

CAP 756

Portable Electronic Device Generated Electro- magnetic Fields on board a Large Transport Aeroplane

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Executive Summary

This report contains the results of a study that was conducted to predict the electro-magnetic interference (EMI) levels that could exist on board a large transport aeroplane in 2010 and includes recommendations for further action. This activity was conducted in response to CAA Safety Intervention (SI) 03/16: Risk of Interference from Portable Electronic Devices (PEDs).

It should be noted that whilst the study was conducted to focus on large transport aeroplanes, the conclusions drawn and recommendations made should be taken to apply to all aircraft.

This report identifies PEDs as sources of uncontrolled electro-magnetic (EM) radiation. PEDs have the potential to generate adverse interference effects to aircraft systems and equipment, through the radiation of EM fields in the Radio Frequency (RF) spectrum. PEDs are categorised as intentional and/or unintentional transmitters.

This report identifies the currently published civil aviation requirements, policy and guidance material that relate to PEDs, and summarises some of the difficulties associated with the control of PED use on board aircraft that are related to human factors.

The current environment is assessed with reference to existing studies, including those previously conducted by the CAA, and the ongoing studies of industry working groups with which the CAA currently remains involved. These studies have attempted to analyse the risks associated with the use of PEDs on board aircraft, by comparing their RF radiation with the RF susceptibility qualification criteria of airborne equipment.

These studies identified difficulties associated with the determination of the PEDs' level of RF radiation. Theoretical analyses based on the PED industry standards could not provide comparisons with airborne equipment test standards due to the differences in test methodology. Measurements of actual PEDs were not conclusive because only a small number of PEDs were tested. In conclusion, the measurement of PED RF radiation would need to use a sufficiently large sample of devices to produce a representative depiction of a potential environment (taking variations of design, manufacture, methods of demonstrating compliance with industry standards, durability and potential failure modes into account) before an accurate definition of the PED RF environment could be produced.

This study identified that the SI task to predict the EMI levels from PEDs in 2010 might have been interpreted as requiring the production of a RF spectrum level definition. However, the ability to produce such an accurate definition would require the analysis of, and the ability to test, the PEDs that would then be in use. Until such PEDs become available, such an approach would not be possible.

Therefore, whilst it is not possible to categorically predict the exact RF levels that will exist in 2010, it has been possible to predict the environment to the extent that certain conclusions could be drawn.

This study has concluded that:

- The RF environment within the aircraft is likely to become more severe, primarily through the increase in number and types of PEDs that will be used on board. This may result in a narrowing of the safety margins between the aircraft systems and equipment RF susceptibility qualification and the actual EM field levels generated, resulting in a potential for an increase in interference to aircraft systems and equipment.
- PEDs are uncontrolled devices and reliance on the PED industry related qualification should not be considered as indicative of the PED's actual performance on board the aeroplane.

- The aeroplane Certification Specifications (CSs) do not specifically refer to PEDs as contributing sources of RF radiation within the internal aircraft environment.
- Aircraft operators need to maintain and enforce adequate controls to prevent the potential risk of adverse interference effects to aircraft systems and equipment.
- There is currently a lack of standardisation in pre-flight briefings and information presented to the passengers, identifying permitted and non-permitted PEDs, which could lead to an escalation of confusion amongst passengers.
- The ability of aircraft crew to recognise and hence prevent prohibited PED use within the cabin is likely to become more difficult without reliance on specialised equipment or training.
- Aircraft operators may wish to seek to allow use of currently prohibited PEDs.
- Certain factors associated with use of PEDs, other than those associated with Radio Frequency Interference (RFI), e.g. human factors, need to be closely monitored to ensure that any associated risks are approached in the appropriate manner.

This study also includes the following recommendations:

- That the development of PED technology be monitored by the responsible aviation authority or agency, to ensure that new technologies are not brought on board aircraft without the proper or appropriate guidance or advice being provided to aircraft operators.
- That the aircraft operators should consider how they will ensure that no person uses a PED that could adversely affect the aircraft's systems and equipment when considering whether to rely on any PED's in-built transmitting or not-transmitting indicator.
- That an accurate, harmonised definition of the aircraft's internal RF environment, as generated by PEDs, be produced for use in conjunction with the aircraft certification requirements.
- That the aircraft certification requirements be reviewed by the responsible aviation authority or agency to ensure that PEDs' RF emissions are considered as one of the sources of effects to the environment within the aircraft that should be taken into account during aircraft certification.
- That the airborne equipment qualification test levels reflect the RF environment generated by PEDs within the aircraft and that the responsible aviation authority or agency remain involved with the aircraft industry working groups (WGs) that are tasked with the development of the airborne equipment test standards and the analysis of PED issues.
- That the UK CAA should continue to provide appropriate guidance to UK aircraft operators regarding the briefing of their PED policy to passengers.
- That work continues with industry to ensure that only those PEDs that have been permitted by the aircraft operator are used.

1 Introduction

- 1.1 SI 03/16 was included with the CAA Safety Regulation Group's 2003 Safety Plan. Titled as "Risk of Interference from Portable Electronic Devices (PEDs)", it identified that research, which had been sponsored under CAA SI 01/10 (2002), had shown that the radiated energy from PEDs could interfere with aircraft systems with unpredictable consequences. The measured levels are known to exceed the older airborne equipment qualification standards, which do not achieve the protection afforded by today's aircraft certification requirements. This, combined with the increasingly widespread use of PEDs, could pose a threat to air safety.
- 1.2 There are an increasing number of reports, including Mandatory Occurrence Reports (MORs) from within the UK, of interference to aircraft systems, which were cited as caused by PEDs or where PEDs were cited as a causal or circumstantial factor.
- 1.3 Following on from the sponsored research, the CAA's initial strategy was to increase awareness and understanding of the risk and to control it by strengthening existing restrictions on the use of PEDs. In addition, the CAA determined the vulnerability of certain example systems, provided guidance to operators, and assessed the use of interference detectors.
- 1.4 SI 01/10 (2002) included the sponsoring of research to identify the susceptibility of vulnerable avionic equipment to interference from commonly used transmitting PEDs and to develop guidance material on immunity standards. This resulted in the publishing of CAA Paper 2003/3 [reference 4] that contained the results of tests that exposed avionic equipment to simulated cell phone EM fields, and the active involvement with EUROCAE WGs, which included investigating the avionic equipment immunity standards with respect to PED emissions.
- 1.5 SI 03/16 identified the need to conduct a study to predict the EMI levels that could exist on board a large transport aeroplane in 2010 and include recommendations for further action.

2 Aircraft Systems Interference from Portable Electronic Devices (PEDs)

- 2.1 A PED is an item of electrically powered equipment that uses internally or externally supplied electrical power and is of a size that enables it to be portable. This includes devices that may be brought on board aircraft by passengers, such as:
 - a) laptop computers and mobile phones;
 - b) devices that are provided to the passengers by the aircraft crew, e.g. Digital Versatile Disc (DVD) players for on-board entertainment; and
 - c) devices that may be used by the aircraft crew when performing their duties, e.g. duty free point of sale equipment.
- 2.2 The use of PEDs on board aircraft by flight crew, cabin crew and passengers is common practice. Such use can present a source of uncontrolled EM radiation with the potential risk of interference effects to aircraft systems and equipment. Given that a civil aircraft flying at high altitude and high speed in busy airspace is in a hazardous environment, and given that many of the on-board systems are safety devices intended to reduce the risks of that environment to tolerable levels, then anything that degrades the effectiveness of those systems will increase the risk to the aircraft.
- 2.3 Over the past ten years, the CAA has received 65 MORs relating to interference experienced with one or more of the aircraft systems that cited PEDs as a factor, which were not subsequently found to be caused by a system's malfunction.

3 Defining the Threat

3.1 PED Categorisation

3.1.1 PEDs will radiate RF emissions from their internal components such as poorly filtered oscillators, processor clocks, unsuppressed electric motors, and power supply converters. These emissions are referred to as unintentional because they occur as a by-product of the PED's operation.

In addition, some PEDs will also need to transmit RF signals at specified frequencies as a part of their functionality. These transmissions are referred to as intentional transmissions.

3.1.2 PEDs fall into two main categories:

- a) those that only emit radio signals as a by-product of their operation (unintentional transmitters); and
- b) those that transmit radio signals as a part of their functionality (intentional transmitters).

3.1.3 Examples of PEDs classified as unintentional transmitters include:

- a) personal computing equipment such as laptops, Personal Digital Assistants (PDAs) etc.;
- b) electronic cameras;
- c) radio receivers;
- d) audio and video reproducers;
- e) electronic games and toys; and
- f) time measuring equipment.

3.1.4 Examples of PEDs classified as intentional transmitters include:

- a) mobile phones;
- b) personal computing equipment (laptops, PDAs, etc.) with wireless network devices (plug-ins or embedded);
- c) two-way pagers;
- d) two-way radios;
- e) radio transmitters; and
- f) remote control equipment, which may include some toys.

3.1.5 When defining the form of radiation emanating from PEDs, it is useful to differentiate between the unintentional components, the intentional components and the effects. For the purposes of this paper, the following terms have been used:

- Emission: Unintentional RF radiation from within any form of PED.
- Transmission: Intentional RF radiation from an intentionally transmitting PED.
- Radiation: RF EM fields, intentional and unintentional, which emanate from a PED.
- Interference: The act of causing effects to aircraft systems and equipment.

3.2 Consideration of PED Radio Frequency (RF) radiation

3.2.1 All components of the RF radiation emanating from a PED should be considered when defining the potential threat. This should include the unintentional emission from unintentionally transmitting PEDs, and both the unintentional emission and the intentional transmission from an intentionally transmitting PED.

- 3.2.2 The intentional transmissions from PEDs are generally kept clear of the aeronautical frequencies by use of frequency bands that are specifically allocated by the spectrum management agencies for the PEDs' use. The intent of this is to prevent any single PED's intentional transmission, considering PEDs that have been produced to conform to the spectrum management agencies' standards, from producing any transmission "product" within the aeronautical bands.
- 3.2.3 However, frequency allocation of intentional transmissions may not prevent intermodulation (the interaction of different technologies or transmissions) from occurring and producing "transmission product" within those bands; nor would it prevent a PED that had been produced without regard to the spectrum management agencies' regulations from producing transmissions that may also fall within the aeronautical frequency bands.
- 3.2.4 The transmissions from intentionally transmitting PEDs may be of sufficient power to affect aircraft systems through direct radiated coupling to aircraft equipment or wiring, although the impact of any coupling to the wiring will be dependent upon the transmission frequency and the distance between the point at which the wiring is radiated and the equipment interface.
- 3.2.5 The unintentional emissions from any PED may fall in the bands used for aeronautical services, and emission levels may be sufficient to affect aircraft system receivers through their antennas or other aircraft systems through direct radiated coupling to their equipment or wiring.
- 3.2.6 Use of a PED on the flight deck may present a particular risk to aircraft systems having antenna systems located in the vicinity, which may include equipment bays and the radome.

3.3 **Aircraft Equipment Qualification**

- 3.3.1 To qualify for approval with the aircraft certification requirements, which (for large aeroplanes that fall under the scope of the European Aviation Safety Agency (EASA)) are contained within EASA Certification Specification 25 (CS-25) [reference 1], equipment that is required to be installed in aircraft must demonstrate that it performs its intended function within the aircraft-operating environment. One element of this is to demonstrate that the required equipment is not susceptible to prescribed levels of radiated EM fields, irrespective of the source.
- 3.3.2 One method of demonstrating partial compliance with CS-25 [reference 1] is to conduct controlled equipment-level tests, using internationally recognised civil aerospace test standards. These provide standardised airborne equipment test levels and procedures that can be selected to represent the environment within a particular aircraft location. A commonly used and accepted test standard is known as both EUROCAE ED-14 and RTCA DO-160 [reference 8], both of which are currently at revision D.
- 3.3.3 One section of these documents addresses the EM performance of airborne equipment over the RF spectrum by demonstrating that the equipment performs as intended when subjected to RF fields of predetermined strengths. This is known as RF susceptibility.
- 3.3.4 The test levels that were set in the original versions of these test standards were set to ensure that qualified airborne equipment could co-exist in the aircraft without mutual interference; however, the risk of an uncontrolled RF EM field sourced from within the aircraft was not addressed.

- 3.3.5 Recognising the inadequacy of the earlier standards, the tests have become progressively more severe. This was primarily to demonstrate that the equipment design would protect against aircraft external threats such as the High Intensity Radiated Field (HIRF) environment, generated from sources that include broadcast transmitters, radars and satellite uplinks. Further information can be found within EUROCAE ED-107 - 'Guide to the Certification of Aircraft in a HIRF environment' [reference 9].
- 3.3.6 In addition to any equipment environmental qualification, equipment is assessed during installation to ensure that its operation produces no adverse effects on the existing aircraft, systems and equipment and, if the equipment is installed to perform a required function, that it performs that intended function.
- 3.3.7 The result of this is a controlled process (which is vital for certification) that verifies the equipment performs as intended, produces no hazard to other aircraft systems or equipment, and, whilst the equipment is an electronic device that will be a source of RF radiation, ensures that this source of RF radiation is controlled.
- 3.4 **PED Qualification / Uncontrolled Items**
- 3.4.1 Whilst aircraft equipment is required to have an airworthiness approval which may include separate airworthiness-related, equipment-level qualification, PEDs are not generally subjected to the same controls.
- 3.4.2 Different classes of PEDs may have different standards of qualification imposed upon them depending upon the functionality offered and the country from which the PED originates.
- 3.4.3 If applied, these standards can require EM compatibility performance to be demonstrated to the extent that the PED's operation does not generate sufficient EM disturbances to other equipment and apparatus with regard to other general equipment, but do not specifically require the prevention of effects to airborne equipment used in aircraft.
- 3.4.4 Therefore, whether or not the standards are applied and whether or not a PED is qualified, there is no PED-qualification standardised process that could ensure that a PED performing in accordance with its design criteria, against which any PED qualification would be considered, could not interfere with airborne equipment.
- 3.4.5 It is not normally possible to determine whether any PED in use continues to conform to its original design criteria, because there are seldom requirements for routine maintenance or checks of PEDs' characteristics or functionality beyond that performed by the owner, who might check for functionality but not for any undesired performance. This lack of continuous monitoring results in the inability to determine whether there is any degradation or alteration of the PED's original, and possibly qualified, EM performance (susceptibility or emissions), which may arise due to modification (addition of peripheral devices or new components) or accidental damage.
- 3.4.6 In considering the above, whether or not a PED is initially subjected to any form of qualification, once the device is in use there is generally no continued monitoring of the PED's performance to enable any form of continued qualification to exist. Because no checks are generally performed to guarantee that even an initially qualified PED has not been altered in any way (damaged or modified), all PEDs¹ brought on board an aircraft are unqualified, un-approvable devices and should be considered as uncontrolled sources of RF radiation.

1. Other than those used and assessed by the aircraft operator, to perform a function for which an airworthiness or operational approval has been granted.

3.4.7 In addition, the uncontrolled nature of PEDs means that it would not be possible to guarantee that any form of failure, of all PED types, could not result in an adverse effect on the airworthiness or safe operation of the aircraft unless specific analysis or testing was conducted by, or on behalf of, the aircraft operator. Therefore, any use of PEDs should continue to be controlled by aircraft operators' operational procedures.

3.5 Interference Coupling

3.5.1 The means by which aircraft systems could be affected by the PED's RF radiation is known as RF susceptibility, as mentioned in section 3.3 above. There are two primary types of RF susceptibility known as conducted and radiated susceptibility. This paper does not attempt to define these in detail, but a brief description is as follows.

3.5.2 The term 'Conducted Susceptibility' characterises the effect of RF energy being coupled into an aircraft system's wiring, thus affecting the lines to/from the system's equipment, e.g. Line Replaceable Units (LRUs) and Antennas. This would normally occur where the aircraft system's wiring passes through an EM field generated by the PED, which is of a frequency that permits the coupled energy to be transmitted along the wiring to the system's equipment. For RF energy to be coupled to aircraft systems, via conducted coupling through the aircraft wiring, the frequency of the EM field would typically be less than 400kHz.

3.5.3 The term 'Radiated Susceptibility' characterises the effects of RF energy being coupled directly into an aircraft system's equipment, e.g. LRUs and Antennas and, to an extent, onto its wiring. This would occur where the aircraft system's equipment or wiring was exposed to an EM field generated by the PED, which is of a frequency that permits the energy to be directly coupled into the equipment through designs with inadequate screening of LRUs or imperfect filtering of antennas. The effect of RF energy being coupled into an aircraft system's wiring and transmitted along the wiring to the system's equipment is less than with conducted coupling due to the aircraft wiring's attenuation of the RF energy at the radiated frequencies. The effect of this is generally a need to consider only the effects on the wiring close to the equipment interfaces. For RF energy to be coupled to an aircraft system's equipment, via radiated coupling, the frequency of the EM field would typically be greater than 400kHz.

3.5.4 Tests for both conducted and radiated susceptibility are contained within EUROCAE ED-14 and RTCA DO-160 [reference 8].

4 The Current Environment

4.1 Current Studies - CAA

4.1.1 The CAA has conducted testing associated with the potential for interference generated by the use of mobile telephones on board aircraft under the auspices of CAA SI 01/10 (2002): Sponsor research to identify the susceptibility to interference from commonly used transmitting devices of vulnerable avionic equipment.

4.1.2 The results of the two phases of tests that were conducted were published in CAA report 'Interference Levels In Aircraft at Radio Frequencies used by Portable Telephones' [reference 3] and CAA Paper 2003/3, 'Effects of Interference from Cellular Telephones on Aircraft Avionic Equipment' [reference 4].

- 4.1.3 The conclusions, relating to the CAA's test results, included the following:
- a) transmission levels produced by a portable telephone used near the flight deck or avionics equipment bay exceeded demonstrated RF susceptibility levels for equipment qualified to standards published prior to July 1984, and as such, as equipment qualified to these standards is installed both in earlier certificated aircraft and in newly built aircraft, the current policy for restricting the use of portable telephones on all aircraft will need to remain in force; and
 - b) various adverse effects on the tested equipment's performance from transmissions intended to simulate possible cell phone generated EM fields. Although the equipment tested demonstrated a satisfactory margin above the original certification criteria for RF susceptibility, that margin was not sufficient to protect against potential cell phone generated transmissions under worst-case conditions.
- 4.1.4 The recommendations of the CAA report and paper [references 3 and 4] included the need to continue to prohibit the use of mobile phones on board aircraft and the amendment of the minimum equipment qualification levels for RF susceptibility (as defined in ED-14D and DO-160D [reference 8]), with the objective of providing increased margins to protect against potential interference from cell phones and other transmitting devices used on board the aircraft.
- 4.2 **Current Studies - Industry**
- 4.2.1 The CAA has actively supported two industry-based working groups (EUROCAE Working Group (WG) 58 and RTCA Special Committee (SC) 202) that investigated the issues associated with the use of PEDs on board aircraft.
- 4.2.2 EUROCAE WG-58 published the results of their study in December 2003 as EUROCAE DOCUMENT (ED)-118 [reference 5].
- 4.2.3 The document produced by RTCA SC-202 (DO-294) [reference 6] built upon the work published in ED-118 [reference 5] and focused on intentionally transmitting PEDs. This included a process that would assist aircraft operators to assess particular PED technologies, enabling a substantiated determination of non-interference to the appropriate airworthiness authority/agency, prior to permitting the use of particular PED technologies.
- 4.2.4 ED-118 [reference 5] and DO-294 [reference 6] define and characterise PEDs in detail to support the aircraft operator's use of the assessment process contained within DO-294 [reference 6]. The following paragraphs summarise that content as it applies to a definition of the currently generated environment.
- 4.2.5 In ED-118 [reference 5], WG-58 set out to identify the field strengths for use as a PED worst-case envelope, for use in comparison with the airborne equipment RF susceptibility test levels contained within ED-14D/DO-160D [reference 8] and hence used in airborne equipment qualification.
- 4.2.6 Such a comparison was intended to determine whether PED radiated fields would meet the criteria and test levels contained within section 21 of ED-14D/DO-160D [reference 8] that provides for the RF emissions tests of airborne equipment.
- 4.2.7 WG-58's study of unintentionally transmitting PED emissions used industry standards and determined that the conducted emissions may not significantly exceed the ED-14D/DO-160D [reference 8] limits. The results were stated to need careful consideration because of differences in test set-up and approach between the PED industry and aerospace standards, and it was noted that the determination of a true worst-case envelope would require measurement of actual device emissions, using a comparable test set-up and procedure to that of ED-14D/DO-160D [reference 8].

- 4.2.8 The study of intentionally transmitting PED emissions and transmissions was based on a combination of analysis and measurements. This determined that the unintentional emissions were not generally greater than those from unintentional transmitters, but that definitive conclusions could not be drawn because only a relatively small number of PEDs could be tested. The determination of intentional transmissions was based upon an analysis of the theoretical peak power and frequencies defined in the industry standards. Due to difficulties with this process, the result was stated as being a possible overestimation of the actual levels and that further analysis and measurement would be necessary to determine the actual worst-case envelope.
- 4.2.9 SC-202, which included representation from WG-58 and the CAA, built upon the studies published by WG-58 by providing a further characterisation of current technology intentionally transmitting PEDs. The purpose of this characterisation within DO-294 [reference 6] is to enable the aircraft operator to determine the worst-case radiation from intentionally transmitting PEDs to compare with the aircraft and equipment RF susceptibility qualification as a part of the process to determine whether use of the intentionally transmitting PEDs could be permitted on board.
- 4.2.10 As with ED-118 [reference 5], the characterisation provided is based upon analysis of industry standards, but suggests that actual measurements of radiated fields could be used if additional factors were taken into account.
- 4.2.11 In summary, whilst providing a form of PED characterisation, WG-58 and SC-202 were unable to accurately determine an actual PED RF radiation environment definition that would provide for a direct comparison with the airborne equipment RF susceptibility qualification.
- 4.2.12 However, SC-202 did conclude that spurious (unintentional) emissions from intentionally transmitting PEDs occurring at the actual industry limits would have the potential to generate interference that could adversely affect the operation of some aircraft systems.
- 4.3 **Cumulative Effects**
- 4.3.1 In establishing the RF environment generated by PEDs, it is necessary to consider the effect of multiple devices' simultaneous operation. Both EUROCAE WG-58 and RTCA SC-202 studied the effects of this and verified that this must be addressed when conducting statistical analyses of the effect of PEDs. The information published in ED-118 [reference 5] regarding cumulative effects was built upon by SC-202 and identified within DO-294 [reference 6] as the Multiple Equipment Factor (MEF).
- 4.3.2 In considering the cumulative effects or MEF, it should be noted that the unintentional emissions from PEDs would add to the overall RF environment, possibly resulting in the raising of the noise floor, with different types of PEDs providing emissions at different parts of the RF spectrum.
- 4.3.3 The intentional transmissions may also accumulate if transmissions from different types of PEDs occurred at the same frequencies. However, power and sequencing control techniques used within some base stations (access point or similar) would normally prevent certain types of PEDs from transmitting simultaneously.
- 4.3.4 RTCA DO-294 [reference 6] provides an outline of certain methods that could be used to calculate a MEF but concludes by stating that additional effort would be necessary to determine the most efficient means of determining the MEF.
- 4.3.5 Any approach taken would need to consider PED coupling paths, failed PEDs and intentionally transmitting PED signal protocols.

5 Human Factors

5.1 The use of PEDs on board aircraft introduces a number of issues that fall under the heading of human factors.

These are covered in some depth within DO-294 [reference 6] and are generally associated with a number of key issues, considered as:

- a) the crew being unable to differentiate between PEDs that are permitted and those that remain restricted or prohibited;
- b) the passengers being aware of the aircraft operator's policy on PED use; and
- c) the improper use of PEDs.

5.2 The issues associated with the difficulties in restricting PED use to only those PEDs that are permitted requires that the crew be able to identify the permitted PEDs and thereby prevent any unrecognisable PED from being used.

5.3 DO-294 [reference 6] recommends the development of an internationally implemented and recognised indication on PEDs that would illuminate when any transmitting element within the PED was active. SC-202 intended that the aircraft crew could monitor for any such indication, and prevent further use of the associated PED if necessary.

5.4 However, use of such a feature would obviously require the aircraft crew to place reliance on the indication provided by the uncontrolled PED, and the airworthiness issues allied with such a process and the associated procedures that would need implementation have yet to be addressed and assessed for their appropriateness.

5.5 The passenger's awareness of an aircraft operator's policy on PED restrictions could be increased by the enhancement of passenger briefings and information provided on corporate policy prior to the date of travel and the display of information whilst on board. One recommendation from SC-202 is the implementation of a "PED Use" light, possibly similar to the fasten seat-belt light, that could indicate when PED use could be permitted.

5.6 In addition, aircraft operators are currently introducing systems that provide interfaces with low power intentionally transmitting PEDs (e.g. Wireless Local Area Networks (WLANs)) and studies are looking into permitting use of mobile phones with a form of on-board system to ensure control of the PEDs' transmitted power. Introducing such systems to some aircraft, and permitting associated PEDs to be used in flight, will possibly result in a change in passengers' expectations and perceptions of restricted PED use. Such behaviour would need to be monitored to ensure that use of PEDs, including mobile phones, continues to be restricted on aircraft where such systems are not introduced. Any passenger confusion arising over such scenarios would require prompt action to prevent any conflict with aircraft crew and prevent the potential of adverse interference effects to the aircraft systems or equipment.

5.7 The issues associated with the improper use of PEDs may be considered to include those that could arise if they are not properly stowed during critical phases of flight and potentially present a loose article hazard within the cabin. Continued use during cabin safety briefings would also be regarded as improper use.

6 Requirements, Policy and Guidance

6.1 Aviation Requirements

- 6.1.1 The airworthiness requirements for the certification of large aeroplanes within the European Union (EU) are contained within CS-25 [reference 1], which includes Airworthiness Codes and Acceptable Means of Compliance (AMC). Similar CSs cover the requirements for other aircraft, including rotorcraft and small aeroplanes.
- 6.1.2 The Joint Aviation Requirements (JARs) applicable to the operation of large aeroplanes are contained in JAR-OPS Part 1 (JAR-OPS 1) [reference 2]. This prescribes the requirements applicable to the operation of any civil aeroplane for the purpose of commercial air transportation. Similar requirements exist for the operation of commercial air transport rotorcraft (JAR-OPS 3).

6.2 Certification Requirements

- 6.2.1 Book 1 of CS-25 - Large Aeroplanes [reference 1] contains section 25.1309, titled Equipment, Systems and Installations. This requires that the aeroplane equipment and systems be designed and installed so that the equipment and systems that are required for type certification or by the operating rules, or whose improper functioning would reduce safety, perform as intended under the aeroplane operating and environmental conditions. These are identified as required equipment and systems. All other equipment and systems, i.e. those that are not required, must not be a source of danger in themselves and must not adversely affect the proper functioning of the required equipment and systems.
- 6.2.2 Book 2 of CS-25 [reference 1] contains the AMC and section 9(a) of AMC 25.1309 covers compliance with CS 25.1309(a). This requires that the equipment be shown to perform its intended function when installed and operated within the conditions expected to be encountered on board the aircraft, considering both the external and internal environment.
- 6.2.3 Any PEDs used to perform a required function must consider the requirements that apply to that function. However, the majority of PEDs used on board an aircraft do not perform any required function, so they could only be considered as devices that may contribute to, or affect, the environment within which the required systems and equipment would be shown to operate. However, PEDs are not currently included within the list of environmental contributory factors within AMC 25.1309, so any potential effects from the use of PEDs within the aircraft would fall outside the basic certification basis.

This establishes the need for PED use to be covered by the operational requirements.

6.3 Operational Requirements

- 6.3.1 The requirements relating to the use of PEDs on board a large commercial aeroplane are found within JAR-OPS 1.110, which requires an operator "... to take all reasonable measures to ensure that no person does use, on board an aeroplane, a portable electronic device that can adversely affect the performance of the aeroplane's systems and equipment".
- 6.3.2 Additional regulations exist within the Air Navigation Order (ANO) 2005 (as amended), which identifies the aircraft equipment that is required for aircraft operation. Whilst recognising that the majority of PEDs do not perform a required function, the ANO requires that non-required equipment, which would include a PED, must not be a source of danger in itself or impair the airworthiness of the aircraft or the proper functioning of any required equipment.

6.4 Requirements Summary

- 6.4.1 The certification and operational requirements require that the use of non-required equipment should not be permitted unless it can be shown that such use does not adversely affect the proper operation of the required aircraft systems and equipment. This affects all non-required equipment, including the installation of airborne equipment such as galleys and In-Flight Entertainment (IFE) equipment, as well as PEDs.
- 6.4.2 The installation of equipment is covered by the type certification requirements and the operation of the non-required PEDs is covered within operational requirements and regulation.
- 6.4.3 In recognising that PEDs are currently not reflected within the definition of the aircraft environment in the certification requirements, all PED use must, in the same way as for installed equipment, be restricted and controlled in accordance with the operational requirements and regulation. This will ensure that the required aircraft systems and equipment continue to operate within an environment that was defined for type certification, and it remains the aircraft operator's responsibility to ensure that no person uses a PED that could adversely affect the aircraft systems and equipment performance.
- 6.4.4 However, in identifying the devices that should not be used, the aircraft operator should continue to determine if use of any PEDs on board their aircraft should be permitted and thereafter ensure that the only PEDs used are those that they have determined will result in no adverse effect to the required aircraft systems and equipment, thus ensuring compliance with the operational requirements. The purpose of showing this is to ensure that under operational conditions compliance with the original certification requirements is maintained.

6.5 Policy and Guidance Material

Both the JAA and CAA published policy and guidance material relating to the use of PEDs.

6.5.1 JAA Policy and Guidance Material Location

The JAA policy and guidance material relating to the use of PEDs on board aircraft which are operated under the jurisdiction of JAR-OPS 1 [reference 2] was published within JAA Temporary Guidance Leaflet (TGL) 29 [reference 10] in October 2001. This was introduced in an attempt to avoid differences between JAR-OPS aircraft operators in the manner in which PED usage was controlled.

6.5.2 CAA Policy and Guidance Material Location

- 6.5.2.1 The CAA policy relating to the use of mobile telephones and other electronic devices was contained within Aeronautical Information Circulars (AICs) published prior to TGL 29 [reference 10]. These were AIC 62/1999 (Pink 196), 'Use of Portable Telephones in Aircraft', and AIC 78/1997 (Pink 148), 'Use of Portable Electronic Games, Calculators etc. in Aircraft', published in 1999 and 1997 respectively.
- 6.5.2.2 The UK CAA revised the information that was contained within these AICs in 2004, by publishing AIC 1/2004 (Pink 62) [reference 11], covering the 'Use of Portable Electronic Devices in Aircraft'. This built upon the information contained within TGL 29 [reference 10] and reflected the experience gained through involvement with industry working groups and the development of the special certification conditions associated with airborne wireless networks.

6.5.3 PED Policy and Guidance

- 6.5.3.1 The current policy relating to the use of PEDs covers the use of both intentionally and unintentionally transmitting PEDs.
- 6.5.3.2 The current policies require that the aircraft operator implement procedures to ensure that all intentionally transmitting PEDs are totally switched off for the entire duration of the flight, whilst unintentionally transmitting PEDs should be totally switched off during critical phases of flight.
- There are certain exceptions to these rules and these can be found, along with further details, within TGL 29 [reference 10] and AIC 1/2004 [reference 11].
- 6.5.3.3 The annex to AIC 1/2004 [reference 11] provides additional guidance on the issues associated with the different types of intentionally transmitting PEDs, which include:
- a) cell phone type devices, including devices with "plane safe" features; and
 - b) non-cell phone type devices, including WLANs and Wireless Personal Area Networks (WPANs).
- 6.5.3.4 Further information is also provided relating to the issues associated with unintentionally transmitting PEDs, and the annex notes that the general aviation community should be alert to the interference risk from any PED in small aircraft.

7 Predicted Environment

7.1 Study Overview

- 7.1.1 This paper has been produced in order to address the action defined within SI 03/16 which was that of predicting the EMI levels that could exist as a result of PED usage on board a large transport aeroplane in 2010.
- 7.1.2 The conducted assessment focused on the frequency range within the EM spectrum at which PED generated interference effects to aircraft systems and equipment occur. This is known as the RF spectrum, which generally covers a frequency range in the order of 10kHz to 40GHz.
- 7.1.3 The statement within SI 03/16 could be interpreted as requiring a RF spectrum level definition to be produced such that the EM field levels in volts per meter (V/m) could be specified over a range of 10kHz up to 40GHz in a similar manner to that currently defined for the HIRF environment today.
- 7.1.4 Such a definition, presented in a format that could be related to the airborne equipment test standards such as ED-14D/DO-160D [reference 8], could then be used to provide a direct comparison with the airborne equipment qualification levels in order to provide a form of compatibility comparison.
- 7.1.5 Determination of these levels could be based either upon the characteristics of the PEDs' radiation as defined by the technology standards and protocols and the regulatory unintentional emission limits, or upon measurement of actual devices' radiation levels conducted under controlled conditions; both of these methods have been covered in detail within EUROCAE ED-118 [reference 5] in an attempt to define the current environment.
- 7.1.6 However, because of the uncontrolled nature of PEDs, utilisation of standards were found to be unlikely to reflect the actual radiation (emission or transmission) produced, and measurement of a single device would not be considered to be representative of all devices conforming to the same model or the same technology.

- 7.1.7 Therefore, whilst the work conducted by WG-58 and published in ED-118 [reference 5] serves to demonstrate a possible means of identifying a theoretical method of determining the environment that could exist, further work would be necessary in order to produce an accurate depiction of the worst-case environment that could exist on board a large transport aeroplane today. The measuring of actual device radiation would need to use a sufficiently large sample of devices in order to produce a representative depiction of a potential environment, taking variations of design, manufacture, methods of demonstrating compliance with industry standards, durability and potential failure modes into account. Using this approach, with ED-14D/DO-160D [reference 8] test methods, a potential environment could be produced and this should be investigated further to identify levels that can be specified.
- 7.1.8 The consumer electronics industry, to which PEDs are considered to belong, is a rapidly developing industry that introduces new technologies and applications very frequently. This results in a constantly changing product base, which makes it very difficult to predict the types of PEDs and technology that would be available in 2010.
- 7.1.9 In order to predict the RF levels that could exist as a result of PED usage on board a large transport aeroplane in 2010, to the degree of accuracy necessary to provide substantiated results and given the difficulties identified in determining a definition of the RF levels from the PEDs in use today, the PEDs and technologies in use in 2010 would need to be analysed and actual devices tested.
- 7.1.10 The analysis would include examination of the PED worst-case failures that would result in the maximum radiation, and any testing conducted should use test methods that could be compared with the airborne equipment qualification test methods.
- 7.1.11 Unfortunately, such an approach, testing the devices that will not be available until 2010, is obviously not currently possible.

7.2 **PED Prediction**

- 7.2.1 Whilst it would not be possible today to predict the exact PED generated RF levels that would exist in 2010, it may be possible to identify how the currently perceived environment may change over the next five years, using a prediction of the technology and behaviour changes that may occur.
- 7.2.2 In 2003, a study [reference 7] conducted on behalf of the Consumer Electronics Association estimated that 76% of people surveyed, who travelled by aeroplane at least once during the past year, carried aboard one or more PEDs. From an evaluation of the situation today that includes:
- a) the perceived move towards a permanently connected society, through use of mobile phones and PDAs that provide instant voice and data access, regardless of location;
 - b) continuing market analysis; and
 - c) the predictions from the consumer electronic industry,

it is believed that the number of PEDs in circulation will continue to increase. This, in turn, will potentially result in more devices being carried on board aircraft by passengers and crew, and so it could be expected that the greater number of devices owned would result in a desire for increased usage on board aircraft.

7.3 **Predicted PED Usage Increase**

- 7.3.1 It could be expected that the aircraft operators will identify a demand to permit the use of more PEDs on board their aircraft, possibly in conjunction with the introduction of on-board systems. These systems may include power supply outlets and wireless area networks.

7.3.2 In addition to an increase in the numbers of PEDs, the diversity of types of PEDs whose use is permitted on board is also thought likely to increase. The current policies restrict the types of devices that may be used to those PEDs that the aircraft operator has determined cannot adversely affect the performance of the aircraft's systems and equipment, and a general prohibition applies to the majority of intentionally transmitting PEDs.

7.3.3 Whilst the operational requirements and policies that require that the aircraft operator determines which PEDs could be used are not likely to change, there is currently a trend towards installing IEEE 802.11b (and similar) standard WLANs on board aircraft for crew and passenger use, which can be used in conjunction with compatible PEDs upon completion of the appropriate technical assessments to satisfy the certification and operational requirements. The provision of this service is expected to result in an increased number of PEDs (including compatible notebook PCs and PDAs) carried for use on board.

7.4 **On-board Cellular Networks**

7.4.1 The rapid growth in mobile phone (cell phone, handy, PCS phones, satellite phones, etc.) usage has presented a particular risk of interference to aircraft systems and potentially to aircraft safety.

7.4.2 Mobile phones, as with other intentionally transmitting PEDs, produce both unintentional emissions and intentional transmissions, the intentional transmission operating on a number of spot channel frequencies. Where the device communicates with a ground-based cellular network, the actual power transmitted at a particular time by this type of phone (normally known as a cell phone) is controlled by the ground network and may vary from a few milliwatts to the maximum rated power of the phone depending on quality of the link between the phone and the network and the need to prevent interference to other networks and their users. However, this may not apply to other phone types, which may utilise other power control techniques.

7.4.3 The simultaneous use in any one location of several mobile phones will result in transmissions at different radio frequencies, potentially leading to intermodulation effects that will contribute to a complex RF environment.

7.4.4 The technical issues associated with permitting the use of cell phones (mobile phones that operate with cellular networks) on board aircraft are currently being investigated within the aviation industry and it is recognised that a number of U.S. aircraft operators currently permit cell phones to be used during taxi-in at the end of a flight. However, the main industry focus at present is associated with the use of cell phones in flight, utilising a form of on-board system in order to control the cell phones' transmission power levels and keep them as low as possible. A number of technical, regulatory and human factors issues must still be addressed before use of cell phones could be permitted, but should the current industry efforts continue it is possible that some use will exist by 2010.

7.4.5 Whilst it is expected that all devices would still be required to be switched off during critical phases of flight, the implementation of such a system could potentially result in the greatest increase in the number of devices that were switched-on during the flight. Regardless of whether the phones, classified as high power transmitting devices, are transmitting or not, their operation will result in unintentional emissions that will have the potential to alter the aircraft internal RF environment.

7.4.6 Aircraft operators will need to focus on the human factors issues associated with the implementation of such systems, including any behavioural issues that may arise from the use of cell phones interfacing with such installed systems on some but not all aircraft, noting the need to ensure that passengers continue to keep their cell phones switched off on aircraft that do not offer such a system. The need to monitor for any potential human factors interaction issues, which may include personal conflict that may arise through use of phones within the confines of the aircraft cabin, may require considerable attention.

7.5 **Radio Frequency Identification Tags**

7.5.1 By 2010, it is possible that devices that take the form of Radio Frequency Identification (RF-Id) tags may be introduced into the aircraft environment.

7.5.2 At present, a number of passive devices are available for use by shipping companies that may utilise airfreight and aircraft operators are required to assess the use of these devices prior to accepting any carriage. In addition, the introduction of active devices that may use GPS receivers and mobile phone technology to transmit their position to a control centre have been proposed. Such devices today have the same operational restrictions placed upon them as for mobile phones, their use being prohibited. Additional studies would be necessary to fully appreciate the impact of such applications, but the continued policy of requiring all devices to be completely turned off during critical phases of flight may prevent such applications. However, this development demonstrates that the source of PED RF emissions may not only emanate from devices traditionally considered as PEDs, i.e. those used within the cabin, but may also emanate from devices located in less easily monitored areas such as the aircraft freight bays.

7.5.3 Studies are also being conducted by airframe manufacturers within the United States, looking at the use of transmitting RF-Id tags on aerospace components installed within the airframe. It is understood that the FAA is monitoring these studies and any applications of the technology may be subject to the standard certification approach for airborne equipment.

7.5.4 Further applications have been identified that include use as personal tracking devices. Examples appear to enable the tracking of a person using GPS and a "high power" transmitter, possibly similar to that used within mobile phones (cell phones or satellite phones) with suggested applications including tags for children to assist in locating the child after abduction. These devices have been stated as being non-removable and unable to be turned off. Aircraft operators would need to be aware of any such devices and use or carriage of these devices handled in the appropriate manner.

7.6 **Medical Implants**

7.6.1 Certain medical implants may utilise intentionally transmitting PEDs to provide their user with a means to control the function provided. The majority of these PEDs are believed to be very short-range devices, but a number are understood to be capable of interfacing with a separate device that can communicate over cellular networks using GSM transmitters. Aircraft operators would need to be aware of any such devices and use or carriage of these devices handled in the appropriate manner.

7.7 **New Technologies**

- 7.7.1 By 2010, it could be presumed that certain PEDs might utilise Ultra Wideband (UWB) transmission type devices or other transmission standards, as yet unknown.
- 7.7.2 UWB can be used in a number of applications that include ground-penetrating radar, but the main use that could be expected within PEDs would be that of providing for high-speed WPANs, essentially a wireless version of serial Universal Serial Bus (USB) connections provided and used today.
- 7.7.3 Such UWB equipped devices would be expected to transmit at low power levels, but across a large part of the spectrum that may include other bands utilised by aeronautical services or for emergency transmissions. The spectrum masks allocated to the UWB development, below 960MHz, are similar to those applied for the unintentional emissions of PEDs today. Whilst this may imply no greater threat should be expected from UWB in these bands, it must be noted that RTCA SC-202 (and previous studies) identified that should PED unintentional emissions actually occur at the spectrum mask limits, the potential to inflict interference effects to the operation of certain required aircraft systems would exist.
- 7.7.4 At present the UWB standards are still in development and until such equipment is available it would not be possible to determine accurately whether use of this technology could appreciably influence the RF environment on board the aircraft, or have any effects on required aircraft systems and equipment.
- 7.7.5 In line with the existing requirements and policies, the aircraft operator should not permit the use of any device that utilises new transmission standards until such time as controlled tests can be conducted.

7.8 **Summary**

- 7.8.1 The ability to produce a definition of EMI levels that could exist as a result of PED usage on board a large transport aeroplane in 2010 would require testing of actual devices and technologies that may not actually exist until that time.
- 7.8.2 The increased pace of technology development and the large numbers of PEDs being produced, and in general use, continue to grow. This will potentially result in people placing a greater dependency on the information contained within devices such as notebook PCs, PDAs and mobile phones as a replacement for paper notebooks, diaries and address books, in addition to the greater move to the always-connected society currently being offered through the use of devices today. The number of PEDs being carried on board aircraft is also increasing and will be expected to continue to increase through 2010 and beyond, resulting in the likelihood that the number of PEDs that will actually be used on board aircraft will also continue to increase.
- 7.8.3 Aircraft are currently being modified to provide interfaces to PEDs. These include PED compatible data interface systems such as those that offer on-board live Internet access through WLANs and those that offer an electrical supply at each passenger seat for the purposes of operating PEDs independent of their battery supply. Additional interfaces may be provided in the future that offer the ability to wirelessly connect mobile phones to the ground cellular networks. It is expected that these systems will result in greater PED use during flight, including greater acceptance of intentionally transmitting PED use in accordance with appropriately controlled operational procedures.
- 7.8.4 RF-Id tags may begin to appear with incorporation in devices such as personal security devices, airfreight or aircraft components.

- 7.8.5 The overall result will be an increase in RF emissions, both intentional and unintentional, from devices within the aircraft. This will continue to alter the RF environment, increasing any EM field's strength within the aircraft in a manner similar to that caused by EM fields generated outside the aircraft including transmitters considered as contributing to the HIRF environment. This will result in a possible narrowing of the safety margins between aircraft systems and equipment RF susceptibility qualification and the actual EM field levels generated, with the possibility that adverse interference to aircraft systems and equipment may increase.
- 7.8.6 In order to limit the number of reported interference events it will be necessary to continue to ensure that the use of PEDs remains appropriately controlled by aircraft operators, that the airborne equipment RF susceptibility levels continue to be examined to ensure that they accurately reflect the actual operating environment and that the certification requirements be reviewed to ensure that the existence of PEDs is specifically reflected within the definition of conditions that require consideration for the aircraft internal environment.

8 Conclusions

The ability to produce an accurate definition of the RF levels generated by PEDs on board an aeroplane in 2010 would require the analysis of, and the ability to test, the PEDs that would then be in use. However, until such PEDs become available, the ability to accurately produce such a definition would not be possible.

Therefore, whilst it is not possible to categorically predict the exact RF levels that will exist in 2010, it has been possible to predict the environment to the extent that the following conclusions could be drawn:

- a) The RF environment within the aircraft is changing and likely to become more severe, primarily through the increase in number and types of PEDs that will be used on board. This increase in PED utilisation will possibly result in a narrowing of the safety margins between the aircraft systems and equipment RF susceptibility qualification and the actual EM field levels generated, resulting in a potential for an increase in interference to aircraft systems and equipment;
- b) PEDs are uncontrolled devices and whilst the majority are designed and constructed in accordance with international standards, an aircraft operator should place no reliance on any form of qualification provided by these bodies as indicative of the performance of an actual PED carried on board in the possession of a passenger or member of the aircraft crew;
- c) the Aircraft Certification Requirements applied to Aircraft Certification, which require that the aircraft's internal environment be considered in assessing the operating environment of installed equipment, do not specifically refer to PEDs as a contributing source of that environment;
- d) the aircraft operator needs to maintain and enforce adequate controls to prevent the potential risk of adverse interference effects to aircraft systems and equipment being caused by the operation of non-permitted PEDs;
- e) there is currently a lack of standardisation in pre-flight briefings and information presented to the passengers, identifying permitted and non-permitted PEDs that could lead to an escalation of confusion amongst passengers;
- f) the ability of aircraft crew to recognise and hence prevent prohibited PED use within the cabin is likely to become more difficult without reliance on specialised equipment or training;

- g) aircraft operators may wish to seek to allow use of currently prohibited PEDs;
- h) certain factors associated with use of PEDs, other than those associated with RFI, such as human factors, need to be closely monitored to ensure that any associated risks are approached in the appropriate manner.

9 Recommendations

The following recommendations are made in response to the findings of this study:

- 1 The responsible civil aviation authority or agency should continue to monitor PED development to ensure that new technologies are not brought on board aircraft without the proper or appropriate guidance or advice being provided to aircraft operators describing, as far as is practical, any identified risks.
- 2 The responsible civil aviation authority or agency should continue to remind the aircraft operators of their responsibilities in ensuring that no person does use, on board an aircraft, a PED that can adversely affect the performance of the aircraft's systems and equipment [reference 2], when considering whether to rely on any PED's in-built transmitting or not-transmitting indicator.
- 3 The appropriate civil aviation authority or agency should be tasked with leading a working group to develop a harmonised definition of the internal RF environment as contributed to by PEDs, with reference to published studies that identify the potential emissions that could exist on board a transport category aircraft today, and use these studies and other material to define the 'environment levels' in a manner similar to that provided for the current external environment definition that includes the effects of HIRF [reference 9]. PED technology developments should be monitored, and the RF level definitions modified if necessary.
- 4 The appropriate civil aviation authority or agency should be tasked with leading a working group to review the AMC material to CS-25 [reference 1] (and other certification specifications applicable to other aircraft types) subpart 1309, to give consideration to explicitly referencing PEDs' RF emissions as one of the examples of sources of effects that should be taken into account when considering the effects of the environment within the aircraft. This should result in aircraft and systems being certificated to take PED emissions into account, and referring to the PED RF environment levels described in recommendation 9.3. This could result in future certificated products' exposure to adverse effects arising from PED emissions being reduced, enabling the types of PEDs that need to be restricted or prohibited by the aircraft operator to be reduced.
- 5 The responsible civil aviation authority or agency should continue to recommend that the airborne equipment qualification levels for RF susceptibility be revised to reflect the internal environment, by catering for PED emissions from within the aircraft, and remaining involved with the aircraft industry working groups that are tasked with the development of airborne equipment test standards and the analysis of PED issues.
- 6 The UK CAA should continue to provide appropriate guidance relating to the policy covering passenger briefings of permitted PED use, conducted by aircraft operators within the CAA's scope of influence.
- 7 The appropriate civil aviation authority or agency should continue to work within the aerospace and PED community working groups to ensure that PEDs permitted to be used on board can be easily distinguishable by the aircraft crew and/or provide additional guidance to aircraft operators on how to monitor PED use to ensure that only identifiable, permitted devices' use is allowed.

Appendix 1 References

- 1 Certification Specification for Large Aeroplanes - EASA CS-25
- 2 Joint Aviation Requirements JAR-OPS 1 Commercial Air Transportation (Aeroplanes)
- 3 Interference Levels In Aircraft at Radio Frequencies used by Portable Telephones - CAA report 9/40:23-90-02
- 4 Effects of Interference from Cellular Telephones on Aircraft Avionic Equipment - CAA Paper 2003/3
- 5 Report on Electro-magnetic Compatibility Between Passenger Carried Portable Electronic Devices (PEDs) and Aircraft Systems - EUROCAE ED-118
- 6 Guidance on Allowing Transmitting Portable Electronic Devices (T-PEDs) on Aircraft - RTCA DO-294
- 7 Portable Electronics Devices on Aircraft Study - eBrain Consumer Research, October 2003
- 8 Environmental Conditions and Test Procedures for Airborne Equipment - EUROCAE ED-14D / RTCA DO-160D
- 9 Guide To Certification of Aircraft in a High Intensity Radiated Field (HIRF) Environment - EUROCAE ED-107
- 10 JAA Temporary Guidance Leaflet No. 29 - Guidance Concerning The Use Of Portable Electronic Devices On Board Aircraft
- 11 CAA Aeronautical Information Circular (AIC) 1/2004 (Pink 62) - Use Of Portable Electronic Devices On Board Aircraft

Appendix 2 Abbreviations

AIC	Aeronautical Information Circular
AMC	Acceptable Means of Compliance
ANO	Air Navigation Order 2005
CAA	(United Kingdom) Civil Aviation Authority
CS	Certification Specification
DVD	Digital Versatile Disc
EASA	European Aviation Safety Agency
ED	EUROCAE Document
EM	Electro-Magnetic
EMI	Electro-Magnetic Interference
EU	European Union
EUROCAE	European Organisation for Civil Aircraft Equipment
FAA	Federal Aviation Administration
GHz	Gigahertz
GPS	Global Positioning System
GSM	Global System for Mobile Communications
HIRF	High Intensity Radiated Field
IEEE	Institute of Electrical and Electronics Engineers
IFE	In Flight Entertainment
JAA	Joint Aviation Authorities
JAR	Joint Aviation Requirements
kHz	Kilohertz
LRU	Line Replaceable Unit
MEF	Multiple Equipment Factor
MHz	Megahertz
MOR	Mandatory Occurrence Report
PC	Personal Computer
PCS	Personal Communications Service
PDA	Personal Digital Assistant
PED	Portable Electronic Device
RF	Radio Frequency
RFI	Radio Frequency Interference
RF-Id	Radio Frequency Identification Tag
RTCA	Radio Technical Commission for Aeronautics (RTCA), Inc.

RTCA DO	RTCA Document
SC	Special Committee
SI	Safety Intervention
TGL	Temporary Guidance Leaflet
UK	United Kingdom
USB	Universal Serial Bus
UWB	Ultra Wideband
WG	Working Group
WLAN	Wireless Local Area Network
WPAN	Wireless Personal Area Network