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Manual on Mode S Specific Services

Approved by the Secretary General
and published under his authority

Second Edition — 2004

International Civil Aviation Organization

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AMENDMENTS

Amendments are announced in the supplements to the *Catalogue of ICAO Publications*; the Catalogue and its supplements are available on the ICAO website at www.icao.int. The space below is provided to keep a record of such amendments.

RECORD OF AMENDMENTS AND CORRIGENDA

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FOREWORD

Mode S secondary surveillance radar (SSR) was standardized in ICAO Annex 10 in 1985. Mode S has a data link capability which can only be taken advantage of when the Mode S subnetwork standards are supplemented with information on the applications that will use the data link.

The purpose of this manual is to provide guidance material on the detailed technical material on Mode S specific services contained in Annex 10 Volume III, Appendix to Chapter 5. The material in that appendix includes the definition of message formats and the detailed specification of algorithms used to format these messages, as well as requirements for the implementation of Mode S specific services including, *inter alia*, enhanced surveillance, dataflash and extended squitter. In addition, this manual will eventually contain both requirements and guidance material for Mode S specific services which are under development.

Any references to this manual should be interpreted as also referring to Annex 10 Volume III, Appendix to Chapter 5 for the Mode S specific services that are standardized.

Corrections or changes to existing material in this document require the approval of the relevant Working Group of the Panel responsible for secondary surveillance radar and collision avoidance systems.

Once approved through the above procedures, changes or new material will be incorporated into this manual by the ICAO Secretariat.

Comments on this manual would be appreciated from all parties concerned with the development of data link applications considered to be suitable for use across the Mode S subnetwork via the Mode S specific services. The comments should be addressed to:

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GLOSSARY

Air-initiated Comm-B (AICB) protocol. A procedure initiated by a Mode S aircraft installation for delivering a Comm-B message to the ground.

Aircraft. The term aircraft may be used to refer to Mode S emitters (e.g. aircraft/vehicles), where appropriate.

Aircraft data link processor (ADLP). An aircraft-resident processor that is specific to a particular air-ground data link (e.g. Mode S) and which provides channel management, and segments and/or reassembles messages for transfer. It is connected to one side of aircraft elements common to all data link systems and on the other side to the air-ground link itself.

Aircraft address. A unique combination of 24 bits available for assignment to an aircraft for the purpose of air-ground communications, navigation and surveillance.

Aircraft/Vehicle. May be used to describe either a machine or device capable of atmospheric flight, or a vehicle on the airport surface movement area (i.e. runways and taxiways).

BDS Comm-B Data Selector. The 8-bit BDS code determines the transponder register whose contents are to be transferred in the MB field of a Comm-B reply. It is expressed in two groups of 4 bits each, BDS1 (most significant 4 bits) and BDS2 (least significant 4 bits).

Broadcast. The protocol within the Mode S system that permits uplink messages to be sent to all aircraft in the coverage area, and downlink messages to be made available to all interrogators that have the aircraft wishing to send the message under surveillance.

Capability Report. Information identifying whether the transponder has a data link capability as reported in the capability (CA) field of an all-call reply or squitter transmission (see *Data link capability report*).

Close-out. A command from a Mode S interrogator that terminates a Mode S link layer communications transaction.

Comm-A. A 112-bit interrogation containing the 56-bit MA message field. This field is used by the uplink standard length message (SLM) and broadcast protocols.

Comm-B. A 112-bit reply containing the 56-bit MB message field. This field is used by the downlink SLM, ground-initiated and broadcast protocols.

Comm-C. A 112-bit interrogation containing the 80-bit MC message field. This field is used by the uplink extended length message (ELM) protocol.

Comm-D. A 112-bit reply containing the 80-bit MD message field. This field is used by the downlink ELM protocol.

Data link capability report. Information in a Comm-B reply identifying the complete Mode S communication capabilities of the aircraft installation.

Downlink. A term referring to the transmission of data from an aircraft to the ground. Mode S air-to-ground signals are transmitted on the 1 090 MHz reply frequency channel.

Frame. The basic unit of data transfer at the link level. A frame can include from one to four Comm-A or Comm-B segments, from two to sixteen Comm-C segments, or from one to sixteen Comm-D segments.

General Formatter/Manager (GFM). The aircraft function responsible for formatting messages to be inserted in the transponder registers. It is also responsible for detecting and handling error conditions such as the loss of input data.

Ground Data Link Processor (GDLP). A ground-resident processor that is specific to a particular air-ground data link (e.g. Mode S) and which provides channel management, and segments and/or reassembles messages for transfer. It is connected on one side (by means of its data circuit terminating equipment (DCE)) to ground elements common to all data link systems, and on the other side to the air-ground link itself.

Ground-initiated Comm-B (GICB). The ground-initiated Comm-B protocol allows the interrogator to extract Comm-B replies containing data from one of the 255 transponder registers within the transponder in the MB field of the reply.

Ground-initiated protocol. A procedure initiated by a Mode S interrogator for delivering standard length (via Comm-A) or extended length (via Comm-C) messages to a Mode S aircraft installation.

Mode S broadcast protocols. Procedures allowing standard length uplink or downlink messages to be received by more than one transponder or ground interrogator, respectively.

Mode S packet. A packet conforming to the Mode S sub-network standard, designed to minimize the bandwidth required from the air-ground link. ISO 8208 packets may be transformed into Mode S packets and vice versa.

Mode S Specific Protocol (MSP). A protocol that provides a restricted datagram service within the Mode S sub-network.

Mode S specific services. A set of communication services provided by the Mode S system which are not available from other air-ground subnetworks and therefore not interoperable.

Packet. The basic unit of data transfer among communications devices within the network layer (e.g. an ISO 8208 packet or a Mode S packet).

Required Navigation Performance (RNP). A statement of the navigation performance accuracy necessary for operation within a defined airspace.

Segment. A portion of a message that can be accommodated within a single MA/MB field in the case of an SLM, or a single MC/MD field in the case of an ELM. This term is also applied to the Mode S transmissions containing these fields.

Standard Length Message (SLM). An exchange of digital data using selectively addressed Comm-A interrogations and/or Comm-B replies.

Subnetwork. An actual implementation of a data network that employs a homogeneous protocol and addressing plan and is under the control of a single authority.

Timeout. The cancellation of a transaction after one of the participating entities has failed to provide a required response within a pre-defined period of time.

Uplink. A term referring to the transmission of data from the ground to an aircraft. Mode S ground-to-air signals are transmitted on the 1 030 MHz interrogation frequency channel.

ACRONYMS

ACAS	Airborne collision avoidance system	II	Interrogator identifier
ADLP	Aircraft data link processor	MA	Message-Comm A
ADS-B	Automatic dependent surveillance — Broadcast	MB	Message-Comm B
ATN	Aeronautical telecommunication network	MC	Message-Comm C
ATS	Air traffic services	MD	Message-Comm D
A/V	Aircraft/vehicle	MOPS	Minimum operational performance standards
BDS	Comm-B data selector	MSP	Mode S specific protocol
BITE	Built-in test equipment	NUC _P	Navigational uncertainty category — Position
CFDIU	Centralized fault display interface unit	NUC _R	Navigational uncertainty category — Rate
CPR	Compact position reporting	RNP	Required navigation performance
ELM	Extended length message	SI	Surveillance identifier
FCU	Flight control unit	SLM	Standard length message
FMS	Flight management system	SPI	Special position identification
GDLP	Ground data link processor	SSE	Specific services entity
GICB	Ground-initiated Comm-B	SSR	Secondary surveillance radar
GFM	General formatter/manager	TIS	Traffic information service
GNSS	Global Navigation Satellite System	UTC	Coordinated universal time

Chapter 1

INTRODUCTION

1.1 GENERAL

1.1.1 This manual provides guidance material on data formats for applications using Mode S specific services which are standardized in Annex 10 Volume III, Appendix to Chapter 5. These applications are, where possible, based on data already available on most modern aircraft or on information from current work on development and testing of data link applications.

1.1.2 This manual is intended to provide a focus for international coordination on the development and standardization of new applications which operate via the Mode S specific services. It will contain a brief description of each application under development together with the data formats to be transmitted and all the necessary control parameters to enable the application to function correctly. The intention is to accurately define the data to be transferred and the format in which they are transferred.

1.1.3 The manual contains the following material:

- a) Guidance material for the transponder Comm-B registers and extended squitter;
- b) Guidance material for the Mode S specific protocols;
- c) Guidance material for the Mode S broadcast protocols; and
- d) Formats for Mode S specific services.

1.1.4 The manual is intended for use by the avionics industry and by the developers of air traffic services (ATS) applications.

1.2 MODE S SPECIFIC SERVICES

1.2.1 Mode S specific services are data link services that can be accessed by a separate dedicated interface to the Mode S subnetwork. On the ground they can also be

accessed via the aeronautical telecommunication network (ATN). They operate with a minimum of overhead and delay and use the link efficiently, which makes them highly suited to ATS applications.

1.2.2 There are three categories of service provided:

- a) *Ground-initiated Comm-B (GICB) protocol.* This service consists of defined data available on board the aircraft being put into one of the 255 transponder registers (each with a length 56 bits) in the Mode S transponder at specified intervals by a serving process, e.g. airborne collision avoidance system (ACAS) or the aircraft data link processor (ADLP). A Mode S ground interrogator or an ACAS unit can extract the information from any of these transponder registers at any time and pass it for onward transmission to ground-based or aircraft applications.
- b) *Mode S specific protocols (MSPs).* This service uses one or more of the 63 uplink or downlink channels provided by this protocol to transfer data in either short- or long-form MSP packets from the ground data link processor (GDLP) to the ADLP or vice versa.
- c) *Mode S broadcast protocol.* This service permits a limited amount of data to be broadcast from the ground to all aircraft. In the downlink direction, the presence of a broadcast message is indicated by the transponder, and this message can be extracted by all Mode S systems that have the aircraft in coverage at the time. An identifier is included as the first byte of all broadcasts to permit the data content and format to be determined.

1.2.3 In the case of an uplink broadcast, the application on board the aircraft will not be able to determine, other than on an interrogator identifier (II) or surveillance identifier (SI) code basis, the source of an interrogation. When necessary, the data source must be identified within the data field. On the downlink, however, the originating aircraft is known due to its aircraft address.

1.3 REFERENCE DOCUMENTS

Standards and Recommended Practices (SARPs) for the SSR Mode S system can be found in Annex 10, Volume IV, Chapters 2 and 3. SARPs for the Mode S subnetwork are contained in Annex 10, Volume III, Part 1, Chapter 5 and for ACAS, in Annex 10, Volume IV, Chapter 4.

Chapter 2

GUIDANCE FOR STANDARDIZED MODE S SPECIFIC SERVICES

2.1 Data formats for transponder registers

2.1.1 Transponder register allocation

Standardized applications that have been allocated transponder register numbers in Annex 10 Volume III Chapter 5 are shown in Table 2-1*.

Note 1.— The transponder register number is equivalent to the Comm-B data selector (BDS) value used to address that transponder register (see 3.1.2.6.11.2.1 of Annex 10, Volume IV).

Note 2.— The details of the data to be entered into transponder registers for applications under development will be defined in this section and shown in Table 2-2.

Note 3.— BDS A,B is equivalent to transponder register number AB₁₆.

Note 4.— The time between the availability of data at the SSE and the time that the data must be processed is specified in Annex 10 Volume III, Appendix to Chapter 5.

2.1.2 General conventions on data formats

2.1.2.1 Validity of data

The bit patterns contained in the 56-bit transponder registers are considered as valid application data only if they comply with the conditions specified in Annex 10 Volume III, Appendix to Chapter 5.

2.1.2.2 Representation of numerical data

Numerical data are represented as follows:

— Whenever applicable, the resolution for data fields has been aligned with ICAO documents or with corresponding ARINC 429 labels. Unless otherwise specified in the individual table, where ARINC 429 labels are given in the tables, they are given as an example for the source of data for that particular field. Other data sources providing equivalent data may be used.

— Where ARINC 429 data are used, the ARINC 429 status bits 30 and 31 should be replaced with a single status bit, for which the value is VALID or INVALID as follows:

- If bits 30 and 31 represent “Failure Warning, No Computed Data” then the status bit shall be set to “INVALID.”
- If bits 30 and 31 represent “Normal Operation,” “plus sign,” or “minus sign,” or “Functional Test” then the status bit shall be set to “VALID” provided that the data are being updated at the required rate.
- If the data are not being updated at the required rate, then the status bit shall be set to “INVALID.”

For interface formats other than ARINC 429, a similar approach is used:

— In all cases where a status bit is used it shall be set to “ONE” to indicate VALID and to “ZERO” to indicate INVALID. This facilitates partial loading of the transponder registers.

— Where the sign bit (ARINC 429 bit 29) is not required for a parameter, it has been actively excluded.

— Bit numbering in the MB field is specified in Annex 10, Volume IV, Chapter 3, 3.1.2.3.1.3.

* All tables appear at the end of this chapter.