CIVIL AVIATION AUTHORITY
Aviation House
Gatwick Airport
West Sussex RH6 0YR
England

REPORT

Interference Levels In Aircraft at Radio Frequencies used by Portable Telephones

This report makes recommendations based on results and observations from interference tests sponsored by the Civil Aviation Authority and performed on a British Airways Boeing 737-236 and a Virgin Atlantic Airways Boeing 747-243B at London Gatwick Airport on 15th February 2000. The report may be downloaded in Adobe Portable Document Format from:

www.srg.caa.co.uk/srg/srg_news.asp

CIVIL AVIATION AUTHORITY
Aviation House
Gatwick Airport
West Sussex RH6 0YR
England

Interference Levels In Aircraft at Radio Frequencies used by Portable Telephones

Executive Summary

Measurements made on two types of civil transport aircraft confirm that transmissions made in the cabin from portable telephones can produce interference levels that exceed demonstrated susceptibility levels for aircraft equipment approved against earlier standards. Since aircraft equipment in this class is currently in use, and can be installed, and is known to be installed, in newly built aircraft, current policy restricting the use of portable telephones on aircraft must continue. Recommendations are made to reduce the interference risk and for further studies to understand more precisely the effects of interference to aircraft equipment arising from the use of portable telephones.

Contents

1 Introduction

1.1 The significant increase in the ownership of personal portable telephones has lead to concerns about the potential risks and consequences of interference to aircraft on-board systems. Given that a civil passenger aircraft, flying at high altitude and high speed in busy airspace, is in an obviously 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 exposure of the aircraft to the hazards.

1.2 The use of a portable telephone in an aircraft generates an intentional transmission at a power level that has the potential to interfere with and affect multiple aircraft systems. Malfunction of aircraft systems due to such interference, even for short periods, can lead to the following:

- (a) False warnings of unsafe conditions.
- (b) Increased work load for the flight crew and the possibility of invoking emergency drills.
- (c) Reduced crew confidence in protection systems which may then be ignored during a genuine warning.
- (d) Distraction of the crew from their normal duties.
- (e) Noise in the flight crew headphones.
- (f) Hidden failures of safety systems with loss of protection.

1.3 Although reports of suspected interference effects are regularly received by the regulatory authorities, proving that a portable telephone was the actual cause of an incident has proved elusive. This is due in part to the lack of detail in the reports together with the many variable factors which apply in the aircraft at the time of an incident, and to the operating characteristics of portable telephones which may vary their power level and operating frequency depending on the link to the ground cell. The result has been that incident reports have been labelled 'anecdotal'.

1.4 Recognising that a better technical understanding of the problem is required, the UK CAA has embarked on a programme of investigation with two phases. The first phase measures, under controlled conditions, the levels of interference on the flight deck and in the avionics equipment bay of examples of transport aircraft types when transmissions at portable telephone frequencies are made in the cabin. The second phase will involve a study in a controlled test environment where examples of aircraft equipment will be exposed to increasing levels of simulated portable telephone transmissions until the equipment ceases to perform its intended function. This report provides results and observations for the first phase of the programme.

1.5 This report does not address interference likely to be radiated as a result of electronic processing within a portable telephone. It only addresses the problem of the intentional transmission.

2 Aircraft Equipment Qualification Standards

2.1 An internationally agreed aviation standard exists for qualifying aircraft equipment for approval with respect to the extremes of its operating environment including exposure to interference. The standard is known in Europe as EUROCAE ED-14 and in the USA as RTCA DO-160. For susceptibility to radiated radio interference, qualification tests are specified to determine whether the equipment will perform its intended function when exposed to a defined level of interference. The severity of the tests depends on the protection offered by the installed location and the criticality category of the equipment as defined in the standard.

2.2 The qualification tests were originally devised to ensure that an item of equipment installed on the aircraft would not suffer interference from another where the emissions from other equipment were properly controlled.

2.3 The standard has been progressively updated as shown in the following table with the qualification tests becoming generally more severe primarily to protect against interference originating external to the aircraft. The levels and radio frequencies of the radiated interference signals to be used in a test are shown in the following table.

Environmental Standard Version	Date of Issue	Test Class	Interference Environment	Maximum Interference Test Level	Highest Test Frequency
ED-14/DO-160	Feb 1975	Z	Assumes a severe environment.	0.1 V/m	1215 MHz
Revision A	Jan 1980	Z	Assumes a severe environment.	0.1 V/m	1215 MHz
B	July 1984	Z	Where interference-free operation is required	1.0 V/m	1215 MHz
C	Dec 1989	Y	Severe exposed	200 V/m	18 GHz
		W	Severe exposed	100 V/m	18 GHz
		V	Moderate open	50 V/m	1215 MHz
		U	Partially protected (Note 1)	20 V/m	1215 MHz
		T	Well protected (Note 2)	5 V/m	1215 MHz
D	July 1997	P	Severe exposed	600 V/m	18 GHz
		Y	Severe exposed	200 V/m	18 GHz
		W	Severe exposed	100 V/m	18 GHz
		V	Moderate open	50 V/m	8 GHz
		U	Partially protected (Note 1)	20 V/m	8 GHz
		T	Well protected (Note 2)	5 V/m	8 GHz
		S	Minimum test level	1 V/m	2 GHz

Notes: (1) Applicable to a partially protected avionics bay in an all-metallic aircraft.
(2) Applicable to a well protected, enclosed avionics bay in an all-metallic aircraft.
(3) Protection criteria against High Intensity Radiated Fields (HIRF) originating from outside the aircraft (Class R) is not included in this table.

2.4 From this table, it can be seen that, for equipment approved prior to December 1989, no qualification tests were required for susceptibility at portable telephone frequencies of 1800 MHz. Also, versions C and D of the Standard permit increased interference susceptibility for equipment installed in a partially protected environment *assuming* that the interference source is external to the aircraft. For example, for test Class T, a qualification test level of 5V/m is permitted for equipment installed in a well protected avionics bay. Few aircraft can claim such a level of protection when the interference source is inside the aircraft.

2.5 Equipment approved in accordance with earlier standards can remain in production and continue to be installed in newly built aircraft which are derivatives of types first certificated in an earlier period.

The significance of this point is that the equipment installed in an aircraft will be a mix of items which have been qualified to different levels of interference susceptibility.

3 Portable Telephones

3.1 Portable telephones (excluding satellite telephones) operate in the frequency bands of approximately 400 MHz, 900 MHz or 1800 MHz. For portable digital telephones, the transmitter effective radiated power typically ranges from 1 Watt (in the 400 MHz and 1800 MHz bands) to 2 Watts (in the 900 MHz band). Some regions of the world use slightly different frequencies and higher output power. Transmission can occur in the Standby and Call active modes. Telephones with an alarm function may switch automatically to On from the Off condition when the alarm activates.

3.2 Applying fundamental principles, the intensity E (known as field strength) of the transmission at a distance D from a source transmitting P Watts of radio frequency power through a half-wave dipole in a free, unobstructed space, can be estimated using the formula:

$$E = (7\sqrt{P}) \text{ divided by the distance } D$$

3.3 Thus, for a 2 Watt telephone, the theoretical field strength in free space at one metre distance from the telephone is approximately 10 Volts per Metre, and at 100 Metres distance, approximately 0.1

Volts per Metre. The latter of these two levels of interference equates to aircraft equipment qualification levels applied before 1984.

3.4 In the confines of an aircraft fuselage, complex propagation paths arise due to reflections from the metallic structure which lead to signal cancellation or re-inforcement at different locations. Although the free space equation does not give reliable results under these conditions, it is reasonable to assume that the field strength of the interfering telephone transmission will exceed by a significant margin the levels used in susceptibility tests for critical avionic equipment qualified prior to 1989, and to other equipment qualified to later versions of the standard but to the permitted minimum levels.

3.5 The primary objective of the tests, performed for the purposes of this report, is to validate this assumption by means of actual test results.

4 Limitations of the Tests

4.1 For a normal measurement to obtain a field strength value with a spectrum analyser connected to an antenna, account is taken of the loss of the cable and the antenna factor. Due to the confined areas of the flight deck and avionics equipment bay, the effect of local metal structure may influence the accuracy of the antenna factor. This effect is likely to be the most pronounced for the tests conducted in the Boeing 737 avionics equipment bay which is very confined. For the Boeing 747, to minimise inaccuracies, the measurements were taken in the less confined, forward cargo bay just aft of the avionics equipment bay. In any case, the effect would be such as to under-read the interference levels rather than to exaggerate them.

4.2 Measurements will be affected by standing waves arising from reflections of the transmitted signal from internal aircraft structure which will cause peaks and troughs of signal strength.

4.3 At the test location, due to the limitations of the site, it was not possible to demonstrate the theoretical signal strength which would be expected in accordance with the formula given in 3.2. However, as a coarse check, measurements were made at distances between the transmitting and receiving antennas of 3m,10m and “the approximate length of the aircraft cabin”. These reference level measurements were taken away from the aircraft on adjacent grassland for the 747 and in the hangar on a concrete floor for the 737.

5 Observations and Conclusions

5.1. The effects of standing waves arising due to reflections inside the aircraft were apparent. Interference levels could be seen to vary by a factor of about 3:1 when moving a receiving source longitudinally along the fuselage. Similarly, moving the transmitting source laterally across the fuselage (to simulate portable telephone use at different seat locations) showed interference level variations for a given power level. These checks showed how interference effects would vary by relatively small changes of location of a portable telephone.

5.2. Persons obstructing the direct transmission path attenuated the received signal. This indicated that the number of passengers on an aircraft would affect the interference levels.

5.3. Internal doors of composite construction, open or closed, did not affect interference levels.

5.4. Pulse modulation of the transmission produced essentially the same peak interference levels as continuous wave (CW) transmissions. Pulse modulation tests were discontinued and the results of the few measurements made are not presented in this report.

Note: This observation should not be interpreted to mean that pulse modulated transmissions would have the same effect on victim systems as CW transmissions. This aspect of the problem will be evaluated in phase 2 of the programme.

5.5 By normalising transmission levels to typical portable telephone output power levels, and by selecting worst case results from the tests (ignoring polarisation), the following interference levels may be estimated:

Boeing 747-243B: Estimated Interference levels in Volts per Metre					
Transmitting from	**Received at**	**Frequency**	**381 MHz**	**881 MHz**	**1782 MHz**
		Phone Power	**1 Watt**	**2 Watts**	**1 Watt**
Rear Cabin	**Flight deck**	**Table A7.3**	Negligible	Negligible	Negligible
	Avionics bay				
Upper Deck	**Flight deck**	**Table A7.3**	2.42	1.14	1.92
	Avionics bay	**Table A7.4**	0.49	1.87	0.35
Forward lower	**Flight deck**	**Table A7.3**	0.73	2.18	0.7
cabin	**Avionics bay**	**Table A7.4**	0.52	1.34	0.44

Boeing 737-236: Estimated Interference levels in Volts per Metre					
Transmitting from	**Received at**	**Frequency**	**381 MHz**	**881 MHz**	**1782 MHz**
		Phone Power	**1 Watt**	**2 Watts**	**1 Watt**
Rear Cabin	**Flight deck**	**Table A7.5**	0.12	0.8	0.29
	Avionics bay	**Table A7.6**	0.1	0.32	0.08
Forward cabin	**Flight deck**	**Table A7.5**	1.89	4.51	2.56
	Avionics bay	**Table A7.6**	0.9	0.97	1.26

5.6 From the above, by comparing the test results with the qualification levels given in Section 2, it can be seen that interference levels produced by a portable telephone, used near the flight deck or avionics equipment bay, will exceed demonstrated susceptibility levels for equipment qualified to standards published prior to July 1984. Since equipment qualified to these standards are installed in older aircraft, and can be installed (and is known to be installed) in newly built aircraft, current policy for restricting the use of portable telephones on all aircraft will need to remain in force.

5.7 Multiple telephone use by passengers subscribing to different networks would generate interference at different frequencies that exceeds demonstrated susceptibility levels of some aircraft equipment.

5.8 Transmissions made from the rear of the Boeing 747 cabin would not produce significant interference levels for equipment installed in the forward part of the aircraft (but has the potential to affect equipment that may be installed at the rear of the aircraft).

6 Recommendations

The following recommendations are made in response to the significant increase in portable telephone ownership and the associated increasing risk of interference to aircraft systems.

6.1 For safety reasons, the Regulatory Authorities should continue to prohibit the use of portable telephones by passengers on aircraft whilst the engines are running.

6.2 The Regulatory Authorities should request airport operators and airlines to consider additional measures to further minimise the risks of inadvertent operation of portable telephones, caused by passengers failing to switch them off, including;

(a) reminder notices in airport departure lounges and at aircraft boarding points; and

(b) an evaluation by airlines of detection equipment and the introduction related procedures that ensure telephones are switched off.

6.3 The Regulatory Authorities, in consultation with EUROCAE and RTCA, should review the minimum qualification levels for radio frequency susceptibility, as defined in EUROCAE ED-14D and RTCA DO-160D, Section 20, with the objective of providing an increased margin against potential interference from portable telephones used on-board the aircraft.

6.4 The Regulatory Authorities should ensure that equipment installed in an aircraft for which an application has been made for the issue or change of a Type Certificate, or a Supplemental Type Certificate, is qualified to an appropriate Class of radio frequency susceptibility taking account of the risk of interference from passenger portable telephones. In the absence of mitigating evidence, Class V (50 V/m) of EUROCAE ED-14D and RTCA DO-160D, Section 20, should be considered as the minimum standard to be applied.

6.5 The Joint Aviation Authorities should consider requiring all equipment, submitted for approval under a Joint Technical Standard Order (JTSO), to be qualified to at least Class V (50 V/m) of EUROCAE ED-14D and RTCA DO-160D, Section 20.

6.6 The Joint Aviation Authorities should consider the need for guidance material dealing with this issue with the objective of establishing policy and procedures, consistent with recommendations 6.1, 6.2 and 6.4, for organisations operating under JAA regulations.

6.7 Further tests should be conducted to determine more precisely the effects of portable telephone transmissions on aircraft equipment and to obtain an estimate of the susceptibility margin above the applied qualification levels. These tests should involve exposing, in a controlled test environment, examples of aircraft equipment to increasing levels of simulated portable telephone transmissions until that equipment ceases to perform its intended function.

7 Acknowledgements

The Civil Aviation Authority wishes to acknowledge its indebtedness to EMV Ltd, to British Airways, and to Virgin Atlantic Airways, for their co-operation and assistance in performing the aircraft tests, and for the production of this report.

8 Reference Documents

8.1 European Standard EN 61000-4-3:Amd A1:1998, Testing and Measurement Techniques- Radiated, radio-frequency, electromagnetic field immunity test.

8.2 EUROCAE ED-14() or RTCA DO-160(), Environmental Conditions and Test Procedures for Airborne Equipment.

8.3 European Telecommunications Standard ETS 300 577, Digital cellular telephone system (Phase 2) Radio transmission and reception (GSM 05.005 v 4.22.2), 14th Edition, December 1998.

9 Attachments

Annex 1: Report "Measurement Method and Results": EMV Ltd, Crownhill, Milton Keynes, England.

A1 Overview

The tests, conducted by EMV Ltd, involved the simulation of portable telephone use on civil aircraft with measurement of resultant signal field strengths at various locations in the aircraft. The radio frequencies licensed for the test were the Tetra frequencies 380.3125 MHz to 391.5125 MHz, the GSM frequency 881.0125 MHz and the DCS frequency 1782.2MHz. A signal generator was used to generate the required frequencies.

Test date: Tuesday 15th February 2000 from 1700 hours into the morning of the 16th February 2000.

A2 Abbreviations

GSM	Global System for Mobile Communications
DCS	Digital Cellular System
RF	Radio Frequency
CW	Continuous Wave
ERP	Effective Radiated Power
AF	Antenna Factor

A3 Test Licence Details

Sector/class/product	601010
Licence number	204143
License holder and address	CIVIL AVIATION AUTHORITY Aviation House, Gatwick Airport West Sussex, RH6 0YR, England
Date of Issue	20 January 2000
Issued by	UK Radiocommunications Agency

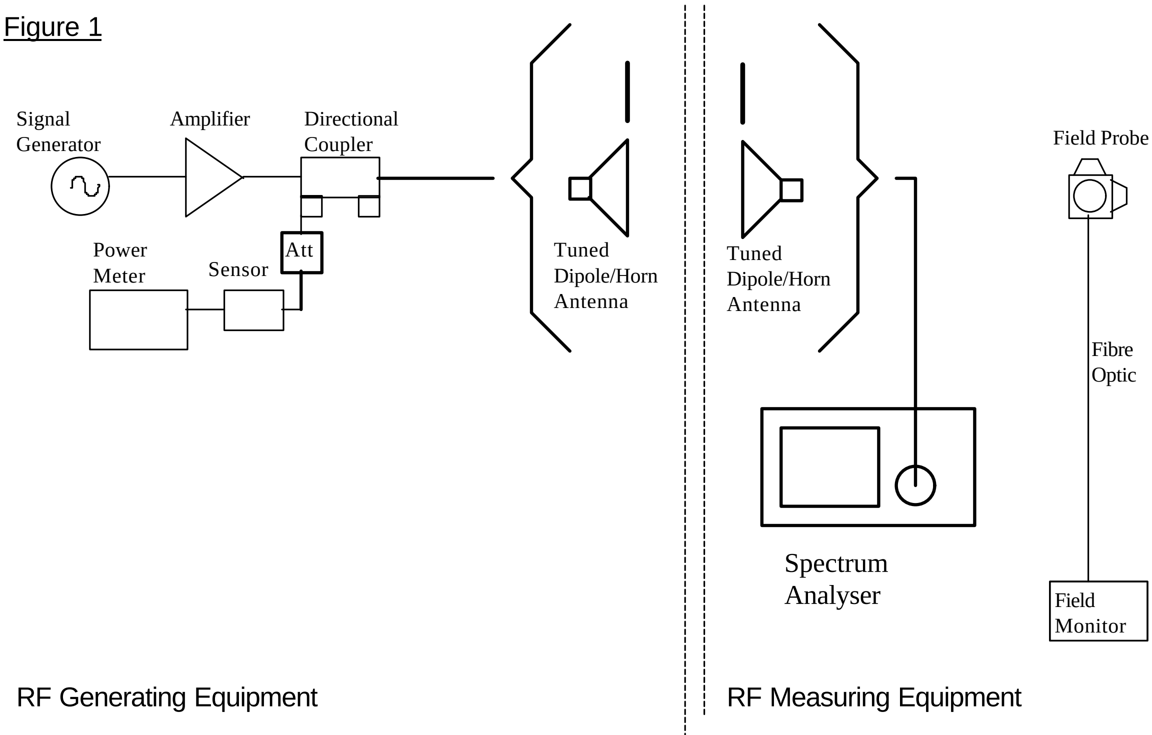
A4 Test Equipment

RF Generating Equipment	S/No.	Cal Date
Marconi 2024 Signal Generator	112236/032	30/07/2000
Tuned Dipoles set 3121C DB4	293	26/05/2000
Horn Antenna	5003	20/05/2000
DC3001 Directional Coupler	15096	14/02/2001
DC7150 Directional Coupler	23215	12/08/2000
Amplifier Research 30W1000 Amplifier		
LR620-10 TWT Amplifier, 1-2GHz		
Marconi 6960A Power Meter	2825	22/07/2000
Marconi 6912 Sensor Head	232	22/07/2000
RF Measuring Equipment		
HP8593EM Spectrum Analyser	3726U00204	30/07/2000
Tuned Dipole 3121C DB4	295	26/05/2000
Horn Antenna 3115	4793	19/05/2000
HI-4417 Radiated Field Survey System (used for indication purposes only)	100334	01/01/2000

A5 Test Set-up

The test equipment set-up is shown in Figure 1.

Figure 1



A5.1 Locations for the Transmit Antenna

The transmit antenna was located as described below to simulate typical portable telephone usage. The transmit antenna was moved laterally across the fuselage to observe any changes in the maximum received field readings on the flight deck and in the avionics equipment bay. The RF generating equipment was located close to the transmitting antenna to minimise cable losses.

(a) In the rear cabin of the 747 adjacent to the last row of seats.
(b) In the upper deck of the 747 adjacent to the last row of seats.
(c) In the forward lower cabin of 747 adjacent the seat row immediately in front of the forward left passenger door.
(d) In the rear cabin of the 737 adjacent to the last row of seats.
(e) In the forward cabin of the 737 adjacent seat row 2.

A5.2 Locations for the Receive Antenna

The receive antenna was located to check levels of potential interference on the flight deck and in avionics equipment bay.

A5.3 Locations for the Measuring Equipment

The spectrum analyser was located as far away as was practicable from the receiving antenna. The distance was determined by the space restriction on the flight deck and in the avionics equipment bay.

The field probe and monitor were used to give an indication of the field present and to observe standing wave effects. No probe measurements were recorded.

A6 Test Method

A forward power level of 5W maximum was fed into the transmit antenna. The antenna length was adjusted to be resonant at the frequency of operation. The directional coupler was used to monitor the forward power level. Calculations were made to determine the ERP by taking the antenna gain and cable loss into consideration. Measurements of received signal levels for both vertical and horizontal polarisations were taken. The results were recorded and adjusted to normalise transmission levels to typical portable telephone output power levels to determine the potential interference threat.

The flight deck tests were performed with the flight deck door open and closed to note any differences.

A7 Test Results

A7.1 To obtain the ERP of the transmit antennas it was necessary to take into account the gain of the antenna and the cable loss as shown below. The gain of a half wave dipole is 2.15dBi. No allowance was taken for antenna matching or reflected power.

@ 381MHz		
Gain = 2.15dBi	Cable Loss = 1.9dB	Correction = 0.25dB
@ 881MHz		
Gain = 2.15dBi	Cable Loss = 2.85dB	Correction = -0.7dB
@ 1782MHz		
Gain = 7.90dBi	Cable Loss = 4.5dB	Correction = 3.4dB

A7.2 All measurements were taken with the spectrum analyser and its antenna. The field probe was used only as an indication that field was present. When transmitting from the rear of the 747 it was noted that the field increased and decreased as the field probe was moved from the rear to the front of the aircraft. An approximate peak-to-trough ratio of 3:1 was observed.

Readings were taken from the spectrum analyser in dBuV. To obtain dBuV/m, Antenna Factor and Cable Loss was added. The corrections required for the different frequencies were obtained from calibration charts supplied with the equipment and are shown below; The results take these corrections into account.

@ 381MHz		
AF = 19.69dB	Cable Loss = 0.75dB	Correction = 20.44dB
@ 881MHz		
AF = 28.25dB	Cable Loss = 1.00dB	Correction = 29.25dB
@ 1782MHz		
AF = 27.25dB	Cable Loss = 1.30dB	Correction = 28.55dB

The results are shown in the following tables with highest values for each location and frequency highlighted in red.

A7.3 Flight Deck Measurements: Virgin Atlantic Airways Boeing 747-234B: G-VGIN

Location of Transmit Antenna		381 MHz		881 MHz		1782 MHz	
	Polarisation	V	H	V	H	V	H
Rear cabin adjacent to the last row of seats	Transmitter ERP in Watts	5.30	5.30	4.26	4.26	10.94	10.94
	Received signal in dBuV/m	70.84	72.25	70.01	68.81	68.65	76.49
	Received signal in V/m	.003	.004	.003	.003	.003	.007
	dB change to normalise to 1 Watt	-7.24	-7.24			-10.39	-10.39
	dB change to normalise to 2 Watts			-3.28	-3.28		
	Estimated interference level in dBuV/m	63.6	65.1	66.73	65.53	58.26	66.1
	Estimated interference level in V/m	0.0015	0.0018	0.002	0.0019	0.0008	0.002
Upper deck adjacent to the last row of seats	Transmitter ERP in Watts	0.53	0.53	0.85	0.85	2.19	2.19
	Received signal in dBuV/m	116.62	124.92	114.39	117.45	126.82	129.07
	Received signal in V/m	0.68	1.76	0.52	0.75	2.19	2.84
	dB change to normalise to 1 Watt	+2.76	+2.76			-3.4	-3.4
	dB change to normalise to 2 Watts			+3.72	+3.72		
	Estimated interference level in dBuV/m	119.38	127.68	118.11	121.17	123.42	125.67
	Estimated interference level in V/m	0.93	**2.42**	0.8	**1.14**	1.48	**1.92**
Forward lower cabin adjacent to the seat row in front of passenger LH door	Transmitter ERP in Watts	5.30	5.30	4.26	4.26	10.94	10.94
	Received signal in dBuV/m	116.16	124.54	124.17	130.06	123.59	127.27
	Received signal in V/m	0.64	1.69	1.62	3.18	1.51	2.31
	dB change to normalise to 1 Watt	-7.24	-7.24			-10.39	-10.39
	dB change to normalise to 2 Watts			-3.28	-3.28		
	Estimated interference level in dBuV/m	108.92	117.3	120.89	126.78	113.2	116.88
	Estimated interference level in V/m	0.28	**0.73**	1.11	**2.18**	0.46	**0.7**

A7.4 Avionics Equipment Bay Measurements: Virgin Atlantic Airways Boeing 747-234B

Location of Transmit Antenna		381 MHz		881 MHz		1782 MHz	
	Polarisation	V	H	V	H	V	H
Upper deck adjacent to the last row of seats	Transmitter ERP in Watts	5.30	5.30	4.26	4.26	10.94	10.94
	Received signal in dBuV/m	121.10	120.27	121.72	128.70	118.48	121.37
	Received signal in V/m	1.14	1.03	1.22	2.72	0.84	1.17
	dB change to normalise to 1 Watt	-7.24	-7.24			-10.39	-10.39
	dB change to normalise to 2 Watts			-3.28	-3.28		
	Estimated interference level in dBuV/m	113.86	113.03	118.44	125.42	108.09	110.98
	Estimated interference level in V/m	**0.49**	0.45	0.84	**1.87**	0.25	**0.35**
Forward lower cabin adjacent to the seat row in front of passenger LH door	Transmitter ERP in Watts	5.30	5.30	4.26	4.26	10.94	10.94
	Received signal in dBuV/m	110.96	121.64	125.79	121.72	118.02	123.33
	Received signal in V/m	0.35	1.21	1.95	1.22	0.80	1.47
	dB change to normalise to 1 Watt	-7.24	-7.24			-10.39	-10.39
	dB change to normalise to 2 Watts			-3.28	-3.28		
	Estimated interference level in dBuV/m	103.72	114.4	122.51	120.6	107.63	112.94
	Estimated interference level in V/m	0.15	**0.52**	**1.34**	1.07	0.24	**0.44**

A7.5 Flight Deck Measurements British Airways 737-236 G-BGJE

Location of Transmit Antenna		381 MHz		881 MHz		1782 MHz	
	Polarisation	V	H	V	H	V	H
Rear cabin adjacent to the last row of seats	Transmitter ERP in Watts	5.30	5.30	4.26	4.26	10.94	10.94
	Received signal in dBuV/m	108.54	102.94	121.35	111.93	119.65	117.35
	Received signal in V/m	0.27	0.14	1.17	0.39	0.96	0.74
	dB change to normalise to 1 Watt	-7.24	-7.24			-10.39	-10.39
	dB change to normalise to 2 Watts			-3.28	-3.28		
	Estimated interference level in dBuV/m	101.3	95.7	118.07	108.65	109.26	106.96
	Estimated interference level in V/m	**0.12**	0.06	**0.8**	0.27	**0.29**	0.22
Forward cabin adjacent to seat row 2	Transmitter ERP in Watts	3.18	3.18	2.55	2.55	6.56	6.56
	Received signal in dBuV/m	130.54	108.64	134.15	122.75	136.35	135.75
	Received signal in V/m	3.37	0.27	5.10	1.37	6.57	6.13
	dB change to normalise to 1 Watt	-5.02	-5.02			-8.17	-8.17
	dB change to normalise to 2 Watts			-1.06	-1.06		
	Estimated interference level in dBuV/m	125.52	103.62	133.09	121.69	128.18	127.58
	Estimated interference level in V/m	**1.89**	0.15	**4.51**	1.21	**2.56**	2.39

A7.6 Avionics Equipment Bay Measurements British Airways 737-236 G-BGJE

Location of Transmit Antenna		381 MHz		881 MHz		1782 MHz	
	Polarisation	V	H	V	H	V	H
Rear cabin adjacent to the last row of seats	Transmitter ERP in Watts	5.30	5.30	4.26	4.26	10.94	10.94
	Received signal in dBuV/m	107.56	103.19	103.65	113.44	95.65	108.37
	Received signal in V/m	0.24	0.14	0.15	0.47	0.06	0.26
	dB change to normalise to 1 Watt	-7.24	-7.24			-10.39	-10.39
	dB change to normalise to 2 Watts			-3.28	-3.28		
	Estimated interference level in dBuV/m	100.32	95.95	100.37	110.16	85.26	97.98
	Estimated interference level in V/m	**0.1**	0.06	0.1	**0.32**	0.02	**0.08**
Forward cabin adjacent to seat row 2	Transmitter ERP in Watts	3.18	3.18	2.55	2.55	6.56	6.56
	Received signal in dBuV/m	124.06	123.32	117.13	120.80	117.05	130.20
	Received signal in V/m	1.6	1.47	0.72	1.1	0.71	3.24
	dB change to normalise to 1 Watt	-5.02	-5.02			-8.17	-8.17
	dB change to normalise to 2 Watts			-1.06	-1.06		
	Estimated interference level in dBuV/m	119.04	118.3	116.07	119.74	108.88	122.03
	Estimated interference level in V/m	**0.9**	0.82	0.64	**0.97**	0.28	**1.26**

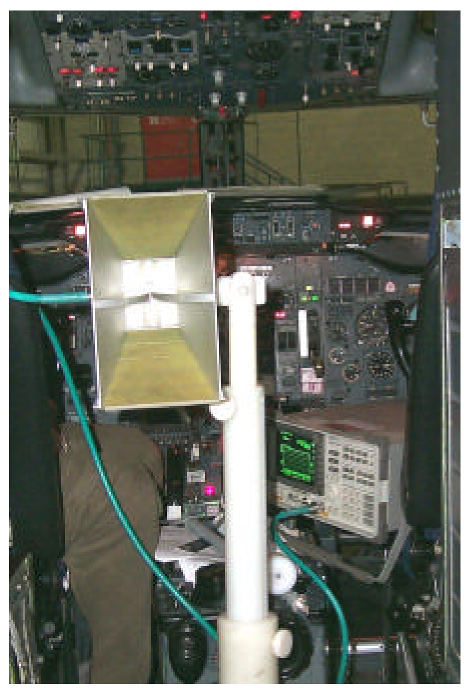
Measuring Equipment Calibration Check Adjacent to Virgin Atlantic Boeing 747

Transmitting from Rear Cabin

Measuring aft of Avionics Rack

British Airways Boeing 737-236 in Gatwick Hangar

Transmitting from Rear Cabin



Horn Antenna on Flight Deck