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

Minimum Operational Performance Standards for Traffic Alert and Collision Avoidance System II (TCAS II)

Version 7.1

Volume I

RTCA DO-185B, Supersedes RTCA DO-185A
June 19, 2008

Prepared by: SC-147
© 2008, RTCA, Inc.

Copies of this document may be obtained from

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

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

Please call RTCA for price and ordering information.

This document is dedicated to the memory of the following individuals who played important roles in the development and standardization of TCAS:

Jerry Anderson, Federal Aviation Administration
David Lubkowski, The MITRE Corporation
Lawrence Nivert, Federal Aviation Administration
Ronald Sandholm, Lincoln Laboratory, M.I.T.

This page intentionally left blank

Foreword

This document was prepared by Special Committee 147 (SC-147) and the European Organisation for Civil Aviation Equipment (EUROCAE) Working Group 75 (WG-75) and approved by the RTCA Program Management Committee (PMC) on June 19, 2008. EUROCAE ED-143 is equivalent to and technically identical with this document.

This document has four components:

- Volume 1 contains the main body of the MOPS.
- Volume 2 contains the Collision Avoidance System Requirements Specification (CRS), a detailed specification of the Collision Avoidance System (CAS) component of the TCAS II system using a precise program specification notation called state charts. It is incorporated by reference into the requirements specification in Volume 1.
- Attachment A to Volume 2 contains an alternate specification of the CAS logic in the form of a program in a simplified programming language developed specifically for the purpose. Equivalence between this form of the CAS logic and the state charts has been demonstrated by testing implementations based on each specification against the CAS test suite. However, Attachment A is provided for informational purposes only, and is not formally incorporated into Volume 1 as an alternative statement of requirements.
- Tests of the CAS logic are specified by computer-readable files which are incorporated by reference into the test procedures in Volume 1. These tests have been developed using a simulator capable of executing programs specified in state chart format. That simulator is also used to ensure that the test suite exercises each state transition in the state charts.

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 Telecommunications 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.

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.

This page intentionally left blank

Table of Contents

1 PURPOSE AND SCOPE 1

1.1 Introduction 1

1.2 System Overview 3

1.3 System Description 5
1.3.1 Minimum TCAS 5
1.3.1.1 Mode S Transponder with Altitude Encoder 7
1.3.1.2 Bearing Estimation 7
1.3.1.3 Surveillance in Airspace Having High Transponder-Equipped Aircraft Traffic Densities 7
1.3.1.4 Surveillance of Aircraft Without Altitude Encoders 7
1.3.2 Optional Features 7
1.3.2.1 Detection of Extended Mode S Squitter 8
1.3.2.2 Reception and Decoding of Extended Squitters from Mode S Transponders 8
1.3.2.3 Mode S Crosslink Capability 8
1.3.2.4 Use of Altitude Alerter 8

1.4 Operational Applications 8
1.4.1 TCAS Operates Independently of the Ground ATC System 8
1.4.2 Control of Interaction With the Air Traffic Control System 8
1.4.3 Effectiveness of Collision Avoidance Maneuvers 9

1.5 Operational Goals 9

1.6 Assumptions and Limitations 10
1.6.1 Improvements or Alternative Techniques 10
1.6.2 Enhancements 10
1.6.3 Degree of Protection Provided 10
1.6.4 Transponder Population 10
1.6.5 Density of Transponder-Equipped Aircraft 10
1.6.6 TCAS Performance Monitor 11
1.6.7 Altimeter Operation 11
1.6.8 Aircraft Performance Limitations 11

1.7 Test Procedures 11
1.7.1 Environmental Tests 11
1.7.2 Bench Tests 12
1.7.3 Installed System Tests 12
1.7.4 Computer Performance Verification Test 12
1.7.5 Interoperability 12

1.8 Glossary of Terms 13

1.9 Abbreviations 18

1.10 References 21

2 TCAS EQUIPMENT REQUIREMENTS AND TEST PROCEDURES 23

2.1 General Requirements 23
2.1.1 Airworthiness 23
2.1.2 General Performance 23
2.1.3 Federal Communications Commission Rules 23
2.1.4 Self-Test 23

2.1.5 Performance Monitoring 23
2.1.6 Interrogation Test Modes 23
2.1.7 Controls 24
2.1.7.1 Operation of Controls 24
2.1.7.2 Accessibility of Controls 25
2.1.7.3 Minimum Flight Crew Control Functions 25
2.1.8 Display Functions 26
2.1.8.1 Minimum Display Functions 26
2.1.9 Equipment Configuration 26
2.1.10 Mode S Transponder Capabilities 26
2.1.10.1 Performance Compatibility with Own Aircraft TCAS 26
2.1.11 TCAS Combined with Other Aircraft Systems 27
2.1.12 Aural Annunciation 27
2.1.13 Effects of Tests 27

2.2 Minimum Performance Standards 27
2.2.1 Definition Of Standard Conditions 27
2.2.1.1 Measurement Conventions 28
2.2.1.2 Operational Environment 28
2.2.1.2.1 Aircraft Density 28
2.2.1.2.2 Aircraft Equipage 29
2.2.1.2.3 Interrogator Environment 29
2.2.1.2.3.1 Maximum ATCRBS Fruit Rate 30
2.2.1.2.3.2 Intruder Transponder Availability 30
2.2.1.2.4 Maximum Level Of ATCRBS Synchronous Garble Interference 30
2.2.1.2.5 Maximum Level Of Multipath Interference 31
2.2.1.2.5.1 Transponder Reply 31
2.2.1.2.5.2 TCAS II Interrogation 31
2.2.1.3 Target-Of-Interest 31
2.2.1.3.1 Maximum Closing Speed 31
2.2.1.3.2 Closing Speed As A Function Of Azimuth 32
2.2.1.3.3 Elevation Angle Relative To TCAS II 32
2.2.1.3.4 Altitude Relative To TCAS II 32
2.2.1.3.5 Minimum AGL Altitude 32
2.2.2 System Performance 32
2.2.2.1 Surveillance Range 33
2.2.2.1.1 For Generation Of Resolution Advisories 33
2.2.2.1.2 For Generation Of Traffic Advisories 33
2.2.2.2 Surveillance Performance Objectives 34
2.2.2.2.1 General Surveillance Performance 34
2.2.2.2.1.1 Probability Of Track 34
2.2.2.2.1.2 False Track Rate 34
2.2.2.2.2 Flight Test Surveillance Performance 34
2.2.2.2.3 Range Accuracy 35
2.2.2.2.4 Bearing Accuracy 35
2.2.3 Compatibility With Other Systems 35
2.2.3.1 Radiated Output Power 35
2.2.3.2 Unwanted Output Power 36
2.2.3.3 Interrogation Spectrum 36
2.2.3.4 Interrogation Jitter 37
2.2.3.5 Transmit Frequency And Tolerance 37
2.2.3.6 Interference Limiting 37
2.2.3.6.1 Interference Limiting Formulas 37
2.2.3.6.2 Interference Limiting Procedures 40

2.2.3.6.3 Interrogations From TCAS On The Ground 42
2.2.3.6.4 Interrogations From TCAS Above 18,000 Ft Barometric Altitude 42
2.2.3.7 Subparagraph Not Used 43
2.2.3.8 Transmit Pulse Characteristics 43
2.2.3.8.1 Mode C Transmissions 43
2.2.3.8.2 Mode S Transmissions 45
2.2.3.9 Mode S Message Field Formats 46
2.2.3.9.1 Data Blocks 47
2.2.3.9.2 Format Structure 47
2.2.3.9.2.1 Bit Numbering and Sequence 47
2.2.3.9.2.2 Fields 47
2.2.3.9.2.2.1 Essential Fields 47
2.2.3.9.2.2.2 Mission Fields 50
2.2.3.9.2.2.3 Subfields 50
2.2.3.9.3 Field Descriptions 50
2.2.3.9.3.1 Fields and Subfields Defined by Reference B. 50
2.2.3.9.3.1.1 AA Address, Announced 50
2.2.3.9.3.1.2 AC Altitude Code 51
2.2.3.9.3.1.3 AQ Acquisition, Special 51
2.2.3.9.3.1.4 BDS: Comm-B Data Selector 52
2.2.3.9.3.1.5 CA Capability 52
2.2.3.9.3.1.6 CC Crosslink Capability 55
2.2.3.9.3.1.7 DR Downlink Request 56
2.2.3.9.3.1.8 FS Flight Status 56
2.2.3.9.3.1.9 MA Message, Comm-A 56
2.2.3.9.3.1.10 MB Message, Comm-B 57
2.2.3.9.3.1.11 ME Message, Extended Squitter 57
2.2.3.9.3.1.12 MU Message, Comm-U 57
2.2.3.9.3.1.13 MV Message, Comm-V 57
2.2.3.9.3.1.14 RI Air-to-Air Reply Information 57
2.2.3.9.3.1.15 RL Reply Length 58
2.2.3.9.3.1.16 RR Reply Request 58
2.2.3.9.3.1.17 SD Special Designator 58
2.2.3.9.3.1.18 VS Vertical Status 59
2.2.3.9.3.2 TCAS II Fields and Subfields 59
2.2.3.9.3.2.1 Subparagraph Not Used 59
2.2.3.9.3.2.2 MA Fields Used by TCAS II 59
2.2.3.9.3.2.3 MB Fields Used by TCAS II 60
2.2.3.9.3.2.3.1 Subfields in MB for RA Report 61
2.2.3.9.3.2.3.1.1 Subfields in MB for RA Report - DO-185A,B Systems 61
2.2.3.9.3.2.3.1.2 Subfields in MB for RA Report - FAA TSO-C119A Systems 64
2.2.3.9.3.2.3.2 Subfields in MB for Data Link Capability Report 66
2.2.3.9.3.2.3.2.1 Coding of Data Link Capability Report - DO-185A,B Systems 66
2.2.3.9.3.2.3.2.2 Coding of Data Link Capability Report - FAA TSO-C119A Systems 66
2.2.3.9.3.2.4 MU Fields Used by TCAS II 67
2.2.3.9.3.2.4.1 Subfields in MU for a TCAS Resolution Message 67
2.2.3.9.3.2.4.2 Subfields in MU for a TCAS Broadcast Interrogation Message 71
2.2.3.9.3.2.4.3 Subfields in MU for an RA Broadcast Interrogation Message 71
2.2.3.9.3.2.5 MV Fields Used by TCAS II 72
2.2.3.9.3.2.5.1 Subfields in MV for a Coordination Reply Message 72
2.2.3.9.3.2.5.1.1 Subfields in MV for a Coordination Reply Message - DO-185A,B Systems 73
2.2.3.9.3.2.5.1.2 Subfields in MV for a Coordination Reply Message - FAA TSO-C119A Systems 73

2.2.3.9.3.2.6 SL TCAS II Sensitivity Level Report 73
2.2.3.9.3.2.7 Unassigned Coding Space 74
2.2.3.10 TCAS II Signal Protocol 74
2.2.3.10.1 Mode C Surveillance Signals 74
2.2.3.10.1.1 ATCRBS-Only All-Call Interrogation 74
2.2.3.10.2 Mode S Surveillance Signals 74
2.2.3.10.2.1 Detection 74
2.2.3.10.2.2 Surveillance Interrogations 75
2.2.3.10.2.2.1 Acquisition 75
2.2.3.10.2.2.2 Tracking 75
2.2.3.10.2.3 Surveillance Replies 75
2.2.3.10.2.3.1 Acquisition 76
2.2.3.10.2.3.2 Tracking 76
2.2.3.10.2.4 TCAS Broadcast Interrogations 76
2.2.3.10.3 Coordination with Other Aircraft 76
2.2.3.10.3.1 Transmission of Coordination Interrogations to Other TCAS Aircraft 77
2.2.3.10.3.2 Processing of Coordination Interrogations Received from Other TCAS Aircraft 77
2.2.3.10.3.3 Coordination Timing Requirements 78
2.2.3.10.4 Communication With Mode S Ground Sensors 79
2.2.3.10.4.1 RA Report 79
2.2.3.10.4.2 Data Link Capability Report 79
2.2.3.10.4.2.1 TCAS Unit Part Number and TCAS Software Part Number 79
2.2.3.10.4.3 TCAS Sensitivity Level Control 80
2.2.3.10.5 Communication With Other Ground Equipment 80
2.2.3.10.5.1 RA Broadcast Interrogations 80
2.2.3.10.6 Mode S Crosslink Capability 80
2.2.3.10.7 Extended Squitter With Aircraft Identification Message 81
2.2.3.11 Compatibility With Own Mode S Transponder 81
2.2.3.12 Aircraft Suppression Bus 82
2.2.3.13 Interfaces With Other Systems 82
2.2.3.13.1 Mode S Transponder Related Interfaces 82
2.2.3.13.2 TCAS II Interface with Mode S Transponder 83
2.2.3.13.2.1 General Requirements of the Interface to the Mode S Transponder 83
2.2.3.13.2.1.1 TCAS/Transponder System Capability Determination 83
2.2.3.13.2.1.2 Data Reception 83
2.2.3.13.2.1.3 Data Integrity 84
2.2.3.13.2.2 Data Provided by the TCAS II Equipment to the Mode S Transponder 84
2.2.3.13.2.2.1 Data Provided to Own Transponder for Use in Special Surveillance Replies (DF=0, 16) 84
2.2.3.13.2.2.2 Data Provided to Own Transponder for Use in Altitude and Identity Surveillance and Comm-B Replies (DF=4, 5, 20, 21) 84
2.2.3.13.2.2.3 Data Provided to Own Transponder for Use in Long Special Surveillance Replies (DF=16) 85
2.2.3.13.2.2.4 Data Provided to Own Transponder for Use in Altitude and Identity Comm-B Replies (DF=20, 21) 85
2.2.3.13.2.3 Data Received by the TCAS II Equipment from the Mode S Transponder 85
2.2.3.13.2.3.1 Data Received in Long Special Surveillance Interrogations (UF=16) from Other TCAS Aircraft via Own Mode S Transponder 85
2.2.3.13.2.3.2 Data Received in Altitude and Identity Comm-A Interrogations (UF=20, 21) from Mode S Ground Stations via Own Mode S Transponder 86
2.2.3.13.3 Other Interfaces 86
2.2.3.13.3.1 Optional Interfaces 86
2.2.4 Surveillance Requirements 86
2.2.4.1 Surveillance Update Rate 86

2.2.4.2 System Delay 87
2.2.4.3 Differential Channel Delay 87
2.2.4.4 Signal Reception 87
2.2.4.4.1 Receiver Sensitivity And Bandwidth 87
2.2.4.4.1.1 In-Band Acceptance 87
2.2.4.4.1.2 Out-of-Band Rejection 88
2.2.4.4.2 Reply Detection And Decoding 88
2.2.4.4.2.1 Mode C Reply Reception 88
2.2.4.4.2.2 Mode S Squitter and Reply Reception 91
2.2.4.5 Interference Rejection And Control 94
2.2.4.5.1 Multipath Rejection 94
2.2.4.5.1.1 Interrogation Link Interference 94
2.2.4.5.1.2 Reply Link Interference 94
2.2.4.5.1.2.1 Narrow Pulse Discrimination 95
2.2.4.5.1.2.2 TACAN and DME Discrimination 95
2.2.4.5.2 Narrow Pulse Rejection 95
2.2.4.5.3 TACAN And DME Signal Rejection 95
2.2.4.5.4 Control Of ATCRBS Synchronous Garble 95
2.2.4.5.4.1 Control Of Synchronous Garble By Whisper-Shout 96
2.2.4.5.4.1.1 Minimum Basic Whisper-Shout Sequence 97
2.2.4.5.4.1.2 Higher Capability Whisper-Shout Sequences for Improved Degarbling Performance 97
2.2.4.5.4.1.3 Determination of Whisper-Shout Based On Synchronous Garble 103
2.2.4.5.4.1.4 Criteria for Selection of A Specific Whisper-Shout Sequence 104
2.2.4.5.4.1.5 Surveillance In Areas of No ATCRBS Intruder Aircraft 105
2.2.4.5.4.2 Control Of Synchronous Garble By Directional Interrogation 106
2.2.4.5.4.2.1 Directional Interrogation Beamwidth Control 106
2.2.4.5.4.2.2 Directional Interrogation Radiated Power 107
2.2.4.5.4.2.3 Degarbling Performance As A Function Of Azimuth Resolution 107
2.2.4.5.5 ATCRBS And Mode S Fruit Rejection 108
2.2.4.6 Surveillance Tracking Requirements 108
2.2.4.6.1 Surveillance Target Track Capacity 108
2.2.4.6.1.1 Surveillance Overload 108
2.2.4.6.1.2 Estimate of Ground Level 109
2.2.4.6.1.3 Determination of Intruder Air-Ground Status 109
2.2.4.6.1.3.1 Determination for Newly Initiated Tracks 109
2.2.4.6.1.3.2 Determination for Intruders Equipped with Mode S Transponders 109
2.2.4.6.1.3.3 Determination for Intruders Equipped with Mode C (ATCRBS) Transponders 110
2.2.4.6.1.3.3.1 Determination for Intruders Equipped with Mode C (ATCRBS) Transponders and Reporting Pressure Altitude 110
2.2.4.6.1.3.3.2 Determination for Intruders Equipped with Mode C (ATCRBS) Transponders and NOT Reporting Pressure Altitude 110
2.2.4.6.1.3.4 Summary of Rules for Determining Air-Ground Status 111
2.2.4.6.2 Range And Altitude Estimation 111
2.2.4.6.2.1 Mode C Targets 111
2.2.4.6.2.1.1 Reply Merging 111
2.2.4.6.2.1.2 Track Initiation 111
2.2.4.6.2.1.3 Maintenance of Established Tracks 112
2.2.4.6.2.1.4 Multipath False Tracks 113
2.2.4.6.2.2 Mode S Targets 113
2.2.4.6.2.2.1 Squitter Processing 113
2.2.4.6.2.2.2 Acquisition 114
2.2.4.6.2.2.3 Maintenance of Established Tracks 115

2.2.4.6.2.2.4 Power Programming 117
2.2.4.6.3 Non-Altitude-Reporting Aircraft 117
2.2.4.6.4 Bearing Estimation 117
2.2.4.6.4.1 General Requirements 117
2.2.4.6.4.2 Bearing Accuracy With Standard Ground Plane 118
2.2.4.6.4.2.1 Accuracy, -10 Deg. To +10 Deg. Elevation 118
2.2.4.6.4.2.2 Accuracy, greater than 10 Deg. To +20 Deg. Elevation 118
2.2.4.6.4.3 Bearing Accuracy in the Presence of Interference 118
2.2.4.6.4.3.1 Mode C Interleaved Replies 118
2.2.4.6.4.3.2 Mode C Overlapped Replies 118
2.2.4.6.4.3.3 Mode S Overlapped Replies 119
2.2.4.6.4.4 Bearing Filter Performance 119
2.2.4.6.4.4.1 Bearing Filter 119
2.2.4.6.4.5 Dynamic Range and Reply Frequency 120
2.2.4.7 Antenna System 120
2.2.4.7.1 Polarization 120
2.2.4.7.2 Radiation Pattern 120
2.2.4.7.2.1 Transmit Radiation Pattern 120
2.2.4.7.2.2 Receive Radiation Pattern 121
2.2.4.7.3 Use of a Directional Antenna for Mode S Interrogations 121
2.2.4.7.4 Antenna Selection 121
2.2.4.7.4.1 Squitter Listening 121
2.2.4.7.4.2 Interrogations and Replies 122
2.2.4.8 Surveillance Interfaces 122
2.2.4.8.1 Data Provided by Surveillance to the CAS Logic 122
2.2.4.8.2 Data Received by Surveillance from the CAS Logic 123
2.2.4.8.3 Data Received by Surveillance from the Monitor 124
2.2.4.8.4 Surveillance Interrogation Mode Selection 124
2.2.5 Collision Avoidance System Requirements 124
2.2.5.1 Collision Avoidance Tracking 125
2.2.5.1.1 Own Aircraft Altitude 125
2.2.5.1.2 Control of Sensitivity Level 125
2.2.5.1.3 Other Aircraft Tracking 127
2.2.5.2 Threat Detection 128
2.2.5.3 Resolution Advisory Selection 130
2.2.5.3.1 Advisory Sense Selection 130
2.2.5.3.1.1 Sense Reversals 131
2.2.5.3.2 Advisory Type Selection 132
2.2.5.3.2.1 Advisories to Increase the Vertical Rate 133
2.2.5.3.3 Multi-Aircraft Logic 134
2.2.5.4 TCAS Communications Interface 134
2.2.5.4.1 Communication of Resolution Advisory Information 134
2.2.5.4.2 Communication (Coordination) with Threat Aircraft Equipped with TCAS On-board Resolution Capability 135
2.2.5.4.2.1 Coordination Processing Within Own TCAS 136
2.2.5.4.2.2 Coordination Interactions Between Two TCAS-equipped Aircraft 138
2.2.5.5 Display of Resolution Advisories 141
2.2.5.6 Traffic Advisories 141
2.2.6 Displays And Controls 142
2.2.6.1 Traffic Displays 142
2.2.6.1.1 Functions 142
2.2.6.1.2 Characteristics 142
2.2.6.1.2.1 General Characteristics 142
2.2.6.1.2.1.1 Own Aircraft Symbol 142

2.2.6.1.2.1.2 Range Rings 142
2.2.6.1.2.1.3 Threat Symbology 143
2.2.6.1.2.1.4 Off-Scale Symbology 143
2.2.6.1.2.1.5 Altitude Data Tag 143
2.2.6.1.2.1.6 Intruder Vertical Speed Arrow 144
2.2.6.1.2.1.7 Non-Altitude Reporting Intruders 144
2.2.6.1.2.1.8 No-Bearing Advisories 144
2.2.6.1.2.1.9 Display of Traffic 145
2.2.6.1.2.1.10 Altitude Band for the Display 146
2.2.6.1.2.1.11 TCAS Operating Mode and Selected Display Range Annunciation 146
2.2.6.1.2.1.12 RA Annunciations 146
2.2.6.1.2.1.13 Lighting Control 146
2.2.6.1.2.1.14 Status and Failure Annunciations 147
2.2.6.1.2.2 Fixed Range Displays 147
2.2.6.1.2.2.1 Display Range 147
2.2.6.1.2.2.2 Range Ring 147
2.2.6.1.2.3 Variable Range Displays 147
2.2.6.1.2.3.1 Display Range 147
2.2.6.1.2.3.2 Range Selection 147
2.2.6.1.2.3.3 Range Rings 147
2.2.6.1.2.4 Part Time (Pop-up) Displays 147
2.2.6.1.2.4.1 Activation 147
2.2.6.1.2.4.2 Information Displayed 148
2.2.6.1.2.4.3 Display Format 148
2.2.6.1.2.4.4 Pilot Selection 148
2.2.6.1.2.5 Full Time Displays 148
2.2.6.1.2.5.1 Display Format 148
2.2.6.1.2.6 Dedicated Displays 148
2.2.6.1.2.6.1 Display Format 149
2.2.6.1.2.6.2 Own Aircraft Symbol and Location 149
2.2.6.1.2.7 Shared Displays 149
2.2.6.1.2.7.1 Shared Weather (WX) Radar Displays 149
2.2.6.1.2.7.1.1 Display Modes 149
2.2.6.1.2.7.1.2 Own Aircraft Symbol and Location 150
2.2.6.1.2.7.2 Shared Navigation Displays (ND) or Electronic Horizontal Situation Indicator (EHSI) 150
2.2.6.1.2.7.2.1 Display Characteristic 150
2.2.6.1.2.7.2.2 Failure Annunciations 151
2.2.6.1.2.7.2.3 Traffic Display 151
2.2.6.1.2.7.2.4 TCAS and Weather Information 151
2.2.6.1.2.7.2.5 TCAS and Navigation Information 151
2.2.6.1.2.7.2.6 HSI Display Mode 151
2.2.6.1.2.7.2.6.1 Display Characteristics 151
2.2.6.1.2.7.2.6.2 Own Aircraft Symbol and Location 154
2.2.6.1.2.7.2.7 EXPANDED Mode 154
2.2.6.1.2.7.2.7.1 Display Characteristics 154
2.2.6.1.2.7.2.7.2 Display Range and Range Ring 154
2.2.6.1.2.7.2.7.3 Own Aircraft Symbol and Location 154
2.2.6.1.2.7.2.8 MAP Display Mode 154
2.2.6.1.2.7.2.8.1 Display Characteristics 154
2.2.6.1.2.7.2.8.2 Display Range and Range Rings 154
2.2.6.1.2.7.2.8.3 Display Orientation 155
2.2.6.1.2.7.2.8.4 Own Aircraft Symbol and Location 155
2.2.6.1.2.7.2.9 North-up Mode 155

2.2.6.1.2.7.2.9.1 Display Characteristics 155
2.2.6.1.2.7.2.9.2 Display Range and Range Rings 155
2.2.6.1.2.7.2.9.3 Own Aircraft Symbol 155
2.2.6.1.2.7.2.9.4 Display Orientation 155
2.2.6.1.2.7.2.9.5 TA or RA Annunciation 155
2.2.6.1.2.7.2.9.6 Selection of Heading Up Display 156
2.2.6.1.2.7.3 Shared EICAS/SYSTEMS Displays 156
2.2.6.1.2.7.3.1 Display Characteristics 156
2.2.6.1.2.7.3.2 Own Aircraft Symbol and Location 156
2.2.6.1.2.7.3.3 Traffic Display Inhibit 156
2.2.6.1.2.7.3.4 Restrictions 156
2.2.6.1.2.7.4 TA/RA/VSI Displays 157
2.2.6.1.2.7.4.1 General Requirements 157
2.2.6.1.2.7.4.1.1 Format 157
2.2.6.1.2.7.4.1.2 VSI Requirements 157
2.2.6.1.2.7.4.2 Traffic Display Function 157
2.2.6.1.2.7.4.2.1 Display Characteristics 157
2.2.6.1.2.7.4.2.2 Own Aircraft Symbol and Location 157
2.2.6.1.2.7.4.2.3 Interference with Vertical Speed Scale 157
2.2.6.2 RA Displays 158
2.2.6.2.1 General 158
2.2.6.2.2 RA/VSI (Round dial VSI) 158
2.2.6.2.2.1 RA Display Characteristics 158
2.2.6.2.2.1.1 Red Arcs 158
2.2.6.2.2.1.2 Green Arcs 158
2.2.6.2.2.1.3 Black Arcs 159
2.2.6.2.2.1.4 Multi-aircraft Encounters 159
2.2.6.2.2.2 VSI Characteristics 159
2.2.6.2.2.3 Lighting Control 159
2.2.6.2.3 RA/VSI (Integrated Tape VSI on a Primary Flight Display [PFD]) 159
2.2.6.2.3.1 RA Display Characteristics 160
2.2.6.2.3.1.1 Red Zone 160
2.2.6.2.3.1.2 Green Zone 160
2.2.6.2.3.1.3 Black Zones 160
2.2.6.2.3.1.4 Multi-aircraft Encounters 160
2.2.6.2.3.2 VSI Characteristics 161
2.2.6.2.3.3 VSI Scale 161
2.2.6.2.3.4 Lighting Control 161
2.2.6.2.4 Pitch Cues on the PFD 161
2.2.6.2.4.1 No-Fly Pitch Angles 162
2.2.6.2.4.2 Mode Annunciation 163
2.2.6.2.4.3 Multi-aircraft Encounters 163
2.2.6.2.5 Flight Director Guidance 163
2.2.6.2.5.1 TCAS Guidance Enabling 163
2.2.6.2.5.2 Return to Flight Path 163
2.2.6.2.6 Heads-up Display 163
2.2.6.2.6.1 No-Fly Zone 163
2.2.6.2.6.2 Mode Annunciation 164
2.2.6.2.6.3 Flight Path Target 164
2.2.6.2.6.4 Multi-aircraft Encounters 164
2.2.6.2.6.5 Display Decluttering 164
2.2.6.2.6.6 RA Guidance Availability 164
2.2.6.3 Aural Annunciations 165
2.2.6.3.1 General 165

2.2.6.3.1.1 Announcement Methodology 165
2.2.6.3.1.2 Aural Annunciation Generation 165
2.2.6.3.1.3 Aural Annunciation Duration 165
2.2.6.3.2 Quality 165
2.2.6.3.3 Aural Annunciation Inhibit 165
2.2.6.3.4 TAs 166
2.2.6.3.5 RAs 166
2.2.6.4 Visual Alerts 166
2.2.6.4.1 TAs 166
2.2.6.4.2 RAs 173
2.2.6.4.3 Message on PFD 173
2.2.6.4.4 Visual Alert Inhibit 173
2.2.6.5 Controls 173
2.2.6.5.1 TCAS/Mode S Controls 173
2.2.6.5.2 Traffic Display Controls 174
2.2.6.5.3 Traffic Display Controls on Shared Weather Radar 174
2.2.6.5.3.1 WX/TCAS Mode 174
2.2.6.5.3.2 WX-and-Traffic Mode 174
2.2.6.5.3.3 Optional Mode Selection 175
2.2.6.6 Status and Failure Annunciations 175
2.2.6.6.1 General 175
2.2.6.6.2 Traffic Display Annunciations 175
2.2.6.6.3 RA Display 175
2.2.6.7 Display and Control Interfaces 176
2.2.6.7.1 Display and Control Outputs 176
2.2.6.7.2 Display and Control Inputs 176
2.2.7 Monitor Requirements 186
2.2.7.1 General Requirements 186
2.2.7.1.1 Failure Response 186
2.2.7.1.2 Noninterference with Normal Operation 186
2.2.7.1.3 Self-Test 186
2.2.7.2 Monitoring of TCAS Components 187
2.2.7.2.1 Computer Monitoring 187
2.2.7.2.2 Coordination Monitoring 187
2.2.7.2.3 TCAS II/Transponder Interface Monitoring 187
2.2.7.2.4 Display Monitoring 187
2.2.7.2.5 Altitude Input Monitoring 190
2.2.7.2.5.1 Barometric Altitude Monitoring 190
2.2.7.2.5.2 Radio Altitude Monitoring - General 190
2.2.7.2.5.2.1 Radio Altimeter Input to the Monitor 190
2.2.7.2.5.2.2 Monitor Inputs to the CAS Logic 190
2.2.7.2.5.2.3 Monitor Verification of Radio Altitude Source Prior to Issuance of Traffic or Resolution Advisories 191
2.2.7.2.5.2.4 Radio Altitude Credibility 191
2.2.7.2.5.2.4.1 Radio Altitude Credibility Determination Test #1 191
2.2.7.2.5.2.4.2 Radio Altitude Credibility Determination Test #2 192
2.2.7.2.5.2.4.2.1 Radio Altitude Track Initiation 192
2.2.7.2.5.2.4.2.2 Operation Subsequent to Radio Altitude Track Initiation 192
2.2.7.2.5.2.5 Radio Altitude Source Failure 193
2.2.7.2.5.3 ICAO 24-Bit Aircraft Address 193
2.2.7.2.5.4 Wind Shear and Ground Proximity Warning System (GPWS) 193
2.2.7.3 Monitor Interfaces 194
2.2.7.3.1 Data Provided by the Monitor to Surveillance 194
2.2.7.3.2 Data Provided by the Monitor to the CAS 194

2.2.7.3.3 Data Received by the Monitor from the CAS 194
2.2.7.3.4 Data Received by the Monitor from the Control Panel via the Mode S Transponder 194
2.2.7.3.5 Data Received by the Monitor from Aircraft Discretes 194
2.2.7.3.6 Data Provided by the Monitor to Displays and Controls 195
2.2.7.3.7 Data Received by the Monitor from Displays and Controls 196

2.3 Equipment Performance - Environmental Conditions 198
2.3.1 Temperature and Altitude Tests 198
2.3.1.1 Low Temperature Test 198
2.3.1.2 High Temperature Test 199
2.3.1.3 Altitude Test 199
2.3.1.4 Decompression Test (When Required) 200
2.3.1.5 Overpressure Test (When Required) 200
2.3.2 Temperature Variation Test 200
2.3.3 Humidity Test 201
2.3.4 Shock Tests 202
2.3.4.1 Operational Shocks 202
2.3.4.2 Crash Safety Shocks 203
2.3.5 Vibration Tests 203
2.3.6 Explosion Test (When Required) 204
2.3.7 Waterproofness Test 204
2.3.7.1 Drip Proof Test (When Required) 204
2.3.7.2 Spray Proof Test (When Required) 204
2.3.8 Fluids Susceptibility Tests 205
2.3.8.1 Spray Test (When Required) 205
2.3.8.2 Immersion Test (When Required) 205
2.3.9 Sand and Dust Test (When Required) 206
2.3.10 Fungus Resistance Test (When Required) 206
2.3.11 Salt Fog Test (When Required) 206
2.3.12 Magnetic Effect Test 206
2.3.13 Power Input Tests 206
2.3.13.1 Normal Operational Conditions 206
2.3.13.2 Abnormal Operating Conditions 207
2.3.14 Voltage Spike Conducted Test 207
2.3.14.1 Category A Requirements (If Applicable) 207
2.3.14.2 Category B Requirements (If Applicable) 208
2.3.15 Audio Frequency Conducted Susceptibility Test 208
2.3.16 Induced Signal Susceptibility Test 208
2.3.17 Radio Frequency Susceptibility Test (Radiated and Conducted) 208
2.3.18 Emission of Radio Frequency Energy Test 208

2.4 Equipment Test Procedures 208
2.4.1 Definitions of Terms and Conditions of Test 208
2.4.1.1 Standard Test Signals 210
2.4.1.2 Test Equipment Capabilities 212
2.4.1.3 Alternative Mode S Transponder Procedures 219
2.4.1.4 Bench Test Coverage of the TCAS Software 219
2.4.2 Detailed Test Procedures 220
2.4.2.1 Surveillance 220
2.4.2.1.1 Transmitter Characteristics 220
2.4.2.1.1.1 Transmit Frequency (2.2.3.5) 220
2.4.2.1.1.2 Radiated Output Power (2.2.3.1) 222
2.4.2.1.1.3 Control of Synchronous Interference by Transmitter Power (2.2.4.5.4.1) 224
2.4.2.1.1.3.1 Whisper-Shout Sequence Relative Amplitude and Timing (2.2.4.5.4.1) 224

2.4.2.1.1.3.2 Determination of Whisper-Shout Sequence (2.2.4.5.4.1.3) 226
2.4.2.1.1.4 TCAS Transmit Pulse Characteristics (2.2.3.8) 229
2.4.2.1.1.5 Interrogation Spectrum (2.2.3.3) 233
2.4.2.1.1.6 Unwanted Output Power (2.2.3.2) 235
2.4.2.1.1.7 Aircraft Suppression Bus (2.2.3.12) 237
2.4.2.1.1.7.1 Suppression Pulse Supplied by TCAS 237
2.4.2.1.1.7.2 Suppression Pulse Supplied By Other Avionics 237
2.4.2.1.1.8 Interrogation Repetition Interval (2.2.4.1) and Jitter (2.2.3.4) 237
2.4.2.1.2 Receiver Characteristics (2.2.4.4.1) 237
2.4.2.1.2.1 In-Band Acceptance (2.2.4.4.1.1) 240
2.4.2.1.2.1.1 Ability to Operate Over the Frequency Band 1087 to 1093 MHz 240
2.4.2.1.2.1.2 Sensitivity and Dynamic Range at 1090 MHz 242
2.4.2.1.2.2 Out-of-Band Rejection (2.2.4.4.1.2) 244
2.4.2.1.3 Reply Link Interference (2.2.4.5.1.2) 246
2.4.2.1.3.1 Mode C Reply Reception (2.2.4.4.2.1). Narrow Pulse Discrimination (2.2.4.5.1.2.1) and TACAN and DME Discrimination (2.2.4.5.1.2.2) 246
2.4.2.1.3.2 Mode S Squitter and Reply Reception (2.2.4.4.2.2), Narrow Pulse Discrimination (2.2.4.5.1.2.1) and TACAN and DME Discrimination (2.2.4.5.1.2.2) 248
2.4.2.1.4 Mode C Reply Reception (2.2.4.4.2.1) 251
2.4.2.1.4.1 Bracket Detection and Reply Decoding (2.2.4.4.2.1) 251
2.4.2.1.4.2 Wide Pulse Detection and Pulse Position Discrimination (2.2.4.4.2.1c) 253
2.4.2.1.4.3 Narrow Pulse Rejection (2.2.4.4.2.1b) 254
2.4.2.1.4.4 Detection of Garbled Replies (2.2.4.4.2.1c) 255
2.4.2.1.4.5 Detection of Interleaved Replies (2.2.4.4.2.1c) 257
2.4.2.1.4.6 Phantom Rejection (2.2.4.4.2.1d) 258
2.4.2.1.4.7 TACAN and DME Pulse Rejection (2.2.4.5.3) 259
2.4.2.1.5 Mode S Squitter and Reply Reception (2.2.4.4.2.2) 260
2.4.2.1.5.1 Mode S Preamble Reception (2.2.4.4.2.2b) 261
2.4.2.1.5.2 Mode S Squitter and Fruit Reply Reception (2.2.4.4.2.2c) 263
2.4.2.1.5.3 Mode S Extended Squitter Reception (Optional Feature) (2.2.3.10.7, 2.2.3.10.2.1, 2.2.4.6.2.2, 2.2.4.4.2.2c) 264
2.4.2.1.5.4 Mode S Error Correction (2.2.4.4.2.2d) 265
2.4.2.1.6 Mode C Target Surveillance Performance (2.2.4.6.2) 266
2.4.2.1.6.1 Mode C Surveillance Initiation (2.2.4.6.2.1.2, 2.2.4.5, 2.2.4.6) 267
2.4.2.1.6.2 Mode C Surveillance Extension (2.2.4.6.2.1.3, 2.2.4.6.2.1.4) 268
2.4.2.1.6.2.1 Elimination of Multipath False Tracks 268
2.4.2.1.6.2.2 Range Correlation 271
2.4.2.1.6.2.3 Altitude Correlation 274
2.4.2.1.6.2.4 Altitude Code Processing 277
2.4.2.1.6.3 Missing Mode C Replies (2.2.4.6.2.1.3) 278
2.4.2.1.6.4 Surveillance Target Capacity (Mode C) (2.2.4.6.1) 279
2.4.2.1.6.5 Surveillance Overload (2.2.4.6.1.1) 282
2.4.2.1.7 Mode S Target Surveillance Performance (2.2.4.6.2.2, 2.2.4.4.2.2) 283
2.4.2.1.7.1 Mode S Surveillance Initiation (2.2.4.6.2.2.1) 284
2.4.2.1.7.2 Mode S Range Acquisition (2.2.4.6.2.2.2, 2.2.4.2, 2.2.4.7, 2.2.4.7.4.1) 288
2.4.2.1.7.2.1 Mode S Acquisition of Transponder Comm-B Register Information (Optional Feature) (2.2.3.10.6) 290
2.4.2.1.7.3 Maintenance of Established Mode S Tracks (2.2.4.6.2.2.3, 2.2.4.7) 292
2.4.2.1.7.4 Interference Limiting (2.2.3.6) 295
2.4.2.1.7.4.1 Interrogation Control of Airborne TCAS (2.2.3.6.2) 295
2.4.2.1.7.4.2 Interrogation Control of TCAS On The Ground (2.2.3.6.3) 298
2.4.2.1.7.4.3 Correct Content of Transmitted TCAS Broadcast Interrogation Messages (2.2.3.9.3.2.4.2 and 2.2.3.10.2.4) 299
2.4.2.1.7.5 Surveillance Target Capacity and Overload (Mode S) (2.2.4.6.1; 2.2.4.6.1.1) . 300

2.4.2.1.7.6 Mode S Power Programming (2.2.4.6.2.2.4) 304
2.4.2.1.8 Combined Mode S and Mode C Surveillance 304
2.4.2.1.8.1 Surveillance Target Capacity (2.2.4.6.1) 304
2.4.2.1.8.2 Altitude and Range Tracking of Mode C and Mode S Targets for Threat Detection (2.2.4.6) 306
2.4.2.1.8.2.1 Range Tracking Accuracy 306
2.4.2.1.8.2.2 Altitude Tracking Accuracy 307
2.4.2.1.9 Bearing Estimation 309
2.4.2.1.9.1 Bearing Accuracy With Standard Ground Plane (2.2.4.6.4.2) 309
2.4.2.1.9.2 Reply Processing (2.2.4.6.4.3) 310
2.4.2.1.9.2.1 Mode C Interleaved Replies (2.2.4.6.4.3.1) 310
2.4.2.1.9.2.2 Mode C Overlapped Replies (2.2.4.6.4.3.2) 311
2.4.2.1.9.2.3 Mode S Overlapped Replies (2.2.4.6.4.3.3) 312
2.4.2.1.9.3 Bearing Filter Performance (2.2.4.6.4.4) 313
2.4.2.1.9.3.1 Bearing Track and Coast (2.2.4.6.4.4.1) 313
2.4.2.1.9.3.2 Filter Lag (2.2.4.6.4.4.1) 314
2.4.2.1.9.4 Radiation Pattern (2.2.4.7.2) 314
2.4.2.1.9.5 Mode C Azimuth Filtering (2.2.4.6.2.1.2) 315
2.4.2.1.10 TCAS Antenna System 315
2.4.2.1.10.1 Use of Directional Interrogations for Mode C Surveillance (2.2.4.7.2.1) and Bearing Receive Radiation Pattern (2.2.4.7.2.2) 315
2.4.2.1.10.2 Use of Directional Antenna for TCAS Broadcast Interrogations (2.2.4.7.3 and 2.2.3.10.2.4) 317
2.4.2.1.10.2.1 Total Radiated Power 318
2.4.2.1.10.2.2 Interrogation Repetition Interval and Jitter 318
2.4.2.2 CAS Test Procedures 318
2.4.2.2.1 Using the Input Files 320
2.4.2.2.1.1 Description of the Encounter Input File 320
2.4.2.2.1.2 Calculating CRS Inputs from the Encounter Input 324
2.4.2.2.2 Using the Output Files 331
2.4.2.2.2.1 Description of the Short Transition Output File 331
2.4.2.2.2.2 Description of the End of Cycle Data Output File 332
2.4.2.2.3 External Parameter Selection 340
2.4.2.2.3.1 Ground Control of Sensitivity Level 341
2.4.2.2.3.2 Manual Sensitivity Level Selection 343
2.4.2.2.4 Coordination 344
2.4.2.2.4.1 Transmission of RA Report to Mode S Sensor and RA Broadcast Interrogation to Other Ground Receivers 344
2.4.2.2.4.2 Coordination with TCAS II 348
2.4.2.2.4.2.1 Sense Selection and Communication 348
2.4.2.2.4.2.2 Validity Check for TCAS-TCAS Communications Link 359
2.4.2.2.4.2.3 TCAS II in Multi-Aircraft Conflict 362
2.4.2.2.4.2.4 Coordination Monitor 362
2.4.2.2.4.2.5 Transponder Replies to Incoming TCAS Resolution Messages 365
2.4.2.2.4.2.6 Transponder/TCAS Throughput 365
2.4.2.2.4.2.7 Operation of TCAS/Transponder Queues 369
2.4.2.2.4.2.8 Coordination Timing 370
2.4.2.2.5 TCAS Capability Reporting (2.2.3.13.2.2.4 and 2.2.3.13.2.2.1) 371
2.4.2.2.6 System Integration Tests 372
2.4.2.3 Display and Controls Stand Alone Tests 374
2.4.2.3.1 Traffic Displays 375
2.4.2.3.1.1 General Characteristics 375

2.4.2.3.1.1.1 Own Aircraft Symbol (2.2.6.1.2.1; 2.2.6.1.2.6.2; 2.2.6.1.2.7.1.2; 2.2.6.1.2.7.2.6.2; 2.2.6.1.2.7.2.7.3; 2.2.6.1.2.7.2.8.4; 2.2.6.1.2.7.2.9.3; 2.2.6.1.2.7.3.2; 2.2.6.1.2.7.4.2.2) 375
2.4.2.3.1.1.2 Range Rings (2.2.6.1.2.1.2; 2.2.6.1.2.2.2; 2.2.6.1.2.3.3; 2.2.6.1.2.7.2.7.2; 2.2.6.1.2.7.2.8.2; 2.2.6.1.2.7.2.9.2) 376
2.4.2.3.1.1.3 Threat Symbology (2.2.6.1.2.1.3; 2.2.6.1.2.1.12) 377
2.4.2.3.1.1.4 Off-Scale Symbology (2.2.6.1.2.1.4; 2.2.6.1.2.1.11; 2.2.6.1.2.1.12) 377
2.4.2.3.1.1.5 Altitude Data Tag (2.2.6.1.2.1.5; 2.2.6.1.2.1.7) 378
2.4.2.3.1.1.5.1 Display of Intruder's Relative Altitude 378
2.4.2.3.1.1.5.2 Display of Intruder's Reported Altitude 379
2.4.2.3.1.1.6 Intruder Vertical Speed Arrow (2.2.6.1.2.1.6) 381
2.4.2.3.1.1.7 No-Bearing Advisories (2.2.6.1.2.1.8; 2.2.6.1.2.1.12) 381
2.4.2.3.1.1.8 Display of Traffic (2.2.6.1.2.1.9) 382
2.4.2.3.1.1.9 Altitude Band for the Display (2.2.6.1.2.1.10; 2.2.6.5.2) 383
2.4.2.3.1.1.10 Display of TCAS Operating Mode (2.2.6.1.2.1.11; 2.2.6.6.2; 2.2.6.1.2.1.14) 384
2.4.2.3.1.2 Fixed Range Displays 385
2.4.2.3.1.3 Variable Range Displays 385
2.4.2.3.1.3.1 Display Range (2.2.6.1.2.3.1) 385
2.4.2.3.1.3.2 Range Selection (2.2.6.1.2.3.2) 386
2.4.2.3.1.4 Part Time Displays 386
2.4.2.3.1.4.1 Activation and Information Displayed (2.2.6.1.2.4.1; 2.2.6.1.2.4.2) 386
2.4.2.3.1.5 Full Time Displays 388
2.4.2.3.1.6 Dedicated Displays 388
2.4.2.3.1.7 Shared Displays 388
2.4.2.3.1.7.1 Shared Weather Radar Displays 388
2.4.2.3.1.7.1.1 Available Display Modes (2.2.6.1.2.7.1.1) 388
2.4.2.3.1.7.1.2 Display Mode Characteristics (2.2.6.1.2.7.1.1) 389
2.4.2.3.1.7.1.2.1 WX/TCAS Mode 389
2.4.2.3.1.7.1.2.2 WX-and-Traffic Mode 390
2.4.2.3.1.7.1.2.3 WX-Only Mode 392
2.4.2.3.1.7.1.2.4 Traffic-Only Mode 393
2.4.2.3.1.7.2 Navigation Displays or Electronic Horizontal Situation Indicators 394
2.4.2.3.1.7.2.1 Failure Annunciations (2.2.6.1.2.7.2.2) 394
2.4.2.3.1.7.2.2 Display of Traffic (2.2.6.1.2.7.2.3) 394
2.4.2.3.1.7.2.3 TCAS and Weather Information (2.2.6.1.2.7.2.4) 395
2.4.2.3.1.7.2.4 TCAS and Navigation Information (2.2.6.1.2.7.2.5) 395
2.4.2.3.1.7.2.5 HSI Display Mode (2.2.6.1.2.7.2.6.1) 396
2.4.2.3.1.7.2.6 EXPANDED Mode (2.2.6.1.2.7.2.7.1) 397
2.4.2.3.1.7.2.7 MAP Mode 398
2.4.2.3.1.7.2.7.1 Display Characteristics (2.2.6.1.2.7.2.8.1) 398
2.4.2.3.1.7.2.7.2 Display Range and Orientation (2.2.6.1.2.7.2.8.2; 2.2.6.1.2.7.2.8.3) 399
2.4.2.3.1.7.2.8 North-up Displays 400
2.4.2.3.1.7.2.8.1 Display Characteristics (2.2.6.1.2.7.2.9.1; 2.2.6.1.2.7.2.9.3; 2.2.6.1.2.7.2.9.4; 2.2.6.1.2.7.2.9.5) 400
2.4.2.3.1.7.2.8.2 Display Orientation (2.2.6.1.2.7.2.9.6) 401
2.4.2.3.1.7.3 EICAS or Systems Displays (2.2.6.1.2.7.3.3) 402
2.4.2.3.1.7.4 TA/RA/VSI 404
2.4.2.3.1.7.4.1 VSI Requirements (2.2.6.1.2.7.4.1.2) 404
2.4.2.3.1.7.4.2 Interference with Vertical Speed Scale (2.2.6.1.2.7.4.2.3) 404
2.4.2.3.2 RA Displays 405
2.4.2.3.2.1 Round Dial VSI (2.2.6.2.2; 2.2.6.2.2.1.1; 2.2.6.2.2.1.2; 2.2.6.2.2.1.3; 2.2.6.2.2.1.4) 405
2.4.2.3.2.1.1 VSI Range (2.2.6.2.2) 409

2.4.2.3.2.2 Vertical Speed Tape (2.2.6.2.3; 2.2.6.2.3.1.1; 2.2.6.2.3.1.2; 2.2.6.2.3.1.3; 2.2.6.2.3.1.4) 410
2.4.2.3.2.2.1 Vertical Speed Tape Range (2.2.6.2.3) 415
2.4.2.3.2.3 Pitch Cues on the PFD (2.2.6.2.4.1; 2.2.6.2.4.2; 2.2.6.2.4.3) 415
2.4.2.3.2.4 Flight Director Guidance (2.2.6.2.5.1) 420
2.4.2.3.2.5 HUD (2.2.6.2.6.1; 2.2.6.2.6.2; 2.2.6.2.6.3; 2.2.6.2.6.4; 2.2.6.2.6.5; 2.2.6.2.6.6) 423
2.4.2.3.3 Controls 428
2.4.2.3.3.1 TCAS/Mode S Controls (2.2.6.5.1) 428
2.4.2.3.3.2 Traffic Display Controls (2.2.6.5.2) 429
2.4.2.3.3.3 Shared Weather Radar/Traffic Display Controls (2.2.6.5.3; 2.2.6.5.3.1; 2.2.6.5.3.2; 2.2.6.5.3.3) 430
2.4.2.3.4 Status and Failure Annunciations (2.2.6.6) 431
2.4.2.3.4.1 Traffic Display Annunciations (2.2.6.6.1) 431
2.4.2.3.4.2 RA Display Annunciations (2.2.6.6.2) 431
2.4.2.4 Automatic Performance Monitoring and Self Test (2.2.7) 432
2.4.2.4.1 Automatic Performance Monitoring (2.2.7.1) 432
2.4.2.4.2 Self-Test (2.2.7.1.3) 432
2.4.2.4.3 Own Transponder ICAO 24-Bit Aircraft Address (2.2.7.2.5.3) 432
2.4.2.5 Performance Compatibility with Own-Aircraft's Mode S Transponder 433
2.4.2.5.1 TCAS to Mode S Transponder Interference (2.1.10.1) 433
2.4.2.5.2 Mode S Transponder to TCAS Interference (2.2.3.11) 433
2.4.3 Computer Performance Verification 433
2.4.3.1 RAM Pattern Tests 434
2.4.3.2 CPU Instruction Tests 434
2.4.3.3 Program Memory Tests 434
2.4.3.4 CPU Input/Output Tests 434
2.4.3.5 CPU Timing Tests 434
2.4.4 Cross-Reference of Requirements and Associated Tests 434

3 INSTALLED EQUIPMENT PERFORMANCE 442

3.1 Test Conditions 442
3.1.1 Power Input 442
3.1.2 Associated Equipment 442
3.1.3 Environment 442
3.1.4 Adjustment of Equipment 442

3.2 Equipment Installation 442
3.2.1 Equipment Accessibility 442
3.2.2 Display Visibility 442
3.2.3 Interference 443
3.2.4 Physical Installation 443
3.2.5 Aircraft Power Source 443
3.2.6 Transmission Lines 443
3.2.7 Antenna Location 443
3.2.7.1 Minimum Distance from Other Antennas 443
3.2.8 Altimetry System 444
3.2.8.1 Barometric Altimetry Performance Required for TCAS Operation 444
3.2.8.2 Altimetry System Error Assessment 445
3.2.8.3 Definitions 446
3.2.9 Number of Intruders Displayed (2.2.6.1.2.1.9) 448
3.2.10 Display of Traffic on EICAS/SYSTEMS Displays (2.2.6.1.2.7.3.3) 448
3.2.11 Use of Flight Director Cues for RA Guidance (2.2.6.2.5.1) 448
3.2.12 Red Visual Alert (2.2.6.4.2) 448

3.3 Minimum Installed Equipment Performance Requirements 448
3.4 Test Procedures for Installed Equipment Performance 448
3.4.1 Conformity Inspection 449
3.4.2 General Test Procedures 449
3.4.2.1 Equipment Function 449
3.4.2.2 Interference Effects (Ground Test) 449
3.4.2.2.1 Suppression Bus 449
3.4.2.3 Accessibility 450
3.4.3 Antenna Gain Performance 450
3.4.3.1 Success Criteria 450
3.4.3.2 Full-Scale Anechoic Antenna Range Measurements of Gain 450
3.4.3.3 Scaled Model Measurements of Gain 451
3.4.3.3.1 Aircraft Model 451
3.4.3.3.2 Model Tests 451
3.4.3.4 Theoretical Calculations of Antenna Gain 452
3.4.3.4.1 Validation of Theoretical Calculations 452
3.4.3.5 Antenna Location Using Distance-Area Calculations 452
3.4.4 Certification Flight Test Procedures 453
3.4.4.1 Mode C Surveillance Flight Tests 453
3.4.4.2 Mode S Surveillance Flight Tests 455
3.4.4.3 Coordination Flight Tests 457
3.4.5 Bearing Estimation Tests 458
3.4.5.1 Success Criteria for Bearing Estimation Measurements 458
3.4.5.2 Antenna Range Measurements of Bearing Accuracy 458
3.4.5.3 Airborne Measurements of Bearing Accuracy 459
3.4.5.4 Scaled Model Measurements of Bearing Accuracy 460
3.4.5.4.1 Aircraft Model 460
3.4.5.4.2 Antenna Model 460
3.4.5.4.3 Model Tests 460
3.4.5.5 Theoretical Calculations of Bearing Accuracy 461
3.4.5.5.1 Validation of Theoretical Calculations of Bearing Accuracy 461

Membership 463

Appendix A: Surveillance Procedures 467

A.1 Interference Limiting Procedure 1
A.2 Rejection of Reply Link Interference 3
A.3 Mode S Error Correction 4
A.4 Determination Of Synchronous Garble Potential 10
A.5 Mode C Track Initiation 17
A.6 Mode C Track Maintenance 18
A.7 Multipath False Targets 20
A.8 Mode S Squitter Processing 21
A.9 Non-Altitude Reporting Aircraft 21
A.10 Bearing Estimation 24
A.11 Mode S Tracker Using A Five-Second Update Rate 26
A.12 Transition From On-The-Ground To Airborne Interference Limiting 26

Appendix B: TCAS RF Communication Paths 29

B.1 Introduction 1

B.2 Air-to-Air Communication 1
B.2.1 Coordination 1
B.2.2 TCAS Broadcast Interrogation Messages 1
B.2.3 RA Broadcast Interrogation Messages 3
B.2.4 Surveillance 3

B.3 Air-to-Ground, Ground-to-Air Communication 3
B.3.1 Sensitivity Level Command Messages (Ground-to-Air) 3
B.3.2 RA Report (Air-to-Ground) 4
B.3.3 Data Link Capability Report (Air-to-Ground) 4
B.3.4 Surveillance 4

Appendix C: Computer Code Examples for Formatting Test Output 5

C.1 Introduction 1

C.2 Pascal Code that Formats Test Suite Output 1

C.3 C Code that Formats Output of Pseudocode-Based Implementation 9

Table of Figures

Figure 1-1 TCAS System Components 6
Figure 2-1 Mode C-Only All-Call Interrogation Pulse Sequence For TCAS. 44
Figure 2-2 Mode S Interrogation Pulse Sequence For TCAS. 46
Figure 2-3 Mode S Interrogation or Uplink Formats Used by TCAS II. 48
Figure 2-4 Mode S Reply or Downlink Formats Used by TCAS II. 49
Figure 2-5 Mode C Reply 89
Figure 2-6 Mode S Reply 92
Figure 2-7 Minimum Basic Whisper-Shout Sequence 98
Figure 2-8 Timing For Six Power Steps In The Minimum Basic Whisper-Shout Sequence For Top Antenna Forward Beam. 99
Figure 2-9 High Resolution Whisper-Shout Sequence 101
Figure 2-10 Coordination Processing Within Own TCAS 137
Figure 2-11 Standard (NonSimultaneous) Coordination 139
Figure 2-12 Simultaneous Coordination 140
Figure 2-13 Sample Navigation Display Modes 152
Figure 2-14 RA Pitch Cues on a PFD 162
Figure 2-15 Signal Relationship Between TCAS, Mode S & Test Equipment 213
Figure 2-16 Definition Of Variables Associated With The Linear Movement Of Targets In The Range Dimension 217
Figure 2-17 Frequency Test Setup 221
Figure 2-18 Peak Power Test Setup 223
Figure 2-19 Whisper-Shout And Interrogation Rate Jitter Test Setup 225
Figure 2-20 Mode S Transmission Test Setup 231
Figure 2-21 DPSK Phase Reversal Tolerance Test Setup 232
Figure 2-22 Mode S RF Spectrum Test Setup 234
Figure 2-23 Unwanted Output Power Test Setup 236
Figure 2-24 Geometrical Illustration Of Multipath 269
Figure 2-25 Real Multipath 269
Figure 2-26 Simulated Multipath 270
Figure 2-27 Reply Sequence For Range Correlation Test Scenario A (Above 10 Kft) 272
Figure 2-28 Reply Sequence For Range Correlation Test Scenario B (Below 10 Kft) 273
Figure 2-29 Reply Sequence For Altitude Correlation Test 275
Figure 2-30 Range Vs. Time Plot For Intruders 1, 2, 23, And 24 282
Figure 2-31 Example of Encounter Geometry 331
Figure 2-32 One Cycle of a Short Transition Output File 333
Figure 3-1 Altimetry System Elements and Error Components 444
Figure 3-2 Ramp Test Geometry Considerations 459
Figure A-1 Interference Limiting Flow Diagram. 2
Figure A-2 Initial Conditions For Error Detection. 6
Figure A-3 Final Conditions Of Error Detection For 56 And 112 Bit Replies. 7
Figure A-4 Initialization Of Error Pattern Location Logic For 56 And 112 Bit Replies. 9
Figure A-5 Generation Of Correction Enable Bit. 11
Figure A-6 Correction Of Decision Sequence. 12
Figure A-7 Final State Of Error Correction Function. 13
Figure A-8 Low Confidence Bit Measurement - Flow Diagram. 14
Figure A-9 Intruder Range Track Comparison - Flow Diagram. 16
Figure B-1 TCAS Communications. 2

Table of Tables

Table 2-1 Aircraft Density 29
Table 2-2 Maximum ATCRBS Fruit Rate 30
Table 2-3 Interrogation Spectrum 36
Table 2-4 Mode C Pulse Shapes 43
Table 2-5 Mode S Pulse Shapes 45
Table 2-6 Field Index 53
Table 2-7 Flight Status Codes 56
Table 2-8 Horizontal Sense Bits (HSB field) 68
Table 2-9 Vertical Sense Bits (VSB field) 70
Table 2-10 Out-of-Band Rejection 88
Table 2-11 Illegal Altitude Codes 93
Table 2-12 Improvement Factors For Higher Resolution Whisper-Shout Sequences 97
Table 2-12A Summary of Rules for Determining Air-Ground Status 111
Table 2-13 Logic Parameter Values 127
Table 2-14 Recommended Location of No-Bearing Advisories 145
Table 2-15 TCAS RA Aural Annunciations and Visual Alerts 167
Table 2-16 Mapping Between RA, Aural Annunciation, and ARINC Word 270 Contents 168
Table 2-17 TCAS Display and Controls Output (Control Panel) 177
Table 2-18 TCAS Display and Controls Output (Displays) 178
Table 2-19 TCAS Display and Controls Outputs (Aural Annunciations) 178
Table 2-20 TCAS Display and Controls Inputs (RA Displays) 179
Table 2-21 TCAS Display and Controls Inputs (Aural Annunciations) 182
Table 2-22 TCAS Display and Controls Inputs (Traffic Display) 183
Table 2-23 Recommended Display Actions and Monitor Response to “Not Operational” Status Received from TCAS Displays 189
Table 2-24 TCAS Display and Controls Inputs (RA Displays) 195
Table 2-25 TCAS Display and Controls Inputs (Aural Annunciations) 195
Table 2-26 TCAS Display and Controls Inputs (Traffic Display) 196
Table 2-27 TCAS Display and Controls Output (Control Panel) 196
Table 2-28 TCAS Display and Controls Output (Displays) 197
Table 2-29 Low Temperature Test Requirements 199
Table 2-30 Altitude Test Requirements 200
Table 2-31 Temperature Variation Test Requirements 201
Table 2-32 Humidity Test Requirements 202
Table 2-33 Operational Shocks Test Requirements 203
Table 2-34 Vibration Tests Requirements 204
Table 2-35 Drip Proof Test Requirements 204
Table 2-36 Spray Test Requirements 205
Table 2-37 Sand and Dust Test Requirements 206
Table 2-38 Normal Operational Conditions Test Requirements 207
Table 2-39 Standard Test Signal Pulse Shapes 211
Table 2-40 Standard Test Signal Total Jitter 212
Table 2-41 Confidence Factor Required For A 90% Confidence Level 239
Table 2-42 Minimum Number Of Trials Vs. Number Of Failures For The Required Probability Of Success Values Specified In 2.4.2.1.2 240
Table 2-43 Squitter And Reply Probability Vs. Range And Altitude 302
Table 2-44 Tests Included in CRS-Based Test Suite 319
Table 2-45 Files Included on Test Disk 319
Table 2-46 Own Aircraft Information Specified in Encounter Input File 321
Table 2-47 Encounter n Information Specified in Encounter Input File 322
Table 2-48 Resolution Messages Specified in Encounter Input File 323

Table 2-49 Ground Stations Information Specified in Encounter Input File 323
Table 2-50 CRS Input Interface: Resolution_Message 324
Table 2-51 CRS Input Interface: Sensitivity_Level_Command 325
Table 2-52 CRS Input Interface: Altitude_Message (Fine and Coarse Altitude Cases) 325
Table 2-53 CRS Input Interface: Own_Update_Message 325
Table 2-54 CRS Input Interface: Surveillance_Report 326
Table 2-55 CRS Input Interface: Radio_Altitude_Report and Radio_Altitude_Status 327
Table 2-56 CRS Input Interface: Aircraft_Discrete_Values 327
Table 2-57 CRS Input Interface: TCAS_Operational_Status 328
Table 2-58 CRS Input Interface: Coordination_Reply 328
Table 2-59 CRS Input Interface: Coordination_Reply_Timeout 328
Table 2-60 CRS Input Interface: Ground_Report 329
Table 2-61 CRS Input Interface: Altitude_Alerter_Report 329
Table 2-62 Items Included in End of Cycle Data Output File and Corresponding CRS Variables 334
Table 2-63 Test Suite Tolerances for Acceptable Differences 339
Table 2-64 Round Dial VSI RA Tests 406
Table 2-65 Vertical Speed Tape RA Tests 411
Table 2-66 RA Tests for Implementations Using Pitch Cues on a PFD 416
Table 2-67 RA Depiction Using Flight Director Guidance 421
Table 2-68 Tests for Implementations Displaying RAs on a HUD 424
Table 2-69 Cross-Reference of Requirements to Associated Tests 435
Table 2-70 Cross-Reference of Associated Tests to Requirements 438
Table 3-1 Specification Of Total Altimetry System Performance 445
Table A-1 Code Pulse Agreement 18

This page intentionally left blank

1 PURPOSE AND SCOPE

1.1 Introduction

This document sets forth minimum operational performance standards for Traffic Alert and Collision Avoidance System II (TCAS II) equipment. TCAS II is intended to improve air safety by acting as a last-resort method of preventing mid-air collisions or near collisions between aircraft. By utilizing Secondary Surveillance Radar (SSR) technology, TCAS II equipment operates independently of ground-based aids and air traffic control (ATC). Aircraft equipped with TCAS II have the ability to interrogate airborne transponders to monitor range, bearing, and reported altitude of other aircraft in the vicinity and assess the risk of collision. Non-transponding aircraft are not detected. TCAS II Version 6.0 was first introduced in the United States in 1990 with collision avoidance logic Version 6.0 and later 6.04 and 6.04a. TCAS II Version 7.0 was introduced in the United States and Europe in 2000 and was subsequently mandated by the International Civil Aviation Organization (ICAO) for all commercial turbine-powered transport aircraft worldwide having more than 19 passenger seats or having a maximum take-off weight above 5700 kg. TCAS II is referred to as the Airborne Collision Avoidance System II (ACAS II) in ICAO terminology.

TCAS II provides traffic advisories (TAs) and if warranted, resolution advisories (RAs) in the vertical plane. RAs are indications given to the flight crew recommending maneuvers intended to provide separation from all threats, or restrictions to maneuvers to maintain existing separation. (In this document the term separation means physical separation, i.e., absence of collision, and should not be confused with the provision of ATC minimum separation.) TCAS II operating procedures give RAs priority over ATC clearances and instructions, i.e., flight crews are instructed to follow an RA even when it conflicts with ATC guidance. Controllers have no knowledge of a TCAS RA unless notified by the flight crew via the radio. (RA information is provided by TCAS II to Mode S SSRs, but it is not normally presented to controllers.) Only wind shear warnings and Ground Proximity Warning System warnings have higher priority than a TCAS RA. Results of United States and European safety studies show that there is a significant safety benefit to be gained from the widespread carriage and operation of TCAS II, specifically, the risk of mid-air collision is reduced by at least a factor of three. Globally, operational experience has shown that TCAS II has significantly improved the safety of flight.

Note: There are three members of the TCAS family. TCAS I is a pilot warning indicator which displays proximate traffic and alerts the crew to other aircraft which may become potential near midair collision threats. TCAS II in addition provides recommended vertical escape maneuvers to the crew to avert potential near midair collisions. The term TCAS IV is reserved for future TCAS equipment that has additional capabilities beyond those of TCAS II equipment to generate resolution advisories in the horizontal plane (e.g., "TURN RIGHT," "TURN LEFT"). The equipment described by this document does not have horizontal resolution capability. In this document, TCAS I is denoted "TCAS I"; the use of the unqualified term "TCAS" refers exclusively to TCAS II; and TCAS IV is explicitly denoted "TCAS IV".

© 2008, RTCA, Inc.

TCAS provides an effective collision avoidance function in traffic densities as high as 0.3 aircraft per square nautical mile (24 transponder-equipped aircraft within five nautical miles of the TCAS-equipped aircraft).

When TCAS operates in traffic densities of 0.3 transponder-equipped aircraft per square nautical mile or higher, it provides protection against collisions with other aircraft that are closing at speeds of less than 500 kt. TCAS is also capable of providing protection against aircraft closing at relative speeds of up to 1200 kt in airspace characterized by densities of less than 0.06 transponder-equipped aircraft per square nautical mile, which is equivalent to eighteen transponder-equipped aircraft within ten nautical miles of the TCAS aircraft.

In addition to the minimum standards contained in this document, several options are described herein which will allow TCAS to request and/or receive information from other MODE S-equipped aircraft. These optional features provide for the exchange of information via the proposed MODE S extended squitter or an air-to-air data link. The purpose for including these options in this standard is to permit a uniform minimum capability to upgrade or enhance TCAS in the future. The specific applications for these optional features and the applications' corresponding minimum operational performance characteristics are not part of these standards.

Incorporated within these standards are system characteristics that should be of value to users, designers, manufacturers, and installers. These characteristics are intended to accommodate the requirements of various users.

This document is published in two volumes.

Section 1.0 of Volume I is intended to provide information needed to understand the rationale for equipment characteristics and requirements stated in the remaining sections. It describes typical equipment applications and operational goals and is the basis for the standards stated in the document. Definitions essential to proper understanding of this document are also provided in Section 1.0.

Section 2.0 of Volume I contains the minimum performance standards for the equipment. These standards define the required performance under standard operating conditions and stressed physical environmental conditions. Section 2.0 includes as guidance material an overview of the TCAS collision avoidance algorithms. It also details the recommended bench test procedures necessary to demonstrate compliance, including specific bench tests for the collision avoidance logic performance.

Section 3.0 of Volume I describes the performance required of the installed equipment. Tests for the installed equipment are included when performance cannot be adequately determined through bench testing.

Volume II contains the required collision avoidance algorithms. The algorithms are presented in a state chart formulation with informational commentary text. In addition, Attachment A of Volume II contains both high and low level pseudocode representations of the collision avoidance algorithms which have been formally proven to be in accordance with the state chart formulation.

Both Volumes I and II contain certain standards and performance requirements that are intended to ensure that TCAS II is fully interoperable (see 1.7.5) with other airspace elements and equipment. It is mandatory that all interoperability provisions be met

© 2008, RTCA, Inc.

without exception or deviation. Other technical and performance requirements stated herein that were derived from the particular implementation approach that formed the basis for the development of this MOPS may be waived if the manufacturer or installer provides evidence of equivalent system performance for an alternative method of implementation and if the alternative implementation does not violate interoperability provisions.

Since the measured values of equipment performance characteristics may be functions of the methods of measurement, standard test conditions and methods of test are recommended in this document.

"TCAS equipment" as used herein includes all components or units necessary (as determined by the manufacturer or installer) for the equipment to perform its function properly with the exception of the Mode S transponder. It should not be inferred that each TCAS equipment design will necessarily have all components or units in separate packages. This will depend on the specific design chosen by the manufacturer. The transponder capabilities may also be implemented as part of the TCAS avionics package but the term "TCAS equipment" will refer only to the TCAS portion of this package. Additional functions and components that may provide expanded equipment capabilities are identified. Other equipment features that are beyond the scope of this document may be described in future RTCA documents.

If the equipment implementation includes a computer software package, compliance with the guidelines contained in RTCA/DO-178B, Software Considerations in Airborne Systems and Equipment Certification, December 1, 1992, and all changes thereto, is required.

1.2 System Overview

The TCAS equipment in the aircraft interrogates air traffic control transponders on aircraft in its vicinity and listens for the transponder replies. By computer analysis of these replies, the airborne TCAS equipment determines which aircraft represent potential collision threats and provides appropriate display indications (or advisories) to the flight crew to avoid collision.

The TCAS equipment described in this document is capable of providing two classes of advisories. Resolution advisories (RAs) indicate vertical maneuvers that are predicted to either increase or maintain the existing vertical separation from threatening aircraft. Traffic advisories (TAs) indicate the positions of intruding aircraft that may later cause resolution advisories to be displayed. All TCAS equipment described in this document display traffic and resolution advisories.

The resolution advisories described herein do not indicate horizontal escape maneuvers and therefore are not intended to increase horizontal separation. Vertical separation is based upon predictions from own and intruder altitude data supplied to the TCAS unit assuming that the intruder does not maneuver.

Traffic advisories indicate the range, range rate, altitude, altitude rate and bearing (when available) of the intruding aircraft relative to own aircraft. Traffic advisories without altitude information are also provided on non-altitude reporting, transponder-equipped aircraft.

© 2008, RTCA, Inc.

Minimum Operational Performance Standards for Traffic Alert and Collision Avoidance System II (TCAS II)

Collision Avoidance System (CAS) Requirements Specification

Version 7.1

Volume II

June 19, 2008
© 2008, RTCA, Inc.

This page intentionally left blank.

TABLE OF CONTENT

TABLE OF CONTENT i
TABLE OF FIGURES x
TABLE OF STATES xii
TABLE OF VARIABLES xv
1. ENVIRONMENT 1
1.1 Components 2
1.2 Input Interfaces 3
1.2.1 Interface: Resolution_Message 4
1.2.2 Interface: Sensitivity_Level_Command 6
1.2.3 Interface: Altitude_Message (Fine Altitude Case) 7
1.2.4 Interface: Altitude_Message (Coarse Altitude Case) 8
1.2.5 Interface: Own_Update_Message 9
1.2.6 Interface: Surveillance_Report 10
1.2.7 Interface: Surveillance_Complete_Report 12
1.2.8 Interface: Radio_Altitude_Report 13
1.2.9 Interface: Radio_Altitude_Status 14
1.2.10 Interface: Aircraft_Discrete_Values 15
1.2.11 Interface: TCAS_Operational_Status 16
1.2.12 Interface: Coordination_Reply 17
1.2.13 Interface: Coordination_Reply_Timeout 18
1.2.14 Interface: Ground_Report 19
1.2.15 Interface: Altitude_Alerter_Report 20
1.3 Output Interfaces 21
1.3.1 Interface: Coordination_Update 22
1.3.2 Interface: Vert_Resolution_Message 23
1.3.3 Interface: Intruder_Info 24
1.3.4 Interface: Sound_Aural_Alarm 25
1.3.5 Interface: Resolution_Advisory 25
1.3.6 Interface: Own_Altitude_Credibility_Message 26
1.3.7 Interface: Coordination_Update_Version_7 27
1.3.8 Interface: RA_Broadcast_Message 28
1.3.9 Interface: SLC_Update_Message 30
1.3.10 Interface: Data_Link_Capability_Report 31
1.3.11 Interface: Surveillance_Update_Message 32
1.3.12 Interface: Surveillance_Traffic_Message 33
2. COLLISION AVOIDANCE SYSTEM 34
2.1 Own Aircraft 40
2.1.1 Input 42
2.1.2 Output 60
2.1.3 Identity Transitions 72
2.1.4 Alt_Layer 74
2.1.5 Descend_Inhibit 80
2.1.6 Increase_Descend_Inhibit 82
2.1.7 Climb_Inhibit 84

© 2008, RTCA, Inc.

2.1.8 Increase_Climb_Inhibit 87
2.1.9 Auto_SL 89
2.1.10 Effective_SL 97
2.1.11 Advisory_Status 104
2.1.11.1 Composite_RA 106
2.1.11.1.1 RA 111
2.1.11.1.1.1 Negative 112
2.1.11.1.1.1.1 Climb_VSL 113
2.1.11.1.1.1.2 Descend_VSL 118
2.1.11.2 Corrective_Climb 123
2.1.11.3 Corrective_Descend 126
2.1.11.4 Combined_Control 128
2.1.11.5 Vertical_Control 133
2.1.12 RA_Mode 139
2.1.13 Broadcast_Cycle 141
2.1.14 Own_Air_Status 143
2.1.15 Altitude_Alerter 145
2.1.16 Own_Tracker 147
2.1.17 Switch_Own_Tracker 150
2.1.18 Own_Tracker_Softness 153
2.2 Other_Aircraft 157
2.2.1 Input 159
2.2.2 Output 176
2.2.3 Identity Transitions 183
2.2.4 Track_Status 187
2.2.4.1 Tracked 192
2.2.4.1.1 Alt_Reporting 193
2.2.4.1.2 Intruder_Status 196
2.2.4.1.2.1 Threat 207
2.2.4.1.2.1.1 Range_Test 209
2.2.4.1.2.1.2 Reversal_Inhibit 211
2.2.4.1.2.1.3 Crossing 212
2.2.4.1.2.1.4 Reversal 217
2.2.4.1.2.1.5 Sense 221
2.2.4.1.2.1.5.1 Climb, Descend 229
2.2.4.1.2.1.5.1.1 Consider_Reversal 230
2.2.4.1.2.1.5.1.2 Strength 232
2.2.4.1.2.1.5.1.2.1 Nominal_1500fpm 255
2.2.4.1.2.1.5.1.3 TCAS_Level_Off 258
2.2.4.1.2.1.6 Status 261
2.2.4.1.3 Level_Wait 262
2.2.4.1.4 Intruder_Status_Sync 266
2.2.4.1.5 Display_Arrow 269
2.2.4.1.6 Traffic_Display_Status 271
2.2.4.1.7 Tau_Rising 273
2.2.4.1.8 Cap_Tau_Calculations 276

 © 2008, RTCA, Inc.

2.2.4.1.9 Horizontal_Miss_Distance_RA_Filter....278
2.2.4.1.9.1 Range_Track_Firmness....280
2.2.4.1.9.2 Range_Bearing_Track_Firmness....283
2.2.4.1.9.3 Range_Trackers....290
2.2.4.1.9.4 Range_Bearing_Tracker....292
2.2.4.1.9.5 Range_Bearing_Tracker_Consistency_Check....294
2.2.4.1.9.6 Maneuver_Detection_Countdown_Timer....297
2.2.4.1.9.7 HMD_Test_Counter....301
2.2.4.1.9.8 Filter_Status....303
2.2.5 RM_Send_Status....305
2.2.6 RM_Count_This_Cycle....309
2.2.7 Intent_Received....312
2.3 Vertical_Tracker....314
2.3.1 Input....315
2.3.2 Identity Transitions....321
2.3.3 100ft_Tracker....323
2.3.3.1 Validity_Check_Prior_To_Switch_To_25ft_Tracker....326
2.3.3.2 Bin_Direction....328
2.3.3.3 100ft_Bin_Transition_Status....332
2.3.3.3.1 Trend....337
2.3.3.4 100ft_Firmness....339
2.3.4 25ft_Tracker....345
2.3.4.1 Validity_Check_Prior_To_Switch_To_100ft_Tracker....348
2.3.4.2 Initialization....350
2.3.4.3 25ft_Bin_Transition_Status....352
2.3.4.4 25ft_Firmness....355
2.4 Mode S Ground Station....362
2.4.1 Input....363
2.4.2 Mode_S_Ground_Station....364
3. MACROS....366
3.1 Macro: 100ft_Crossing....366
3.2 Macro: Aircraft_Maneuver_Adversely....366
3.3 Macro: All_Other_Aircraft_Evaluated....367
3.4 Macro: Alt_Separation_Test....368
3.5 Macro: Any_Crossing....369
3.6 Macro: Any_Increase....369
3.7 Macro: Any_Maintain....370
3.8 Macro: Any_Reverse....371
3.9 Macro: Approaching_Alerter_Assigned_Altitude....372
3.10 Macro: Aural_Alarm_Condition....373
3.11 Macro: Climb_Descend_Inhibit....373
3.12 Macro: Climb_RA_Weakened....374
3.13 Macro: Composite_RA_In_Same_State....374
3.14 Macro: Consider_Increase_Projections....375
3.15 Macro: Corrective_Strength_Has_Changed....375
3.16 Macro: Crossing_RA....376

© 2008, RTCA, Inc.

3.17 Macro: Crossing_Reversal_Geometry 377
3.18 Macro: Descend_RA_Weakened 378
3.19 Macro: Extreme_Alt_Check 378
3.20 Macro: HMD_Bearing_Logic_Reliability 379
3.21 Macro: HMD_Intruder_Selection_Test 380
3.22 Macro: HMD_Maneuver_Detected 381
3.23 Macro: HMD_Range_Bearing_Tracker_Initialization 382
3.24 Macro: HMD_Tracker_Lost 382
3.25 Macro: Insufficient_Separation(Position, Threshold) 383
3.26 Macro: MA_Aircraft_Conflicting(i, j) 384
3.27 Macro: MA_All_Climb 385
3.28 Macro: MA_All_Descend 386
3.29 Macro: MA_Choose_Reverse_Increase(New_Threat, Other_Aircraft) 387
3.30 Macro: MA_Conflicting_Composite_RA(i) 388
3.31 Macro: MA_Converging_Test 389
3.32 Macro: MA_Increase_Inhibited_Macro(i) 391
3.33 Macro: MA_Individual_Reversal_Triggered 392
3.34 Macro: MA_Positive_Reversal_Test 393
3.35 Macro: MA_Retention_Level_OK(New_Threat, Other_Threat) 395
3.36 Macro: MA_Reversal_From_Level(Other_Threat) 396
3.37 Macro: MA_Reversal_From_Positive(Other_Threat) 397
3.38 Macro: MA_Select_Level_Now(New_Threat, Other_Threat) 398
3.39 Macro: MA_Simultaneous_Retain(Other_Threat) 399
3.40 Macro: MA_Switch_Sense_Cont(i) 400
3.41 Macro: MA_Switch_Sense_New(New_Threat, Other_Threat) 401
3.42 Macro: MA_TCAS_TCAS_Controlled(i) 402
3.43 Macro: MA_Threat_New_Or_Deferred(i) 402
3.44 Macro: Multiple_Threats 403
3.45 Macro: New_Climb_RA_Crossing 403
3.46 Macro: New_Descend_RA_Crossing 404
3.47 Macro: New_Increase_Climb 405
3.48 Macro: New_Increase_Descend 405
3.49 Macro: No_Strengthen 406
3.50 Macro: No_Vertical_Intent 406
3.51 Macro: No_Weaken_Positive(Threshold) 407
3.52 Macro: Noncrossing_Biased_Climb 408
3.53 Macro: Noncrossing_Biased_Descend 409
3.54 Macro: Not_Exceeding_Increase_Rate 410
3.55 Macro: Not_Meeting_Climb_Goal 410
3.56 Macro: Not_Meeting_Descend_Goal 411
3.57 Macro: Own_Altitude_Coast 412
3.58 Macro: Own_Tracker_Lagging 413
3.59 Macro: Performance_Monitor_Select_SL_1 413
3.60 Macro: Potential_Threat_Alt_Test 414
3.61 Macro: Potential_Threat_Condition 415
3.62 Macro: Potential_Threat_Range_Test 415

 © 2008, RTCA, Inc.

3.63 Macro: Preventive_To_Corrective 417
3.64 Macro: Proximate_Traffic_Condition 417
3.65 Macro: RA_Achieves_Enough_Separation 418
3.66 Macro: RA_Inhibit 419
3.67 Macro: RA_Strength_Changed 420
3.68 Macro: Radar_Bad_For_RADARLOST_Cycles 421
3.69 Macro: Report_Matches(SURVNO, IDINTR) 421
3.70 Macro: Reversal_Conditions 422
3.71 Macro: Reversal_Geometry 423
3.72 Macro: CP112E_Reversal_Geometry 426
3.73 Macro: CP112E_Cancel_Reversal 431
3.74 Macro: CP112E_Own_Not_Follow_Reversal 432
3.75 Macro: CP112E_VMD_2_Out_3 434
3.76 Macro: CP112E_VMD_Reversal 435
3.77 Macro: SL_Change_Inhibited 438
3.78 Macro: Some_Threat_Altitude_Lost 438
3.79 Macro: Some_Threat_Clear_Of_Conflict 439
3.80 Macro: Some_Threat_Track_Dropped 439
3.81 Macro: Standby_Condition 440
3.82 Macro: Standby_Since(i) 440
3.83 Macro: Strength_Modeling_Enabled 441
3.84 Macro: TCAS_Initialized 442
3.85 Macro: TCAS_Intent_Select_Climb 443
3.86 Macro: TCAS_Intent_Select_Descend 444
3.87 Macro: TCAS_TCAS_Crossing_Test 445
3.88 Macro: TCAS_TCAS_Level_Off 446
3.89 Macro: Test_VSL_Rate(Rate) 447
3.90 Macro: Threat_Alt_Test 449
3.91 Macro: Threat_Condition 451
3.92 Macro: Threat_Range_Test 453
3.93 Macro: Try_VSL_Test(Threshold) 454
3.94 Macro: Two_Of_Three 456
3.95 Macro: Valid_Resolution_Message(VSB, CVC, VRC, CHC, HRC, HSB) 456
3.96 Macro: VSL_OK(VSL_RATE, TAU, ALIMOD, OTHER_RATE) 457
3.97 Macro: VT_100ft_Coast 458
3.98 Macro: VT_100ft_No_Transition 459
3.99 Macro: VT_100ft_Spurious_Oscillation 459
3.100 Macro: VT_100ft_Tracker_Active 460
3.101 Macro: VT_100ft_Transition 460
3.102 Macro: VT_100ft_Transition_Overdue_Poor_Firmness 461
3.103 Macro: VT_25ft_Coast 462
3.104 Macro: VT_Credible_Report(T, DZM, TSTART, TDAT, ZD, QUANT) 463
4. CAS FUNCTIONS 464
4.1 Function: Alerter_Altitude 464
4.2 Function: Alerter_Transition_Time 465
4.3 Function: Alt_Layer_Value 466

© 2008, RTCA, Inc.

4.4 Function: Climb_Goal 467
4.5 Function: Climb_Strength 468
4.6 Function: Conflict_SL 469
4.7 Function: Current_Vertical_Separation 470
4.8 Function: CVC 471
4.9 Function: Descend_Goal 473
4.10 Function: Descend_Strength 474
4.11 Function: Displayed_Model_Goal 475
4.12 Function: Down_Separation(Model_Type) 477
4.13 Function: HMD_Acceleration_Threshold 479
4.14 Function: HMD_Cartesian_Predicted_Acceleration 480
4.15 Function: HMD_Cartesian_Predicted_Range 481
4.16 Function: HMD_Cartesian_Predicted_Range_Rate 483
4.17 Function: HMD_Cartesian_Smoothed_Acceleration 485
4.18 Function: HMD_Cartesian_Smoothed_Range 487
4.19 Function: HMD_Cartesian_Smoothed_Range_Rate 488
4.20 Function: HMD_dt 489
4.21 Function: HMD_dtb 490
4.22 Function: HMD_Horizontal_Miss_Distance 491
4.23 Function: HMD_Parabolic_Predicted_Acceleration 494
4.24 Function: HMD_Parabolic_Predicted_Range 495
4.25 Function: HMD_Parabolic_Predicted_Range_Rate 496
4.26 Function: HMD_Parabolic_Residual_Standard_Deviation 497
4.27 Function: HMD_Parabolic_Smoothed_Acceleration 498
4.28 Function: HMD_Parabolic_Smoothed_Acceleration_Rate 499
4.29 Function: HMD_Parabolic_Smoothed_Range 500
4.30 Function: HMD_Parabolic_Smoothed_Range_Rate 501
4.31 Function: HMD_RB_cosb 503
4.32 Function: HMD_RB_hmd 505
4.33 Function: HMD_RB_Orthoradial_Positional_Smoothing_Parameter 507
4.34 Function: HMD_RB_Orthoradial_Range_Residual 509
4.35 Function: HMD_RB_Orthoradial_Range_Residual_Sign 510
4.36 Function: HMD_RB_Orthoradial_Velocity_Smoothing_Parameter 512
4.37 Function: HMD_RB_Predicted_Cov_0_0 514
4.38 Function: HMD_RB_Predicted_Cov_0_1 516
4.39 Function: HMD_RB_Predicted_Cov_1_1 517
4.40 Function: HMD_RB_Radial_Range_Residual 518
4.41 Function: HMD_RB_sinb 519
4.42 Function: HMD_RB_Smoothed_Cov_0_0 521
4.43 Function: HMD_RB_Smoothed_Cov_0_1 523
4.44 Function: HMD_RB_Smoothed_Cov_1_1 525
4.45 Function: HMD_RB_Smoothed_X_Position 527
4.46 Function: HMD_RB_Smoothed_X_Speed 528
4.47 Function: HMD_RB_Smoothed_Y_Position 529
4.48 Function: HMD_RB_Smoothed_Y_Speed 531
4.49 Function: Increase_Separation(DIRECTION) 532

 © 2008, RTCA, Inc.

4.50 Function: Inhibit_Biased_Climb(Model_Type) 534
4.51 Function: Last_Own_Fine_Track_Update_Time 535
4.52 Function: Latest_Threat 536
4.53 Function: Level_Separation(i) 537
4.54 Function: Lowest_Ground 538
4.55 Function: Min_Current_Increase_RA_Separation(Threat1, Threat2) 539
4.56 Function: Min_Reverse_Separation(Reverse_Threat, Other_Threat) 540
4.57 Function: Modified_Own_Tracked_Altitude 541
4.58 Function: Modified_Own_Tracked_Altitude_Rate 542
4.59 Function: Modified_Tau_Capped 543
4.60 Function: Modified_Tau_Uncapped 544
4.61 Function: New_Threat_Type 545
4.62 Function: Number_Of_Attempts 546
4.63 Function: Other_Alt_Rate_At_RA 547
4.64 Function: Other_Projected_Alt 548
4.65 Function: Other_Track_Firmness 549
4.66 Function: Other_Tracked_Alt 550
4.67 Function: Other_Tracked_Alt_Rate 551
4.68 Function: Other_Tracked_Alt_Rate_Inner 552
4.69 Function: Other_Tracked_Alt_Rate_Outer 553
4.70 Function: Other_Tracked_Range 554
4.71 Function: Other_Tracked_Range_Rate 555
4.72 Function: Other_Tracked_Relative_Alt 556
4.73 Function: Other_Tracked_Relative_Alt_Rate 557
4.74 Function: Own_Alt_At_RA 558
4.75 Function: Own_Alt_Rate_At_RA 559
4.76 Function: Own_Fine_Tracked_Alt 560
4.77 Function: Own_Fine_Tracked_Alt_Rate 561
4.78 Function: Own_Tracked_Alt 563
4.79 Function: Own_Tracked_Alt_Rate 564
4.80 Function: Reverse_Separation(i) 565
4.81 Function: Separation(ZDGOAL, DELAY, ACCEL, DIRECTION, ZOWN, ZDOWN, ZINT, ZDINT, START_TIME) 567
4.82 Function: Separation_At_Current_RA 570
4.83 Function: Separation_Second_Choice 571
4.84 Function: SL_Altitude 573
4.85 Function: Status_Of_Track 574
4.86 Function: Threat_ID 575
4.87 Function: Time_Advisory_Changed 577
4.88 Function: Time_Last_New_RA 578
4.89 Function: Time_Positive_RA 579
4.90 Function: Time_To_Co_Alt 580
4.91 Function: Traffic_Score 581
4.92 Function: True_Tau_Capped 583
4.93 Function: True_Tau_Uncapped 584
4.94 Function: Up_Separation(Model_Type) 585

© 2008, RTCA, Inc.

4.95 Function: Version_7_ARA 587
4.96 Function: Vertical_Miss_Distance(RELZ, RELZD, TAU1, TAU2, CLIP) 590
4.97 Function: Vertical_Projection(TPROJ, Z, ZD, ZDGOAL, DELAY, ACCEL) 591
4.98 Function: Vertical_Rate_Projection(TPROJ, Z, ZD, ZDGOAL, DELAY, ACCEL) 592
4.99 Function: VRC 593
4.100 Function: VSB(CVC, VRC) 594
4.101 Function: VT_100ft_Bin_Cross_Estimate 595
4.102 Function: VT_100ft_Bins_At_Rate 597
4.103 Function: VT_100ft_Bins_At_Rate_Update_For_Transition 599
4.104 Function: VT_100ft_Bins_Crossed 601
4.105 Function: VT_100ft_Firmness_AB_Transition 602
4.106 Function: VT_100ft_Firmness_No_Transition 604
4.107 Function: VT_100ft_Firmness_Prior_To_Coast 606
4.108 Function: VT_100ft_Firmness_Trend_Transition 608
4.109 Function: VT_100ft_Firmness_Value 610
4.110 Function: VT_100ft_Last_Alt_Report_Time 611
4.111 Function: VT_100ft_Predicted_Altitude 612
4.112 Function: VT_100ft_Previous_Alt_Report 613
4.113 Function: VT_100ft_Start_Oscil_Time 614
4.114 Function: VT_100ft_Start_Tracking_Time 615
4.115 Function: VT_100ft_Time_In_Bin 616
4.116 Function: VT_100ft_Tracked_Alt 617
4.117 Function: VT_100ft_Tracked_Alt_Rate 619
4.118 Function: VT_100ft_Tracked_Alt_Rate_Inner 621
4.119 Function: VT_100ft_Tracked_Alt_Rate_Outer 626
4.120 Function: VT_100ft_Transition_Time 632
4.121 Function: VT_100ft_Transition_Time_Residual_Error 635
4.122 Function: VT_100ft_Trend_Tracked_Alt 637
4.123 Function: VT_100ft_Trend_Tracked_Alt_Rate 640
4.124 Function: VT_100ft_Trend_Transition_Rate_Bound(Bound_Type) 643
4.125 Function: VT_25ft_AB_Index_Level 645
4.126 Function: VT_25ft_AB_Tracked_Alt 646
4.127 Function: VT_25ft_AB_Tracked_Alt_Accel 648
4.128 Function: VT_25ft_AB_Tracked_Alt_Rate 650
4.129 Function: VT_25ft_Firmness_Prior_To_Coast 652
4.130 Function: VT_25ft_Last_Alt_Report_Time 653
4.131 Function: VT_25ft_Predicted_Altitude 654
4.132 Function: VT_25ft_Previous_Alt_Report 655
4.133 Function: VT_25ft_Start_Tracking_Time 656
4.134 Function: VT_25ft_Track_Firmness_Value 657
4.135 Function: VT_25ft_Tracked_Alt 658
4.136 Function: VT_25ft_Tracked_Alt_Rate 659
4.137 Function: VT_25ft_Tracked_Alt_Rate_Inner 660
4.138 Function: VT_25ft_Tracked_Alt_Rate_Outer 662
4.139 Function: VT_25ft_Transition_Time 664
4.140 Function: ZDPROJ_From_RA 665

 © 2008, RTCA, Inc.

TABLE OF CONTENTS

4.141 Function: ZPROJ_From_RA 666
APPENDIX A: Constant Definitions 1
APPENDIX B: Table Definitions 1
APPENDIX C: Event Definitions 1
APPENDIX D: Notation 1
D.1 Basic Statechart Diagrams 1
D.2 Parallel States 2
D.3 Statechart Array 3
D.4 Conditional Connective 4
D.5 Transition Bus 5
D.6 Transitions 5
D.6.1 Identification 6
D.6.2 Location 6
D.6.3 Triggering Event 7
D.6.4 Condition 7
D.6.5 Output Action 8
D.7 Macros, Functions and Abbreviations 8
D.7.1 Macros 8
D.7.2 Functions 9
D.7.3 Abbreviations 10
D.8 Identity Transitions 10
D.9 Interface 10
D.9.1 Variable Descriptions 11
D.10 Time 12
D.10.1 Synchrony Hypothesis 12
D.11 Constants 12
D.12 Retained Values 12
APPENDIX E: Table of Symbols 1

© 2008, RTCA, Inc.

TABLE OF FIGURES

Figure 1-1: TCAS System Components 2
Figure 2-1: TCAS_Controller 34
Figure 2-2: Power_On 37
Figure 2-3: Own_Aircraft 40
Figure 2-4: Alt_Layer 74
Figure 2-5: Descend_Inhibit 80
Figure 2-6: Increase_Descend_Inhibit 82
Figure 2-7: Climb_Inhibit 84
Figure 2-8: Increase_Climb_Inhibit 87
Figure 2-9: Auto_SL 89
Figure 2-10: Effective_SL 97
Figure 2-11: Advisory_Status 104
Figure 2-12: Composite_RA 106
Figure 2-13: RA 111
Figure 2-14: Negative 112
Figure 2-15: Climb_VSL 113
Figure 2-16: Descend_VSL 118
Figure 2-17: Corrective_Climb 123
Figure 2-18: Corrective_Descend 126
Figure 2-19: Combined_Control 128
Figure 2-20: Vertical_Control 133
Figure 2-21: RA_Mode 139
Figure 2-22: Broadcast_Cycle 141
Figure 2-23: Own_Air_Status 143
Figure 2-24: Altitude_Alerter 145
Figure 2-25: Own_Tracker 147
Figure 2-26: Switch_Own_Tracker 150
Figure 2-27: Own_Tracker_Softness 153
Figure 2-28: Other_Aircraft 157
Figure 2-29: Track_Status 187
Figure 2-30: Tracked 192
Figure 2-31: Alt_Reporting 193
Figure 2-32: Intruder_Status 196
Figure 2-33: Threat 207
Figure 2-34: Range_Test 209
Figure 2-35: Reversal_Inhibit 211
Figure 2-36: Crossing 212
Figure 2-37: Reversal 217
Figure 2-38: Sense 221
Figure 2-39: Climb, Descend 229
Figure 2-40: Consider_Reversal 230
Figure 2-41: Strength 232
Figure 2-42: Nominal_1500fpm 255
Figure 2-43: TCAS_Level_Off 258

 © 2008, RTCA, Inc.

TABLE OF FIGURES

Figure 2-44: Status 261
Figure 2-45: Level_Wait 262
Figure 2-46: Intruder_Status_Sync 266
Figure 2-47: Display_Arrow 269
Figure 2-48: Traffic_Display_Status 271
Figure 2-49: Tau_Rising 273
Figure 2-50: Cap_Tau_Calculations 276
Figure 2-51: Horizontal_Miss_Distance_RA_Filter 278
Figure 2-52: RM_Send_Status 305
Figure 2-53: RM_Count_This_Cycle 309
Figure 2-54: Intent_Received 312
Figure 2-55: Vertical_Tracker 314
Figure 2-56: 100ft_Tracker 323
Figure 2-57: Validity_Check_Prior_To_Switch_To_25ft_Tracker 326
Figure 2-58: Bin_Direction 328
Figure 2-59: 100ft_Bin_Transition_Status 332
Figure 2-60: Trend 337
Figure 2-61: 100ft_Firmness 339
Figure 2-62: 25ft_Tracker 345
Figure 2-63: Validity_Check_Prior_To_Switch_To_100ft_Tracker 348
Figure 2-64: Initialization 350
Figure 2-65: 25ft_Bin_Transition_Status 352
Figure 2-66: 25ft_Firmness 355
Figure 2-67: Mode_S_Ground_Station 362
Figure D-1: A Basic Statechart 1
Figure D-2: A Superstate 2
Figure D-3: A Parallel State 3
Figure D-4: A Statechart Array 3
Figure D-5: Conditional Connectives 4
Figure D-6: Transition Busses 5
Figure D-7: A Macro Reference 9
Figure D-8: A Simple Macro 9
Figure D-9: A Parameterized Macro 9
Figure D-10: A Sample Variable Definition 11

© 2008, RTCA, Inc.

TABLE OF STATES

100ft_Bin_Transition_Status 332
100ft_Firmness 339
100ft_Tracker 323
25ft_Bin_Transition_Status 352
25ft_Firmness 355
25ft_Tracker 345
Advisory_Status 104
Alt_Layer 74
Alt_Reporting 193
Altitude_Alerter 145
Auto_SL 89
Bin_Direction 328
Broadcast_Cycle 141
Cap_Tau_Calculations 276
Climb 229
Climb_Inhibit 84
Climb_VSL 113
Combined_Control 128
Composite_RA 106
Consider_Reversal 230
Corrective_Climb 123
Corrective_Descend 126
Crossing 212
Descend 229
Descend_Inhibit 80
Descend_VSL 118
Display_Arrow 269
Effective_SL 97
Filter_Status 303
Fully_Operational 34
HMD_Test_Counter 301
Horizontal_Miss_Distance_RA_Filter 278
Increase_2500fpm 232
Increase_Climb_Inhibit 87
Increase_Descend_Inhibit 82
Initialization 350
Intent_Received 312
Intruder_Status 196
Intruder_Status_Sync 266
Level_Wait 262
Maneuver_Detection_Countdown_Timer 297
Mode_S_Ground_Station 362
Negative (Substate of RA) 112
Negative (Substate of Strength) 232

 © 2008, RTCA, Inc.

No_RA 106
Nominal_1500fpm 255
Not_Tracked 187
Not_Tracking (Substate of 100ft_Tracker) 323
Not_Tracking (Substate of 25ft_Tracker) 345
Other_Aircraft 157
Other_Traffic 196
Own_Air_Status 143
Own_Aircraft 40
Own_Tracker 147
Own_Tracker_Softness 153
Positive (Substate of RA) 106
Positive (Substate of Strength) 232
Potential_Threat 196
Power_Off 34
Power_On 37
Proximate_Traffic 196
RA 111
RA_Deferal 232
RA_Mode 139
Range_Bearing_Track_Firmness 283
Range_Bearing_Tracker 292
Range_Bearing_Tracker_Consistency_Check 294
Range_Test 209
Range_Track_Firmness 280
Range_Trackers 290
Reversal 217
Reversal_Inhibit 211
RM_Count_This_Cycle 309
RM_Send_Status 305
Sense 221
Sense_Not_Selected 221
Standby 34
Status 261
Strength 232
Switch_Own_Tracker 150
Tau_Rising 273
TCAS_Controller 36
TCAS_Level_Off 258
Threat 207
Threat_Not_Tracked 187
Track_Status 187
Tracked 192
Tracking (Substate of 100ft_Tracker) 323
Tracking (Substate of 25ft_Tracker) 345
Traffic_Display_Status 271

© 2008, RTCA, Inc.

Trend 337
Validity_Check_Prior_To_Switch_To_100ft_Tracker 348
Validity_Check_Prior_To_Switch_To_25ft_Tracker 326
Vertical_Control 133
Vertical_Tracker 314

 © 2008, RTCA, Inc.

TABLE OF VARIABLES

Advisory_Code 182
Aircraft_Altitude_Limit 51
Alerter_Data_Available 58
Alerter_Value 57
Alt_Report 317
Altitude_Climb_Inhib_Active 53
Altitude_Reporting 316
Aural_Alarm_Inhibit 61
Barometric_Altimeter_Status 49
Climb_RA 65
Combined_Control_Out 62
Config_Climb_Inhibit 52
Crossing_Out 64
Descend_RA 66
Display_Arrow_Out 176
Ground_Commanded_SL 363
Ground_Level 47
Horizontal_RAC 70
Increase_Climb_Inhibit_Discrete 54
Initial_Alt_Rate 319
Mode_S_Version 55
Mode_Selector 45
Other_Alt 159
Other_Alt_Reporting 165
Other_Alt_Reporting_Out 181
Other_Alt_Valid 170
Other_Bearing 171
Other_Bearing_Measurement 174
Other_Bearing_Measurement_Valid 175
Other_Bearing_OK_Out 180
Other_Bearing_Out 179
Other_Bearing_Valid 173
Other_Capability 164
Other_HRC 162
Other_Mode_S_Address 160
Other_Range 167
Other_Range_Out 178
Other_Range_Valid 169
Other_Relative_Alt_Out 177
Other_Sensitivity_Level 163
Other_VRC 161
Own_Alt_Barometric 44
Own_Alt_Radio 43
Own_Corrected_Altitude 59

© 2008, RTCA, Inc.

Own_Goal_Alt_Rate 67
Own_Mode_A_Address 56
Own_Mode_S_Address 48
Radio_Altimeter_Status 46
Range_Report_Time_Stamp 168
Report_Time 318
Sound_Aural_Alarm 60
Surveillance_Mode 172
Surveillance_No 166
TCAS_Operational_Status 42
Track_Quant 320
Traffic_Display_Permitted 50
Valid_Report 315
Vertical_Control_Out 63
Vertical_RAC 68

 © 2008, RTCA, Inc.

1. ENVIRONMENT

This chapter describes assumptions regarding the behavior of the non-Collision Avoidance System (CAS) components of the TCAS II system. The CAS requirements are based on these assumptions. Effects of their violation should be carefully considered. This is the first chapter to use state chart notation, which is described in Appendix D. Symbols used in this document are defined in Appendix E. When comparing or assigning numerical values, the units of measurement must be considered. For example, 10 ft is less than 1 nmi.

© 2008, RTCA, Inc.