

RTCA, Inc.
1150 18th Street, NW, Suite 910
Washington D.C. 20036

**Minimum Aviation System Performance Standards:
Required Navigation Performance for
Area Navigation**

RTCA DO-236C
Supersedes DO-236B
June 19, 2013

Prepared by SC-227
©2013, RTCA, Inc.

Copies of this document may be obtained from
RTCA, Inc.
Telephone: 202-833-9336
Facsimile: 202-833-9436
Internet: www.rtca.org

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

FOREWORD

This report was prepared by RTCA Special Committee 227 (SC-227) and EUROCAE Working Group 85(WG-85) and approved by the RTCA Program Management Committee (PMC) on June 19, 2013

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

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

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

Currently in preview, click buy full version

This Page Intentionally Left Blank

TABLE OF CONTENTS

1. PURPOSE AND SCOPE	1
1.1 Introduction.....	1
1.2 System Overview.....	2
1.2.1 Position Estimation	2
1.2.2 Path Definition	4
1.2.3 Path Steering	4
1.2.4 User Interface.....	5
1.2.5 Navigation System Controls and Features	5
1.3 Operational Goals and Applications	5
1.3.1 Path Definition	5
1.3.2 Containment Methodology	5
1.3.3 Contribution to Increased Capacity.....	6
1.3.4 User-Preferred Trajectories and Trajectory Based Operations	6
1.4 Required Navigation Performance (RNP).....	6
1.4.1 Area Navigation	6
1.4.2 PBN and RNP Concept	6
1.4.3 Application of the Term RNP	7
1.4.4 Navigation Accuracy.....	7
1.4.5 Vertical Navigation (VNAV).....	8
1.5 Assumptions	8
1.5.1 Navigation Infrastructure	8
1.5.2 Defining Airspace	8
1.5.3 Navigation Error	9
1.5.4 Navigation Data	9
1.5.5 Reference Earth Model	9
1.5.6 Desired Path	9
1.5.7 Transitions Between Legs.....	10
1.5.8 Datalink Considerations	11
1.5.9 Polar Navigation	11
1.5.10 Dispatch Assessment	11
1.6 Verification Procedures.....	11
1.7 Performance	11
1.7.1 Required Navigation Performance	11
1.7.2 Error Terms	12
1.7.3 Lateral Containment Concept	14
1.7.4 Vertical Performance.....	17

2. SYSTEM PERFORMANCE REQUIREMENTS	19
2.1 Accuracy	19
2.1.1 RNP.....	19
2.1.2 VNAV	19
2.2 Containment Integrity	21
2.2.1 RNP RNAV.....	21
2.2.2 VNAV	21
2.3 Containment Continuity.....	21
2.3.1 RNP RNAV.....	21
2.3.2 VNAV	22
2.4 Estimated Time of Arrival	22
2.5 Time of Arrival Control	22
2.6 Lateral Control Performance	22
2.7 Speed Control Performance.....	23
3. FUNCTIONAL REQUIREMENTS	25
3.1 Position Estimation Requirements	25
3.1.1 Estimate of Position	25
3.1.2 Estimate of Position Uncertainty (EPU)	25
3.1.3 Containment Radius.....	25
3.1.4 Position Estimation Effects on System Compliance.....	26
3.2 Path Definition Requirements	26
3.2.1 Flight Path Legs Developed from the Navigation Database	27
3.2.2 Flight Path Legs Developed from User-Defined Data.....	27
3.2.3 Leg Definition.....	28
3.2.4 Special Operations	32
3.2.5 Error Terms.....	36
3.2.6 Applicable RNP	43
3.2.7 Prohibited Leg Types.....	44
3.2.8 Vertical Path Definition	44
3.3 Path Steering Requirements	52
3.3.1 RNP RNAV.....	52
3.3.2 VNAV.....	53
3.3.3 Continuous Lateral Path Steering.....	53
3.4 Estimated Time of Arrival	53
3.4.1 Equipment Requirements	53
3.4.2 Operational Considerations.....	53
3.5 Time of Arrival Control	53
3.5.1 Equipment Requirements	53

3.6	User Interface Requirements	54
3.6.1	General.....	54
3.6.2	Displays and Controls.....	54
3.7	System Features and Capabilities	55
3.7.1	Initialization Capability.....	55
3.7.2	Path Selection.....	56
3.7.3	Navigation Source (Navaid) Selection.....	6
3.7.4	Path Steering.....	62
3.7.5	Displays/Status.....	63
3.7.6	Alerting.....	68
3.7.7	Estimated Time of Arrival.....	69
3.7.8	Time of Arrival Control.....	69
3.8	Navigation Database Requirements	70
3.8.1	Content.....	70
3.8.2	Access.....	70
3.8.3	Database Standard.....	70
3.9	Datalink Interface	70
3.10	Navigation Display Interface	70
4.	NAVIGATION SYSTEM PERFORMANCE EVALUATION	73
4.1	General	73
4.1.1	Certification and Process Basis.....	73
4.1.2	Navigation Accuracy and Containment Compliance.....	73
4.2	Performance Accuracy Compliance	76
4.2.1	Lateral Performance.....	76
4.2.2	Vertical Performance.....	77
4.3	General Containment Compliance	77
4.3.1	Containment Integrity.....	77
4.3.2	Containment Continuity.....	78
4.4	Containment Integrity and Continuity Evaluation	78
4.4.1	System Development Evaluation and System Monitoring.....	78
4.4.2	Failure Analysis Description.....	80
5.	MEMBERSHIP	85

APPENDIX A: REFERENCES, GLOSSARY, ACRONYMS AND ABBREVIATIONS.....	A-1
APPENDIX B: EXAMPLE OF SYSTEM COMPLIANCE ANALYSIS.....	B-1
APPENDIX C: NAVIGATION SYSTEM REQUIREMENTS AND INFRASTRUCTURE CHARACTERISTICS	C-1
APPENDIX D: INTENTIONALLY LEFT BLANK.....	D-1
APPENDIX E: HOLDING PATTERN ENTRY EXAMPLE	E-1
APPENDIX F: CNS-ATM SYSTEM CONSIDERATIONS	F-1
APPENDIX G: RNP RNAV / VNAV / TOAC REQUIREMENTS CROSS REFERENCE	G-1
APPENDIX H: TEMPERATURE COMPENSATION	H-1
APPENDIX I : RNP LESS THAN 0.3 NM	I-1

Table of Figures

FIGURE 1-1	Navigation System Block Diagram	3
FIGURE 1-2	Lateral Components of Navigation Error Terms	12
FIGURE 1-3	Vertical Components of Navigation Error Terms	13
FIGURE 1-4	Cross-Track Containment Parameters	14
FIGURE 1-5	Navigation System Operational States	15
FIGURE 1-6	Position Estimation Performance Measures	17
FIGURE 1-7	Vertical Path Performance Limit	17
FIGURE 2-1	Illustration of VPPL Along Vertical Profile	20
FIGURE 3-1	Track to Fix (TF) Leg	28
FIGURE 3-2	Radius to Fix (RF) Leg	29
FIGURE 3-3	Fix to Altitude (FA) Leg	30
FIGURE 3-4	Direct to Fix (DF) Leg	31
FIGURE 3-5	Course to Fix (CF) Leg	31
FIGURE 3-6	Holding Pattern Definition	33
FIGURE 3-7	Offset Path Definition	36
FIGURE 3-8	Fly-By Theoretical Transition Area	41
FIGURE 3-9	Fixed Radius Transition	42
FIGURE 3-10	Descent Path Permitted by Two "WINDOW" Constraints, Two AT Constraints and Cruise and Altitude	47
FIGURE 3-11	Descent Path defined by AT constraints and a Cruise Altitude	49
FIGURE 3-12	Waypoint with Vertical Constraint	50
FIGURE 3-13	Fly-By Transition	50
FIGURE 4-1	System Development and Safety Assessment Processes	74
FIGURE 4-2	System Validation Processes	75
FIGURE 4-3	Top Level Navigation Fault Tree	82
FIGURE B-1	Single System Fault Diagram	B-7
FIGURE B-2	Dual System Fault Diagram	B-8
FIGURE E-1	Holding Entry Sectors	E-2
FIGURE E-2	Sector 1 Entry Procedure	E-2
FIGURE E-3	Sector 2 Entry Procedure	E-3
FIGURE E-4	Sector 3 Entry Procedure	E-3
FIGURE E-5	Sector 4 Entry Procedure	E-4

Table of Tables

TABLE 1-1	RNP Applicability Range	8
TABLE 2-1	Vertical Path Performance Limit for Vertical Navigation.....	19
TABLE 3-1	Maximum Holding Airspeeds (KIAS)	34
TABLE 3-2	Error Terms	36
TABLE 3-3	Operational Applicability of Speed Restrictions.....	46
TABLE 3-4	Example of Vertical Height Loss for Fly-By	5
TABLE 3-5	Display/Entry Resolutions.....	55
TABLE 3-6	Non-Numeric Display Requirements	5
TABLE 4-1	Containment Characterization of Navigation System	83
TABLE B-1	Assumptions	B-3
TABLE B-2	Analysis Results Summary	B-6
TABLE C-1	Maximum VOR Ranges	C-2
TABLE C-2	Maximum DME Ranges.....	C-3
TABLE G-1	Requirements Cross Reference.....	G-1

1.0 PURPOSE AND SCOPE

1.1 Introduction

The International Civil Aviation Organization (ICAO) recognized a need for dramatic improvements to the existing air navigation system. The ICAO Special Committee of Future Air Navigation Systems (FANS) developed a new concept expressed in terms of communication, navigation, surveillance and air traffic management (CNS/ATM). It was intended to be an evolutionary means of achieving improvements in the global air navigation system. To obtain the benefits of the CNS/ATM concept, aircraft need to achieve accurate, repeatable and predictable navigation performance. This is referred to as Required Navigation Performance (RNP).

The FANS concept evolved further into specific ATM modernization programs in the United States, Europe and other countries. All of these programs relied on both RNAV and RNP to enable the operational improvements needed for improved capacity, efficiency, safety, environment and global interoperability. However, the implementations led to differences in the operational applications, aircraft requirements and associated authorizations, causing confusion in the aviation community e.g. the designation of RNP 10 which through its own terms could be seen as RNAV 10.

The ICAO Performance Based Navigation (PBN) Study Group (SG) was formed after increasing misunderstanding, confusion and feedback resulted from States implementing RNAV and RNP operations in ways that differed from the original applications. The differences were significant in terms of the operational assumptions, mitigation of operational issues, management and assurance of the aircraft capabilities, etc., that could impede global interoperability and safety. The PBN SG's primary task was to create information to clarify RNAV and RNP, provide guidance to aid implementation, and harmonize and better specify area navigation and RNP, all in the development of the ICAO PBN Manual. The navigation specifications and other material in the manual are the result of the PBN SG efforts.

This document contains Minimum Aviation System Performance Standards (MASPS) for area navigation systems operating in an RNP environment. These standards are intended for designers, manufacturers, and installers of avionics equipment, service providers and users of these systems for world-wide operations. The MASPS provides guidance to aid in the development of airspace and operational procedures needed to obtain the benefits of improved navigation capability.

The requirements of this MASPS are intended to be consistent with the definitions of RNP developed by the ICAO PBN SG. The MASPS uses the term RNP RNAV for the aircraft system because it encompasses a more complete set of technical standards, definitions, considerations and requirements than is contained in any one of the individual specifications in the ICAO Manual. The MASPS represents a single, comprehensive collection of features and capabilities that can be applied in total or as a feature set tailored to specific needs e.g. as in a single PBN navigation specification, but where the features all follow the common standard established by this MASPS. In addition, barometric vertical navigation (VNAV) requirements are defined for aircraft that provide this optional capability to ensure accurate and predictable vertical paths. The VNAV requirements in this document are consistent with instrument approach procedures with vertical guidance (APV). Due to the wide disparity of climb performance of different aircraft types, this MASPS only addresses vertical path definition requirements for level flight and descent. Finally, requirements for an optional estimated time of arrival (ETA) function is defined for systems that provide these capabilities.