

RTCA, Inc.
1140 Connecticut Avenue, NW, Suite 1020
Washington, DC 20036-4001 USA

**Minimum Operational Performance Standards
(MOPS) DGNSS Instrument Approach System:
Special Category I (SCAT-I)**

RTCA DO-217
August 27, 1993

Prepared by: SC-159
© 1993 RTCA, Inc.

Copies of this document may be obtained from

RTCA, Inc.

Telephone: 202-833-9339

Facsimile: 202-833-9434

Internet: www.rtca.org

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

FOREWORD

This document was prepared by RTCA Special Committee 159 (SC-159). It was approved by the RTCA Technical Management Committee on August 27, 1993.

RTCA, Incorporated 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.

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 Overview	3
1.2.1 GNSS Satellite Signals	3
1.2.2 Airborne Equipment	4
1.2.2.1 Airborne GNSS Receiver Function	4
1.2.2.2 Airborne Navigation Processing Function	4
1.2.2.3 Airborne Navigation Data Base	5
1.2.2.4 DIAS Data Link Equipment	5
1.2.3 Ground Equipment	5
1.2.3.1 Ground DGNSS Reference Receiver Function	6
1.2.3.2 Ground DGNSS Data Processing Function	6
1.2.3.3 Ground DGNSS Data Transmitter	6
1.2.3.4 Ground DGNSS Signal Integrity Monitoring Function ...	6
1.2.3.5 DIAS Data Link	7
1.3 Operational Applications	7
1.3.1 Operational Characteristics of SCAT-I Instrument Approach Procedures	7
1.3.2 Transition to End-State DGNSS Instrument Approaches	8
1.4 Operational Goals	9
1.5 Assumptions	9
1.5.1 General	9
1.5.2 Interoperability	9
1.5.3 DIAS Range	10
1.5.4 Selective Availability (SA)	10
1.5.5 Wide Area Differential GNSS (WADGNSS)	11
1.5.6 TSO-C129	11
1.6 Integrated Avionics Systems	11

	<u>Page</u>	
2.1.8.4	Caution Associated with Excessive Flight Technical Error	22
2.1.8.5	Alerts Associated with Ground-based Hardware Failure . .	22
2.1.8.6	Alarms Associated with Station Not Working	22
2.1.8.7	Warning Associated with Airborne Hardware Failure . . .	23
2.1.8.8	Alarms Associated with Out-of-Tolerance Satellites	23
2.2	Airborne Equipment Requirements	23
2.2.1	General Requirements	23
2.2.1.1	Airworthiness	24
2.2.1.2	Fire Resistance	24
2.2.1.3	Operation of Controls	24
2.2.1.4	Accessibility of Controls	24
2.2.1.5	Control/Display Capability	24
2.2.1.6	Control/Display Readability	25
2.2.1.7	Equipment Interfaces	25
2.2.1.8	Maneuver Anticipation and Waypoint Alerting	25
2.2.1.9	Display Rate and Latency	25
2.2.1.10	System Integrity and Software Standards	26
	2.2.1.10.1Hardware Compliance	26
	2.2.1.10.2Software Compliance	26
2.2.2	Precision Approach Functional Requirements	27
2.2.2.1	Accuracy	27
	2.2.2.1.1 Cross-Track Deviation Display	31
	2.2.2.1.2 Vertical Path Deviation Display	31
2.2.2.2	Integrity	32
	2.2.2.2.1 Display of Warnings, Cautions, and Status Indicators	32
	2.2.2.2.2 Pilot Responses to Warnings, Cautions, and Status Indicators	33
	2.2.2.2.3 Activation of Warnings	34
	2.2.2.2.4 Integrity Warning Latency	37
2.2.2.3	Continuity of Function	37
2.2.2.4	Long-Term Availability	38
2.2.2.5	Vertical Profile	38
2.2.2.6	Waypoint Distance Display	38

	<u>Page</u>
2.2.2.7 TO-FROM Indication	38
2.2.2.8 DGNSS Precision Approach Selection and Activation . . .	38
2.2.2.9 Display of Precision Approach Waypoints	39
2.2.2.10 Precision Approach Waypoint Entry Procedure	39
2.2.2.11 DGNSS Waypoint Storage	39
2.2.2.12 Data Inspection	40
2.2.2.13 Satellite Selection and Indication	40
2.2.2.14 Output (to Aircraft Guidance System) Signal Requirements	41
2.2.3 Signal Processing Requirements	41
2.2.3.1 GNSS Signal Processing Requirements	41
2.2.3.1.1 Continuous Wave Interference (CWI)	41
2.2.3.1.2 Acquisition Time	41
2.2.3.1.3 Reacquisition Time	42
2.2.3.1.4 Dynamic Tracking	42
2.2.3.1.5 Minimum Constellation Requirements	42
2.2.3.2 Differential Signal Processing Requirements	44
2.2.3.2.1 Differential Message Processing	44
2.2.3.2.2 Application of Differential Corrections	45
2.2.3.2.3 Data Link to Navigation Equipment Interface	45
2.2.3.2.4 Dynamic Range	46
2.2.4 Airborne Equipment Performance - Environmental Conditions	46
2.2.4.1 Temperature and Altitude Tests (DO-160C, Section 4) . . .	47
2.2.4.1.1 Operating Low Temperature Test	47
2.2.4.1.2 Short-Time High Operating Temperature Test	48
2.2.4.1.3 Operating High Temperature Test	48
2.2.4.1.4 In-Flight Loss of Cooling Test (When Required)	49
2.2.4.1.5 Altitude Test	49
2.2.4.1.6 Decompression Test (When Required)	50
2.2.4.1.7 Overpressure Test (When Required)	50
2.2.4.2 Temperature Variation Test (RTCA/DO-160C, Section 2.2.4.3 Humidity Test (RTCA/DO-160C, Section 6)	51
	52

	<u>Page</u>	
2.2.4.4	Operational Shocks and Crash Safety Tests (RTCA/DO-160C, Section 7)	52
2.2.4.4.1	Operational Shocks	52
2.2.4.4.2	Crash Safety Shocks	53
2.2.4.5	Vibration Test (RTCA/DO-160C, Section 8)	53
2.2.4.6	Explosion Proofness Test (RTCA/DO-160C, Section 9) (When Required)	54
2.2.4.7	Waterproofness Test (RTCA/DO-160C, Section 10)	54
2.2.4.7.1	Drip Proof Test (When Required)	54
2.2.4.7.2	Spray Proof Test (When Required)	55
2.2.4.7.3	Continuous Stream Proof Test (When Required)	55
2.2.4.8	Fluids Susceptibility Tests (DO-160C, Section 11)	56
2.2.4.8.1	Spray Test (When Required)	56
2.2.4.8.2	Immersion Test (When Required)	57
2.2.4.9	Sand and Dust Test (DO-160C, Section 12) (When Required)	58
2.2.4.10	Fungus Resistance Test (DO-160C, Section 13) (When Required)	58
2.2.4.11	Salt Spray Test (DO-160C, Section 14) (When Required)	59
2.2.4.12	Magnetic Effect Test (DO-160C, Section 15)	59
2.2.4.13	Power Input Tests (DO-160C, Section 16)	59
2.2.4.13.1	Normal Operating Conditions	60
2.2.4.13.2	Abnormal Operating Conditions	60
2.2.4.14	Voltage Spike Test (DO-160C, Section 17)	61
2.2.4.15	Audio Frequency Conducted Susceptibility Test (DO-160C, Section 18)	62
2.2.4.16	Induced Signal Susceptibility Test (DO-160C, Section 19)	62
2.2.4.17	Radio Frequency Susceptibility Test (Radiated and Conducted)(DO-160C, Section 20)	63
2.2.4.18	Emission of Radio Frequency Energy Test (DO-160C, Section 21)	63
2.2.4.19	Lightning Induced Transient Susceptibility (DO-160C, Section 22)	64

	<u>Page</u>	
2.3.3.3	DGNSS System Integrity Monitoring Function Requirements	73
2.3.3.3.1	Monitored Performance Parameters	74
2.3.3.3.2	DGNSS Signal Integrity Monitoring Function Alarm Conditions	76
2.3.3.3.3	DGNSS Signal Integrity Monitoring Function Maintenance Alert Condition	78
2.3.3.3.4	DIAS Ground Station Remote Monitoring	79
2.3.3.4	DIAS Data Link Requirements	79
2.3.3.4.1	Spurious Emissions	79
2.3.3.4.2	Data Link to Reference Equipment Interface	79
2.3.3.4.3	Antenna Requirements	80
2.3.4	Ground Equipment Performance - Environmental Conditions	80
2.3.4.1	Temperature	80
2.3.4.2	Relative Humidity	80
2.3.4.3	Altitude (ft. above sea level)	80
2.3.4.4	Wind	81
2.3.4.5	Ice Loading	81
2.3.4.6	Rain	81
2.3.4.7	Electromagnetic Interference (EMI)	81
2.3.4.8	Input power	81
2.4	DIAS Data Link Requirements	81
2.4.1	Continuity of Function	81
2.4.2	Availability	82
2.4.3	Integrity	82
2.5	Precision Approach Test Procedures	82
2.5.1	Definitions of Terms and Conditions of Tests	82
2.5.2	Test Procedures	84
2.5.3	Airborne Equipment Bench Test Procedures	104
2.5.3.1	Display Rate and Latency, Cross-Track Deviation Display, Display of Warnings and Cautions, Display of Warnings, Cautions, and Status Indicators	104
2.5.3.2	Vertical Path Deviation, Display of Warnings and Cautions, Display of Warnings, Cautions, and Status Indicators	110

	<u>Page</u>
2.5.3.3	Display of Warnings, Cautions and Status Indicators 110
2.5.3.4	Activation of Warnings 113
2.5.3.5	Waypoint Distance Display, DGNSS Precision Approach Selection and Activation, Display of Precision Approach Waypoints, DGNSS Waypoint Storage, Data Inspection . 121
2.5.3.6	Satellite Selection and Indication 121
2.5.3.7	Output (to Aircraft Guidance System) Signal Requirements 122
2.5.4	Signal Processing Requirements Bench Test Procedures 122
2.5.4.1	Acquisition Time 122
2.5.4.2	Reacquisition Time 124
2.5.4.3	Minimum Constellation Requirements 126
2.5.4.4	Differential Message Processing (2.2.3.2.1) 127
2.5.4.5	Application of Differential Corrections (section 2.2.3.2.2) 128
2.5.4.6	Message Type Recognition 128
2.5.5	Ground Equipment Bench Test Procedures 129
2.5.5.1	Acquisition Time 129
2.5.5.2	Reacquisition Time 129
2.5.5.3	Differential Message Format, Message Type 1 130
2.5.5.3.1	User Differential Range Error 130
2.5.5.4	Differential Message Standard Algorithms 130
2.5.5.5	Monitored Performance Parameters 132
2.5.5.6	DGNSS Signal Integrity Monitoring Function Alarm Conditions 132
2.5.5.7	Integrity Monitoring Function Maintenance Alert Conditions 134
2.5.5.8	Impedance and VSWR 135
2.5.5.9	Input Power 135
3.0	Installed Equipment Performance 139
3.1	Airborne Equipment Installation Guidance 139
3.1.1	Installed Airborne Equipment Performance Requirements 139
3.1.1.1	Coverage 139
3.1.1.2	Cross-Track Deviation Display 139
3.1.1.3	Vertical Path Deviation Display 139

	<u>Page</u>
3.1.1.4	Display of Precision Approach Waypoints 140
3.1.1.5	Installed Accuracy 140
3.1.2	Conditions of Test 140
3.1.2.1	Power Input 140
3.1.2.2	Associated Equipment or Systems 140
3.1.2.3	Environment 140
3.1.2.4	Adjustment of Equipment 141
3.1.2.5	Warm-Up Period 141
3.1.3	Missed Approach 141
3.2	Installed Ground Equipment Performance 141
3.2.1	Ground Equipment Installation and Siting 141
3.2.1.1	Ground Equipment Installation 141
3.2.1.2	Ground Equipment Siting 141
3.2.2	GNSS Antenna and Airport Survey Requirements 142
3.2.3	GNSS Multipath 143
3.2.4	Electrical Power 143
3.2.5	Interference Effects 143
3.2.6	Installed Ground Equipment Performance Requirements 143
3.2.6.1	General Performance Requirements 143
3.2.6.2	Installed Accuracy 143
3.2.7	Conditions of Ground Equipment Test 144
3.2.7.1	Associated Equipment or Systems 144
3.2.7.2	Environment 144
3.2.7.3	Adjustment of Equipment 144
3.2.7.4	Warm-Up Period 144
3.3	Test Procedures for Installed Equipment Performance 144
3.3.1	Conditions of Test 145
3.3.1.1	Power Input 145
3.3.1.2	Environment 145
3.3.1.3	Adjustment of Equipment 145
3.3.1.4	Warm Up Period 145

	<u>Page</u>	
3.3.2	Ground Test Procedures	145
3.3.2.1	Inspection	146
3.3.2.2	Equipment Function	146
3.3.2.3	Interference Effects	146
3.3.2.4	Power Supply Fluctuations	147
3.3.2.5	Ground Subsystem Equipment Accessibility	147
3.3.2.6	GNSS Coverage	148
3.3.2.7	Integrity Monitoring Function Maintenance Conditions . .	148
3.3.2.8	Ground Station Data Base Verification	148
3.3.2.9	System Accuracy	148
3.3.3	Flight Test Procedures	148
3.3.3.1	Flight Demonstration	148
3.3.3.2	Airborne System Signal Reception	150
4.0	EQUIPMENT OPERATIONAL PERFORMANCE CHARACTERISTICS	153
4.1	Required Operational Performance Requirements for DGNSS Ground Station Equipment	153
4.1.1	Power Input	153
4.1.2	Ground Station Data Base Verification	153
4.1.3	GNSS Receiver	153
4.1.4	Data Link	153
4.2	Operational Performance Test Procedures for Airborne DGNSS Instrument Approach Equipment	153
4.2.1	Power Input	154
4.2.2	GNSS Receiver	154
4.2.3	DGNSS Data Link	154
4.2.4	Navigation Subfunction	154
4.2.5	Display Subfunction	154
Membership	155
APPENDIX A	SCAT-I DIFFERENTIAL MESSAGE FORMAT	
APPENDIX B	ALLOCATION OF SCAT-I SYSTEM ACCURACY	
APPENDIX C	ALLOCATION OF SCAT-I SYSTEM CONTINUITY	
APPENDIX D	ALLOCATION OF SCAT-I SYSTEM INTEGRITY	
APPENDIX E	SCAT-I INTEGRITY ALARM SYSTEM LATENCY	
APPENDIX F	VHF/UHF IMPLEMENTATION OF SCAT-I DATA LINK	

APPENDIX G	IMPLEMENTATION OF SCAT-I DATA LINK AT THE MODE S UPLINK FREQUENCY
APPENDIX H	CLASS D EQUIPMENT REQUIREMENTS
APPENDIX I	DIAS GROUND SUBSYSTEM AND APPROACH WAYPOINT SURVEYS
APPENDIX J	SYSTEM PERFORMANCE TRADEOFFS
APPENDIX K	THE TUNNEL CONCEPT AND RNP PRECISION APPROACHES
APPENDIX L	GLOSSARY AND ACRONYMS

This Page Intentionally Left Blank

1.0 PURPOSE AND SCOPE

1.1 Introduction

This document contains Minimum Aviation System Performance Standards (MASPS) for a system to support differential GNSS (DGNSS) special instrument approaches. Initial applications of this system are anticipated to support Special Category I (hereafter termed "SCAT-I") precision approaches, which are specially authorized approaches made to MLS/ILS Category I minima with DGNSS used to provide navigation guidance. DGNSS special instrument approaches must be authorized by the FAA, using appropriate airworthiness and operational approval processes, based upon an aircraft operator's demonstrated capability and equipment as well as the availability of approved ground equipment. Such authorizations are expected to be made for specific aircraft approaching specific airports. For air carriers, these authorizations are expected to be made through modification to the carrier's operational specifications. For general aviation, these approvals are planned to be made through the issuance of a certificate of authorization.

The development of standards for DGNSS Instrument Approach Systems (DIAS) and subsystems has followed the Required Navigation Performance (RNP) concept. Primary RNP parameters are accuracy, availability, integrity, and continuity. These parameters are specified herein at the approach system level and then allocated to subsystems in this MASPS using a "risk tree" methodology as explained in Appendix K. Although the specific values of RNP parameters used in this document have been chosen to support SCAT-I operations, the system design principles used herein can be adapted to support DGNSS-based instrument approaches with both more and less stringent minima. The term "DIAS" will be used in discussions generic to systems supporting DGNSS Instrument Approach Systems. The term "SCAT-I system" will be used for a DIAS system specifically developed to support the RNP required for Special Category I approaches.

Incorporated within these standards are equipment characteristics that should be useful to users, designers, manufacturers, installers, and operators of the equipment. Functional specifications are used where possible in order that implementers may have flexibility in developing the DIAS equipment. This document is intended to support initial operational SCAT-I approaches within the National Airspace System in late 1993 or 1994.

Consistent with FAA guidance and the recommendations of the RTCA GNSS Task Force Report dated September 1992, the standards in this document are specifically oriented toward supporting early operational implementation. For example, the DGNSS data links specified have been chosen on the basis of three