industrial environment is used

A1.3 FCC (Federal Communications Commission) Standards

FCC standards are produced by the Federal Communications Commission. They limit the radiated and conducted emissions for most electronic devices operated in the USA. The Code of Federal Regulations (CFR) contains, in four volumes, the intentional and incidental use of the spectrum. The part relevant to EMC are part 15 (Radio - frequency devices) and part 18 (Industrial, Scientific and Medical equipment). These two parts are described in the following paragraphs.

FCC-CFR Part 15

This part governs emissions from communication devices (intentional spectrum users) and from computing devices (sub-part j). Only this sub-part has been considered for this survey.

Computing devices are defined as computers and electronic equipment using timing signals or pulses at a rate greater than 10 kHz, and using digital techniques. There are two classifications of these devices :

Class A : Use in commercial, industrial and business environment,

Class B : Use in a residential environment.

Some computing devices are excluded from sub-part j, including those used in transportation vehicles, process control equipment, domestic appliances and specialised medical equipment. In that case, manufacturers are only strongly advised to meet the limits.

Class A devices must have a label warning users that operation in a residential area may cause interference requiring a corrective action.

Class B labelling for certified devices states that the equipment complies with the limits.

FCC-CFR Part 15 Sub-part J - Radiated emissions (quasi-peak)

Standard	FCC Part 15	FCC Part 15
Class	A (Non - domestic)	B (Domestic)
Measurement distance	10 metres	3 metres
30 - 88 MHz	40 dB µV/m	40 dB µV/m
88 - 216 MHz	43 dB µV/m	43 dB µV/m
216 MHz - 960 MHz	46 dB µV/m	46 dB µV/m
960 MHz - 1 GHz	50 dB µV/m	54 dB µV/m

FCC-CFR Part 15 Sub-part J - Conducted emissions (quasi-peak)

Standard	FCC Part 15	FCC Part 15
Class	A (Non - domestic)	B (Domestic)
450 kHz - 1705 kHz	60 dB µV	48 dB µV
1705 kHz - 30 MHz	70 dB µV	48 dB µV

FCC-CFR Part 18

Consumer ISM equipment is subject to certification prior to use or marketing. Applications for certification must be accompanied by a description of the measurement facilities and a technical report.

Radiated emissions are restricted but each category of equipment has different specifications. Therefore, it would be necessary to refer to the equipment qualification report to determine its radiated emission levels. For conducted emissions, limits are only specified for ultrasonic equipment, and inductive cooking and lighting devices. Again, the specified levels are different for each equipment category. The conducted limits are given, for example, in the following table for lighting equipment.

FCC-CFR Part 18 Lighting equipment - Conducted emissions (quasi-peak)

Standard	FCC Part 18	FCC Part 18
Class	Non - consumer equipment	Consumer equipment
450 kHz - 1600 kHz	60 dB µV	48 dB µV
1705 kHz - 30 MHz	70 dB µV	48 dB µV

Comparison between EMC standards and EUROCAE ED14

The goal of this chapter is to give an overview in order to show that, at individual equipment level, the standards are very comparable

The field limits of several standards have been extrapolated to a distance of 1 metre from the tested device and compared with each other in the table A1-1. The conditions of extrapolation are widely discussed in § 5.3.2.2.2 .

The conducted levels have been compared directly in the table A1-2. For the conducted emissions, the levels can be directly compared to each other and with the voltage/current limits required by ED14 (narrow band) because each standard requires the measurement of current/voltages on very similar Line Impedance Stabilising Networks

Of course this comparison is available only for one piece of the equipment of an apparatus.

EN equivalent to CISPR

Frequency bands (MHz)	**EN 55011 EN 55022 Cl. A**	**EN 55011 EN 55022 Cl. B**	**EN 55013**	**FCC Part 15 Cl. A**	**FCC Part 15 Cl. B**	**ED14 Sec. 21 Cat. A**
30 – 41	60	50	62	60	50	36
41 – 68	60	50	62	60	50	38
68 – 88	60	50	62	60	50	41
88 – 174	60	50	62	63	53	43
174 – 216	60	50	62	63	53	49
216 – 230	60	50	62	66	56	50
230 – 300	67	57	62	66	56	51
300 – 470	67	57	66	66	56	51
470 – 760	67	57	66	66	56	56
760 – 960	67	57	66	66	56	60
960 – 1000	67	57	66	70	64	62

Table A1-1 :

Comparison of national and international standards (normalised to 1 metre)

for radiated emission limits **(**Levels given in dB µV/m)

Frequency bands (MHz)	**EN 55011 EN 55022 Cl. A**	**EN 55011 EN 55022 Cl. B**	**EN 55013**	**FCC Part 15 Cl. A**	**FCC Part 15 Cl. B**	**ED14 Sec. 21 Supply**	**ED14 Sec. 21 Signal**
0,15 - 0,5	79	66 to 56	66 to 56	60	48	62 to 56	82 to 76
0,5 - 1,7	79	56	56	60	48	56 to 51	76 to 71
1,7 - 5	79	56	56	70	48	51 to 46	71 to 66
5 - 30	73	60	60	70	48	46	66

Table A1-2

Comparison of national and international standards

for conducted emission limits **(**Levels given in dB µV)

ANNEX 2

Radiated Emission of the electrical/electronic equipment installed on an aircraft

A2.1. Radiated emission of the electronics bays

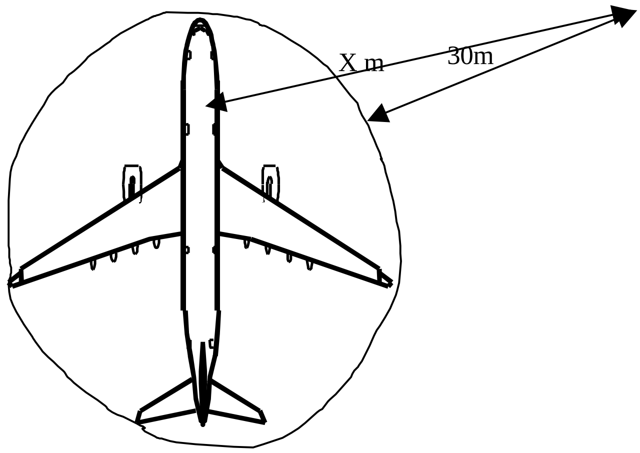
All equipment in the electronic bays comply with the EUROCAE ED14 cat A limits which are given at 1m from the equipment see table 1/5.

From this value it is difficult to give the radiated emission of an aeroplane at 30m from the apparatus.

But some numbers can be given:

The radiated emission at the same location of the measurement but with the attenuation of the fuselage will be 20dB lower. This is because 20 dB is a typical value for large civil aeroplane. The geographic reference point is of major importance: this typical value is measured by calibrating the field in free space at the location were the electronic bay will be then by measuring the same field at the same location from the field source but with the presence of the aeroplane.

The radiated emission at a given distance from the aeroplane must consider this reference point. Physically the electronic bay is located far from the more external point of the aeroplane as per the following sketch:



For a large aeroplane the distance is about 10m far from the more external point of the aeroplane.

With these numbers the radiated emission becomes:

Frequency bands (MHz)	**ED14 Sec. 21 Cat. A**	**Radiated emission of an aeroplane at 30m** **Due to the electronic bay equipment** **ED14 equipment level –20dB (attenuation)-32dB(40m distance attenuation**
30 - 41	36	-16
41 - 68	38	-14
68 - 88	41	-11
88 - 174	43	- 9
174 - 216	49	- 3
216 - 230	50	-2
230 - 300	51	-1
300 - 470	51	-1
470 - 760	56	4
760 - 960	60	8
960 - 1000	62	10

Table A2.1

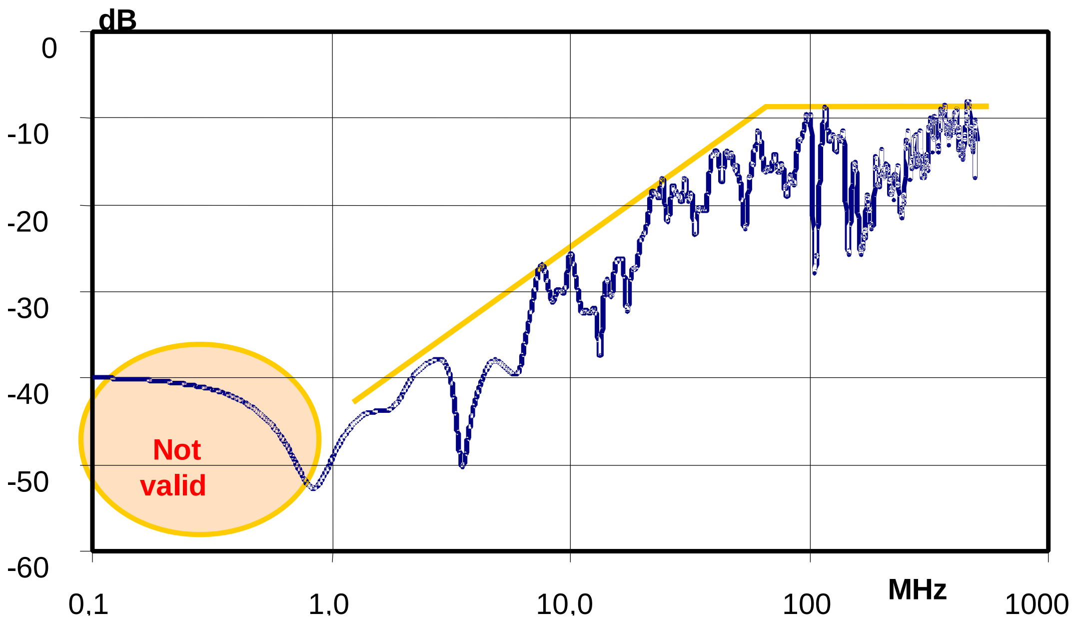
Levels given in dB µV/m

A2.2 Radiated emission of the cockpit

The analysis will be the same but the attenuation factor is lower as well as the distance, all the electronics satisfying the same requirements

Below is a typical attenuation of a large aeroplane cockpit. This curve comes for A320 measurements, but the cockpit being very similar whatever the size of the aeroplane is this result is applicable for all large aeroplane size.

E-field attenuation inside the cockpit



It is likely that, depending on the cockpit windshield window glass treatment, de-icing system, the attenuation will be lower. In this case the cockpit equipment participation to the aircraft radiated emission is very similar to the external equipment participation see § 5.3.2.2.1.

The values become when taking 9dB for attenuation and 35m from the distance:

Frequency bands (MHz)	**ED14 Sec. 21 Cat A (Cat M)**	**Radiated emission of an aeroplane at 30m** **Due to the cockpit equipment** **ED14 equipment level - 9dB (attenuation) – 31 dB (35m distance attenuation)**
30 - 41	36	-4
41 - 68	38	-2
68 - 88	41	1
88 - 100	43	3
100 - 150	43 **(34)**	-3
150 - 174	43	3
174 - 216	49	9
216 - 230	50	10
230 - 300	51	11
300 - 470	51	11
470 - 760	56	16
760 - 960	60	20
960 - 1000	62	22

Table A2.2

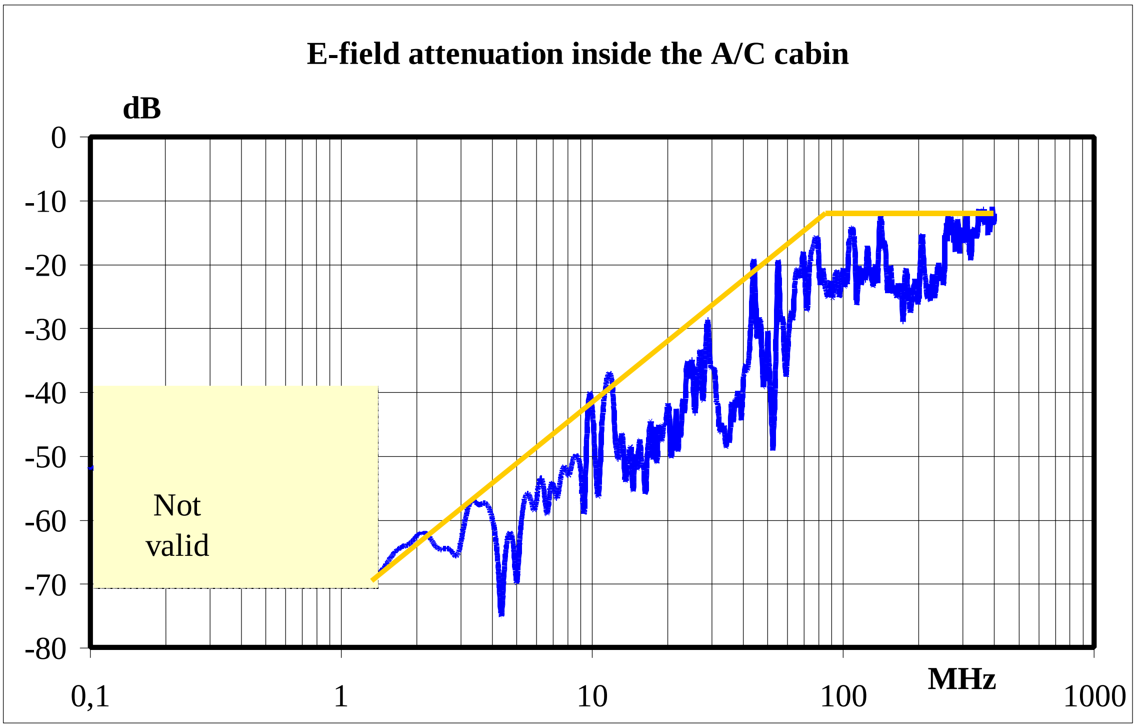
Levels given in dB µV/m (Cat M values are in brackets)

A2.3 Radiated emission of the cabin

The electrical/electronic equipment installed inside the cabin generally satisfies the EUROCAE ED14 category M requirements as per the TABLE 5.3.2.2.1.4. It can not be guarantee that some piece of equipment satisfies only category B. The table gives with these two requirements the radiated field of the aeroplane.

Below is an attenuation curve of the cabin of an Airbus A320. The behaviour of larger aeroplane will be very similar because:

- the cut off frequency is driven by the size of the windows which is identical on all size of aeroplane,
- the level is driven by: the energy interring the fuselage and by the internal losses which at the end gives similar results.



Then in this band, with a 12dB attenuation of the fuselage and 40m distance, the numbers become:

Frequency bands (MHz)	**ED14 Sec. 21 Cat. B**	**ED14 Sec. 21 Cat. M**	**Radiated emission of an aeroplane at 30m** **Due to the cabin equipment** **ED14 equipment level - 12dB (attenuation) – 32 dB (40m distance attenuation)** **With Cat B**	**Radiated emission of an aeroplane at 30m** **Due to the cabin equipment** **ED14 equipment level - 12dB (attenuation) – 32 dB (40m distance attenuation)** **With Cat M**
30 - 41	56	36	12	-8
41 - 68	58	38	14	-6
68 - 88	61	41	17	-3
88 - 100	63	43	18	-2
100 - 150	63	**34**	18	**-8**
150 - 174	63	43	18	-2
174 - 216	69	49	25	5
216 - 230	70	50	26	6
230 - 300	71	51	27	7
300 - 470	71	51	27	7
470 - 760	76	56	32	12
760 - 960	80	60	36	16
960 - 1000	82	62	38	16

Table A2.3

Levels given in dB µV/m

A2.4 Radiated emission of the external equipment : Engine, wings tail plane

The electrical/electronic equipment installed on the external parts of the aeroplane satisfy the EUROCAE ED14 category A, there is no attenuation and the distance from the aeroplane could be the distance from this equipment if we consider for example the light on the wing tip; the numbers become:

FREQUENCY BANDS (MHZ)	**ED14 Sec. 21 Cat. A**	**ED14 SEC. 21 CAT. H**	**Radiated emission of an aeroplane at 30m Due to the external equipment ED14 equipment level – 30dB (30m distance attenuation) With Cat A**	**Radiated emission of an aeroplane at 30m Due to the external equipment ED14 equipment level – 30dB (30m distance attenuation) With Cat H**
30 - 41	36	36	6	6
41 - 68	38	38	8	8
68 - 88	41	41	11	11
88 - 100	43	43	13	13
100 - 150	43	25	13	-5
150 - 174	43	43	13	13
174 - 216	49	49	19	19
216 - 230	50	50	20	20
230 - 300	51	51	21	21
300 -310	51	51	21	21
310 - 330	51	38	21	7
330 - 470	51	51	21	21
470 - 760	56	56	26	26
760 - 960	60	60	30	30
960 - 1000	62	62	32	32

Table A2.4

Levels given in dB µV/m

INDEX OF ABBREVIATIONS

ACJ	Advisory Circular Joint
AMJ	Advisory Material Joint
AOC	Air Operator Certificate
ATC/TCAS	Air Traffic Control / Traffic Collision Avoidance System
CISPR	International Special Committee on Radioelectric Interference – Commité International Special des Perturbations Radioelectrique
DME	Distance Measuring Equipment
DOA	Design Organisation Approval
EMC	Electromagnetic compatibility
EN	European Standard
EUROCAE	European Organization for Civil Aviation Equipment
EUT	Equipment Under Test
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FCC	Federal Communication Commission
GPS	Global Positioning System
HF	High Frequency
HIRF	High Intensity Radiated Fields
ICAO	International Civil Aviation Organization
ILS G/S	Instrument Landing System Glide/Slope Rx
ILS Loc	Instrument Landing System Localizer Rx
ISO	International Standards Organization
JAA	Joint Aviation Authorities
JAR	Joint Aviation Requirement
JIP	Joint Implementation Procedure
JTSO	Joint Technical Standards Orders
JPA	Joint Part Approval
(M)OPS	(Minimum) Operational Performance Specification
POA	Production Organisation Approval
RF	Radio Frequency
RTCA	Radio Technical Commission for Aeronautics
SAE	Society of Automotive Engineers
SATCOM	Satellite Communications
TSO	Technical Standard Orders
VOR	Variable Omni-Range
VHF	Very High Frequency

INDEX OF REFERENCES

EN 50081-2:1993	Electromagnetic compatibility – Generic emission standard – Part 2: Industrial environment
EN 50082-2:1995	Electromagnetic compatibility – Generic immunity standard – Part 2: Industrial environment
CISPR 11	Industrial, scientific and medical (ISM) radio-frequency equipment - Electromagnetic disturbance characteristics - Limits and methods of measurement
CISPR 13	Limits and method of measurement of radio interference characteristic of sound and television broadcast receivers and associated equipment
CISPR 14-1	Electromagnetic compatibility – Requirements for household appliances, electric tools and similar apparatus - Part 1: Emission - Product family standard
CISPR 22	Information technology equipment – Radio disturbance characteristics - Limits and methods of measurement
DO 160	Environmental conditions and test procedures for airborne equipment
ED 14	Environmental conditions and test procedures for airborne equipment (DO 160D)
ED 23	Minimum operational performance specification for VOR airborne equipment
Regulation 3922/91	Council Regulation on the harmonisation of technical requirements and reference to recognized technical and administrative procedures in the field of aviation
Directive 89/336/ECC	Council Directive on the approximation of the laws of the Member States relating to electromagnetic compatibility