

RTCA  
1828 L Street, NW, Suite 805  
Washington, DC 20036

**Minimum Operational Performance Standards for Airborne Area Navigation  
Equipment Using a Single Collocated VOR/DME Sensor Input**

RTCA DO-180A  
May 24, 1990

Prepared by:  
SC-137

Copies of this document may be obtained from

RTCA, Incorporated  
1828 L Street, NW, Suite 805  
Washington, D.C. 20036-5133 U.S.A.

Telephone: 202-833-9339

Facsimile: 202-833-9434

Internet: [www.rtca.org](http://www.rtca.org)

Please contact RTCA for price and ordering information.

## F O R E W O R D

This document was prepared by Special Committee 137 of the Radio Technical Commission for Aeronautics. It was approved by RTCA on May 24, 1990 and supersedes RTCA/DO-180, *Minimum Operational Performance Standards for Airborne Area Navigation Equipment Using VOR/DME Reference Facility Sensor Inputs*, approved September 17, 1982.

RTCA is an association of aeronautical organizations of the United States from both government and industry. Dedicated to the advancement of aeronautics, RTCA seeks sound technical solutions to problems involving the application of electronics and telecommunications to aeronautical operations. Its objective is the resolution of such problems by mutual agreement of its member organizations.

The findings of RTCA are in the nature of recommendations to all organizations concerned. 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.

Coordination of these standards was accomplished by RTCA SC-137 with the European Organisation for Civil Aviation Equipment (EUROCAE) WG-13.

THIS PAGE INTENTIONALLY LEFT BLANK

# TABLE OF CONTENTS

	<u>Page</u>
FOREWORD .....	i
TABLE OF CONTENTS .....	iii
1.0 PURPOSE AND SCOPE .....	1
1.1 Introduction .....	1
1.2 System Characteristics .....	2
1.2.1 Waypoint Definition .....	2
1.2.2 Course Selection .....	3
1.2.2.1 "TO-FROM" Equipment .....	3
1.2.2.2 "TO-TO" Equipment .....	3
1.2.3 Path Computation .....	3
1.2.4 Coordinate Systems .....	3
1.2.5 Aircraft Position Computation .....	4
1.2.6 Navigation Modes and Annunciation .....	4
1.2.7 Station Selection .....	4
1.2.8 VOR/DME Latitude/Longitude Sensors .....	4
1.2.9 Lateral and Vertical Steering Outputs .....	5
1.2.10 Holding Pattern Manuevering .....	5
1.3 Intended Use and Operational Environment .....	5
1.3.1 Area Navigation in the Present ATC System .....	5
1.3.2 Historical Considerations .....	6
1.3.3 Route Width Consideration .....	10
1.3.3.1 En route RNAV Route .....	10
1.3.3.2 En route VOR Airway Route .....	10
1.3.3.3 Terminal .....	10
1.3.3.4 Approach .....	10
1.3.4 Postulated Air Traffic Control Environment .....	11
1.3.5 Operational Environment Assumptions .....	12
1.4 Error Budgets .....	12
1.4.1 Error Budget - 2D .....	12
1.4.1.1 VOR/DME Sensors .....	12
1.4.1.2 North Reference Effects .....	13
1.4.2 Error Budget - VNAV .....	13
1.5 Test Procedures .....	13
1.5.1 Bench Tests .....	14
1.5.2 Environmental Tests .....	14
1.5.3 Installed Tests .....	14

	<u>Page</u>
1.5.4 Operational Tests . . . . .	14
1.6 Definitions of Terms . . . . .	14
<b>2.0 EQUIPMENT PERFORMANCE REQUIREMENTS AND TEST PROCEDURES . . . . .</b>	<b>15</b>
2.1 General Requirements . . . . .	15
2.1.1 Airworthiness . . . . .	15
2.1.2 General Performance . . . . .	15
2.1.3 Fire Resistance . . . . .	15
2.1.4 Operation of Controls . . . . .	15
2.1.5 Accessibility of Controls . . . . .	15
2.1.6 Sensor Interfaces . . . . .	15
2.1.7 Control/Display Capability . . . . .	15
2.1.8 Control/Display Readability . . . . .	15
2.1.9 Effects of Test . . . . .	16
2.1.11 Maneuver Anticipation and Direct-To Function . . . . .	16
2.1.11 Display Update Rate . . . . .	16
2.2 2D RNAV Functional and Accuracy Requirements - Standard Conditions . . . . .	17
2.2.1 Equipment Functional Requirements . . . . .	17
2.2.1.1 Cross-Track Deviation . . . . .	17
2.2.1.1.1 Numeric Display Information . . . . .	17
2.2.1.1.2 Non Numeric Display Information . . . . .	17
2.2.1.2 Waypoint Distance Display (Output Display) . . . . .	17
2.2.1.3 "TO-FROM" Indication . . . . .	18
2.2.1.4 Course Selection . . . . .	18
2.2.1.5 Waypoint and Station Selection . . . . .	18
2.2.1.5.1 Waypoint Entry . . . . .	18
2.2.1.5.2 VOR/DME Facility Selection . . . . .	18
2.2.1.6 Waypoint Storage . . . . .	18
2.2.1.7 Waypoint or Leg Sequencing . . . . .	20
2.2.1.7.1 Holding Pattern Maneuvering . . . . .	20
2.2.1.8 Position Display . . . . .	20
2.2.1.9 Input Data Observation . . . . .	20
2.2.1.10 Failure/Status Indications . . . . .	20
2.2.1.11 Slant Range Error Correction . . . . .	21
2.2.1.12 Equipment Computational Response Time . . . . .	21
2.2.2 2D Accuracy Requirements . . . . .	21
2.2.3 Dynamic Tracking . . . . .	22
2.2.4 Tracking Through Short Outages . . . . .	23
2.3 VNAV Functional and Accuracy Requirements - Standard Conditions . . . . .	25

	<u>Page</u>	
2.3.1	Equipment Functional Requirements . . . . .	25
2.3.1.1	Waypoint Altitude . . . . .	25
2.3.1.2	Vertical Path Deviation . . . . .	25
2.3.1.3	Vertical Profile . . . . .	25
2.3.2	VNAV Accuracy Requirements . . . . .	25
2.4	Equipment Performance - Environmental Conditions . . . . .	27
2.4.1	Temperature and Altitude Tests . . . . .	27
2.4.1.1	Operating Low Temperature Test . . . . .	27
2.4.1.2	Short-Time Operating High Temperature Test . . . . .	27
2.4.1.3	Operating High Temperature Test . . . . .	28
2.4.1.4	In-Flight Loss of Cooling Test . . . . .	28
2.4.1.5	Altitude Test . . . . .	28
2.4.1.6	Decompression Test . . . . .	28
2.4.1.7	Overpressure Test . . . . .	29
2.4.2	Temperature Variation Test . . . . .	29
2.4.3	Humidity Test . . . . .	29
2.4.4	Shock Tests . . . . .	29
2.4.4.1	Operational Shocks . . . . .	29
2.4.4.2	Crash Safety Shocks . . . . .	30
2.4.5	Vibration Test . . . . .	30
2.4.6	Explosion Proofness Test . . . . .	30
2.4.7	Waterproofness Tests . . . . .	30
2.4.7.1	Drip Proof Test . . . . .	30
2.4.7.2	Spray Proof Test . . . . .	30
2.4.7.3	Continuous Steam Proof Test . . . . .	31
2.4.8	Fluids Susceptibility Tests . . . . .	31
2.4.8.1	Spray Test . . . . .	31
2.4.8.2	Immersion Test . . . . .	31
2.4.9	Sand and Dust Test . . . . .	32
2.4.10	Fungus Resistance Test . . . . .	32
2.4.11	Salt Spray Test . . . . .	32
2.4.12	Magnetic Effect Test . . . . .	33
2.4.13	Power Input Tests . . . . .	33
2.4.13.1	Normal Operating Conditions . . . . .	33
2.4.13.2	Abnormal Operating Conditions . . . . .	33
2.4.14	Voltage Spike Conducted Test . . . . .	33
2.4.14.1	Category A Requirements . . . . .	33
2.4.14.2	Category B Requirements . . . . .	34

	<u>Page</u>	
2.4.15	Audio Frequency Conducted Susceptibility Test . . . . .	34
2.4.16	Induced Signal Susceptibility Test . . . . .	34
2.4.17	Radio Frequency Susceptibility Test (Radiated and Conducted)	35
2.4.18	Emission of Radio Frequency Energy Test . . . . .	35
2.4.19	Lightning Induced Transient Susceptibility . . . . .	35
2.5	Equipment Test Procedures . . . . .	37
2.5.1	Definitions of Terms and Conditions of Tests . . . . .	37
2.5.2	Test Procedures . . . . .	37
2.5.2.1	Cross Reference . . . . .	38
2.5.3	2D RNAV Functional and Accuracy Requirements - Standard Conditions	38
2.5.3.1	Static Tests . . . . .	38
2.5.3.1.1	Matrix of Test Conditions . . . . .	38
2.5.3.1.2	Waypoint Distance and Aircraft Position Displays . . . . .	43
2.5.3.1.3	Waypoint Storage and Input Data Observation . . . . .	43
2.5.3.1.4	Navigation Mode Indication and Failure/Status Indications . . . . .	43
2.5.3.1.5	Slant Range Correction . . . . .	44
2.5.3.1.6	Cross-Track Deviation Display . . . . .	44
2.5.3.2	Dynamic Tests . . . . .	44
2.5.3.2.1	"TO-FROM" Indication and 2D Accuracy Requirements . . . . .	47
2.5.3.2.2	Waypoint or Leg Sequencing and Equipment Computational Response Time . . . . .	47
2.5.3.2.3	Tracking Through Short Outages . . . . .	53
2.5.4	VNAV Functional and Accuracy Requirements - Standard Conditions . . . . .	53
2.5.4.1	Static Tests . . . . .	53
2.5.4.2	Dynamic Tests . . . . .	57
3.0	INSTALLED EQUIPMENT PERFORMANCE . . . . .	61
3.1	Equipment Installation . . . . .	61
3.1.1	Accessibility . . . . .	61
3.1.2	Display Visibility . . . . .	61
3.1.3	Interference Effects . . . . .	61
3.1.4	Inadvertent Turnoff . . . . .	61
3.2	Installed Equipment Performance Requirements . . . . .	61
3.2.1	General Performance Requirements . . . . .	61
3.2.1.1	Cross-Track Deviation Display . . . . .	61
3.2.1.2	Vertical Path Deviation Display . . . . .	61
3.2.1.3	Lateral Maneuver Anticipation . . . . .	62
3.2.1.4	Automatic Lateral Change . . . . .	62

	<u>Page</u>
3.2.1.5 Direct-To Function . . . . .	62
3.2.1.6 Vertical Maneuver Anticipation . . . . .	62
3.2.1.7 Automatic Altitude Change . . . . .	62
3.2.1.8 Display of Selected Waypoint . . . . .	66
3.2.2 Installed Accuracy . . . . .	66
3.2.2.1 Background . . . . .	66
3.2.2.2 Standard Error Budget . . . . .	66
3.2.2.3 System Error Tradeoffs . . . . .	67
3.3 Conditions of Test . . . . .	67
3.3.1 Power Input . . . . .	67
3.3.2 Associated Equipment or Systems . . . . .	67
3.3.3 Environment . . . . .	67
3.3.4 Adjustment of Equipment . . . . .	67
3.3.5 Warm-Up Period . . . . .	67
3.4 Test Procedures for Installed Equipment Performance . . . . .	68
3.4.1 Ground Test Procedures . . . . .	68
3.4.1.1 Conformity Inspection . . . . .	68
3.4.1.2 Equipment Function . . . . .	68
3.4.1.3 Interference Effects . . . . .	68
3.4.1.4 Power Supply Fluctuations . . . . .	68
3.4.1.5 Equipment Accessibility . . . . .	68
3.4.2 Flight Test Procedures . . . . .	68
3.4.2.1 Displayed Data Readability . . . . .	68
3.4.2.2 Interference Effects . . . . .	69
3.4.2.3 Flight Demonstration . . . . .	69
3.4.2.4 Simulator Demonstration . . . . .	70
4.0 OPERATIONAL CHARACTERISTICS . . . . .	71
4.1 Required Operational Characteristics . . . . .	71
4.1.1 Power Input . . . . .	71
4.1.2 Navigation Displays . . . . .	71
4.1.3 Navigation Controls . . . . .	71
4.1.4 System Operational Integrity . . . . .	71
4.1.5 Equipment Operating Limitations . . . . .	71
4.2 Test Procedures for Operational Characteristics . . . . .	71
4.2.1 Power Input . . . . .	71
4.2.2 Navigation Displays . . . . .	71
4.2.3 Navigation Controls . . . . .	71
4.2.4 System Operational Integrity . . . . .	71

**MEMBERSHIP** ..... 73

**APPENDIX A** Postulated Area Navigation Operational Environment Definition

**APPENDIX B** Acceptable Trade-off Techniques for Determining Systems Performance

**APPENDIX C** Glossary of Terms for Navigation Functions

**APPENDIX D** Great Circle Course Computations

**APPENDIX E** Implementing Epoch Year Magnetic Variation Values

**APPENDIX F** Acceptable Procedural Techniques for Lateral Maneuver Anticipation

## 1.0 PURPOSE AND SCOPE

### 1.1 Introduction

This document contains minimum operational performance standards (MOPS) for airborne area navigation equipment (2D and 3D) operated in the National Airspace System (NAS) using inputs from a single collocated VOR/DME station. Performance standards for equipment operated in other airspace, such as the North Atlantic Minimum Navigation Performance Standard (MNPS), are contained in the respective guidance material for that airspace. RNAV performance standards for equipment using other sensor inputs, such as multiple VOR or DME stations, including scanning DMEs, inertial navigation sensors and Loran-C, are contained in other RTCA MOPS. Incorporated within these standards are equipment characteristics that should be useful to users, designers, manufacturers and installers of the equipment. This document defines the performance, functions and features for a 2D system that performs only lateral guidance and a 3D system that performs both lateral and vertical guidance. Equipment may be manufactured and tested to meet 2D or 3D requirements (or both) in the en route, terminal and approach modes or any combination thereof.

Section 1.0 of this document provides 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 forms the basis for the standards stated in Sections 2.0 through 4.0. Definitions and assumptions essential to proper understanding of this document are also provided in Section 1.0.

Section 2.0 contains the minimum performance standards for the equipment. These standards define required performance under standard operating conditions and stressed physical environmental conditions. It also details the recommended bench test procedures necessary to demonstrate compliance.

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

Section 4.0 describes the operational characteristics for equipment installations and defines conditions that will assure the operator that operations can be conducted safely and reliably in the expected operational environment.

Compliance with these standards by manufacturers, installers and users is recommended as one means of assuring that the equipment will satisfactorily perform its intended function(s) under conditions normally encountered in routine aeronautical operations. In addition, to safely and efficiently implement area navigation, it is mandatory that the airborne equipment be designed such that all airborne operations responding to like controller instructions will result in similar maneuvering of the aircraft, regardless of system type.

The word "equipment" as used in this document includes all components or units necessary (as determined by the equipment manufacturer or installer) for the equipment to properly perform its intended function. For example, the airborne area navigation "equipment" may include: sensor(s), a computer unit, an input-output unit which interfaces with existing aircraft displays/systems, a control unit, a display, shock mount(s), etc. In the case of this example, all of the foregoing components or units comprise the "equipment." It should not be inferred from this example, however, that every area navigation equipment will necessarily include all of the foregoing components or units. This will depend upon the design used by the equipment manufacturer.