RTCA, Inc.
1150 18th Street NW, Suite 910
Washington, DC 20036
USA

Minimum Operational Performance Standards (MOPS) for Aircraft VDL Mode 2 Physical Link and Network Layer

RTCA DO-281C
September 20, 2018
Supersedes DO-281B

Prepared by: SC-214
© 2018 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

This document was originally prepared by RTCA Special Committee 214 (SC-214) and approved by the RTCA Program Management Committee (PMC) on September 20, 2018.

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 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; and
- 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 organization's 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 and several advisory circulars.

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.

DISCLAIMER

This publication is based on material submitted by various participants during the SC approval process. Neither the SC nor RTCA has made any determination whether these materials could be subject to valid claims of patent, copyright or other proprietary rights by third parties, and no representation or warranty, expressed or implied is made in this regard. Any use of or reliance on this document shall constitute an acceptance thereof "as is" and be subject to this disclaimer.

This Page Intentionally Left Blank

EXECUTIVE SUMMARY

This document has been structured with guidelines according to the RTCA MOPS Drafting Guide dated December 16, 2015.

The material in this document highlights the minimum procedures for the physical link and network layer of the VDL Mode 2 subnetwork.

The test procedures used in this document have been coordinated with EUROCAE Working Group 92 during the preparation of EUROCAE Document ED-92C.

This document includes four appendices. Appendix B should be considered a normative appendix.

This Page Intentionally Left Blank

TABLE OF CONTENTS

1. PURPOSE AND SCOPE 1

1.1 Introduction 1

1.2 System Overview 2

1.3 Possible Configuration of Aircraft Equipment 3
1.3.1 Separated Equipment 3
1.3.2 Integrated Equipment 4

1.4 Operational Applications 5

1.5 Operational Goals 5

1.6 Equipment Performance Verification 5
1.6.1 Bench Tests 6
1.6.2 Environmental Tests 6
1.6.3 Installed Equipment Tests 6
1.6.4 Operational Tests 6

1.7 Definitions of Terms 6
1.7.1 Adjacent Channel 6
1.7.2 Adjacent Channel Power 6
1.7.3 Adjacent Channel Rejection (ACR) 7
1.7.4 Bit Error Rate (BER) 7
1.7.5 Co-channel Interference (CCI) 7
1.7.6 Error Vector Magnitude (EVM) 7
1.7.7 Reference Signal Level 7
1.7.8 Undesired VDL Mode 2 Test Signal 7
1.7.9 Reference Bit Sequence 8

1.8 Reference Documents 8

1.9 RESERVED 8

2. MINIMUM PERFORMANCE STANDARDS 9

2.1 General Design Requirements 9
2.1.1 Airworthiness 9
2.1.2 Intended Function 9
2.1.3 ITU and FCC Rules and Regulations 9
2.1.4 Fire Protection 9
2.1.5 Operation of Controls 9
2.1.6 Accessibility of Controls 9
2.1.7 Effects of Test 9
2.1.8 Equipment Classes 10

2.1.8.1 Receivers 10
2.1.8.2 Transmitters 10
2.1.9 VDL Mode 2 Avionics Architecture Classes 10
2.1.9.1 ISO 8208-compliant Equipment Classes 10
2.1.9.1.1 Class X 10
2.1.9.1.2 Class Y 10
2.1.9.1.3 Class Z 11
2.1.9.2 Non-ISO 8208 Equipment Classes 11
2.1.9.2.1 Class V 11
2.1.9.2.2 Class W 11
2.1.10 Software Management 11

2.2 Minimum Performance Requirements - Standard Conditions 12
2.2.1 VDL Mode 2 Physical Layer Requirements 12
2.2.1.1 Transceiver Requirements 12
2.2.1.1.1 Tuning Range and Channel Increments 12
2.2.1.1.2 Modulation 12
2.2.1.1.3 Tuning Time 12
2.2.1.1.4 Receive to Transmit Switching Time 12
2.2.1.1.5 Transmit to Receive Switching Time 13
2.2.1.1.6 Channel Sensing 13
2.2.1.2 Receiver Requirements 13
2.2.1.2.1 Sensitivity 14
2.2.1.2.2 Adjacent Channel Rejection 14
2.2.1.2.3 Receiver Performance in the Presence of Strong Signals Within the VHF Aeronautical Band 14
2.2.1.2.4 Receiver Performance in the Presence of Strong Signals Outside the VHF Aeronautical Band 14
2.2.1.2.5 Desired Signal Dynamic Range 15
2.2.1.2.6 Symbol Rate Capture Range 15
2.2.1.2.7 Frequency Capture Range 15
2.2.1.2.8 Phase Acceleration 16
2.2.1.2.9 Co-channel Interference (CCI) 16
2.2.1.2.10 Conducted Spurious Emission 16
2.2.1.2.11 FM Broadcast Intermodulation 16
2.2.1.2.12 In-band Intermodulation 16
2.2.1.3 Transmitter Requirements 17
2.2.1.3.1 Channel Bit Rate 17
2.2.1.3.2 RF Output Power 17
2.2.1.3.3 RF Power Rise Time 17
2.2.1.3.4 RF Power Release Time 18
2.2.1.3.5 Symbol Constellation Error 18
2.2.1.3.6 Spurious Emissions 18
2.2.1.3.7 Adjacent Channel Power 19
2.2.1.3.8 (Reserved) 20
2.2.1.3.9 Load VSWR Capability 20
2.2.1.3.10 Frequency Tolerance 20
2.2.2 VDL Mode 2 Link Layer Requirements 20
2.2.3 VDL Mode 2 Network Layer 8208 Requirements 21
2.2.4 VDL Mode 2 Network Layer Mobile SNDCF Requirements 21

2.2.5 Non-ISO 8208 Use of VDL Mode 2 21
2.2.6 Data/Management Interface 21

2.3 Minimum Performance Requirements - Environmental Conditions 21
2.3.1 Introduction 21
2.3.2 Receiver 22
2.3.3 Transmitter 22

2.4 Equipment Test Procedures 27
2.4.1 Definition of Terms and Conditions of Tests 27
2.4.1.1 Warm-up and Stabilization of Test Equipment/Equipment Under Test 27
2.4.1.2 Alignment, Adjustment and Calibration for Equipment Under Test 27
2.4.1.3 Equipment Termination 27
2.4.1.4 Test Equipment Calibration and Replacement 27
2.4.1.5 Failure of the Equipment Under Test 27
2.4.1.6 Measurement Error Due to Test Equipment and Test Setup 27
2.4.1.7 Default RF Signal Level for Avionics High Level Protocol Testing 28
2.4.2 Special Test Mode and Test Equipment for Physical Layer Tests 28
2.4.2.1 Frame Error Rate Testing 28
2.4.2.1.1 FER Test 28
2.4.2.1.2 FER Test Setup 29
2.4.2.2 Bit Error Rate Testing 29
2.4.2.2.1 External BER Test Fixture 30
2.4.2.2.2 Test Payload 30
2.4.2.2.3 BER Test Setup 30
2.4.2.3 Desired VDL Mode 2 Signal Source 31
2.4.2.3.1 VDL Mode 2 Data Generator 31
2.4.2.3.2 VHF Signal Generator 31
2.4.2.4 Undesired VDL Mode 2 Signal Source 31
2.4.3 VDL Mode 2 Test Set Definitions 31
2.4.3.1 Upper Tester (UT) 32
2.4.3.1.1 Aircraft Test Tool / Protocol Analyzer (ATT) 33
2.4.3.1.2 Upper Data/Management Interface Test Tool (UDMITT) 34
2.4.3.2 Lower Tester (LT) 34
2.4.3.2.1 Ground Station Emulator (GSE) 35
2.4.3.2.2 VDL Mode 2 Lower Data/Management Interface Test Tool (LDMITT) 36
2.4.3.2.3 Air/Ground Router 36
2.4.3.2.4 Standard LT Configurations 36
2.4.3.2.4.1 LT Configuration 1 36
2.4.3.2.4.2 LT Configuration 2 37
2.4.3.2.4.3 LT Configuration 3 37
2.4.3.2.4.4 LT Configuration 4 37
2.4.3.2.4.5 LT Configuration 5 38
2.4.4 Physical Layer Test Procedures 38
2.4.4.1 Receiver Test Procedures 38
2.4.4.1.1 Sensitivity 38
2.4.4.1.2 Adjacent Channel Rejection 39
2.4.4.1.3 Rejection of Signals Within the VHF Aeronautical Band 40
2.4.4.1.4 Rejection of Signals Outside the VHF Aeronautical Band 41
2.4.4.1.5 Desired Signal Dynamic Range 42

2.4.4.1.6 Symbol Rate Capture Range 42
2.4.4.1.7 Frequency Capture Range 43
2.4.4.1.8 Phase Acceleration 43
2.4.4.1.9 Co-Channel Interference 44
2.4.4.1.10 Conducted Spurious Emission 45
2.4.4.1.11 FM Broadcast Intermodulation 45
2.4.4.1.12 In-Band Intermodulation/Desensitization 47
2.4.4.2 Transmitter Test Procedures 48
2.4.4.2.1 Bit Rate 48
2.4.4.2.2 RF Output Power 48
2.4.4.2.3 RF Power Rise Time 49
2.4.4.2.4 RF Power Release Time 50
2.4.4.2.5 Symbol Constellation Error 51
2.4.4.2.6 Spurious Emissions 51
2.4.4.2.7 Adjacent Channel Power 52
2.4.4.2.8 (Reserved) 58
2.4.4.2.9 Load VSWR Capability 58
2.4.4.2.10 Frequency Tolerance 59
2.4.4.3 Physical Layer System Level Test Procedures 59
2.4.4.3.1 Receive to Transmit Switching Time 59
2.4.4.3.2 Transmit to Receive Switching Time 60
2.4.4.3.3 Channel Sensing 62
2.4.4.3.4 Tuning Time 65
2.4.5 VDL Mode 2 Link Layer Test Procedures 65
2.4.5.1 Test Procedure Structure 65
2.4.5.1.1 Overview of Test Cases 65
2.4.5.1.2 Declarations Part 65
2.4.5.1.3 Constraints Part 65
2.4.5.1.4 Detailed Test Cases 65
2.4.5.1.5 Test Case Description 66
2.4.5.1.5.1 Procedure description 66
2.4.5.1.5.2 Message Sequence Charts 66
2.4.5.1.6 Test Cases Macros 66
2.4.5.1.6.1 Establish a link layer connection (SET_{AVLC}) 67
2.4.5.1.6.2 Establish (explicit) a network layer connection (SET_{8208}) 68
2.4.5.1.6.3 RESERVED 68
2.4.5.1.6.4 Check link is established ($CHECK_{link}$) 68
2.4.5.1.6.5 Check network link is established ($CHECK_{Network}$) 69
2.4.5.1.6.6 Close a link layer connection 69
2.4.5.1.6.7 Close network layer connection 69
2.4.5.2 (Reserved) 69
2.4.5.3 MAC Sublayer 69
2.4.5.3.1 MAC services 69
2.4.5.3.1.1 Multiple Access 69
2.4.5.3.1.2 Channel Occupancy 70
2.4.5.3.1.3 Channel Congestion 70
2.4.5.3.2 MAC System Parameters 70
2.4.5.3.2.1 Timer TM1 (inter-access delay timer) 70
2.4.5.3.2.2 Timer TM2 (channel busy timer) 72
2.4.5.3.2.3 Parameter p (persistence) 73

2.4.5.3.2.4 Counter M1 (maximum access attempts) 75
2.4.5.3.3 Description of MAC Layer Procedures 75
2.4.5.3.3.1 Channel Sensing 75
2.4.5.3.3.2 Access Attempt 75
2.4.5.3.3.3 Signal Quality Parameter 76
2.4.5.3.3.3.1 Original SQP 76
2.4.5.3.3.3.2 Supplement 4 SQP (Optional) 76
2.4.5.4 Data Link Service Sublayer 77
2.4.5.4.1 Services 78
2.4.5.4.1.1 Frame Sequencing 78
2.4.5.4.1.2 Error Detection 78
2.4.5.4.1.3 Station Identification 79
2.4.5.4.1.4 Broadcast Addressing 80
2.4.5.4.1.5 Data Transfer 80
2.4.5.4.1.6 Grouped frames 81
2.4.5.4.2 AVLC Data Link Protocol 81
2.4.5.4.2.1 Frame Format 81
2.4.5.4.2.2 Address Structure 81
2.4.5.4.2.3 Address Fields 82
2.4.5.4.2.4 Broadcast Address 83
2.4.5.4.2.5 Link Control Field 83
2.4.5.4.2.6 Information Field 83
2.4.5.4.3 Data Link Service System Parameters 84
2.4.5.4.3.1 Timer T1 (delay before retransmission) 84
2.4.5.4.3.2 Timer T2 (delay before acknowledgement) 86
2.4.5.4.3.3 Timer T3 (link initialization time) 86
2.4.5.4.3.4 Timer T4 (maximum delay between transmissions) 88
2.4.5.4.3.5 Parameter N1 (maximum number of bits in frame) 89
2.4.5.4.3.6 Counter N2 (maximum number of transmissions) 91
2.4.5.4.3.7 Parameter k (window size) 92
2.4.5.4.4 Modes of Operation 93
2.4.5.4.4.1 Operational Mode 93
2.4.5.4.4.2 Non-Operational Mode 93
2.4.5.4.4.2.1 DISC Frame 94
2.4.5.4.4.2.2 DM Frame 95
2.4.5.4.4.2.3 Frame Reject Mode 96
2.4.5.4.4.2.4 Selective Reject Mode 97
2.4.5.4.5 Use of the P/F bit 97
2.4.5.4.5.1 General 97
2.4.5.4.5.2 INFO frames 98
2.4.5.4.5.3 Unnumbered Frames 99
2.4.5.4.6 Unnumbered Command Frames Collisions 99
2.4.5.4.6.1 Data Link Entity (DLE) Procedures 100
2.4.5.4.6.2 LME Procedures 101
2.4.5.4.7 XID Frame 104
2.4.5.4.8 Broadcast 105
2.4.5.4.9 Information Transfer 105
2.4.5.4.9.1 Transmit Queue Management 106
2.4.5.4.9.1.1 Eliminate Redundant Frames 106
2.4.5.4.9.1.2 Procedures for Transmission 106
2.4.5.4.9.2 SREJ Frame 108

2.4.5.4.9.3 FRMR Frame 109
2.4.5.4.9.4 UA Frame 110
2.4.5.4.9.5 UI Frame 111
2.4.5.4.9.6 TEST Frame 112
2.4.5.5 Link Management Entity 112
2.4.5.5.1 Services 113
2.4.5.5.1.1 Link Provision 113
2.4.5.5.1.2 Link Change Notification 113
2.4.5.5.2 Exchange Identity (XID) Formats 114
2.4.5.5.2.1 Encoding 114
2.4.5.5.2.2 Public Parameters 114
2.4.5.5.2.3 Private Parameters 115
2.4.5.5.2.4 General Purpose Private Parameters 115
2.4.5.5.2.5 Aircraft Initiated Private Parameters 115
2.4.5.5.2.6 Ground Initiated Modification Private Parameters 116
2.4.5.5.2.7 Ground Initiated Private Parameters 116
2.4.5.5.3 LME Service System Parameters 117
2.4.5.5.3.1 Timer TG1 (frequency dwell time) 117
2.4.5.5.3.2 Timer TG2 (maximum idle activity time) 118
2.4.5.5.3.3 Timer TG3 (maximum time between transmissions) 119
2.4.5.5.3.4 Timer TG4 (maximum time between GSIFs) 119
2.4.5.5.3.5 Timer TG5 (maximum link overlap time) 119
2.4.5.5.4 Description of LME Procedures 119
2.4.5.5.4.1 Frequency Management 119
2.4.5.5.4.2 Link Connectivity 128
2.4.5.5.4.3 Ground Station Identification 128
2.4.5.5.4.4 Link Establishment 129
2.4.5.5.4.5 Link Parameter Modification 136
2.4.5.5.4.6 Aircraft Initiated Handoff 137
2.4.5.5.4.7 RESERVED 144
2.4.5.5.4.8 Ground Initiated Handoff 144
2.4.5.5.4.9 Ground Requested Aircraft Initiated Handoff 153
2.4.5.5.4.10 Ground Requested Broadcast Handoff (optional) 169
2.4.5.5.4.11 Ground Requested Autotune 174
2.4.5.5.4.12 Expedited Subnetwork Connection Management (optional) 176
2.4.5.5.4.13 Frequency Support List 177
2.4.6 VDL Mode 2 Network Layer Test Procedures 200
2.4.6.1 Architecture 200
2.4.6.1.1 Access Points 200
2.4.6.2 Services 200
2.4.6.2.1 Subnetwork Connection Management 200
2.4.6.2.2 Packet Fragmentation and Reassembly 202
2.4.6.2.3 Error Recovery 203
2.4.6.2.4 Connection Flow Control 204
2.4.6.3 Packet Format 205
2.4.6.3.1 General Format Identifier 206
2.4.6.3.2 Calling and Called DTE Addresses 206
2.4.6.3.2.1 Encoding 206
2.4.6.3.2.2 Aircraft DTE Address 206
2.4.6.3.2.3 Ground DTE Address 207

2.4.6.3.2.4 Ground Network DTE Address 207
2.4.6.3.3 Call User Data Field 208
2.4.6.3.4 Packet Types 208
2.4.6.4 Subnetwork Layer System Parameters 209
2.4.6.4.1 Packet Size 209
2.4.6.4.2 Parameter W (transmit window size) 210
2.4.6.4.3 Parameter A (acknowledgement window size) 210
2.4.6.5 Description of Procedures 210
2.4.6.5.1 Supported Facilities 210
2.4.6.5.1.1 Nonstandard Default Packet Sizes 211
2.4.6.5.1.2 Nonstandard Default Window Sizes 211
2.4.6.5.1.3 Flow Control Parameter Negotiation 211
2.4.6.5.1.4 Fast Select 211
2.4.6.5.1.5 Fast Select Acceptance 212
2.4.6.5.1.6 Called Line Address Modified Notification 212
2.4.6.5.1.7 Called Address Extension 212
2.4.6.5.2 Unsupported Facilities 212
2.4.6.5.3 Subnetwork Establishment and Connection Management 212
2.4.6.5.3.1 Subnetwork Entity Initialization 213
2.4.6.5.3.2 Subnetwork Connection Establishment 213
2.4.6.5.3.2.1 Explicit Subnetwork Connection Establishment 213
2.4.6.5.3.2.2 Expedited Subnetwork Connection Establishment (optional) 213
2.4.6.5.4 Subnetwork Connection Maintenance 213
2.4.6.5.4.1 Explicit Subnetwork Connection Maintenance 213
2.4.6.5.4.2 Expedited Subnetwork Connection Maintenance (optional) 214
2.4.6.5.4.3 Broadcast Subnetwork Connection Maintenance 214
2.4.6.5.4.4 Call Redirection for X.121-based Networks 214
2.4.6.5.5 Error Handling 214
2.4.6.5.6 Acknowledgements 214
2.4.7 VDL Mode 2 Mobile SNDCF Test Procedures 215
2.4.7.1 (Reserved) 215
2.4.7.2 Call User Data Encoding 215
2.4.7.2.1 ISH PDU 215
2.4.7.2.2 Maintained/Initialized Status Bit 215
2.4.7.2.3 CALL REQUEST 216
2.4.7.2.4 CALL ACCEPTED 216
2.4.8 Non-ISO 8208 Use of VDL Mode 2 216
2.4.9 Data/Management Interface 217

3. INSTALLED EQUIPMENT TESTS 219

3.1 Equipment Installation 219
3.1.1 Accessibility 219
3.1.2 Aircraft Environment 219
3.1.3 Display Visibility 219
3.1.4 Dynamic response 219
3.1.5 Failure Protection 219
3.1.6 Inadvertent Turnoff 219
3.1.7 Aircraft Power Source 219

3.2 Installed Equipment Performance Requirements 220
3.2.1 Dynamic Response 220
3.2.2 Interference Effects 220

3.3 Conditions of Test 221
3.3.1 Power Input 221
3.3.2 Associated Equipment or Systems 221
3.3.3 Environment 221

3.4 Test Procedures for Installed Equipment Performance 223
3.4.1 Conformity Inspection 223
3.4.2 Equipment Function 223
3.4.3 Equipment Accessibility 223
3.4.4 Interference Effects 223
3.4.5 Power Supply Fluctuations 223
3.4.6 Reception 223
3.4.7 Transmission 224

4. EQUIPMENT OPERATIONAL PERFORMANCE CHARACTERISTICS .. 225

4.1 Required Operational Performance Requirements 225
4.1.1 Power Inputs 225
4.1.2 Displays 225
4.1.3 Communications Controls 225
4.1.4 Equipment Operating Functions 225
4.1.5 System Operational Indication 225
4.1.6 Equipment Operating Limitations 225

4.2 Test Procedures for Operational Performance Requirements 225
4.2.1 Power Input 225
4.2.2 Communications Displays 226
4.2.3 Communications Controls 226
4.2.4 Functional Operating Tests 226
4.2.5 System Operational Indication 226
4.2.6 Equipment Operating Limitations 226

5. MEMBERSHIP 227

APPENDIX A: ACRONYMS AND GLOSSARY A-1

APPENDIX B: REQUIREMENTS CROSS REFERENCE MATRICES – VERIFICATION TESTING AND EQUIPMENT ARCHITECTURE CLASS (NORMATIVE) B-1

APPENDIX C: ANALYSIS OF BER VS. BLOCK FAILURE RATE C-1

APPENDIX D: ASSUMED FUNCTIONAL CAPABILITIES OF THE DATA/MANAGEMENT INTERFACE D-1

APPENDIX E: DIFFERENCES BETWEEN RTCA DO-281C AND EUROCAE ED92C……..E-1

APPENDIX F: DO-281C CHANGE SUGGESTION FORM..... F-1

TABLE OF TABLES

Table 2-1: Receiver Environmental Test Conditions Matrix 23
Table 2-2: Transmitter Environmental Test Conditions Matrix..... 25
Table 2-3: *Pro Forma* Test Description Table..... 67
Table 2-4: Default Values for GSIF Parameters..... 85
Table 2-5: Minimum and Maximum Values of T1 for Testing 85
Table 2-6: Minimum and Maximum Values of T3 for Testing 87
Table 3-1: Example of Interference Protection for GNSS and AMSS 222
Table B-1: Traceability Matrix for Environmental Conditions…… B-2
Table B-2: Traceability Matrix for Standard Conditions……..B-13
Table C-1: Tabulation of E_h/N_0, BER, BFR for VDL Mode 2……...C-4
Table C-2: AVLC Frame Format……C-6

TABLE OF FIGURES

Figure 1-1: VDL Mode 2 Protocol Layers Using ATN/OSI Nomenclature 3
Figure 1-2: VDL Functions for Combination Class Y/Z Equipment..... 4
Figure 1-3: Integrated Class X VDL Mode 2 Architecture..... 5
Figure 2-1: Receive to Transmit Turnaround Time 13
Figure 2-2: Accept/Reject/Continue Regions for Sequential FER Test..... 29
Figure 2-3: Frame Error Rate Test Set Up..... 29
Figure 2-4: Bit Error Rate Test Setup 31
Figure 2-5: ISO 9646 Test Configuration..... 32
Figure 2-6: Upper Tester for Class X or Class Z Equipment..... 33
Figure 2-7: Upper Tester for Class Y Equipment 33
Figure 2-8: Lower Tester for Class X or Class Y Equipment..... 34
Figure 2-9: Lower Tester for Class Z Equipment 35
Figure 2-10: Lower Tester Configuration 1 36
Figure 2-11: Lower Tester Configuration 2 37
Figure 2-12: Lower Tester Configuration 3 37
Figure 2-13: Lower Tester Configuration 4 37
Figure 2-14: Lower Tester Configuration 5 38
Figure 2-15: Frequency Modulated VDL Mode 2 Source 44
Figure 2-16: Intermodulation Measurement (BER)..... 47
Figure 2-17: Intermodulation Measurement (FER) 47
Figure 2-18: Output Power Measurement..... 49
Figure 2-19: RF Power Rise and Release Time Measurement 50
Figure 2-20: Ramp Up and Beginning of VDL Mode 2 Synchronization Sequence..... 50
Figure 2-21: Spurious Emissions Measurement 52

Figure 2-22: First Adjacent Channel Power Measurement 53
Figure 2-23: Second, Third and Fourth Adjacent Channel Power Measurement 55
Figure 2-24: Measurement beyond 4th Adjacent Channel 58
Figure 2-25: Load VSWR Capability 58
Figure 2-26: Receive to Transmit Turn-Around Time Measurement 60
Figure 2-27: Transmit to Receive Turn-Around Time Measurement 61
Figure 2-28: Channel Sensing Test Configuration 64
Figure 2-29: PIN Attenuator Control Signals for Channel Sense Test 64
Figure 2-30: Error Detection 79
Figure 2-31: Station Identification 79
Figure 2-32: Timer T1 (delay before retransmission) 85
Figure 2-33: Timer T2 (delay before acknowledgement) 86
Figure 2-34: Timer T3 (link initialization time) 87
Figure 2-35: Parameter N1 (maximum number of bits in frame) 90
Figure 2-36: Counter N2 (maximum number of transmissions) 91
Figure 2-37: Parameter k (window size) 92
Figure 2-38: Operational Mode 93
Figure 2-39: Non-Operational Mode 94
Figure 2-40: Frame Reject Mode 97
Figure 2-41: INFO frames 99
Figure 2-42: DLE Procedures 100
Figure 2-43: XID Frame 105
Figure 2-44: Procedures for Transmission 107
Figure 2-45: SREJ Frame 108
Figure 2-46: TEST Frame 112
Figure 2-48: Link Establishment 129
Figure 2-49: Ground Requested Broadcast Handoff (a) (partial) 171
Figure 2-50: (RESERVED) 202
Figure 2-51: Packet Fragmentation and Reassembly 203
Figure 2-52: Error Recovery 204
Figure 2-53: Connection Flow Control 205
Figure C-1: Upper Bound of FER vs. BER for VDL Mode 2 Reed-Solomon Decoding ----------C-3

1. PURPOSE AND SCOPE

1.1 Introduction

This document contains the Minimum Operational Performance Standards (MOPS) and test procedures for aircraft Very High Frequency (VHF) Digital Link (VDL) Mode 2 physical, link and network layer protocol components which comprise an avionics transmitter/receiver (transceiver) function intended to be used for Air/Ground (A/G) data communications. This document is designed so that equipment certified to it will be compatible with the relevant Minimum Aviation System Performance Standards (MASPS) in RTCA DO-224D, *Signal-In-Space MASPS For Advanced VHF Digital Data Communications Including Compatibility with Digital Voice Techniques*, and with International Civil Aviation Organization (ICAO) Doc 9776, *Manual on VHF Digital Link (VDL) Mode 2*, which is also known as the VDL Mode 2 Technical Manual. Additional information on VDL Mode 2 is contained in ARINC Specification 631 and ARINC Characteristics 750 and 758.

Compliance with this MOPS is one means of assuring that the VDL Mode 2 equipment will function satisfactorily under all conditions normally encountered in air traffic services communications and that data formats will be compatible with the Aeronautical Telecommunication Network (ATN). These standards specify characteristics useful to designers, manufacturers, installers, and users of the VDL Mode 2 A/G communications system equipment. This document is organized with the following order and format:

- Section 1 describes the purpose and scope.
- Section 2 describes the minimum operational performance standards for:

  - general design requirements
  - standard conditions
  - environmental conditions
  - equipment test procedures
- Section 3 describes the installed equipment tests.
- Section 4 describes the operational tests.

Appendix A contains a list of acronyms used in this document.

Appendix B provides a correlation matrix between the test procedures of Section 2.4 and the VDL Mode 2 system level requirements given in RTCA DO-224D, and the equipment architecture classes defined in Section 1.3. This appendix is normative in the sense that it specifically identifies which requirements make up the minimum set for the standard classes of equipment.

Appendix C provides the analysis that establishes the equivalency between the Frame Error Rate and the bit error rate. This appendix provides the basis for the use of either bit error rate or frame error rate in the verification procedures of Section 2.4.

Appendix D defines the minimum functionality of the Data/Management Interface for Class Y and Class Z architectures. This functionality is described at a high level. No protocol details (i.e., bit definition, data rate, physical layer details, etc.) for the Data/Management Interface are given in this document. Such a standardized interface is the Aviation VHF Link Control (AVLC) Simple Interface Protocol (ASIP) described in Attachment 10 to ARINC Characteristic 750.

Appendix E describes the differences between RTCA DO-281C and EUROCAE ED-92C.

 © 2018 RTCA, Inc.

Appendix F contains a DO-281 change suggestion form.

1.2 System Overview

The VDL Mode 2 system provides interconnectivity for data communications between aircraft and ground-based users. The VDL Mode 2 A/G communications system architecture is defined to provide coverage similar to today's analog-based data communication system. VDL Mode 2 is a digital packet data system using phase-shift modulation. VDL Mode 2 provides a significant increase in capacity over the existing Aircraft Communications Addressing and Reporting System (ACARS) currently in use by many aircraft.

VDL Mode 2 is designed to be a subnetwork of the ATN and is organized according to the Open Systems Interconnection (OSI) reference model of the International Standards Organization (ISO). Point-to-point data communications between the aircraft router and the ground ATN router are provided through the VDL Mode 2 system via the ISO 8208 network interface. In addition to ISO 8208 communications, point-to-multi-point data communication is also provided as one-way data broadcast from the ground station to the aircraft stations.

The VDL Mode 2 system is related to the three lower layers of the OSI model (illustrated in Figure 1-1) providing services described as follows:

- Layer 1 (Physical layer): provides transceiver frequency control, bit exchanges over the radio media, and notification functions. These functions are more often known as "radio" and "modulation" functions.

  RTCA DO-224D defines the VDL Mode 2 modulation as being a differentially encoded eight phase shift keying (D8PSK) modulation scheme providing a 31.5 kb/s bit rate (at layer 1).

- Layer 2 (Link Layer) is split into two sublayers and a management entity:

  The Media Access Control (MAC) sublayer provides access to the Physical layer by a Carrier Sense Multiple Access (CSMA) algorithm.

  The Data Link Services (DLS) sublayer is composed of the Aviation VHF Link Control (AVLC) protocol derived from the High-Level Data Link Control (HDLC) protocol (ISO 3309). The main functions of the AVLC protocol are frame exchanges, frame processing and error detection.

  The Link Management Entity (LME) manages link establishment between DLS peers.

- Layer 3: DO-224D defines only the Subnetwork Access Protocol (SNAcP) sublayer, the lowest network sublayer of OSI layer 3. It is compliant with the Subnetwork sublayer requirements defined in the ATN SARPs and conforms to ISO 8208. ISO 8208 is the network layer of the international X.25 standard published by International Telecommunication Union-Telecommunication Standardization Sector (ITU-T). It provides packet exchanges over a virtual circuit, error recovery, connection flow control, packet fragmentation and reassembly, and subnetwork connection management functions.

© 2018 RTCA, Inc.