RTCA, Inc.
1828 L Street, NW, Suite 805
Washington, DC 20036-5133 USA

Guidance on Allowing Transmitting Portable Electronic Devices (T-PEDS) on Aircraft

RTCA DO-294C
December 16, 2008

Prepared by: SC-202
© 2008 RTCA, Inc.

Copies of this document may be obtained from

RTCA, Inc.

Telephone: 202-833-9339
Facsimile: 202-833-9434
Internet: www.rtca.org

Please visit the RTCA Online Store for document pricing and ordering information.

FOREWORD

The original report was prepared by RTCA Special Committee 202 (RTCA SC-202) and approved by the RTCA Program Management Committee (PMC) on October 19, 2004 with a Revision A prepared, and approved on March 14, 2006. Revision B was prepared by SC-202, and approved by the PMC on December 13, 2006, and Change 1 to Revision B likewise prepared and approved on December 6, 2007.

This Revision C was similarly prepared, and approved on December 16, 2008.

RTCA, Incorporated is a not-for-profit corporation formed to advance the art and science of aviation and aviation electronic systems for the benefit of the public. The organization functions as a Federal Advisory Committee and develops consensus-based recommendations on contemporary aviation issues. RTCA's objectives include but are not limited to:

- Coalescing aviation system user and provider technical requirements in a manner that helps government and industry meet their mutual objectives and responsibilities
- Analyzing and recommending solutions to the system technical issues that aviation faces as it continues to pursue increased safety, system capacity, and efficiency
- Developing consensus on the application of pertinent technology to fulfill user and provider requirements, including development of minimum operational performance standards for electronic systems and equipment that support aviation
- Assisting in developing the appropriate technical material upon which positions for the International Civil Aviation Organization and the International Telecommunication Union and other appropriate international organizations can be based

The organizations' recommendations are often used as the basis for government and private sector decisions as well as the foundation for many Federal Aviation Administration Technical Standard Orders.

Since RTCA is not an official agency of the United States Government, its recommendations may not be regarded as statements of official government policy unless so enunciated by the U.S. government organization or agency having statutory jurisdiction over any matters to which the recommendations relate.

TABLE OF CONTENTS

TABLE OF CONTENTS I
TABLE OF FIGURES IV
TABLE OF TABLES IV
TABLE OF APPENDICES V
EXECUTIVE SUMMARY XI
1 INTRODUCTION 1
1.1 Problem Statement 2
1.2 Terms of Reference (TOR) 3
2 GUIDANCE ON THE PROCESS FOR EVALUATING T-PED EFFECTS ON AIRCRAFT OPERATION 7
2.1 Background 7
2.2 Overview of the T-PED Allowance Process 8
2.2.1 Gather Preliminary Information 8
2.2.1.1 Define and Characterize T-PED Technologies for Evaluation 8
2.2.1.2 Define and Characterize Airplane Models for Evaluation 10
2.2.1.3 Determine Aircraft-Specific T-PED Usage Scenarios 11
2.2.1.4 Identify and Obtain Applicable Existing Data 12
2.2.2 Develop "Allowance" Plan Document 12
2.2.3 Coordinate with Regulatory Authorities for Agreement 13
2.2.4 Perform Electromagnetic Compatibility (EMC) and IPL Analysis and/or Test 13
2.2.4.1 Analysis 13
2.2.4.2 Test 13
2.2.5 Perform Risk/Safety Assessment and Mitigation 14
2.2.6 Evaluate Human Factors Effects 14
2.2.7 Develop T-PED Technology Report Document 15
2.2.8 Coordinate with Regulatory Authorities for Agreement 15
2.2.9 Establish Policy to "Allow" or "Prohibit" 15
2.2.10 Initiate Long-Term Data Collection 15
2.3 Outputs of the Process 16
2.3.1 Allowance Plan Document 16
2.3.2 T-PED Technology Report Document 16
3 T-PED CHARACTERIZATION 17
3.1 T-PED Characterization Sub-Process 17
3.1.1 Characterize Nominal Performance 17
3.1.2 Characterize Worst-Case Performance 18
3.1.3 Characterize Failure Modes 19
3.1.4 Identify T-PED Transmit Power Control Methods 21
3.1.5 Identify Typical Usage Scenarios 21
3.2 PED Characterization Matrix 22
4 (THIS SECTION NOT USED) 23
5 CHARACTERIZE AIRCRAFT CONFIGURATION 25
5.1 Introduction 25
5.2 Characterize Subject Aircraft Sub-Process Description 25

5.2.1 Define Aircraft-Specific T-PED Usage Scenarios 25
5.2.2 Establish Multiple Equipment Factor 27
5.3 Characterization of Coupling Paths 30
5.3.1 Source Systems and Nominal Operating Frequencies 30
5.3.2 Potential Victim Receiver Systems and Operating Frequencies 30
5.3.3 Coupling Path Nomenclature 31
5.3.4 Interference Path Loss (IPL) 33
5.3.4.1 Definition 33
5.3.4.2 IPL Determination: Recommended Practices 34
5.3.4.2.1 Front-door Coupling (IRA and NIRA) 34
5.3.4.2.2 Back-door Coupling 35
5.3.4.2.2.1 Radiated to Units (IRU and NIRU) 35
5.3.4.2.2.2 Radiated to Cables (IRC and NIRC) 35
5.3.4.2.2.3 Directly Conducted into Cables (CEI and CCT) 35
5.3.4.3 IPL Data Summary and Applicability 35
5.3.4.3.1 Data Summary 35
5.3.4.3.2 Data Applicability and Discussion 37
5.3.4.4 Aircraft Measurement Issues 37
5.3.5 IPL Data Collection 38

6 AIRCRAFT & AVIONICS SUSCEPTIBILITY CHARACTERIZATION 41
6.1 Introduction 41
6.1.1 Reports of Susceptibility 41
6.1.2 The Reality of Susceptibility 41
6.1.3 Threat Coupling Categories and Interference Solutions 42
6.1.3.1 Additional Assumptions 42
6.1.3.2 Analysis Findings 43
6.2 Front-door Coupling Susceptibility 43
6.2.1 Description of the Front-door Problem 45
6.2.2 Aircraft Receiver Systems 45
6.2.3 Discussion of Table 6-2 47
6.2.3.1 MOPS Required Sensitivity 47
6.2.3.2 MOPS Out-of-Band Susceptibility and Spurious Response 47
6.2.3.3 Analytical Sensitivity 48
6.2.3.4 Analytical Aggregate T-PED Interference Threshold CW 48
6.2.3.5 Analytical Aggregate T-PED Interference Threshold PSD 48
6.2.3.6 Assumed Net Antenna Gain for Analysis 50
6.2.4 Primary Interference Effects 55
6.2.4.1 Victim Receiver Desensitization 55
6.2.4.2 Victim Spurious Responses 56
6.2.4.3 Intermodulation 56
6.2.4.3.1 Avionics Receiver 56
6.2.4.3.2 T-PED Transmitter 57
6.2.4.3.3 Passive Intermodulation 57
6.2.4.3.4 Characterization of Intermodulation Effects 57
6.2.4.4 Cross-modulation 59
6.2.4.4.1 Cross-modulation Theory 59
6.2.4.4.2 Cross-modulation Effect Estimates 60
6.2.4.5 PED Transmitter Out-of-band Emissions 62
6.2.5 Front-door Coupling Susceptibility Assessment Process 62
6.2.5.1 Front-door Susceptibility Assessment Process Steps 63

6.2.5.2 *Pro forma* Simplified Link Budget 66
6.2.5.2.1 Desensitization (IRA) 67
6.2.5.2.2 Spurious Response (IRA) 67
6.2.5.2.3 Intermodulation Effects 68
6.2.5.2.4 T-PED Undesired Emissions 68
6.2.5.2.5 Cross-modulation Effects 69
6.2.5.3 Considerations for Assessment of IRA Impact 69
6.2.6 Front-door Coupling Assessment Example(s) 71
6.2.6.1 WLAN T-PED on Localizer at Cat I Decision Height 71
6.2.6.2 TDMA (GSM 850) Mobile Telephone on Localizer at Limits of Coverage 73
6.3 Back-door Coupling Susceptibility 74
6.3.1 Description of Problem 74
6.3.2 Affected Systems 77
6.3.3 Primary Interference Threats 77
6.3.4 Back-door Susceptibility Assessment Process 77
6.3.4.1 Systems to be Assessed 78
6.3.4.2 Existing System RF Susceptibility Requirements 79
6.3.4.3 Data Required 80
6.3.4.4 Test and Analysis Considerations 80
6.3.4.5 Rationale for Exclusion of NIRU and NIRC 80
6.3.5 Output of the Back-door Evaluation 81

7 RISK/SAFETY ASSESSMENT AND MITIGATION 83
7.1 Risk Assessment Flow Chart 83
7.1.1 The Safety Analysis Process 84
7.1.2 Multiple Iterations and Mitigating Actions in the Safety Assessment Process 84
7.2 Process Flow Definitions and External References 85
7.2.1 Risk Assessment Process 86

8 OPERATIONAL RECOMMENDATIONS CONSIDERING HUMAN FACTORS 89
8.1 Introduction 89
8.2 Guidelines 89
8.2.1 PED Categorization 89
8.2.2 Passenger Concerns 90
8.2.3 Education 90
8.2.3.1 Industry-accepted PED/T-PED Lists 90
8.2.3.2 Public Awareness Campaigns 94
8.2.4 Recommended Solutions 94
8.2.4.1 Technical 94
8.2.4.2 Procedural 95

9 CONCLUSIONS & RECOMMENDATIONS 97
9.1 Conclusions 97
9.2 Recommendations 98

10 MEMBERSHIP 103

APPENDICES 107

TABLE OF FIGURES

Figure 2-1 Recommended Allowance Process for On-board T-PED Operation 9
Figure 3-1 T-PED Characterization Sub-Process 21
Figure 5-1 Characterize Aircraft Configuration Sub-Process 26
Figure 5-2 Depiction of Front-door and Back-door Coupling 33
Figure 5-3 Definitions of IPL and ED-118 TF 34
Figure 6-1 Process of Assessing Front-door Susceptibility of Aircraft Systems to T-PED Emissions 64
Figure 7-1 Safety Assessment and Mitigation Process 87
Figure 7-2 System Risk Assessment Process 88
Figure 8-1 Recommended Content and Timing of Announcements Regarding Permitted Use of PEDs/T-PEDs 91

TABLE OF TABLES

Table 2-1 Aircraft Operational Phases 11
Table 5-1 Summary of CNS Receiver Operating Frequencies 30
Table 5-2 Classification of Coupling Paths Types 32
Table 5-3 Summary of Measured NIRA IPL Values in Decibels for Large and Small Transport Aircraft 36
Table 5-4 Measured IRA IPL Values in Decibels for a Boeing 747-400 Aircraft, 2.4 GHz and 5.2 GHz ISM Bands 36
Table 6-1 Coupling Categories and Suggested Strategies to Determine Effects of T-PEDs on Aircraft Systems 44
Table 6-2 Characterization of On-board Radio Receivers 51
Table 6-3 Potential Intermodulation Products in VOR Band 58
Table 6-4 Analysis-based Values of IRA IPL to Ensure Minimum Cross-modulation Effect on Aircraft Radio Systems 61
Table 6-6 Example Preliminary Analysis: WLAN on Localizer at Cat I Decision Height 72
Table 6-7 Example Preliminary Analysis: TDMA Mobile Telephony on Localizer at Limits of Coverage 75
Table 6-8 Example Preliminary Analysis: TDMA Mobile Telephony on Glide Slope at Cat 1 Decision Height 76
Table 6-9 Typical Aircraft Avionics and Electrical Systems Considered During Back-door Coupling Susceptibility Assessment 78
Table 8-1 Outline of Employee Training Regarding PED Usage Policies 92
Table 8-2 Human Factors Scenarios and Possible Solutions 93
Table 8-3 Suggestions for Increasing Public Awareness of PED/T-PED-related Issues 95

TABLE OF APPENDICES

APPENDIX 0 DOCUMENT DEFINITIONS
0.A DOCUMENT DEFINITIONS 0.A-1

APPENDIX 1 BIBLIOGRAPHY
1.A BIBLIOGRAPHY 1.A-1

APPENDIX 2 (THIS APPENDIX IS NOT USED)

APPENDIX 3 T-PED CHARACTERIZATION
3.A DEFINITIONS FOR PED MATRIX HEADINGS IN APPENDIX 3.B 3.A-1
3.B TRANSMITTING PORTABLE ELECTRONIC DEVICES: T-PED CHARACTERIZATION MATRIX 3.B-1
3.B.1 Category: Unlicensed Devices 3.B-1
3.B.1.1 Category: Unlicensed Devices, Technology: Family Radio Service (FRS) 3.B-1
3.B.1.2 Category: Unlicensed Devices, Technology: General Mobile Radio Service (GMRS) 3.B-2
3.B.1.3 Category: Unlicensed Devices, Technology: 802.15.1 – Bluetooth 3.B-3
3.B.1.4 Category: Unlicensed Devices, Technology: 802.11a 3.B-5
3.B.1.5 Category: Unlicensed Devices, Technology: 802.11b 3.B-6
3.B.1.6 Category: Unlicensed Devices, Technology: 802.11g 3.B-8
3.B.1.7 Category: Unlicensed Devices, Technology: 802.11n 3.B-9
3.B.1.8 Category: Unlicensed Devices, Technology: Ultra-Wide Band (UWB) .. 3.B-10
3.B.1.9 Category: Unlicensed Devices, Technology: Radio Frequency Identification (RFID) 3.B-11
3.B.2 Category: Licensed Devices 3.B-13
3.B.2.1 Category: Licensed Devices, Technology: 2-Way Pagers 3.B-13
3.B.2.2 Category: Licensed Devices, Technology: cdmaOne, cdma2000®, 1xEv-DO 3.B-14
3.B.2.3 Category: Licensed Devices, Technology: W-CDMA, UMTS (FDD mode) 3.B-16
3.B.2.4 Category: Licensed Devices, Technology: EDGE 3.B-18
3.B.2.5 Category: Licensed Devices, Technology: GSM 3.B-20
3.B.2.6 Category: Licensed Devices, Technology: iDEN 3.B-22
3.B.2.7 Category: Licensed Devices , Technology: AMPs 3.B-23
3.B.2.8 Category: Licensed Devices , Technology: Tetra 3.B-25
3.B.3 Category Licensed and Unlicensed Devices 3.B-26
3.B.3.1 Category: Licensed & Unlicensed Devices, Technology: Medical Devices (Licensed) 3.B-26
3.B.3.2 Category: Licensed & Unlicensed Devices, Technology: Medical Devices (Unlicensed) 3.B-27
3.B.3.3 Category: Licensed & Unlicensed Devices, Technology: Medical Devices (European Rules) 3.B-29
3.C T-PED FAULT MODE CHARACTERIZATION GUIDANCE 3.C-1
3.C.1 Introduction 3.C-1
3.C.2 T-PED Maximum Radiated Power - Intentional Transmit Band 3.C-2
3.C.3 Out-of-Band Radiated Emissions 3.C-2

3.C.4 Frequency Stability 3.C-4
3.C.5 Filter Component Probability of Failure 3.C-4
3.C.6 Composite Worst-case Interference Mask 3.C-5
3.C.7 Example Fault Mode Analysis 3.C-5
3.C.7.1 Overview of RF Transmit Chain of a CDMA Mobile Phone 3.C-6
3.C.7.2 Power Management 3.C-7
3.C.7.3 RF Calibration 3.C-8
3.C.7.4 Power Amplifier 3.C-9
3.C.8 Composite Worst-case Interference Mask 3.C-11
3.C.8.1 Frequency Stability 3.C-12
3.C.8.2 Increased Transmitter Power Output 3.C-13
3.C.8.3 Increased Out-Of-Band and Spurious Emissions 3.C-13
3.C.9 References 3.C-14
3.D INTRODUCTION TO WLAN/WPAN TECHNOLOGIES (INCLUDING MARKET DATA ON NORMAL MODES OF OPERATION) 3.D-1
3.D.1 Introduction 3.D-1
3.D.1.1 Frequencies Used in the U.S. 3.D-1
3.D.1.2 802.11 WLAN Technologies 3.D-2
3.D.1.3 IEEE 802.15 WPAN Technologies 3.D-2
3.D.1.4 Other Publications Reviewing WLAN/WPAN Technologies 3.D-3
3.D.2 Packaging Considerations 3.D-3
3.D.3 Normal Operating Modes 3.D-4
3.D.3.1 Protocol Considerations 3.D-4
3.D.3.2 RF Considerations 3.D-5
3.D.3.3 In-Band Emissions 3.D-5
3.D.3.4 FCC Rules 3.D-10
3.D.4 Market Data, Available WLAN Equipment Supporting Normal Modes 3.D-11
3.E INTRODUCTION TO WWAN TECHNOLOGIES (INCLUDING MARKET DATA ON NORMAL MODES OF OPERATION) 3.E-1
3.E.1 Introduction 3.E-1
3.E.2 Mobile Phone Subscriber Demographics 3.E-2
3.E.3 Mobile Phone Technologies 3.E-2
3.E.3.1 Multiplexing Schemes 3.E-2
3.E.3.2 Details On The Multiplexing Schemes 3.E-3
3.E.3.3 Analog And Digital Technology Definitions 3.E-3
3.E.4 Mobile Phone Network Architecture 3.E-4
3.E.4.1 Mobile phone power control 3.E-5
3.E.5 FCC Rules Governing In-Flight Cell Phone Use 3.E-6
3.E.6 Market Data Supporting Normal Modes 3.E-7
3.E.6.1 Mobile Phones Maximum Radiated Power - FCC Authorizations 3.E-7
3.F WPAN AND WLAN TECHNOLOGIES FAULT, FAILURE AND MALFUNCTION CONSIDERATIONS 3.F-1
3.F.1 Worst-case Transmitter-Receiver Technology Behavior 3.F-1
3.F.1.1 Regarding Potential Faults Associated with Inter-Stage Oscillation 3.F-4
3.F.1.2 Regarding Potential Faults Associated with Power Amplifier Oscillation 3.F-4
3.F.1.3 Regarding Potential Faults Associated with Failed Automatic Gain Control 3.F-4
3.F.1.4 Regarding Potential Faults Associated with PA Bias 3.F-5
3.F.1.5 Regarding Potential Faults Associated with Antenna 3.F-5
3.F.1.6 In-Band Emissions (Worst-case) 3.F-5
3.F.1.7 Out-of-Band Emissions (Worst-case) 3.F-6

3.F.1.8 Worst-Case Device Behavior 3.F-6
3.F.2 Conclusions 3.F-6
3.F.2.1 Excessive In-Band Emissions 3.F-6
3.F.2.2 Out-of-Band Emissions 3.F-7
3.G RFID AND T-MED 3.G-1
3.G.1 Radio Frequency Identification (RFID) 3.G-1
3.G.1.1 Passive Tags 3.G-1
3.G.1.2 Semi-Active Tags 3.G-2
3.G.1.3 Active Tags 3.G-2
3.G.2 Medical T-PED's 3.G-2
3.G.3 Ultra Wideband (UWB) Technology 3.G-3
3.G.3.1 Use and Modes of Operation 3.G-3

APPENDIX 4 (THIS APPENDIX IS NOT USED)

APPENDIX 5 CHARACTERIZE AIRCRAFT CONFIGURATION
5.A AIRCRAFT INTERFERENCE PATH LOSS - REVIEW AND SUMMARY OF EXISTING WORK 5.A-1
5.B INTERFERENCE PATH LOSS SUMMARY (IPL/dB) 5.B-1
5.C RECOMMENDED PRACTICES FOR INTERFERENCE PATH LOSS MEASUREMENTS AND MODELING 5.C-1
5.C.1 IRA/NIRA (Front-door) IPL Measurement Method 5.C-1
5.C.2 IRU/NIRU IPL Measurement Method 5.C-5
5.C.3 IRU/NIRU IPL Modeling Method 5.C-6
5.C.4 Conversion of Received Power to IPL 5.C-8
5.D ELECTROMAGNETIC PATH LOSS FROM CABIN TO VHF ON AIRBUS A320 AND AIRBUS A340-600 ..... 5.D-1
5.D.1 Introduction 5.D-1
5.D.2 Measurements in A320 in Both Unfurnished and Furnished Cabin 5.D-2
5.D.2.1 Measurements In A320 Type Without Cabin Interior Furnishings, Coupling From Different Positions Within The Fuselage Cross-Section 5.D-2
5.D.2.2 Influence From Furnishing And Identification Of Coupling Paths To VHF Communication 5.D-4
5.D.2.3 Measurements In Furnished A340-600 Type 5.D-6
5.D.3 Conclusion 5.D-7
5.D.4 Measurement setup 5.D-8
5.E MULTIPLE EQUIPMENT ASSESSMENT 5.E-1
5.E.1 Introduction 5.E-1
5.E.1.1 Definition of the Multiple Equipment Factor 5.E-2
5.E.2 Conclusions on MEF in General 5.E-11
5.F EXAMPLE –AIRCRAFT-SPECIFIC T PED USAGE SCENARIO 5.F-1
5.F.1 Aircraft and Onboard Infrastructure 5.F-1
5.F.2 T-PED Quantities 5.F-2
5.F.2.1 T-PED Population Assessment 5.F-2
5.F.2.2 T-PED Ad Hoc Networks 5.F-3
5.F.3 T-PED Operational Constraints 5.F-4
5.F.3.1 Flight Phase Constraints 5.F-4
5.F.4 T-PED WLAN Technology Worst-case Aircraft Use Assessment 5.F-4
5.F.4.1 T-PED Normal Power: 5.F-5
5.F.4.2 T-PED Maximum Specified Power: 5.F-5
5.F.4.3 T-PED Worst-Case (Fault) In-Band Power 5.F-5

5.F.4.4 T-PED Worst-Case (Fault) Out-Of-Band Power 5.F-5

APPENDIX 6 AIRCRAFT & AVIONICS SUSCEPTIBILITY CHARACTERIZATION
6.A (Appendix Deleted)
6.B LUFTHANSA'S APPROACH FOR VERIFICATION OF ANECDOTAL EMI REPORTS IN THE YEAR 1999 ..... 6.B-1
6.B.1 Worldwide Situation 6.B-1
6.B.2 Lufthansa Situation in the Late Nineties 6.B-2
6.B.3 Lufthansa Approach 6.B-3
6.B.4 Lufthansa Results 6.B-3
6.B.5 Analysis of the Typical Mechanism of Creating Incorrect Reports 6.B-4
6.B.6 Rectification of the Human Factors Problem 6.B-5
6.B.7 Actual Status and Conclusions 6.B-5
6.C (Appendix Deleted)
6.D EMC GROUND TEST GUIDANCE TO EVALUATE AIRPLANE SYSTEM PERFORMANCE WITH TRANSMITTING PORTABLE ELECTRONIC DEVICE (T-PED) TECHNOLOGY FOR DETERMINATION OF OPERATOR ALLOWANCE 6.D-1
6.D.1 Purpose 6.D-1
6.D.2 References 6.D-2
6.D.3 Procedural Guidance For An EMC Ground Test 6.D-3
6.D.3.1 Site Requirements and Conditions 6.D-3
6.D.3.2 Resources To Be Supplied 6.D-3
6.D.3.3 Pre-Test Activity 6.D-3
6.D.3.4 Test Procedure Guidance 6.D-4
6.E INTERMODULATION NOISE ASSESSMENT 6.E-1
6.E.1 Not Used 6.E-2
6.E.2 Not Used 6.E-2
6.E.3 Not Used 6.E-2
6.E.4 Not Used 6.E-2
6.E.5 Not Used 6.E-2
6.E.6 Not Used 6.E-2
6.E.7 Measurements Methods And Results For Intermodulation Detection 6.E-2
6.E.7.1 Conducted Test Setup 6.E-2
6.E.7.2 Radiated Test Setup 6.E-4
6.E.7.3 Conducted & Radiated Test Results 6.E-7
6.E.7.4 Comments on Conducted Test Results 6.E-8
6.E.7.5 Determining Which Phone Radiated the IM Signal 6.E-9
6.E.7.6 Comments on Radiated Results 6.E-10
6.E.8 Design Analysis of IM Generation 6.E-13
6.E.8.1 Intermodulation Signals Generated within Mobile Phones 6.E-13
6.E.8.2 Signal Propagation within Mobile Phones to the Power Amplifier 6.E-14
6.E.8.3 Insertion Loss Tests 6.E-15
6.E.8.4 Comments on the Insertion Loss Tests 6.E-21
6.E.9 Antenna Rejection Tests 6.E-22
6.E.10 Conclusions 6.E-23
6.F DERIVATION OF TEST SIGNALS AND FIELD STRENGTH TO EMULATE INTENTIONAL TRANSMITTERS 6.F-1
6.F.1 EMI Characterization of Radio Communication Standards 6.F-2
6.F.2 Transmitting Power and Field Strength 6.F-2
6.F.3 Criteria for Assessing the EMI Potential of Radio Communication Standards 6.F-3

6.F.4 Wireless Communication Standards Categories and Test Waveform Derivations . 6.F-4
6.F.4.1 Pulse, Amplitude Modulated Standards 6.F-4
6.F.4.2 FDMA/CDMA Standards 6.F-11
6.F.4.3 Extended Basic Waveforms for Complete IRA Testing 6.F-17
6.G PREPARATION FOR AIRCRAFT TESTING AGAINST THE INTENTIONAL EMISSION OF T-PEDS 6.G-1
6.G.1 Multiple Device Risk Assessment for Aircraft Interaction Testing 6.G-1
6.G.2 Accumulation of Spurious Emissions 6.G-2
6.G.3 Accumulation of Intentionally Transmitted Signals from T-PEDs 6.G-3

APPENDIX 7 (THIS APPENDIX IS NOT USED)

APPENDIX 8 GUIDANCE TO AIRCRAFT OPERATORS FOR DEVELOPMENT OF STANDARDIZED PED POLICIES, PROCEDURES AND OPERATION OF PICOCELL SYSTEMS
8.A GUIDANCE TO AIRCRAFT OPERATORS FOR DEVELOPMENT OF STANDARDIZED PED POLICIES AND PROCEDURES 8.A-1
8.A.1 Development of Common PED Policies and Procedures 8.A-1
8.A.2 Factors Influencing Development of T-PED Policies and Procedures 8.A-2
8.A.2.1 Regulatory Requirements 8.A-2
8.A.2.2 Differing Aircraft Types Within Aircraft Operators Fleet 8.A-2
8.A.2.3 International Harmonization 8.A-3
8.A.2.4 Human Factors Related Requirements for an Effective Policy 8.A-3
8.A.2.5 Identification of PEDs 8.A-4
8.A.3 General Guidance for Development of an Operator-Specific PED Policy 8.A-5
8.A.3.1 Basic Guidelines 8.A-5
8.A.3.2 Crew PED Usage 8.A-5
8.A.3.3 Initial T-PED Policy Development, Reviews and Updates 8.A-5
8.A.3.4 Communications Complexity 8.A-6
8.A.3.5 Passenger-Targeted Communications 8.A-6
8.A.3.6 Flight Deck Crew and Cabin Crew Training 8.A-8
8.A.3.7 Coordination with Airline Ground Staff and Handling Agents 8.A-9
8.A.4 PED Policy Template 8.A-9
8.A.4.1 General PED Restriction 8.A-10
8.A.4.2 Unrestricted Use 8.A-10
8.A.4.3 Restricted Use 8.A-11
8.A.4.4 Controlled Use 8.A-12
8.A.5 Prohibited Use 8.A-13
8.A.6 Special Case Usage 8.A-14
8.B PICOCELL SYSTEM CONSIDERATIONS IN FLIGHT OPERATIONS 8.B-1

APPENDIX 9 PROPOSED CHANGES TO FAA ADVISORY AND REGULATORY MATERIALS
9.A PROPOSED REWORDING OF AC 91.21-1A 9.A-1
9.B PROPOSED CFR REVISIONS TO INCORPORATE PED USAGE SIGNAGE 9.B-1

APPENDIX 10 RTCA SC-202 RECOMMENDATIONS ON PED SPURIOUS EMISSION LIMITS
10.A RTCA SC-202 RECOMMENDATIONS ON FCC SPURIOUS EMISSION LIMITS 10.A-1
10.A.1 Introduction 10.A-1

10.A.2 Phase 1 Near-Term PED Technology Assessment 10.A-1
10.A.3 Phase 2 Longer-Term PED Technology Assessment 10.A-2
10.A.4 Discussion Regarding Derivation of Recommendations to FCC on Spurious Emissions 10.A-2
10.A.5 Recommendation 10.A-3
10.B RTCA SC-202 DISCUSSIONS WITH CONSUMER ELECTRONICS INDUSTRY ON SPURIOUS EMISSION LIMITS 10.B-1
10.B.1 Purpose and Utility of These Statements on Spurious Emissions Limits 10.B-1
10.B.2 Consumer Electronics Association Response 10.B-1
10.B.3 WiMedia Alliance recommendations to SC-202 ..... 10.B-5
10.B.4 WiFi Alliance and IEEE 802.18 recommendations to SC-202 ..... 10.B-5

APPENDIX 11 (THIS APPENDIX IS NOT USED)

APPENDIX 12 SCOPE OF CERTIFICATION AND OPERATIONAL ASPECTS OF PICOCELL SYSTEM INSTALLATION
12.A SCOPE OF CERTIFICATION AND OPERATIONAL ASPECTS OF PICOCELL SYSTEM INSTALLATION 12.A-1
12.A.1 Background 12.A-1
12.A.2 Issues and Considerations Related to Picocell System Certification and Operation 12.A-2
12.A.2.1 Safety 12.A-2
12.A.2.2 RF and EMI Assessment 12.A-3
12.A.2.3 Instructions for Continued Airworthiness (ICA) 12.A-4
12.A.2.4 Certification Flight Test Plan 12.A-4
12.A.2.5 Aircraft Flight Manual (AFM) Limitations 12.A-5

EXECUTIVE SUMMARY

The United States Federal Aviation Administration (FAA) requested that RTCA, Inc. form a special committee to present an up-to-date evaluation of the use of portable electronic devices (PEDs) on board civil aircraft with emphasis on intentional transmitters such as devices enabled with cellular technologies, wireless RF network devices, and other wireless-enabled devices such as personal digital assistants (PDAs). This document refers to such PEDs as transmitting PEDs, or "T-PEDs", as distinct from non-transmitting PEDs, such as compact disk players and calculators. The overall class of PEDs includes both T-PEDs and the traditional non-transmitting PEDs.

The committee included representatives from consumer electronic device manufacturers, avionics manufacturers, aircraft manufacturers, airlines, aircraft operators, pilot and flight attendant associations, regulatory agencies, and related industry associations. The committee worked closely with other industry groups such as the Consumer Electronics Association. This work has been coordinated with EUROCAE Working Group 58. This report is also consistent with the findings and recommendations of RTCA Special Committee 159 and RTCA/DO-235A.

This report addresses the objectives of the Terms of Reference including the consideration of near-term T-PED technologies such as existing devices enabled with cellular technologies, wireless local area networks (WLANs), and wireless personal area networks (WPANs) as well as emerging PED technologies, for example active RF Identification (RFID) tags, transmitting medical devices, and picocells for devices enabled by cellular technologies for use on board aircraft. In addition, the committee has developed, with the support of national and international regulatory and standards bodies, changes to recommended RF emission limits for consumer PEDs. With the exception of human factors considerations that are applicable to all PEDs, this report concentrates on the use of T-PEDs. PEDs that do not include intentional transmitters were considered by RTCA SC-177, and the findings are contained in RTCA DO–233.

The Terms of Reference objective of providing specific guidance to mitigate the risks identified for portable electronic devices via aircraft design and certification has been addressed in RTCA/DO-307.

This document recognizes that there is a desire for immediate guidance on the use of T-PEDs, as there is known use of such devices on commercial flights today. Differences in the policies adopted by various aircraft operators, or with respect to aircraft models, are not clear to the public or, quite often, even to crewmembers.

The configuration of each aircraft is dependent on the model, the aircraft operators' requirements, and the modification status of the aircraft. Therefore, it is virtually impossible to define a single T-PED policy that fits all cases. This report does not attempt to recommend any specific policies with respect to the use of specific T-PED technologies on board aircraft while on the ground or while in flight.

This document defines and recommends a process by which aircraft operators and/or manufacturers may assess the risk of interference due to a specific T-PED technology within any aircraft type and model. The process described here is envisioned as a cooperative effort between aircraft operators, aircraft manufacturers, avionics manufactures, and T-PED manufacturers, with the aircraft operator having overall responsibility. The process will provide a means for aviation regulatory authorities, aircraft operators, aircraft manufacturers, PED manufacturers, and others as appropriate, to determine acceptable and enforceable policies and processes for the allowance of passenger and crew use of T-PEDs.

Although the process has been carefully thought out, it is a new process. Similar processes have already been implemented on a case-by-case basis to allow limited use of certain T-PED technologies on operational aircraft. Nevertheless, the aviation, T-PED, and regulatory communities will be well served by adopting the process recommended in this document and subsequently accumulating operational information for the purpose of improving this process.

At this point, there is not sufficient information to support a universal change in existing policies regarding the use of T-PEDs on board aircraft. Practical cabin and passenger-management issues dictate that guidance regarding the use or prohibition of T-PEDs needs to be applicable to large, readily identifiable classes of T-PEDs. It is impractical to establish a prohibition against a specific T-PED technology while permitting the operation of other technologies when the devices are indistinguishable to the casual observer. Such a policy recommendation could place unrealistic expectations on crewmembers and passengers.

This RTCA SC-202 report includes several conclusions and recommendations that can be broadly grouped and summarized as follows:

1. The process defined should be implemented on a collaborative basis involving T-PED manufacturers, aircraft manufacturers, avionics manufacturers, aircraft operators, and national and international regulatory and standards bodies to assure that any T-PED use allowance does not compromise the continued safe operation of the aircraft
2. As design efforts for advanced aircraft, avionics, and new T-PED technologies evolve, the engineering design of all elements should specifically consider means to minimize the effect of T-PED emissions on aircraft operations
3. Human factors issues will be an important consideration in the implementation of "T-PED on board" policies

Since the initial publication of RTCA/DO-294, the industry has communicated that the processes defined, while comprehensive, required streamlining for practical application and administration by the aircraft operators and national aviation authorities. To that end, the committee applied RTCA/DO-294 processes to complete an analysis of aircraft receiver susceptibility. T-PED transmitting waveforms were evaluated to establish generic test waveforms that could represent broad families of T-PED products. T-PED data was reviewed and updated to ensure consistency and establish test values. The accumulated effect of multiple T-PEDs was tabulated to facilitate calculation of test values.

Thereafter, the Test Procedure Guidance for EMC Ground Test was completely revised to take advantage of the new analyses and available data. Guidance was created to provide aircraft operators with standardized policies and procedures for T-PED use for both domestic and international flights. Finally, draft CFRs were proposed for consistent aircraft cabin briefings and signage related to PED usage. These items were included in an interim update to RTCA/DO-294 published March 2006.

A second update to DO-294 provided:

- Further data for analysis and test
- Revised conclusions and recommendations
- Further streamlined the document for easier use
- Additional guidance materials on operational, installation and certification aspects of airborne picocell systems
- Documented recommended changes to the FCC RF emission limits for consumer portable electronic devices.

This final update to the document, RTCA/DO-294C has:

1. DO-294B change 1 modifications for Tables 6-5 through 6-8 have been incorporated
2. Table 6-2 has been updated to better correspond with data and analysis done for DO-307; the "Assumed IPL" column was removed as redundant and potentially misleading
3. Typographical errors were corrected as appropriate
4. Section 9.2 Conclusions and Recommendations is revised to align with data and analysis done for DO-307
5. Appendix 10.A is updated to align conclusions, data and analysis done for DO-307
6. Added Appendix 10.B to document the results of dialog with consumer electronics manufacturers associations on alternatives for the use of portable electronic devices on aircraft

THESE DOCUMENT REVISIONS AND ADDITIONS OFFER AIRCRAFT OPERATORS PRACTICAL GUIDANCE TO EVALUATE T-PED IMMUNITY OF EXISTING AIRCRAFT, IN LINE WITH RTCA/DO-307 GUIDANCE FOR DESIGN AND CERTIFICATION OF AIRCRAFT FOR PED TOLERANCE.

1 INTRODUCTION

Portable electronic devices (PEDs) that intentionally radiate signals[1] within the airplane fuselage are potential sources of radio frequency interference to installed aircraft systems. The primary concern is that radiated radio frequency energy can couple into aircraft control and safety systems, including very sensitive communications, navigation and surveillance equipment, thus introducing the potential to compromise normal aircraft operation. In general, the threat of such interference was not considered in the development of the RTCA and EUROCAE minimum performance standards[2] applying to radio receivers used for communications, navigation and surveillance functions, nor to the certification and testing of other electronic systems directly involved in the operation of the aircraft. The use of such intentionally transmitting PED devices, whose performance is not subject to the certification processes required of equipment installed on aircraft, represents a new paradigm in aircraft operation. Therefore, caution must be taken to perform careful characterization, analysis, and measurement before allowing such devices to operate on board aircraft.

As initially envisioned in the Terms of Reference (discussed in subsection 1.2) this document would have provided recommendations about specific T-PED technologies. During the preparation of the document, however, it became clear that the number and range of variables involved in such guidance was too great to permit such broadly applicable guidance to be developed. Therefore, this document recommends a process by which such characterization, analysis and measurement should be performed. These operational approval guidelines are directly applicable guidance related to use of portable electronic devices on board air carrier aircraft. Extensive appendices provide supporting data to both illustrate the process and to provide information that simplifies the effort of completing various process steps.

This document was first modified from its original published form to introduce expanded guidance to specifically assist regulators, and aircraft operators seeking operational approval for use of T-PEDs. This additional guidance takes the form of recommended aircraft test strategies, supporting analyses and aircraft operator policies to manage T-PED usage. Considerations for addressing additional T-PED technologies (such as active Radio Frequency Identification (RFID) tags, Ultra Wide Band (UWB), transmitting medical devices, and picocell technology) have also been incorporated. Clarified definitions and means of addressing the effects of intermodulation and cross-modulation are incorporated. Recommended RF emission limit changes for consumer portable electronic devices are included in this revision to the document as well.

This most recent document revision incorporates refinements in the characterization data for on-board radio receivers, and revises the recommended

[1] To simplify the discussion throughout the remainder of this report, unless clearly stated otherwise the term T-PED will be used to describe a Portable Electronic Device that contains an intentional transmitter.
[2] RTCA standards documents are Minimum Operational Performance Standards (MOPS) and Minimum Aviation System Performance Standards (MASPS). EUROCAE documents are generally limited to MOPS.

© 2008 RTCA, Inc.

RF emission limits based on work done for RTCA/DO-307 aircraft design and certification. This revision to the document adds consensus recommendations based on dialog with a number of consumer electronics manufacturers associations on alternatives for the use of portable electronic devices on aircraft.

1.1 Problem Statement

Suspected Electromagnetic Interference (EMI) from PEDs aboard aircraft is a popular subject for mass media reporting. Such reports are often anecdotal and can be erroneous or misinterpreted. However; they have aided the aircraft operators industry in passenger education regarding the potential risk of PED use during flight and, to a certain extent, have helped the public to better understand Title 14 of the Code of Federal Regulations 91.21 (14 CFR 91.21) safety announcement segment prior to each flight. Conversely, a perceived lack of substantive published and publicly available PED-aboard-aircraft EMI reports contributes to skepticism regarding limitations to on-board use.

There have been reported incidents where pilots initially attributed aircraft system anomalies to PED interference, but after further evaluation a fault condition unrelated to PED operation was discovered in a specific airplane system, refer to Appendix 6.B. However, there have also been reports of on-board interference that has simply "gone away" when all PEDs have been turned off. Even studies conducted by the CAA [1], NASA ([2], for example), Boeing, Lufthansa, and US Airways lead to contradictory conclusions if the contexts of the studies are not fully taken into account. A partial bibliography of such studies is contained in Appendix 1.A.

One goal of this document is to identify a process by which the effects of T-PEDs on aircraft systems can be methodically investigated and mitigated.

In order to consider the potential for interference from T-PEDs by passengers on commercial aircraft, the unique aspects of PEDs must be taken into account. These include:

- Lack of managed configuration and maintenance of passenger-owned PEDs
- The ambiguous location of onboard devices
- The ambiguous number of active, inactive, and stowed devices, considering PEDs in general and T-PEDs in particular
- Unknown T-PED operating state such as automatic medical T-PED transmission at unknown times and irrespective of flight status
- Lack of packaging consistency or identifying markings on T-PED devices indicating technology employed
- Different RF emission standards for aircraft installed equipment and T-PEDs – T-PED RF radiated emission limits are typically less stringent at their operating frequency and in the frequency bands coinciding with the aircraft radio bands

© 2008 RTCA, Inc.