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Minimum Operational Performance Standards (MOPS) for Air Traffic Control Radar Beacon System (ATCRBS) Airborne Equipment

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FOREWORD

These Minimum Operational Performance Standards (MOPS) were prepared by RTCA Special Committee 209 (SC-209) and approved by the RTCA Program Management Committee (PMC) on October 2, 2008. This document represents the consolidated performance requirements from two sources; RTCA/DO-144, "*Minimum Operational Characteristics for Airborne ATC Transponder Systems,"* dated March 12, 1970, plus Change 1 to DO-144, posted as RTCA Paper No. 232-70/EC-643, dated November 5, 1970, and the performance standards referred to in paragraph (a)(1) of Federal Aviation Administration (FAA) Technical Standard Order (TSO) -C74c, dated February 20, 1973.

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- 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 (MOPS) 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 (ICAO) and the International Telecommunication Union (ITU) and other appropriate international organizations can be based.

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1 PURPOSE AND SCOPE

1.1 Introduction

This document sets forth Minimum Operational Performance Standards (MOPS) for Air Traffic Control Radar Beacon System (ATCRBS) airborne equipment. Incorporated within these standards are system characteristics that will be useful to users of the system as well as designers, manufacturers and installers. These performance standards represent a consolidation of performance requirements from two sources; RTCA/DO-144, "*Minimum Operational Characteristics for Airborne ATC Transponder Systems,"* dated March 12, 1970, plus Change 1 to DO-144, posted as RTCA Paper No. 232-70/EC-643, dated November 5, 1970, and the performance standards referred to in paragraph (a)(1) of Federal Aviation Administration (FAA) Technical Standard Order (TSO)-C74c, dated February 20, 1973.

Compliance with these MOPS is required to achieve at least that minimum performance, on which control and separation of aircraft is based, and to insure against derogation of service to other users of aviation navigation and communication services. These MOPS are applicable to all users of airborne ATC transponder systems who are required by regulation to participate in the ATC system, or who voluntarily choose to do so.

Note: *The use of "**shall**" in the body of this document indicates a requirement. The use of "**should**" indicates a characteristic that is highly recommended, but is not required.*

It is recognized that any regulatory application of these standards is the responsibility of appropriate government agencies.

Because the measured values of equipment performance characteristics may be a function of the measurement method, standard test conditions and methods of test are recommended in this document.

This document considers an equipment configuration consisting of: transponder, control panel, antenna and interconnecting cables. It should not be inferred that all ATCRBS airborne equipment will necessarily include all of the foregoing components as separate units; this will depend on the design configuration chosen by the manufacturer.

If the equipment implementation includes a computer software package, the guidelines contained in the most current issue of RTCA/DO-178, Software Considerations in Airborne Systems and Equipment Certification, should be considered.

1.1.1 International Standards

The performance standards of this document also reflect current International Civil Aviation Organization (ICAO) Annex 10, Volume IV, Amendment 82, Chapter 3 requirements for airborne systems having only Mode A and Mode C capabilities.

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1.1.2 Preparation of Minimum Operational Performance Standards for Airborne Systems

The Federal Aviation Administration is the responsible agency for certain aviation standards. However, FAA's regulatory effort is vastly improved by intelligent utilization of government/industry working arrangements, by which a variety and wealth of talent may be brought to bear on the development of a particular minimum requirement.

Therefore, to implement the concepts that have been outlined, RTCA established Special Committee 209 to update the Minimum Operational Performance Standards for Airborne Transponder System Elements (both ATCRBS and Mode S), together with a method of demonstration of compliance. However, as pointed out in these concepts, concise statements of system characteristics are a prerequisite to meaningful minimum operational characteristics for airborne systems. Accordingly, RTCA SC-209 was directed to consider such system characteristics that exist and to include them in its reports. If none exist, best assumptions were to be formulated by RTCA SC-209 and included in the reports.

1.2 The ATCRBS Secondary Surveillance Radar (SSR) Environment

Although the trend towards equipage of ATCRBS/Mode Select (S) capable transponders is increasing, a large number of aircraft are still equipped with ATCRBS-only capable transponders. Since Mode S transponders are required on aircraft with TCAS, Mode S transponders are installed on a large segment of the aircraft population. However, General Aviation aircraft continue to represent the largest percentage of the aircraft in the airspace and ATCRBS transponders are still the dominant equipage for these aircraft.

The primary purpose of the ATCRBS transponder is to support ATC secondary surveillance radar (SSR) requirements. The ATCRBS SSR environment consists of the airborne ATCRBS transponders, ground interrogator-receiver, processing equipment, and an antenna system. The antenna may or may not be associated with, or slaved to, a primary surveillance radar. In operation, an interrogation pulse-pair transmitted from the interrogator-transmitter unit, via an antenna assembly, triggers each airborne transponder located in the direction of the main beam, causing a multiple pulse reply group to be transmitted from each transponder. These replies are received by the ground receiver and, after processing, are displayed to the controller. Measurement of the round-trip transit time determines the range (rho) to the replying aircraft while the mean direction of the main beam of the interrogator antenna, during the reply, determines the azimuth (theta). Based on the time spacing of the interrogation pulse-pair transmitted, the airborne transponder provides a multiple-pulse reply that represents either an individualized identity code (Mode A reply) or the aircraft’s current pressure altitude (Mode C reply).

The ATCRBS transponder also replies to airborne Mode A and Mode C interrogators, thereby making its presence known to aircraft that are equipped with Traffic Advisory and Collision Avoidance System (TCAS) or Airborne Collision Avoidance System (ACAS).

Additional information on ground and airborne interrogator characteristics is contained in §2.1.10.

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1.3 Assumptions

This document defines the basic surveillance and link characteristics of ATCRBS transponders. Adherence to the requirements of this document will meet the needs of the airspace for surveillance of aircraft so equipped. There is no upgrade path for the ATCRBS system going forward as surveillance needs of the future may rely on different technologies.

1.4 Equipage Classes

Class A equipment is intended for installation in aircraft which operate at altitudes above 15,000 feet. Additional information on Class A equipment is contained in §2.2.3.2.1.

Class B equipment is intended for installation in aircraft which operate at altitudes not exceeding 15,000 feet. Additional information on Class B equipment is contained in §2.2.3.2.2.

1.5 Test Procedures

The specified test procedures and associated limits are intended as one means of demonstrating compliance with the minimum acceptable performance parameters. Although specific test procedures are cited, it is recognized that other methods may be preferred by the test organization. These alternate methods may be used if they provide at least equivalent information. In such cases, the procedures cited should be used as one criterion in evaluating the acceptability of the alternate procedures.

The order of tests suggests that the equipment be subjected to a succession of different tests as it moves from design and design qualification into operational use. For example, the equipment should have demonstrated compliance with the requirements of Section §2.0 as a precondition to satisfactory completion of the installed system tests of Section §3.0.

Three types of test procedures are included which should be used at different stages in the equipment approval cycle. These are discussed in the following paragraphs.

1.5.1 Environmental Tests

Environmental tests are specified in Subsection §2.3. The procedures and their associated limit requirements are intended to provide a means of determining the electrical and mechanical performance of the equipment under environmental conditions expected to be encountered in actual operations. Equipment manufacturers may use test results as design guidance in preparation of installation instructions and, in certain cases, for obtaining formal approval of equipment design and manufacture.

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1.5.2 Detailed Test Procedures

Detailed test procedures are specified in Subsection §2.4. These tests are conducted at the equipment level and are intended to provide a laboratory means of demonstrating compliance with the requirements of Subsections §2.1 and §2.2. Equipment manufacturers may use test results as design guidance, for monitoring manufacturing compliance and, in certain cases, for obtaining formal approval of equipment design and manufacture.

1.5.3 Installed System Tests

The installed system test procedures and their associated requirements are specified in Section §3.0. Although bench and environmental test procedures are not included in the installed system tests, their successful completion is a precondition to completion of the installed tests. In certain instances, however, installed system tests may be used in lieu of bench test simulation of such factors as power supply characteristics, interference from or to other equipment installed on the aircraft, etc. Installed tests are normally performed under two conditions:

a. with the aircraft on the ground and using simulated or operational system inputs, and/or

b. with the aircraft in flight using operational system signals appropriate to the equipment under test.

Test results may be used to demonstrate functional performance in the intended operational environment.

In addition, the ground test procedures may be used as an optional check of equipment performance following corrective maintenance.

1.6 Definition of Terms

ATCRBS – Air Traffic Control Radar Beacon System.

Desensitization – Temporary reduction of transponder sensitivity after receipt of a signal. This helps to reduce echo (multipath) effects.

Interrogation – A ground or airborne signal propagated toward an ATCRBS transponder to elicit a Mode A or Mode C response.

Mode A Interrogation – A signal to elicit an ATCRBS transponder reply for identity (4096 code) and surveillance.

Mode C Interrogation – A signal to elicit an ATCRBS transponder reply for automatic pressure-altitude transmission and surveillance

Multipath – The propagation phenomenon that results in signals reaching the receiving antenna by two or more paths, generally with a time or phase difference between the two.

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National Airspace System (NAS) – The common system of facilities, equipment, regulations, procedures and personnel providing services and standard procedures for the safe and efficient movement of civil and military aircraft within the jurisdiction of the United States.

PAM – Pulse Amplitude Modulation. The modulation technique utilized in both the interrogation and reply signals.

Reply – A signal propagated from the transponder.

Side Lobe Suppression (SLS) Transmission – A transmission intended to prevent responses from transponders not in the main beam of the interrogating antenna.

Special Position Identification (SPI) – A special pulse used in ATCRBS located 4.35 microseconds following the last framing pulse. When used in Mode S, SPI appears as a code in the flight status (FS) field and in the surveillance status subfield (SSS).

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