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

Minimum Operational Performance Standards for GPS Local Area Augmentation System Airborne Equipment

RTCA DO-253D
July 13, 2017

Prepared by: SC-159
© 2017 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 prepared by Special Committee 159 (SC-159) and approved by the RTCA Program Management Committee (PMC) on July 13, 2017.

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; 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

RTCA/DO-253C was originally prepared by RTCA Special Committee 159 (SC-159). It was approved by the RTCA Program Management Committee on December 16, 2008. RTCA/DO-253D was also prepared by RTCA Special Committee 159 (SC-159). It was approved by the RTCA Program Management Committee on July 13, 2017 and supersedes RTCA/DO-253C.

This document is the complementary avionics standard to the International Civil Aviation Organization Annex 10 Volume I Ground Based Augmentation System standards and recommended practices (SARPs) for Ground based augment system Approach Service Types C (GAST C) and D (GAST D) as well as the differentially corrected positioning service (DCPS). Together, GAST C and GAST D support all categories of approach and landing operations with vertical and lateral guidance, as well as guided takeoff. DCPS supports horizontal positioning in local airport and terminal area environments. This version of RTCA/DO-253 includes changes resulting from the final validation of GAST D and the promulgation of Annex 10 with GAST D by ICAO. It also includes maintenance updates for the other GBAS services including GAST C (previously referred to as "Category I precision approach") and DCPS.

This Page Intentionally Left Blank.

TABLE OF CONTENTS

1 PURPOSE AND SCOPE 1

1.1 Introduction 1
1.2 System Overview 3
1.3 Operational Goals 4
1.3.1 GBAS Approach Service Types 4
1.3.2 Notable Changes from Previous Version 4
1.4 LAAS Airborne Equipment Functions 5
1.5 Assumptions 7
1.5.1 GPS Signal-in-Space 7
1.5.2 SBAS Signal-in-Space 7
1.5.3 LAAS Signal-in-Space 7
1.5.4 GPS/LAAS Applications 7
1.5.5 Applicability 7
1.5.6 LAAS Ground Subsystem 8
1.5.7 Interoperability 8
1.5.8 RF Interference 8
1.6 Test Considerations 8
1.6.1 Environmental Tests 8
1.6.2 Bench Tests 9
1.6.3 Installed Tests 9
1.7 Aircraft Equipment Information Vulnerabilities 9
1.8 Applicable Standards and Regulatory Documents 11

2 EQUIPMENT PERFORMANCE REQUIREMENTS AND TEST PROCEDURES 13

2.1 General GPS/LAAS Airborne Requirements 13
2.1.1 Airworthiness 13
2.1.2 Intended Function 13
2.1.3 Fire Protection 13
2.1.4 General Human Factors Requirements and Applicable Documents 14
2.1.4.1 Operation of Controls 14
2.1.4.2 Accessibility of Controls 15
2.1.4.3 Control Labels 15
2.1.4.4 Equipment Operating Procedures 15
2.1.4.5 Minimum Workload Functions 15
2.1.4.6 Displays 16
2.1.4.7 Annunciations 17
2.1.5 Effects of Test 17
2.2 VHF Data Broadcast (VDB) Receiver Subsystem 17
2.2.1 General Requirements 17
2.2.1.1 Design Assurance 18
2.2.1.2 VDB Receiver Equipment Classes 19
2.2.2 Tuning 21
2.2.2.1 Frequency Range 21
2.2.2.2 Frequency Selection 21
2.2.2.3 Response Time 21
2.2.3 Data Latency 22
2.2.4 Data Format Decoding 22
2.2.5 Message Failure Rate 22
2.2.5.1 Class A Receivers 22

2.2.5.2 Class B Receivers 23
2.2.6 VDB Signal Tracking Requirements 23
2.2.6.1 Carrier Frequency Capture Range 23
2.2.6.2 Carrier Frequency Slew Rate 23
2.2.6.3 Symbol Rate Tolerance 23
2.2.7 Co-Channel Rejection 23
2.2.7.1 VDB as the Undesired SignaL 23
2.2.7.2 VOR as the Undesired Signal 24
2.2.7.3 ILS Localizer as the Undesired Signal 24
2.2.8 Adjacent Channel Rejection 24
2.2.8.1 1st Adjacent 25 kHz Channels (±25 kHz) 25
2.2.8.2 2nd Adjacent 25 kHz Channels (±50 kHz) 25
2.2.8.3 3rd Adjacent 25 kHz Channels (±75 kHz) and Beyond 25
2.2.9 Out-of-Band Rejection 25
2.2.9.1 VDB Interference Immunity 25
2.2.9.2 FM Immunity 27
2.2.9.3 BurnOut Protection 30
2.2.10 Receiver-to-Antenna Interface 30
2.2.10.1 Receiver Voltage Standing Wave Ratio (VSWR) 30
2.2.10.2 Antenna Characteristics 30
2.3 Position and Navigation (PAN) Subsystem 32
2.3.1 General 32
2.3.2 Design Assurance 32
2.3.2.1 Hardware 32
2.3.2.2 Software 33
2.3.3 Interference and Dynamics Environment 33
2.3.4 Approach and Reference Station Selection 33
2.3.5 Reference Data Selectors and Frequency Mapping 34
2.3.6 GNSS Receiver Function 34
2.3.6.1 Ranging Sources 34
2.3.6.2 Sensitivity and Dynamic Range 35
2.3.6.3 Equipment Burn-out Protection 36
2.3.6.4 GPS Signal Processing 37
2.3.6.5 SBAS Signal Processing 42
2.3.6.6 Smoothing 44
2.3.6.7 Measurement Quality Monitoring 45
2.3.6.8 Accuracy 46
2.3.6.9 Integrity in the Presence of Interference 47
2.3.6.10 Integrity in the Presence of Abnormal Dynamics 47
2.3.6.11 Airborne Code Carrier Divergence (CCD) Filtering 48
2.3.7 Message Processing Function 49
2.3.7.1 VDB Message Validity Check 50
2.3.7.2 VDB Message Block Identifier Check 50
2.3.7.3 VDB Message Authentication Protocols 50
2.3.7.4 Message Processing Requirements for Forward Compatibility 51
2.3.8 Corrected Pseudorange 52
2.3.8.1 Conditions for Use of Differential Corrections 52
2.3.8.2 Application of Differential Corrections 54
2.3.8.3 Tropospheric Correction 55
2.3.9 LAAS Differential Position Requirements 55
2.3.9.1 Differential Position Solution – One Acceptable Means 55
2.3.9.2 Service Type Specific Differential Position Solution Requirements 57
2.3.9.3 Reserved 59

2.3.9.4 Satellite Geometry Screening 59
2.3.9.5 Differential Correction Magnitude Check 60
2.3.9.6 Fault Detection 61
2.3.9.7 Dual Solution Pseudorange Ionospheric Gradient Monitoring (DSIGMA) 62
2.3.10 Position, Velocity, and Time (PVT) Outputs 63
2.3.10.1 Message Processing -- GBAS ID Selection 64
2.3.10.2 Protection Level, Ephemeris Error Bound, & Figures of Merit 64
2.3.10.3 Figures of Merit Outputs 66
2.3.10.4 PVT Output Latency 67
2.3.10.5 Velocity Accuracy 67
2.3.11 Precision Approach Guidance Outputs 67
2.3.11.1 Message Processing 67
2.3.11.2 Precision Approach Region 68
2.3.11.3 Approach Status Verification 69
2.3.11.4 Ground Continuity Integrity Designator (GCID) Conditions 70
2.3.11.5 Outputs 70
2.3.12 Error Models 85
2.3.12.1 Model of Airborne Pseudorange Performance 85
2.3.12.2 Model of Tropospheric Residual Uncertainty 87
2.3.12.3 Model of Ionospheric Residual Uncertainty 87
2.4 Equipment Performance Environmental Conditions 88
2.4.1 Environmental Tests 89
2.4.1.1 VDB Required Performance 89
2.4.1.2 PAN Required Performance 93
2.4.1.3 Clarification of Environmental Tests 96
2.5 Equipment Test Procedures 97
2.5.1 Definition of General Test Terms and Conditions 97
2.5.1.1 Power Input Voltage 97
2.5.1.2 Power Input Frequency 97
2.5.1.3 RF Signal Levels 98
2.5.1.4 Adjustment of Equipment 98
2.5.1.5 Test Instrument Precautions 98
2.5.1.6 Ambient Conditions 98
2.5.1.7 Warm-Up 98
2.5.1.8 Connected Loads 98
2.5.1.9 EMI Testing 98
2.5.1.10 Analysis 98
2.5.1.11 Demonstration 98
2.5.1.12 Inspection 99
2.5.1.13 Test 99
2.5.1.14 Test Cross Reference Matrix 99
2.5.2 VDB Receiver Subsystem Test Procedures 132
2.5.2.1 Definition of VDB Test Terms and Conditions 132
2.5.2.2 Detailed Test Procedures 133
2.5.3 Precision Approach Navigator Tests 170
2.5.3.1 Definition of PAN Test Terms and Conditions 170
2.5.3.2 Accuracy 172
2.5.3.3 Interference Rejection 177
2.5.3.4 Velocity Accuracy and Velocity Figure of Merit Tests 178

3 INSTALLED EQUIPMENT PERFORMANCE REQUIREMENTS 185

3.1 General Performance Requirement 185

3.2 Interference Effects 185
3.3 Inadvertent Turnoff 185
3.4 Test Environment 185
3.5 Associated Equipment or Systems 185
3.6 Environmental Conditions 185
3.7 Adjustment of Equipment 185
3.8 Warm-Up Period 185
3.9 GPS Antenna and Installation Requirements 186
3.10 VDB Aircraft Implementation Loss (AIL) 186
3.10.1 Class A Receivers 186
3.10.2 Class B Receivers 186
3.11 GNSS Electromagnetic Compatibility 187
3.12 VDB Electromagnetic Compatibility 187
3.13 Equipment Interfaces 187

4 OPERATIONAL PERFORMANCE REQUIREMENTS 189

4.1 Alert Presentation 189
4.2 Guidance Reference Point 189
4.3 Missed Approach Guidance 189

5 MEMBERSHIP 191

APPENDIX A: ACRONYMS, ABBREVIATIONS, AND DEFINITIONS A-1

A.1 Acronyms and Abbreviations A-1
A.2 Definitions A-5

APPENDIX B: REQUIREMENTS CHANGES BETWEEN VERSIONS B-1

B.1 Requirements Changes Between RTCA/DO-253 and RTCA/DO-253A B-1
B.2 Requirements Changes Between RTCA/DO-253A and RTCA/DO-253B B-4
B.3 Requirements Changes Between RTCA/DO-253B and RTCA/DO-253C B-5
B.4 Requirements Changes Between RTCA/DO-253C and RTCA/DO-253D B-7

APPENDIX C: FINAL APPROACH SEGMENT AND DEVIATION EXAMPLE C-1

C.1 Introduction C-1
C.2 Final Approach Segment (FAS) C-1
C.2.1 FAS Definition C-1
C.2.2 Example Calculation of FAS Unit Vectors C-2
C.3 Deviation Computations C-3
C.3.1 Lateral Deviations C-3
C.3.1.1 Lateral Deviation Definition C-3
C.3.1.2 Lateral Deviation Example Calculations C-4
C.3.2 Vertical Deviations C-5
C.3.2.1 Vertical Deviation Definition C-5
C.3.2.2 Vertical Deviation Example Calculations C-6

APPENDIX D: STANDARD GPS INTERFERENCE ENVIRONMENT D-1

D.1 Introduction D-1
D.2 Operating Interference Environment D-1
D.2.1 Out-of-Band Interference D-1

D.2.1.1 Out-of-Band PulseD Interference D-1
D.2.2 In-Band and Near-Band Interference D-3
D.2.2.1 In-Band and Near-Band Pulsed Interference D-4
D.2.3 GNSS Noise D-4
D.3 Minimum Standard Antenna Frequency Selectivity D-5

APPENDIX E: SERVICE VOLUME DEFINITIONS AND MAXIMUM USE DISTANCE E-1

E.1 Background E-1
E.2 Description of SARPs Service Volume Requirements Changes E-1
E.3 Considerations for Setting Dmax for the Positioning Service E-1
E.4 Considerations for Setting Dmax for the Approach Service Volume E-1
E.5 Operational Considerations E-4
E.6 Expanded Service Volumes E-5

APPENDIX F: RESERVED F-1

APPENDIX G: ROTORCRAFT POINT-IN-SPACE (PINS) APPROACH OPERATIONS TO HELIPORTS G-1

G.1 General G-1
G.2 Non-Numeric Deviation G-1
G.2.1 Non-Numeric Lateral Cross-Track Deviation G-1
G.2.2 Non-Numeric Vertical Deviation G-2
G.2.3 Encoding of a PinS FAS Data Block. G-2
G.2.4 Flight Director and Autopilot Displacement Gains G-3
G.3 Primary Navigation Display G-3
G.4 Alerts and Advisories G-3
G.5 Protection Level G-3
G.5.1 Lateral Protection Level G-3
G.5.2 Vertical Protection Level G-3
G.5.3 Other Protection Level Considerations G-3
G.6 Autopilot Considerations G-3
G.7 Heliport Approach Databases G-3
G.8 References G-4

APPENDIX H: TEST CONSIDERATIONS H-1

H.1 Accuracy Test Statistical Justification H-1
H.2 Message Failure Rate Test Statistical Justification H-2
H.3 Example Test Set-up and Compensation of Signals, Noise and Interference H-2
H.3.1 Description of the Test Set-up H-2
H.3.2 Use of the Test Set-up for the Accuracy Test (See Section 2.5.3.2.1) H-3

APPENDIX I: SERVICE TYPES, FACILITY CLASSIFICATIONS AND AIRBORNE EQUIPMENT CLASSIFICATION I-1

I.1 Background I-1
I.2 GBAS Service Types I-1
I.3 GBAS Approach Service Types (GAST) I-2
I.3.1 GAST A, B and C I-2
I.3.2 GAST D I-2
I.4 GBAS Facility Classifications I-3

I.4.1 Facility Approach Service Type (FAST) I-3
I.4.2 GBAS Facility Classification Examples I-3
I.5 Approach Facility Designations I-4
I.5.1 Approach Facility Designation Elements I-4
I.5.2 Approach Facility Designation Examples I-5
I.6 GBAS Airborne Equipment Classification I-6
I.6.1 GBAS Airborne Equipment Classification Examples I-6

APPENDIX J: RELATIONSHIP BETWEEN AIRBORNE RECEIVER GEOMETRY SCREENING AND AIRWORTHINESS ANALYSES J-1

J.1 Introduction J-1
J.1.1 Airworthiness Requirements J-1
J.1.2 GBAS Errors and Monitoring Requirements J-2
J.1.3 Airborne Geometry Screening Techniques J-2
J.2 Geometry Screening, Airworthiness, and Airplane Performance J-4
J.2.1 Unsuccessful Landing J-4
J.2.2 Nominal Condition J-4
J.2.3 Limit Condition J-5
J.2.4 Malfunction Condition J-7

APPENDIX K: RATIONALE FOR THE VDB AIRBORNE REQUIREMENTS K-1

K.1 Introduction K-1
K.2 VDB Coverage Volume K-1
K.3 VDB RF Field Strength K-1
K.3.1 VDB RF Field Strength Variation K-2
K.4 Rationale for Field Strength Requirement K-4
K.4.1 Determination of Aircraft Implementation Loss (AIL) K-15
K.4.1.1 Maximum and Minimum Mismatch Plus RF Loss Values K-16
K.4.2 Examples of AIL Analyses K-28
K.4.3 Aircraft Implementation Loss Computation K-29
K.4.3.1 Background K-29
K.4.3.2 Power Loss in a Transmission Line K-29
K.4.3.3 References: K-33
K.5 Conversion between receiver input power and signal field strength requirements K-33
K.5.1 Conversion of receiver requirements specified in absolute power (dBm) K-34
K.5.1.1 Signal power at the desired VDB frequency K-34
K.5.1.2 Signal power not at the desired VDB frequency K-35
K.5.2 Conversion of receiver requirements specified relative to the desired VDB signal power (D/U dB) K-37
K.5.2.1 Undesired signal at the same frequency as the desired signal K-37
K.5.2.2 Undesired signal at a different frequency as the desired signal K-38

APPENDIX L: RULES FOR B-VALUE USE IN GBAS GROUND STATIONS WHEN SUPPORTING GBAS AIDED INERTIAL SYSTEMS L-1

L.1 Motivation L-1
L.2 Ground Facility Requirement Discussion L-1
L.3 Expiration time determination L-2

TABLE OF TABLES

TABLE 2-1: GPS/LAAS AIRBORNE EQUIPMENT OUTPUT REQUIREMENTS 13

TABLE 2-2A: FREQUENCY AND POWER OF UNDESIRED SIGNALS 26

TABLE 2-2B: FREQUENCY AND POWER OF UNDESIRED SIGNALS 26

TABLE 2-3A: DESENSITIZATION FREQUENCY AND POWER REQUIREMENTS THAT APPLY FOR VDB FREQUENCIES 108.000 TO 111.975 MHZ 27

TABLE 2-4A: DESENSITIZATION FREQUENCY AND POWER REQUIREMENTS THAT APPLY FOR VDB FREQUENCIES 112.000 TO 117.975 MHZ 27

TABLE 2-3B: DESENSITIZATION FREQUENCY AND POWER REQUIREMENTS THAT APPLY FOR VDB FREQUENCIES 108.000 TO 111.975 MHZ 28

TABLE 2-4B: DESENSITIZATION FREQUENCY AND POWER REQUIREMENTS THAT APPLY FOR VDB FREQUENCIES 112.000 TO 117.975 MHZ 28

TABLE 2-5: NORMAL MANEUVERS MAXIMUM VALUES 33

TABLE 2-6: GPS TRACKING CONSTRAINTS FOR E-L DLL DISCRIMINATORS 38

TABLE 2-7: GPS TRACKING CONSTRAINTS FOR DD DLL DISCRIMINATORS 39

TABLE 2-8: SBAS RANGING SOURCE REQUIREMENTS 43

TABLE 2-9: SBAS RANGING FUNCTION TRACKING CONSTRAINTS 44

TABLE 2-10: ABNORMAL MANEUVERS 48

TABLE 2-11: RPI FIRST CHARACTER MAPPING TO SSID AND TYPE 2 MESSAGE SLOTS 51

TABLE 2-12: SUMMARY OF SERVICE TYPE SPECIFIC REQUIREMENTS FOR WEIGHTING COMPUTATIONS 57

TABLE 2-13: NON-NUMERIC ELECTRICAL OUTPUT REQUIREMENTS 71

TABLE 2-14: LATERAL ALERT LIMIT 78

TABLE 2-15: VERTICAL ALERT LIMIT 78

TABLE 2-16: FAULT-FREE MISSED DETECTION MULTIPLIER (K_{FFMD}) 79

TABLE 2-17: MISSED DETECTION MULTIPLIER (K_{MD}) 81

TABLE 2-18: APPROACH SERVICE TYPE DEPENDENT PARAMETERS USED IN PROTECTION LEVEL CALCULATIONS 85

TABLE 2-19: VDB ENVIRONMENTAL PERFORMANCE REQUIREMENTS 89

TABLE 2-20: VDB ANTENNA PERFORMANCE REQUIREMENTS 91

TABLE 2-21: PAN ENVIRONMENTAL PERFORMANCE REQUIREMENTS 94

TABLE 2-22: TEST CROSS-REFERENCE MATRIX 99

TABLE 2-23: TEST CONDITIONS FOR SENSITIVITY AND DYNAMIC RANGE TESTS 138

TABLE 2-24: TEST CONDITIONS FOR FRAME-TO-FRAME VARIATION TESTS 139

TABLE 2-25: TEST FREQUENCIES FOR SLOT-TO-SLOT VARIATION TESTS 141

TABLE 2-26: EMBEDDED SYNCHRONIZATION AND AMBIGUITY RESOLUTION SEQUENCE TEST MESSAGE 143

TABLE 2-27: TEST CONDITIONS FOR SAME SLOT CO-CHANNEL VDB REJECTION TESTS 150

TABLE 2-28: TEST CONDITIONS FOR CO-CHANNEL VOR REJECTION TESTS 151

TABLE 2-29: TEST CONDITIONS FOR CO-CHANNEL LOCALIZER REJECTION TESTS . 153

TABLE 2-30: TEST CONDITIONS FOR 1ST ADJACENT CHANNEL VDB REJECTION TESTS 154

TABLE 2-31: TEST CONDITIONS FOR 2ND ADJACENT CHANNEL VDB REJECTION TESTS 154

TABLE 2-32: TEST CONDITIONS FOR 3RD ADJACENT CHANNEL VDB REJECTION TESTS 154

TABLE 2-33: TEST CONDITIONS FOR 1ST ADJACENT CHANNEL VOR REJECTION TESTS 155

TABLE 2-34: TEST CONDITIONS FOR 2ND ADJACENT CHANNEL VOR REJECTION TESTS 155

TABLE 2-35: TEST CONDITIONS FOR 3RD ADJACENT CHANNEL VOR REJECTION TESTS 156

TABLE 2-36: TEST CONDITIONS FOR 1ST ADJACENT CHANNEL LOCALIZER REJECTION TESTS 156

TABLE 2-37: TEST CONDITIONS FOR 2ND ADJACENT CHANNEL LOCALIZER REJECTION TESTS 157

TABLE 2-38: TEST CONDITIONS FOR 3RD ADJACENT CHANNEL LOCALIZER REJECTION TESTS 157

TABLE 2-39: TEST CONDITIONS FOR REJECTION TESTS WITH NO ON-CHANNEL VDB SIGNAL 158

TABLE 2-40: TEST FREQUENCIES FOR VDB INTERFERENCE IMMUNITY TESTS 160

TABLE 2-41: TEST CONDITIONS FOR DESENSITIZATION TESTS 162

TABLE 2-42: TEST CONDITIONS FOR INTERMODULATION REJECTION TESTS 164

TABLE 2-43: TEST FREQUENCIES FOR RECEIVER VSWR TESTS 165

TABLE 2-44: TEST FREQUENCIES FOR HORIZONTAL ANTENNA GAIN TESTS 166

TABLE 2-45: TEST FREQUENCIES FOR VERTICAL ANTENNA GAIN TESTS 169

TABLE 2-46: STEADY-STATE ACCURACY TEST CWI VALUES 174

TABLE 2-47: SATELLITE EQUIVALENT POWER SPECTRAL DENSITY 174

TABLE 2-48: PASS THRESHOLD TABLE 176

TABLE 2-49: PLATFORM DYNAMICS FOR HORIZONTAL VELOCITY ACCURACY TEST 180

TABLE 2-50: PLATFORM DYNAMICS FOR VERTICAL VELOCITY ACCURACY TEST 182

TABLE B-1: LAAS REQUIREMENTS CHANGES BETWEEN RTCA/DO-253 AND RTCA/DO-253A……..... B-1

TABLE B-2: LAAS REQUIREMENTS CHANGES BETWEEN RTCA/DO-253A AND RTCA/DO-253B…… B-4

TABLE B-3: LAAS REQUIREMENTS CHANGES BETWEEN RTCA/DO-253B AND RTCA/DO-253C……. B-5

TABLE B-4: LAAS REQUIREMENTS CHANGES BETWEEN RTCA/DO-253C AND RTCA/DO-253D…… B-7

TABLE C-1: THE FAS DEFINITION PARAMETERS C-1

TABLE D-1: OUT-OF-BAND PULSE INTERFERENCE D-3

TABLE D-2: IN-BAND AND NEAR-BAND INTERFERENCE BANDWIDTH DEFINITIONS . D-4

TABLE D-3: IN-BAND AND NEAR-BAND PULSE INTERFERENCE D-4

TABLE D-4: EFFECTIVE NOISE DENSITY FOR ALL GNSS SOURCES D-5

TABLE D-5: FREQUENCY SELECTIVITY D-5

TABLE K-1: VDB LINK BUDGET FOR NOMINAL OPERATION K-7

TABLE K-2: VDB LINK BUDGET FOR RECEIVER BURNOUT K-9

TABLE K-3A: VDB LINK BUDGET FOR CO-CHANNEL ON A DIFFERENT TIME SLOT FOR HORIZONTAL POLARIZATION WITH UNDESIRED VDB "ON" K-10

TABLE K-3B: VDB LINK BUDGET FOR CO-CHANNEL ON A DIFFERENT TIME SLOT FOR VERTICAL POLARIZATION WITH UNDESIRED VDB "ON" K-11

TABLE K-3C: VDB LINK BUDGET FOR CO-CHANNEL ON A DIFFERENT TIME SLOT FOR HORIZONTAL POLARIZATION WITH UNDESIRED VDB "OFF".....K-12

TABLE K-3D: VDB LINK BUDGET FOR CO-CHANNEL ON A DIFFERENT TIME SLOT FOR VERTICAL POLARIZATION WITH UNDESIRED VDB "OFF".....K-14

TABLE K-4A: MAXIMUM MISMATCH PLUS RF LOSS VERSUS MATCHED RF LOSS RECEIVER VSWR = 1.5:1.....K-17

TABLE K-4B: MINIMUM MISMATCH PLUS RF LOSS VERSUS MATCHED RF LOSS RECEIVER VSWR = 1.5:1.....K-17

TABLE K-5A: MAXIMUM MISMATCH PLUS RF LOSS VERSUS MATCHED RF LOSS RECEIVER VSWR = 2.0:1.....K-19

TABLE K-5B: MINIMUM MISMATCH PLUS RF LOSS VERSUS MATCHED RF LOSS RECEIVER VSWR = 2.0:1.....K-19

TABLE K-6A: MAXIMUM MISMATCH PLUS RF LOSS VERSUS MATCHED RF LOSS RECEIVER VSWR = 2.5:1.....K-21

TABLE K-6B: MINIMUM MISMATCH PLUS RF LOSS VERSUS MATCHED RF LOSS RECEIVER VSWR = 2.5:1.....K-21

TABLE K-7A: MAXIMUM MISMATCH PLUS RF LOSS VERSUS MATCHED RF LOSS RECEIVER VSWR = 3.0:1.....K-23

TABLE K-7B: MINIMUM MISMATCH PLUS RF LOSS VERSUS MATCHED RF LOSS RECEIVER VSWR = 3.0:1.....K-23

TABLE K-8A: MAXIMUM MISMATCH PLUS RF LOSS VERSUS MATCHED RF LOSS RECEIVER VSWR = 3.5:1.....K-25

TABLE K-8B: MINIMUM MISMATCH PLUS RF LOSS VERSUS MATCHED RF LOSS RECEIVER VSWR = 3.5:1.....K-25

TABLE K-9A: MAXIMUM MISMATCH PLUS RF LOSS VERSUS MATCHED RF LOSS RECEIVER VSWR = 4.0:1.....K-27

TABLE K-9B: MINIMUM MISMATCH PLUS RF LOSS VERSUS MATCHED RF LOSS RECEIVER VSWR = 4.0:1.....K-27

TABLE K-10: FREQUENCY AND POWER OF UNDESIRED SIGNALS.....K-35

TABLE K-11: DESENSITIZATION FREQUENCY AND POWER REQUIREMENTS THAT APPLY FOR VDB FREQUENCIES 108.000 TO 111.975 MHZ K-36

TABLE K-12: DESENSITIZATION FREQUENCY AND POWER REQUIREMENTS THAT APPLY FOR VDB FREQUENCIES 112.000 TO 117.975 MHZ K-36

TABLE K-13: ADJACENT CHANNEL REJECTION D/U (DB) AT ANTENNA OUTPUT K-39

TABLE OF FIGURES

FIGURE 1-1: GPS/LAAS SYSTEM 3

FIGURE 1-2: LAAS AIRBORNE EQUIPMENT FUNCTIONS 6

FIGURE 1-3: VDB RECEIVER FUNCTIONAL BLOCK DIAGRAM 7

FIGURE 2-1: MAXIMUM TOLERABLE EQUAL-LEVEL FM BROADCAST SIGNALS 29

FIGURE 2-2: ANTENNA WITH PREAMPLIFIER CONFIGURATION 36

FIGURE 2-3: RECEIVER BANDWIDTH VS. AVERAGE CORRELATOR SPACING 41

FIGURE 2-4: PSEUDORANGE PROCESSING 54

FIGURE 2-5: PRECISION APPROACH REGION 69

FIGURE 2-6: FINAL APPROACH SEGMENT DEFINITION 71

FIGURE 2-7: FULL-SCALE DEFLECTION FOR PROPORTIONAL LATERAL DEVIATION 73

FIGURE 2-8: FULL-SCALE DEFLECTION FOR PROPORTIONAL VERTICAL DEVIATION 74

FIGURE 2-9: RESERVED 133

FIGURE 2-10: RESPONSE TIME TEST EQUIPMENT CONNECTION 135

FIGURE 2-11: DATA LATENCY TEST EQUIPMENT CONNECTION 136

FIGURE 2-12: DATA FORMAT DECODING TEST EQUIPMENT CONNECTION 137

FIGURE 2-13: SENSITIVITY AND DYNAMIC RANGE IN AN AWGN CHANNEL TEST EQUIPMENT CONNECTION 138

FIGURE 2-14: FRAME-TO-FRAME TIMING DIAGRAM 1 139

FIGURE 2-15: FRAME-TO-FRAME TIMING DIAGRAM 2 140

FIGURE 2-16: SLOT-TO-SLOT (AND FRAME-TO-FRAME) VARIATION TEST EQUIPMENT CONNECTION 141

FIGURE 2-17: SLOT-TO-SLOT TIMING DIAGRAM 142

FIGURE 2-18: CARRIER FREQUENCY CAPTURE RANGE (AND SLEW RATE) TEST EQUIPMENT CONNECTION 147

FIGURE 2-19: SYMBOL RATE TOLERANCE TEST EQUIPMENT CONNECTION 149

FIGURE 2-20: VDB/VDB CO-CHANNEL (AND ADJACENT CHANNEL) REJECTION TEST EQUIPMENT CONNECTION 150

FIGURE 2-21: VOR (ILS) AS THE UNDESIRED SIGNAL TEST EQUIPMENT CONNECTION 152

FIGURE 2-22: INTERFERENCE IMMUNITY TEST EQUIPMENT CONNECTION 160

FIGURE 2-23: DESENSITIZATION TEST EQUIPMENT CONNECTION 162

FIGURE 2-24: FM BROADCAST INTERMODULATION REJECTION TEST EQUIPMENT CONNECTION 164

FIGURE 2-25: HORIZONTAL (STANDARD DIPOLE) ANTENNA GAIN TEST CONFIGURATION 167

FIGURE 2-26: HORIZONTAL (VDB) ANTENNA GAIN TEST CONFIGURATION 167

FIGURE 2-27: VERTICAL (STANDARD DIPOLE) ANTENNA GAIN TEST CONFIGURATION 169

FIGURE 2-28: VERTICAL (VDB) ANTENNA GAIN TEST CONFIGURATION 170

FIGURE C-1: FINAL APPROACH SEGMENT DEFINITION C-2

FIGURE C-2: LATERAL DEVIATIONS C-4

FIGURE C-3: GNSS ELEVATION REFERENCE POINT DEFINITION C-5

FIGURE C-4: GNSS VERTICAL DEVIATION DEFINITION C-6

FIGURE D-1: INTERFERENCE LEVELS AT THE ANTENNA PORT D-2

FIGURE D-2: IN-BAND AND NEAR-BAND INTERFERENCE ENVIRONMENTS D-2

FIGURE D-3: FREQUENCY SELECTIVITY D-6

FIGURE E-1: OPTION 1 WITH DMAX COINCIDENT WITH THE APPROACH SERVICE VOLUME E-2

FIGURE E-2: APPROACH SERVICE INTEGRITY COINCIDENT WITH DMAX E-3

FIGURE E-3: OPTION 2 SHOWS DMAX SET LARGER THAN THE APPROACH SERVICE VOLUME E-3

FIGURE E-4: OPTION 3 SHOWS DMAX SET TO “NO DISTANCE LIMITATION” E-4

FIGURE E-5: EXPANDED SERVICE VOLUME EXAMPLES E-5

FIGURE G-1: LATERAL DISPLAY SCALING AND ORIENTATION OF THE FTP TO THE HELIPORT G-1

FIGURE G-2: VERTICAL DISPLAY SCALING G-2

FIGURE H-1: PSEUDORANGE ACCURACY TEST PASS CRITERIA H-1

FIGURE H-2: PSEUDORANGE ACCURACY TEST PASS PROBABILITY H-2

FIGURE H-3: EXAMPLE TEST SET-UP H-2

FIGURE I-1: SERVICE TYPES, FACILITY CLASSIFICATIONS AND AIRBORNE EQUIPMENT CLASSES I-1

FIGURE I-2: RELATIONSHIP BETWEEN GBAS FACILITY CLASSIFICATION AND APPROACH FACILITY DESIGNATION I-4

FIGURE J-1: LIMIT ON THE PROBABILITY THAT A RANGE ERROR DUE TO A FAULT WITH MAGNITUDE $|E_R|$ GOES UNDETECTED BY GROUND REFERENCE STATION MONITORING J-2

FIGURE J-2: NOTIONAL EXAMPLES OF UNSUCCESSFUL LANDING PROBABILITY J-7

FIGURE K-1: MISMATCH PLUS RF LOSS VERSUS MATCHED RF LOSS RECEIVER VSWR = 1.5:1 ..... K-18

FIGURE K-2: MISMATCH PLUS RF LOSS VERSUS MATCHED RF LOSS RECEIVER VSWR = 2.0:1 ..... K-20

FIGURE K-3: MISMATCH PLUS RF LOSS VERSUS MATCHED RF LOSS RECEIVER VSWR = 2.5:1 ..... K-22

FIGURE K-4: MISMATCH PLUS RF LOSS VERSUS MATCHED RF LOSS RECEIVER VSWR = 3.0:1 ..... K-24

FIGURE K-5: MISMATCH PLUS RF LOSS VERSUS MATCHED RF LOSS RECEIVER VSWR = 3.5:1 ..... K-26

FIGURE K-6: MISMATCH PLUS RF LOSS VERSUS MATCHED RF LOSS RECEIVER VSWR = 4.0:1 ..... K-28

FIGURE L-1: FAULT IMPACT AND 60 SECOND RELAXATION BEFORE COASTING L-3

FIGURE L-2: FAULT IMPACT AND 300 SECOND RELAXATION BEFORE COASTING L-3

This Page Intentionally Left Blank

1 PURPOSE AND SCOPE

1.1 Introduction

This document contains minimum operational performance standards (MOPS) for airborne navigation equipment using the Global Positioning System (GPS) augmented by the Local Area Augmentation System (LAAS). These standards are partially derived from the requirements specified in RTCA/DO-245(), *Minimum Aviation System Performance Standards (MASPS) for the Local Area Augmentation System (LAAS)*. Additional requirements have been derived by analysis of operational intent and direct allocation of performance requirements between airborne and ground systems. Throughout this document, the term "LAAS" is used as a generic reference to ground-based augmentation systems (GBAS) as defined by the International Civil Aviation Organization (ICAO), as the requirements in this standard are intended to comply with the ICAO Standards and Recommended Practices (SARPs) for the GBAS aircraft element.

***Note**: This MOPS was developed in conjunction with the ICAO Annex 10 Volume I SARPs (through Amendment 91). The shorter notation "ICAO Annex 10" is used in this document to refer to the SARPs.*

The standards in this document define minimum performance requirements, functions and features for LAAS airborne equipment to support multiple types of service that are intended to support precision approach operations and guided takeoff for all weather minimums. This standard also covers the computation and output of position, velocity, and time (PVT) to support area navigation and other applications.

***Note**: The requirements for area navigation systems continue to evolve. Applicable standards include RTCA/DO-236(), RTCA/DO-229(), RTCA/DO-187() [as amended by TSO-C115()] and RTCA/DO-316().*

Compliance with these standards by manufacturers, installers and users is recommended as a means of assuring that the equipment will satisfactorily perform its intended functions under conditions encountered in routine aeronautical operations.

The regulatory application of these standards is the responsibility of appropriate government agencies. The Federal Aviation Administration (FAA) and the European Aviation Safety Agency (EASA) have published two Technical Standard Orders (TSO) for GPS/LAAS equipment, one for the LAAS VHF Data Broadcast (VDB) receiver function (TSO/ETSO-C162) and another for the LAAS Position And Navigation (PAN) function (TSO/ETSO-C161). These TSOs and ETSOs do not currently address GBAS Approach Service Type D (GAST D). It is expected that regulators will use this MOPS for authorizations with GAST D.

The VDB Adjacent Channel interference requirements specified in this MOPS are harmonized with the ICAO Annex 10 GBAS SARPs. The ICAO NSP Spectrum Working Group (SWG), with support from RTCA SC-159, is updating the GBAS SARPs frequency compatibility criteria that are intended to be effective in November 2020. It is intended that this MOPS remain harmonized with the ICAO Annex 10 GBAS SARPs, including changes to the avionics D/U requirements that may result from updating the GBAS SARPs frequency compatibility criteria. Refer to Section K.5.2.2 in Appendix K for further details.

The word "equipment", as used in this document, includes all components or units necessary (as determined by the equipment manufacturer or installer) to properly perform its intended function.

© 2017 RTCA, Inc.

In this document, the term "shall" is used to indicate requirements. An approved design would comply with every requirement, which can be assured by inspection, test, analysis, or demonstration. The term "must" is used to identify items which are important but are either duplicated somewhere else in the document as a "shall", or are considered to be outside the scope of this document. The term "should" is used to denote a recommendation that would improve the LAAS equipment, but does not constitute a minimum requirement.

This document facilitates traceability by identifying each specific requirement with a requirement designator. The notation "*[LAAS-xxx]*", where xxx is a three-digit number, identifies each specific requirement for traceability purposes.

Section 1 of this document provides information and assumptions needed to understand the rationale for equipment characteristics and requirements stated in the remaining sections. It describes typical equipment applications and operational goals and forms the basis for the standards stated in Sections 2 through 4.

Section 2 contains the equipment performance requirements and test procedures for the VDB receiver function and the PAN function. These standards define required performance under standard operating conditions and stressed physical environmental conditions.

Section 3 describes those additional requirements and tests that ensure that the LAAS equipment performs its intended function in a particular installation. Tests for the installed equipment are included when performance cannot be adequately determined through bench testing.

Section 4 describes the characteristics of installed LAAS equipment, and the expected pilot reactions to specified displays.

Appendix A contains a listing of abbreviations and definition of terms used in this document.

Appendix B lists requirements, by requirements number, that have changed from the prior version of this document. It also indicates requirements that have been added.

Appendix C contains an example of Final Approach Path and deviation calculations.

Appendix D defines the GPS interference environment for which the PAN equipment is required to operate.

Appendix E describes the approach and positioning service volumes and the maximum distance for use of differential corrections.

Appendix F is reserved.

Appendix G defines rotorcraft specific requirements for LAAS equipment. It is noted that the PinS operations defined in Appendix G are based on GAST C. This MOPS was not developed to support rotorcraft operations based on GAST D.

Appendix H discusses test considerations.

Appendix I discusses GBAS Approach Service Types, Facility Classifications, Airborne Equipment Classifications, and Approach Facility Classifications.

Appendix J gives an example of how airborne geometry screening requirements can be derived based on ground monitor requirements and airplane performance for one airplane integration.

Appendix K provides the rationale for the VDB airborne receiver sensitivity and dynamic range requirements based upon the overall VDB system link budget.

© 2017 RTCA, Inc.

Appendix L describes how a ground station uses reference receivers and the broadcast B-value parameters corresponding to the H_1 hypotheses to support GBAS aided inertial systems.

1.2 System Overview

The GPS/LAAS consists of three primary subsystems as shown in Figure 1-1:

a) The satellite subsystem, which produces ranging signals. This standard explicitly addresses the use of GPS and Satellite Based Augmentation System (SBAS) satellite L1 C/A signals.

b) The ground subsystem, which provides a VDB containing differential corrections and other pertinent information.

c) The airborne subsystem, which encompasses the aircraft equipment used to receive and process the GPS/LAAS signal in space in order to compute and output a position solution, deviations relative to a desired reference path, and appropriate annunciations.

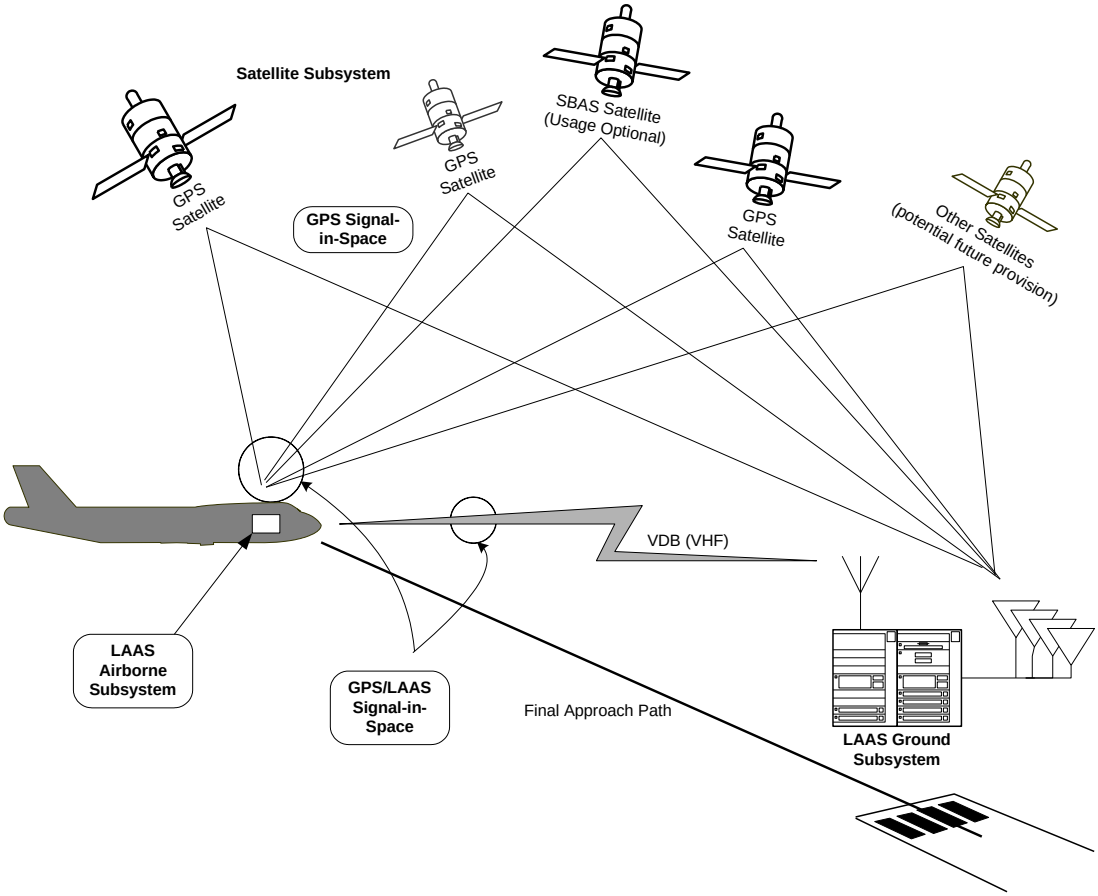


Figure 1-1: GPS/LAAS System

The GPS and SBAS satellites provide both the airborne subsystem and the ground subsystem with ranging signals. The ground subsystem produces ground-monitored differential corrections and integrity-related information as well as data including the definition of the final approach path, a geometric path-in-space to which the aircraft on approach will navigate. The final approach path is a straight line that extends indefinitely; other paths may be defined in the future. These data are transmitted on a VDB to the

© 2017 RTCA, Inc.